PRACTICAL

ELECTRONICS

MARCH 1977

40p

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a Vital Series... starting this month

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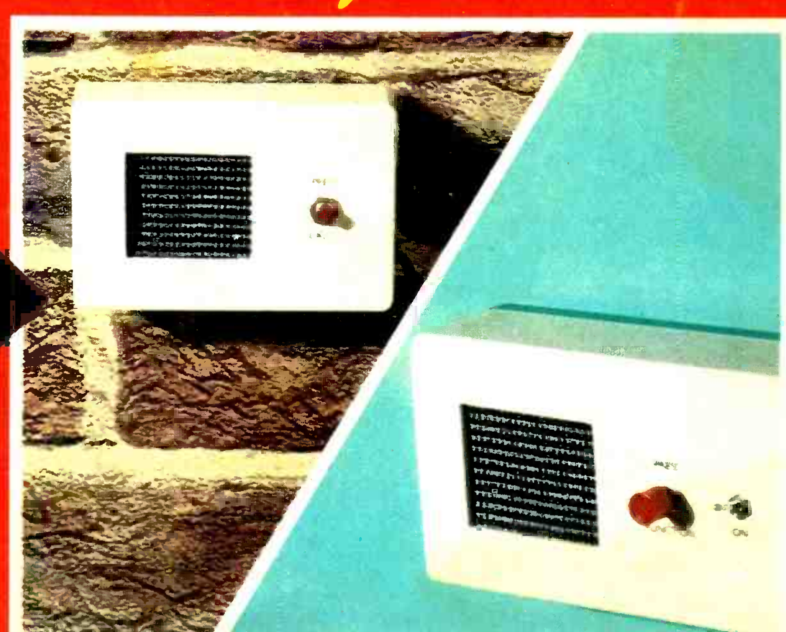

Also...
AUTOWAH for GUITARS and ORGANS

PRACTICAL ELECTRONICS

VOLUME 13 No. 3 MARCH 1977

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FREE WITH THIS ISSUE

DIODE IDENTICHART

Our April issue will be on sale on Friday, March 11, 1977

(for details of special supplement and other contents, see page 205)

Build yourself this high quality touch-sensitive piano. The design also features the new transpose control which is an external tuning control—this tunes the entire keyboard higher or lower than the concert pitch by one whole octave. Two models are available: TS50 which is a straight piano and TS53 has piano, honky tonk, harpsichord, and fast and slow tremolo effects. These professional pianos can be built in just 12 hours.

Parts List	Price
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1 × AY-1-5051 i.c. divider	£1·20
25 × diodes low noise high resistance (5p each)	£1·25
5 × transistors 2N3703 (12p each)	60p
10 × elect. caps 3 3µF 25V (5p each)	50p
48 × resistors watt 5% (1p each)	48p
12 × terminal pins (½p each)	6p
1 × p c. board, drilled	£1·00
2 × 0·01 (4p each)	8p
3 × 0·02 (4p each)	12p
Total Price per unit (11 units required)	£5·29

ESU/6 Divider and Touch-Sensitive Keyer Unit

1 × AY-1-6721/5	£1·30
30 × diodes low noise high resistance (5p each)	£1·50
6 × transistors 2N3703 (12p each)	72p
12 × elect. caps 3·3µF 25V (5p each)	60p
58 × resistors watt 5% (1p each)	58p
14 × terminal pins (½p each)	7p
1 × P.C. board, drilled	£1·00
2 × 0·01 (4p each)	8p
4 × 0·02 (4p each)	16p
Total Price (only 1 unit required)	£6·01

Power Supply

3 × yards main cable (10p yard)	30p
1 × mains transformer 20-0-20 1A	£2·45
1 × mains plug and socket	76p
2 × fuse holders (20p each)	40p
2 × fuses 1A (6p each)	12p
4 × rectifier diodes (5p each)	20p
2 × elect. caps 2.200µF 40V (95p each)	£1·90
1 × elect. caps 1.000µF 35V	40p
2 × resistors 5W (12p each)	24p
1 × neon lamp	25p
1 × pot with switch	54p
1 × metal knob	55p
2 × capacitor clamps (5p each)	10p
1 × chassis	60p
Total Price (only 1 unit required)	£8·81

1 × voltage regulator	£1·75
1 × 5-octave keyboard C-C or F-F	£22·00
1 × cabinet, front plate and fittings	£26·00
1 × jack socket	15p
1 × switched jack socket	50p
1 × stereo jack socket	25p
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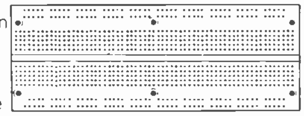

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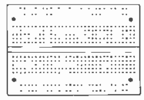

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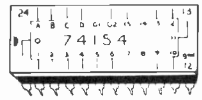

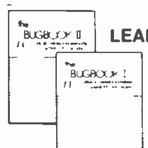

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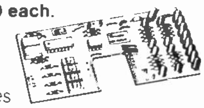

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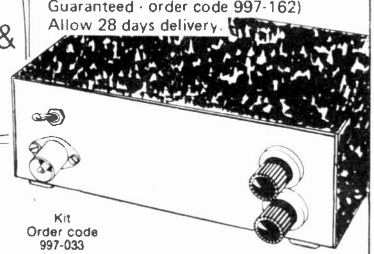

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Value	No.	Price
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0–100μA	1303	£4·50
0–500μA	1304	£4·50
0–1mA	1305	£6·00
0–50V	1306	£6·00

2in RANGE
Size 2½ × 1¾ × 1¼in

Value	No.	Price
0–50μA	1307	£3·50
0–100μA	1308	£3·50
0–500μA	1309	£3·50
0–1mA	1310	£3·50
0–50V	1311	£3·50

MR2P TYPE
Size 42 × 42 × 30mm

Value	No.	Price
0–50μA	1313	£4·80
0–1mA	1315	£3·20

EDGEWISE
Size 3½ × 1¼ × 2½in
Cut out 2¾ × 1⅛in

Value	No.	Price
0–1mA	1316	£4·05
0–500μA	1317	£4·05

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Size 23 × 22 × 26mm
Sensitivity 100/0/100mA

No.	Price
1318	£1·95

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Size 45 × 22 × 34mm
Sensitivity 100/0/100μA

No.	Price
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Size 40 × 40 × 29mm
Sensitivity 130μA

No.	Price
1321	£2·00

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U51	150	Germ. OA70/81 diode	16131	£0·60
U52	100	Silicon diodes 200mA OA200	16132	£0·60
U53	150	Diodes 75mA 1N4148	16133	£0·60
U54	50	Sil rect top hat 750mA	16134	£0·60
U55	20	Sil rect stud type 3 amp	16135	£0·60
U56	50	400mW zeners DO7 case	16136	£0·60
U57	30	NPN trans BC107/8 plastic	16137	*£0·60
U58	30	PNP trans BC177/178 plastic	16138	*£0·60
U59	25	NPN TO39 2N697/2N1711 silicon	16139	£0·60
U60	25	PNP TO59 2N2905 silicon	16140	£0·60
U61	30	NPN TO18 2N706 silicon	16141	£0·60
U62	25	NPN BFY50/51	16142	£0·60
U63	30	NPN plastic 2N3906 silicon	16143	*£0·60
U64	30	PNP plastic 2N3905 silicon	16144	*£0·60
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U66	15	Plastic power 2N3055 NPN	16146	£1·20
U67	10	TO3 metal 2N3055 NPN	16147	£1·20
U68	20	Unijunction trans IIS43	16148	£0·60
U69	10	1 amp SCR TO39	16149	£1·20
U70	8	3 amp SCR TO66 case	16150	£1·20

Code Nos. mentioned above are given as a guide to the type of device in the pak. The devices themselves are normally unmarked.

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Pak No.	Qty.		Order No.	Price
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C2	150	Capacitors mixed value approx. (count by weight)	16165	*£0·60
C3	50	Precision resistors. Mixed values	16166	£0·60
C4	80	⅛W resistors mixed preferred values	16167	*£0·60
C5	5	Pieces assorted ferrite rods	16168	*£0·60
C6	2	Tuning gangs. MW/1W VHF	16169	*£0·60
C7	1	Pack wire 50 metres assorted colours single strand	16170	£0·60
C8	10	Reed switches	16171	*£0·60
C9	3	Micro switches	16172	*£0·60
C10	15	Assorted pots	16173	*£0·60
C11	5	Metal jack sockets 3 × 3·5mm 2 × standard switch types	16174	*£0·60
C12	30	Paper condensers preferred types mixed values	16175	*£0·60
C13	20	Electrolytics trans. types	16176	*£0·60
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C16	20	Assorted tag strips and panels	16179	£0·60
C17	15	Assorted control knobs	16180	*£0·60
C18	4	Rotary wave change switches	16181	*£0·60
C19	2	Relays 6–24V operating	16182	*£0·60
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CP6	Single Microphone H/Duty	3131	12p
CP7	3-core Mains (5 amp)	3132	9p
CP8	2-core Oval (2·5 amp)	3133	8p
CP9	2-core Speaker	3134	7p
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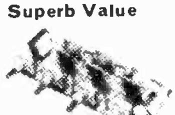

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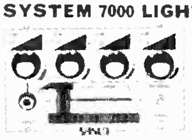

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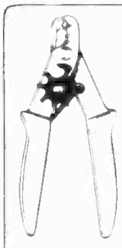

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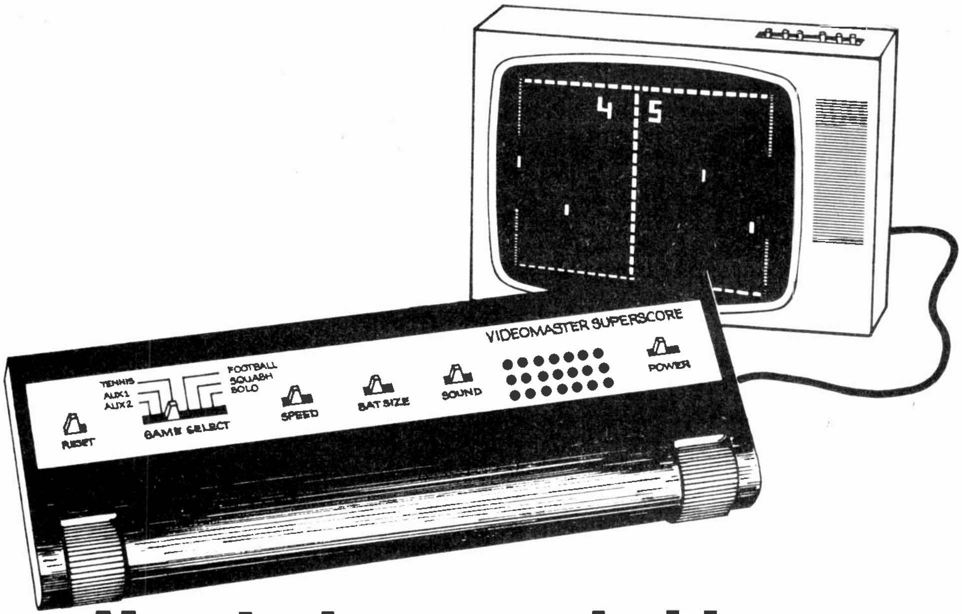
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MICROPROCESSORS

How much invention is the result of directed endeavour; how much on the other hand is the result of some happy chance discovery? One thing we do know is that serendipity has figured significantly in the semiconductor story.

Remember how the transistor came about? Recall the development of the integrated circuit—a "reverse" development, from factory to lab—suggested by the technique involved in the bulk manufacture of discrete transistors. Now the microprocessor, invented by Intel in answer to a calculator manufacturer's request for a single LSI chip suitable for a whole range of different calculators.

The wider significance of this invention is now clear to see. The microprocessor has introduced an alternative approach to conventional logic design, based on a chip infinitely variable in arithmetic and control operations, and amenable to instructions.

That first microprocessor came about as the result of a determined investigation into a particular problem, but serendipity really comes into the picture again, as the consequential advantages of this new device—way outside the application which was the cause of its creation—were recognised. It has now become the intelligent centre of all manner of electronic control and computing systems. The sometime lavish-sounding claims made on its behalf are now seen to be credible, as the microprocessor finds its way into industrial, scientific and even domestic equipments.

Amateurs have naturally been keen, albeit complexed, sideline observers of the rapid developments in the microprocessor field. For most of them the relevance of microprocessors to their hobby is still represented by a big question mark.

One thing at least soon became clear, to professionals no less than to amateurs. This was not going to be an easy comfortable transition, like from discretes to i.c.s. Even the trauma of changing from valves to transistors would in no way equal the radical changes in the approach to circuit design that the microprocessor would bring about. For another discipline comes into play, as the keyboard takes over from the soldering iron as the most important implement during development work. The user of microprocessors must get on familiar terms with computer programming: with the peculiar language or jargon, as well as with the techniques which have to be learnt and practised. Peripherals have to be taken into account—more especially if one is interested in building a stand-alone minicomputer—and these are generally expensive pieces of apparatus.

And yet computing, as an end in itself, is not the only aspect of microprocessors that will interest the constructor. Microprocessors will also be used in "dedicated" functions. In such roles these devices are really to be seen as extra-powerful building blocks. The scope of amateur built equipment will expand to enormous proportions with the use of such dedicated microprocessors.

As Mr. Coles says in his opening article, no one should *ignore* microprocessors. This without doubt is the message of the moment. Whether a "chance" invention or not, the coming of the microprocessor is an event equalled only by the discovery of the transistor.

F.E.B.

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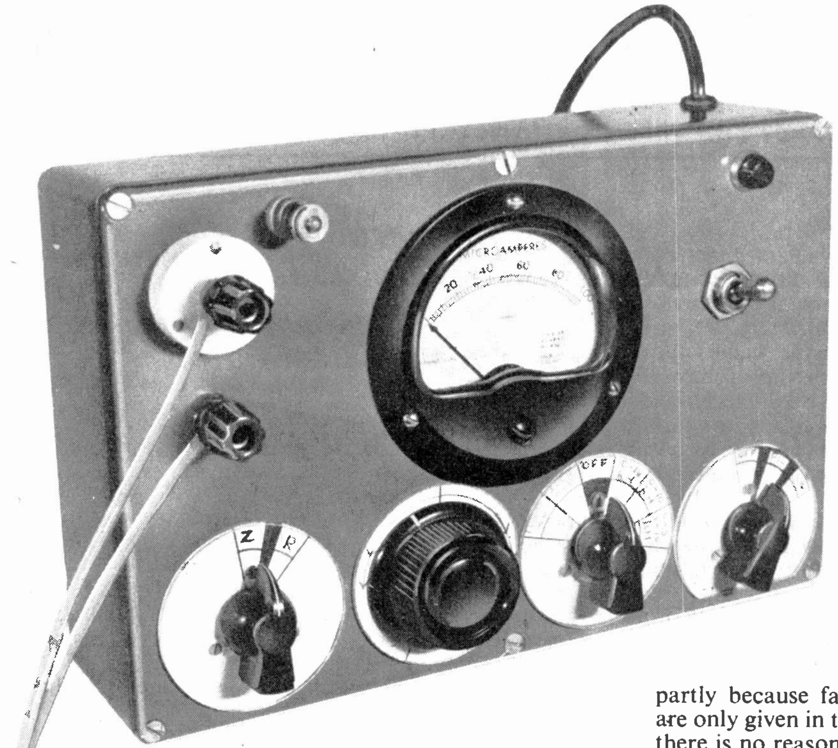


Part 1

pH METER

By K. E. LANGFORD

ORIGINALLY a research laboratory curiosity, pH determination has now become one of the more important measurements needed by industry, technology, agriculture and medicine.

The pH value of a substance is a measure of its acidity, and is therefore dependent upon the concentration of Hydrogen ions present. The symbol for this concentration is $[H^+]$, and the units are grams per litre. To convert this Hydrogen ion concentration figure to a pH value, it must be expressed as an exponent of ten (as a common logarithm), but with the exponent polarity reversed. It was the Swedish scientist Sorensen who devised this scale, and decided how the pH value should be arrived at, and this theory will be expanded later.

No modern electroplating plant could function without rigid pH control of its various electrolytes. Similarly, effluent treatment plant has pH controllers and recorders monitoring most steps in the purification cycle. Food preparation and brewing both rely heavily on tight control of acidity for successful functioning of the various fermentation stages upon which they depend. In medicine, blood pH measurements are sometimes used as an index of the respiratory state during surgery, while another clinical application is a check on the acidic properties of certain body fluids. Special equipment and techniques are called for in these latter applications.

Determination of soil pH is a vital necessity, particularly where intensive agriculture methods are applied, since most crops have a definite narrow band over which optimum growth rate occurs. A deviation of soil pH by four units either side of neutrality would result in the extinction of almost all plant life, though needless to say this deviation is unlikely to occur.

Until recently the amateur has regarded pH measurement, apart from the use of colourimetric test sets, as being for the professional laboratory only. This has been partly due to the expense of such equipment, and partly because facts about electrometric pH methods are only given in the more serious text books. However, there is no reason why anyone with a modicum of skill and plenty of patience should not be able to construct this device, and make accurate pH measurements, and voltage readings in the range zero to two volts.

THEORY

Many chemicals readily dissolve in water, producing a solution that conducts electricity. These chemicals have the property of splitting up, usually into two separately charged entities called ions. This ionization takes place when the solvent has a high dielectric constant, and can therefore separate and support unlike charges. Pure water is a poor conductor and so serves as a dielectric.

Two types of ion are produced: One is called the *cation* which is derived from the metallic part of the molecule and possesses a positive charge, and the other is called the *anion*, non-metallic in origin and negatively charged.

Common salt, sodium chloride (NaCl) splits up exactly as described.

$$\underset{\text{(neutral molecule)}}{NaCl} \rightleftharpoons \underset{\text{(cation)}}{Na^+} + \underset{\text{(anion)}}{Cl^-}$$

The double arrows in the equation indicate that the splitting up may not be complete, such that only a percentage of the salt is ionized. The amount will depend on certain physical conditions like the strength of solution, temperature, and type of salt. The unionized portion is assumed to consist of neutral molecules. Note how plus and minus signs are used to indicate the ion charges.

ACIDS AND ALKALIS

All acids produce Hydrogen ions H^+, and all alkalis produce Hydroxyl ions OH^-. This is in fact the modern definition of these substances.

Sulphuric acid (H_2SO_4) ionizes:

$$H_2SO_4 \rightleftharpoons 2H^+ + SO_4^{--}$$

A two-part article explaining an electronic method of pH determination; a field of interest to gardeners, aquarium owners, chemists, home brewers and students.

An instrument is described which will not only measure pH accurately, but make very high impedance voltage readings up to two volts.

PART ONE

- ***Some basic theory of acids and alkalis, and electrometric detection techniques***

PART TWO *(next month)*

- ***Complete design and construction details of a pH meter***
- ***Standardising and using the instrument***

Since each Hydrogen ion H^+ can carry one positive charge only, and each H_2SO_4 molecule is *electrically* neutral, the sulphate ion must have two negative charges SO_4^{--}.

The anion can be either a non-metallic element or, as in this case, a radical. A radical is a fundamental group of atoms such as sulphate (SO_4), nitrate (NO_3), phosphate (PO_4) and carbonate (CO_3), that behave as individual entities and remain unchanged by most chemical reactions.

The alkali caustic soda (NaOH) ionizes:

$$NaOH \rightleftharpoons Na^+ + OH^-$$

This being an alkali molecule will produce a Hydroxyl ion OH^-, whereas the sulphuric acid molecule produced two Hydrogen ions $2H^+$. Note that Hydroxyl ions OH^- are in fact radicals.

WATER

Solutions which conduct electricity more readily (electrolytes) are those in which the percentage ionization is high, sometimes as much as 100 per cent. Such electrolytes include sulphuric, hydrochloric and nitric acids, and alkalis like caustic soda, caustic potash, ammonia and calcium hydroxide.

Water is a special case because it only slightly ionizes, and gives rise to both Hydrogen and Hydroxyl ions. The *product* of Hydrogen and Hydroxyl ions in pure water at 25°C has been found to be 10^{-14} grams per litre. This accounts for the very small but definite conductivity of even the purest water. Tap-water however, is generally a good conductor.

Therefore:

$$[H^+] \times [OH^-] = 10^{-14} \text{ g/l} \quad . \quad . \quad . \quad (1)$$

Also since water is electrically neutral, $[H^+]$ must equal $[OH^-]$. Making this substitution, equation (1) becomes:

$$[H^+] \times [H^+] = [H^+]^2 = 10^{-14} \quad . \quad . \quad . \quad . \quad (2)$$

Therefore:

$$[H^+] = \sqrt{10^{-14}} = 10^{-7} \quad . \quad . \quad . \quad (3)$$

The Hydrogen ion concentration of pure water is 10^{-7} g/l.

THE pH SCALE

In 1922 Sorensen suggested taking the exponent of ten with the sign changed to + and using this to form a scale up to fourteen (at 25°C). This would give neutrality at pH 7 (based on water), so that equation (3) becomes:

$$[H^+] = 10^{-7} \text{ or pH} + 7$$

Neutrality here refers to the balance between Hydrogen ions and Hydroxyl ions. At pH 7 both types of ion are present in equal quantities.

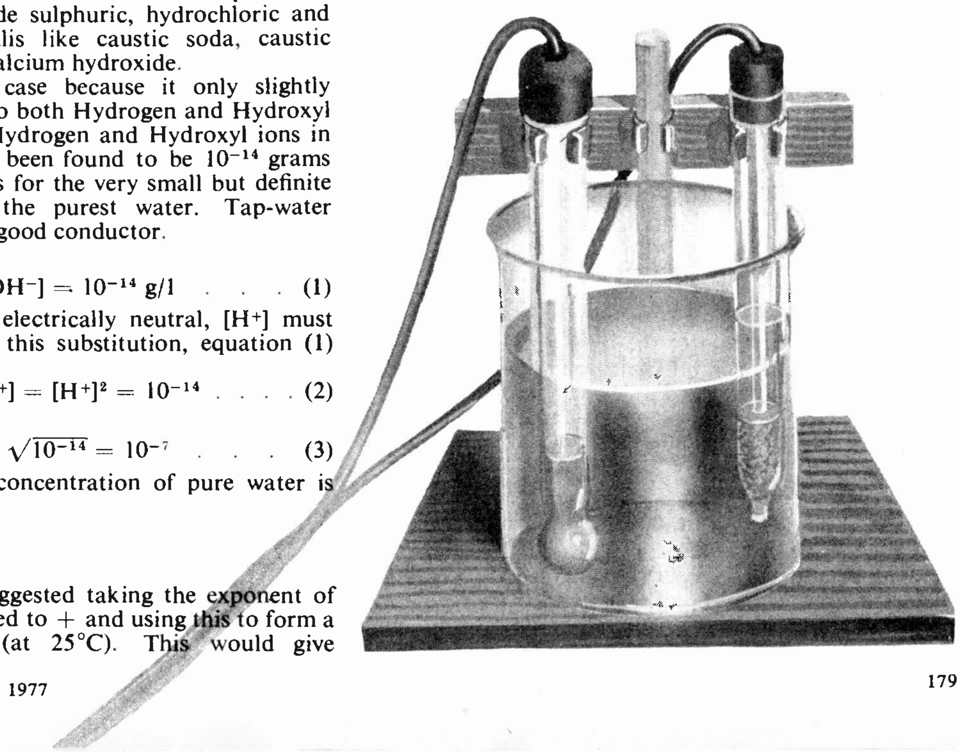
Were it not for the exponent reversal, the pH value would simply be the logarithm to base ten of the $[H^+]$ value.

However, the mathematical translation is now:

$$\text{pH} = \log_{10} \frac{1}{[H^+]}$$

$$\text{and } [H^+] = 10^{-\text{pH}}$$

The "ionic product of water" ($[H^+] \times [OH^-]$) that Sorensen used to fix the length of the pH scale, depends upon temperature, and varies from about 14·9 at 0°C to 13·0 at 60°C. This complicates pH measurement considerably, causing variation even at pH 7. As a consequence, the scale of any pH meter will be correct only at the temperature at which it was calibrated.



Note that with the pH scale, increasing acidity is shown by a lower pH, and increasing alkalinity is shown by a higher pH. Also, halving the pH does not double the $[H^+]$, but increases it ten times. A reading of zero pH (for 25°C) will be a Hydrogen ion concentration of one gram per litre, and concentrations in excess of this would indeed give a negative pH value. Finally, the letters pH are an abbreviation of *exponent* of *Hydrogen* ion concentration.

CONCEPT OF POTENTIAL

All that is needed to measure pH then, is a method of counting the number of Hydrogen ions in a solution.

Consider a metallic electrode immersed in a solution containing its own ions, such as copper in copper sulphate, or zinc in zinc chloride. The metal will have a tendency to enter the solution by forming further metal ions. This tendency is called the Electrolytic Solution Pressure (E.S.P.) and is greater for some metals than others. This ion formation is opposed by the Osmotic Pressure (O.P.) which tends to do the reverse; depositing ions from the solution onto the metal electrode. If E.S.P. is greater than O.P. the electrode metal will release some positive ions, leaving behind a negative charge on the electrode. Conversely, if O.P. is greater than E.S.P., positive metal ions deposit themselves on the electrode, which then accumulates a positive charge. When E.S.P. is equal to O.P. a state of balance exists.

The imbalance is precisely what happens in a primary cell, where an electrode of each type described is immersed in the same electrolyte. The external circuit (the load) is the path through which electrons from the negative electrode return to the electron-starved positive electrode, constituting the electric current.

The most important factor influencing E.S.P. is the concentration of metal ions in the liquid. Also, E.S.P. $\propto [M^+]$, where M is the metal from which the electrode is constructed, and M^+ is the ion quantity produced from M by loss of electrons.

ELECTRODES

Obviously probes are needed for the pH meter, and one type is the Hydrogen electrode. If E.S.P. is proportional to $[M^+]$ with a metal electrode, then E.S.P. is proportional to $[H^+]$ with a Hydrogen electrode. Unfortunately Hydrogen is a gas! However, there are metals such as platinum and palladium, that possess the property of adsorbing Hydrogen gas on their surfaces and causing it to ionize. In this condition it will come into equilibrium with the quantity of Hydrogen ions present, in any aqueous solution in which it is placed.

The Hydrogen electrode effectively produced acquires a potential proportional to the $[H^+]$ or the pH of the liquid. Therefore, E.S.P. (of Hydrogen electrode) $\propto$ pH.

Although the Hydrogen electrode is feasible and forms the basis of all reference standards, it suffers from serious practical limitations both constructional and manipulative, so that it is only rarely used outside the research laboratory.

As a standard of potential however, the Hydrogen electrode immersed in a solution containing H^+ at a concentration of one gram per litre, is by convention assigned the value of zero volts. Values on either side of it receiving a plus or minus sign. This is the origin of the electrochemical series.

A voltaic cell presupposes two electrodes immersed in a suitable electrolyte *between* which a potential difference is developed. To find the E.S.P. the same need arises; to combine the detecting electrode (in this case Hydrogen) with another to form a complete cell, the potential difference of which can be measured. Also, if E.S.P. varies with pH, the second electrode must give an independent fixed potential to avoid a second variable. A standard reference potential is therefore chosen as the second half of the complete cell. Each electrode is often called a half cell, and the one providing the fixed potential, a standard half cell.

The most commonly used reference electrode is the calomel half cell, a modern form of which is shown in Fig. 1. The potassium chloride solution which functions as the electrolyte, is sometimes called the *salt bridge*. This dates back to when two separate electrodes were electrically connected by means of an inverted U tube containing potassium chloride, which bridged the two electrodes and so completed the circuit.

This particular salt is comparatively inexpensive, easily purified by recrystallisation, is a good conductor, and possesses ions which travel at similar velocities. This final advantage ensures that junction potentials at each end of the bridge are virtually eliminated. Originally the saturated salt solution linked the two electrodes, whereas in pH measurement the sample to be tested will link the two half cells, forming a complete cell whose voltage can be measured. The standard half cell still contains a salt bridge, but electrical continuity to the sample in which it is placed, is effected by a porous plug situated at the bottom of the electrode. This allows slow diffusion (about 3cc/day) of electrolyte, thus maintaining exterior electrical continuity.

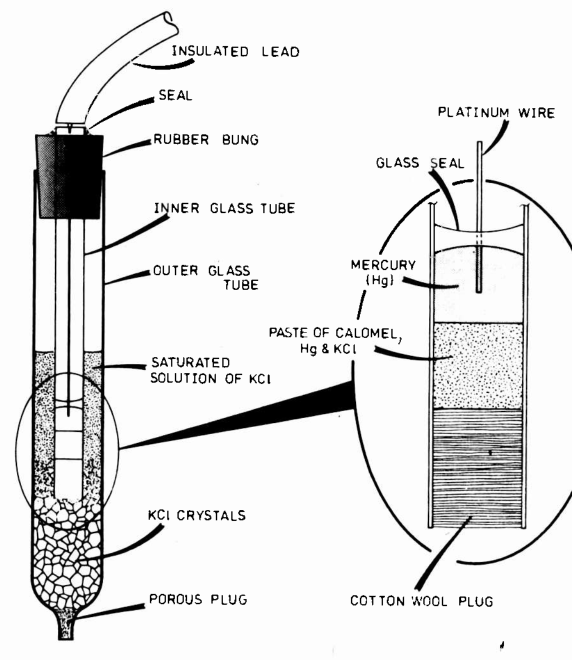


Fig. 1. Calomel half cell

Although the Hydrogen electrode was considered impractical, it does, when combined with a calomel half cell, enable pH measurements to be carried out with comparatively simple circuitry.

THE GLASS ELECTRODE

There is, however, one electrode which is sensitive to Hydrogen ions, is unaffected by most chemical compounds, is more manageable and easily made commercially, and gives a rapid response to changes in $[H^+]$. This is the glass electrode, and its construction is shown in Fig. 2.

Glass is generally considered to be an insulator, but since conductivity is a relative thing, it will be no surprise to discover that a glass electrode may have a resistance from 50 to 1,000MΩ, depending upon the type and temperature.

The electrode is constructed from a special glass with properties selected to enable it to function over as wide a pH range as possible (ordinary glass is attacked by strong alkalis at pH greater than ten), to possess a comparatively low internal resistance, and to respond rapidly to changes in pH. It usually consists of a Pyrex glass tube to which a special glass disc is attached at one end by partial fusion. The disc is then blown out into a small bulb of very thin wall, hence its fragility. After fabrication the electrode is annealed to reduce stresses which affect the "asymmetric potential".

To make electrical contact with the inner glass surface, since the pH-dependent voltage is developed between the inner and outer surfaces, a small volume of dilute hydrochloric acid or buffer solution is introduced into the bulb. Into this liquid dips a silver wire, the immersed end of which is electrically coated with silver chloride (AgCl). This inner combination actually forms another electrode, but since its potential is constant and unaffected by external conditions, it plays no part in pH determination provided temperature is kept constant. At the opposite end of the Pyrex tube is an insulated cap, inside which the silver wire is soldered to a flexible coaxial connecting lead. The other end of the lead has a suitable termination for connection to the meter unit.

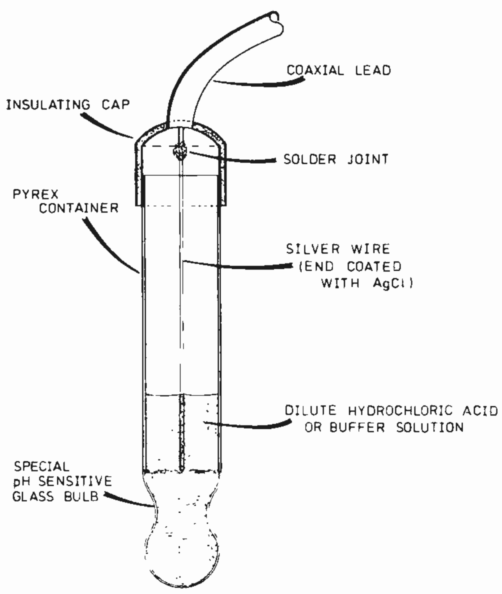


Fig. 2. Glass electrode

The glass electrode is considered to function as a kind of ion exchange membrane, in which Hydrogen ions in the liquid under test exchange with calcium, lithium, barium or other ions within the lattice structure of the glass. This phenomenon, which is not completely understood, gives rise to the potential difference across the glass membrane.

A glass electrode in combination with a calomel or other reference electrode and connected by a salt bridge, functions as a rather sophisticated primary cell, the potential difference of which depends upon two factors: (a) the reference potential, and (b) the potential developed by the glass electrode.

Assuming all controllable variables are kept constant, the potential difference across the electrode combination is proportional to the pH of the liquid in which the glass electrode is placed.

Nernst, a German electrochemist, derived an equation involving calculus which enabled E.S.P. to be calculated, and it is known from this equation that the E.S.P. of an electrode (usually expressed in millivolts), is a linear function of the ion concentration, except perhaps at the extreme ends of the pH scale. With the potential difference of our electrodes being a linear relationship to $[H^+]$, the only remaining problem is how to measure this potential with a source resistance of, say, 100MΩ. The internal resistance of the calomel half cell is ignored since it falls within the Kilo-ohm range. The potential across the cell is about one volt, so the available current will be in the region of ten nano-amperes.

If we require the results to be within one per cent, we need a voltmeter with a resistance of 10,000MΩ or greater. Few other measurements of potential except perhaps flame conduction, call for input resistances of such magnitude.

MEASURING POTENTIAL

Two distinct methods of measuring the potential developed by the glass-calomel electrode combination have been used in commercial meters. One method first amplifies the signal, then compares it with a standard potential from a Weston cell, or a secondary standard lead acid accumulator which has been itself standardised from the Weston cell. The comparison is made using the Poggendorf Potentiometer, incorporating a galvanometer as a null point detector. The circuit is essentially simple, and free from scale errors often associated with direct reading voltmeters. For routine pH measurements it has the disadvantage that pH changes cannot readily be followed, since a fresh null point must be found after any change in $[H^+]$. It was used in the earliest pH meters, and is still used where results of the highest accuracy are needed as opposed to rapid routine measurements.

The alternative method gives rise to the direct reading pH meter, and is in effect a d.c. voltmeter with a very high input resistance. In view of the minute current available, the signal must be amplified before it can give a reading, even on a micro-ammeter. The first stage of the amplifier for both types of pH meter is a valve acting as an impedance converter giving an output of a few micro-amps, and a voltage gain of slightly less than unity. For the direct reading meter this output current is further amplified, so that the resulting current can actuate a micro-ammeter which may be calibrated in pH units.

ELECTROMETER VALVE

For this particular application the electrometer valve still has much to offer, in the way of low noise and high input resistance. This valve is of rather special construction, and its peculiarities are that the cathode is directly heated with d.c., it requires a very low anode voltage, it is under-run by comparison with other types of valve, and the grid current is extremely low.

The exterior of the glass envelope is silicone coated to prevent condensation, and maintain a high surface resistance. As a consequence of this, THE VALVE MUST NEVER BE HANDLED WITH THE FINGERS; TWEEZERS SHOULD BE USED, and no insulation or sleeving must be placed on the grid lead.

By dispensing with the valve base, leakage via plastics insulation is avoided, while under-running the valve reduces ionization of any residual gas in the

CONSTRUCTORS NOTE

The ME1404 is no longer available direct from Mullard Ltd, but can be obtained from the following distributors:

R. S. T. Valve Mail Order Company,
Climax House, Fallsbrook Road,
Streatham, London, SW16 6ED.

Black Bow Electronics Ltd,
Millbrook Road, Stover Trading Estate,
Yate, Bristol.

Farnell Electronic Components Ltd,
Canal Road, Leeds, LS12 2TU.

We recommend that due to the limited availability of the ME1404 electrometer valve, anyone intending to construct the pH meter should secure this device before purchasing any other item.

COMPONENTS...

Resistors
R1 220Ω (V)
R2 100kΩ (V)
R3 1kΩ (V)
R4 10kΩ
R5 10kΩ
R6 56kΩ
R7 130kΩ + 10kΩ in series
R8–12 (high stability) see text
VR1 15kΩ wire-wound

Semiconductors
TR1, TR2, OC140 or equivalent (2 off)

Valves
V1 ME1404 (V)

Miscellaneous
S1 1 pole 2 way nylon loaded or ceramic switch (see text).
S2 2 pole 6 way rotary.
S3 2 pole 3 way (from 2P 6W standard rotary switch). (V)
ME1 100μA f.s.d. meter. 1kΩ resistance or less.
Terminals to fit glass and reference electrodes.
Earth terminal. Matrix board. 4BA and 6BA nuts and bolts.
Suitable knobs. Perspex sheet, $\frac{1}{16}$in. or $\frac{3}{32}$in. thick (1·6mm–2·4mm).
Metal box to give good screening. Prototype used 222mm × 146mm × 5·7mm die cast box.

(V) As valves become obsolete, they become difficult or impossible to replace. Therefore part two of this article will give details of an alternative f.e.t. input stage, which directly replaces the cheaper ME1404 with only a few modifications. Hence, components marked (V) should not be purchased if the f.e.t. version is to be constructed at the outset.

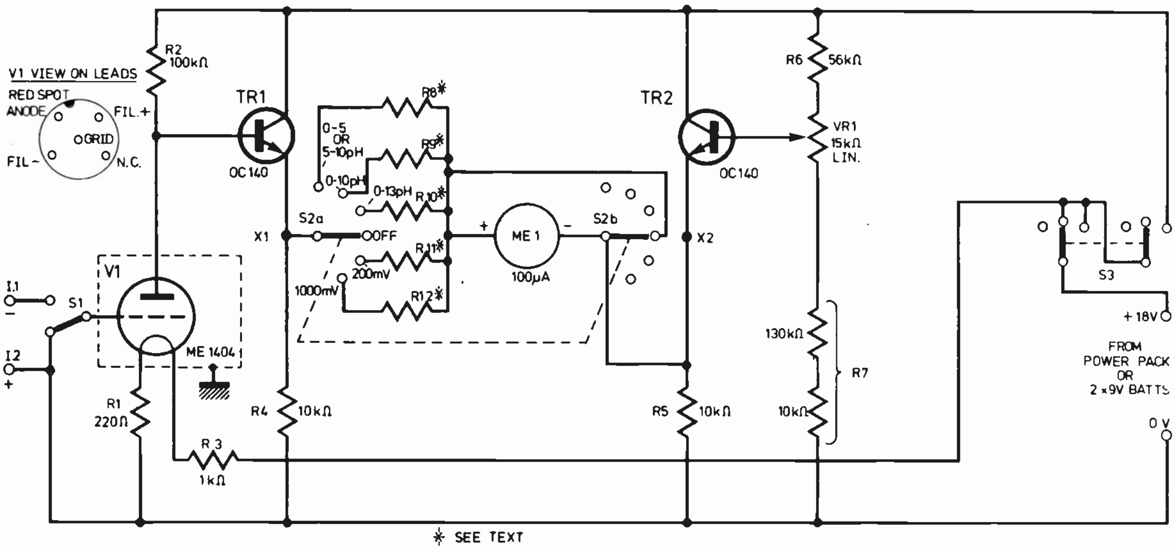


Fig. 3. Basic meter circuit using the Mullard electrometer valve

POWER PACK

Resistors
R1, R2 see text

Capacitors
C1 220μF 50V

Diodes
D1, D2 1N 914 (2 off)
D3 BZX61C 18V Zener (1 watt)

Miscellaneous
On/off panel switch (mains voltage).
Min mains transformer,
20-0-20 volts (50mA).
Mains indicator neon.

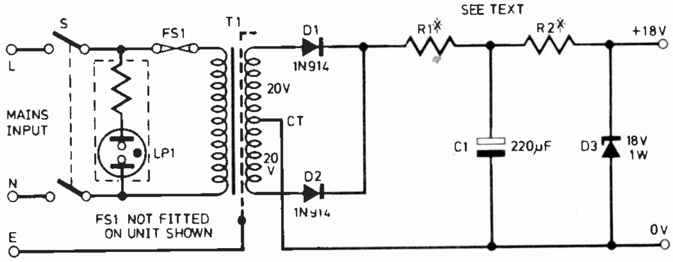


Fig. 4. Optional power pack

envelope, and maintains low grid current. Using d.c. to heat the cathode eliminates any noise or possible filament vibration.

THE pH METER UNIT

If the construction scheme is followed carefully, the resulting meter will be capable of measuring pH to 0·05 unit or better, but if corners are cut, accuracy will suffer. Because there is no ready way of knowing if a pH meter is reading correctly, as some meter deflection will result under almost any condition, accuracy must be built in if the user is to have confidence in the final results.

The basic meter circuit is given in Fig. 3. The valve is a Mullard ME1404 subminiature electrometer triode. The filament-cathode is fed at 1·2 to 1·3 volts, and passes a current of about 14mA. The line potential of 18 volts is dropped by R3, while R1 has a similar function, in addition to giving the grid a bias of minus 2 volts. The output voltage is developed across the load resistor R2 when V1 conducts. Note the very low anode voltage with this class of valve.

The arms of the bridge are formed by TR1 and TR2, together with R4 and R5. With S1 in the ZERO position there is a certain standing current in V1, and the bridge may be balanced by adjusting VR1. When balance is achieved there is no potential difference between points X1 and X2, and the meter reads zero. On applying a p.d. across the input points I1 and I2, and switching S1 to the READ position, the anode current changes, causing a corresponding change in anode potential and hence in bias to TR1. The change in current in TR1 upsets the bridge balance, giving meter deflection.

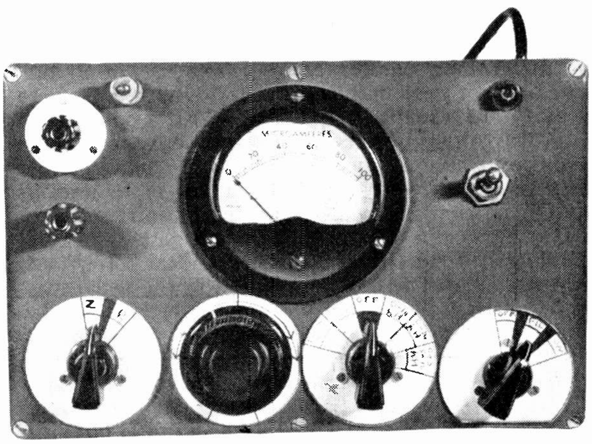
Within the limits of accuracy of this circuit and over the restricted range involved, the anode current is linear with respect to the grid current, so the meter reading bears a straight line relationship with the input from the electrodes. The micro-ammeter can be calibrated to read directly in pH units, or millivolts. All that is required is to select the correct values for resistors R8 to R12 on a multi-range version.

The circuit is uncomplicated, needing very few components, but some special points need clarification. Switch S1 is a two position selector and must be either ceramic or nylon loaded, and not a normal type with insulation of a lower order. The negative input terminal to which the glass electrode is connected must be insulated from the case with Fluon, Perspex or polystyrene. All connections between the input, S1 and the grid of the valve must be made with stiff bare copper wire, insulation depending only on the air gap. These requirements preserve the high input resistance of the instrument on which its accuracy depends. Beyond the grid, no special precautions are necessary, normal good quality insulation and wiring being satisfactory. Detailed drawings of the construction of the unit will be given next month.

The transistors TR1 and TR2, which ideally could be a matched pair, are mounted together in a double holder (or two bolted together), to give thermal coupling. S3 calls for an ordinary two-pole, three-way rotary switch, but is wired to ensure that the valve filament is switched on before the anode. This is a requirement for electrometer valves which promotes stability during their life. A make-before-break switch is preferred.

The meter is driven from two 9 volt batteries in series, if the instrument is to be portable, or the power pack shown in Fig. 4 can be used. The power pack is recommended, as unnoticed inaccurate results may arise from failing batteries. The selection of values for R1 and R2 in the power supply will be described in Part 2 of the project.

Next Month: Constructional details, calibration, and f.e.t. alternative input stage. Also, suppliers of glass electrode and calomel half cells will be detailed



Constant Volume INTERCOM

By R. A. Penfold

AMONG the most useful and popular of constructional projects for the electronics enthusiast is an intercom. Many designs for these have been published in the past, and in the author's experience these all suffer from one main shortcoming. This is the lack of any form of volume control.

This results in some users being barely audible over the system as they tend to talk too softly at too great a distance from the microphone. On the other hand, some people tend to talk unusually loudly into the microphone at very close quarters. This results in excessive volume and distortion at the receiving end of the system.

One way of overcoming all this would be to merely fit manual volume controls to the circuit, but a more satisfactory method would be to incorporate some form of automatic volume control (a.v.c.) in the system. It is on this concept that the intercom described in this article was designed.

THE CIRCUIT

The complete circuit diagram of the constant volume intercom is shown in Fig. 1. The input stage uses TR1, a dual gate MOSFET, in the common source configuration (the FET equivalent of the bipolar common emitter circuit). The use of a dual gate MOSFET here may seem a little unusual as these devices are usually only used in r.f. applications. However, these devices do operate satisfactorily in audio applications such as this, where the fact that they do not provide quite such a low noise level as JUGFET or bipolar devices is not too important.

Of course, the reason that a dual gate MOSFET is employed in the circuit is that it is ideal for circuits that use a.v.c. The device is biased in the usual way, with source bias resistor VR1 and gate bias resistor R1. C4 is the source bypass capacitor and R3 is the drain load resistor.

The gain of this stage is controlled by the voltage at the g2 terminal of TR1. Gain is at a maximum with this terminal held about 1 to 2 volts above the

COMPONENTS...

Resistors

R1	56Ω	R6	4·7kΩ
R2	100kΩ	R7	220Ω
R3	4·7kΩ	R8	390Ω
R4	680Ω	R9	120kΩ
R5	2·2MΩ	R10	12kΩ

All $\frac{1}{4}$W carbon

Potentiometers

VR1, 2 2·2kΩ horizontal preset (2 off)

Capacitors

C1	100μF 10V elect.	C7	100nF type C280
C2	2·2μF 10V elect.	C8	100μF 10V elect.
C3	100nF type C280	C9	100μF 10V elect.
C4	10μF 10V elect.	C10	2·2μF 10V elect.
C5	100μF 10V elect.	C11	100μF 10V elect.
C6	15nF type C280		

Semiconductors

IC1 LM380N
TR1 40673
TR2 BC108
D1 and D2 OA91 (2 off)

Switches

S1 D.P.D.T. (see text)
S2 S.P.S.T. miniature toggle
S3 Push to make, release to break type

Loudspeakers

LS1 and LS2 Miniature (50 to 65mm) 40 to 80Ω

Miscellaneous

Two plastics cases, one about 150 × 80 × 50mm, and one about 115×75×36mm (Verobox type 65-2520J, and plastics box type PB1, both available from M.E.S.)
Connecting cable of three core sub-miniature mains lead
0·1in. matrix Veroboard and Veropins
14 pin d.i.l. i.c. holder for IC1
Speaker cloth or fret, grommets, wire, solder, etc.

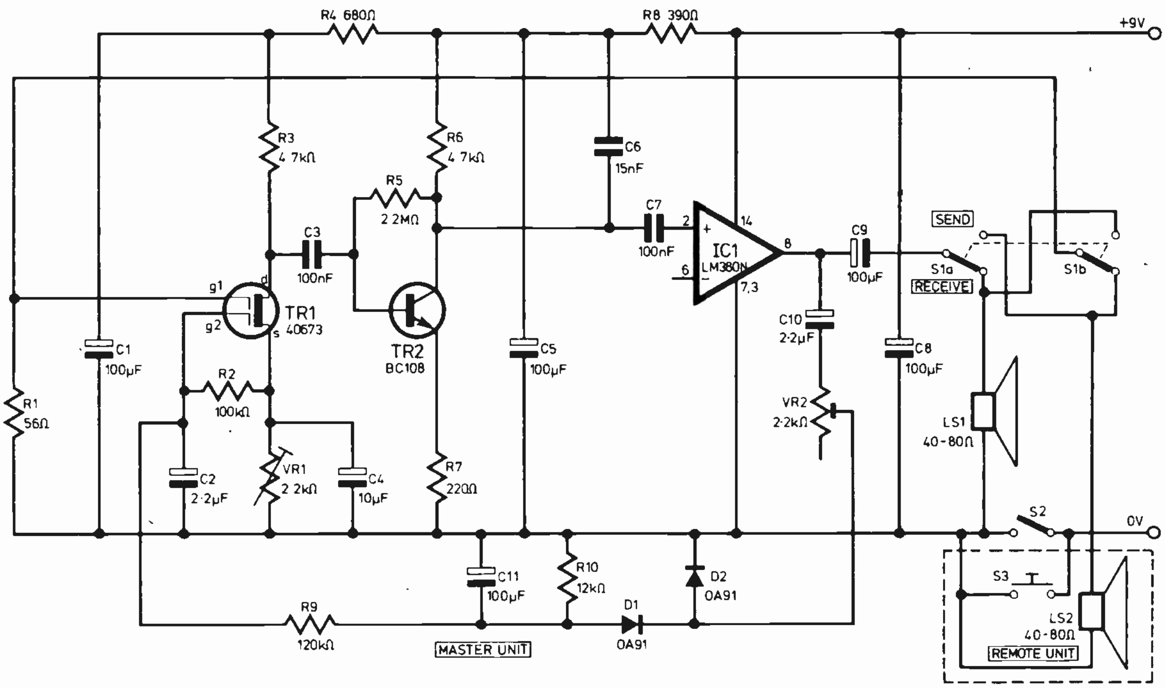


Fig. 1. Circuit diagram of the constant volume intercom

negative supply rail potential. Under quiescent conditions a bias voltage of approximately this level is obtained from TR1 source via R2. Reducing the g2 bias voltage results in a decrease in stage gain, and thus a simple a.v.c. action can be obtained by applying a negative a.v.c. bias to TR1 g2.

INPUT IMPEDANCE

As usual with this type of equipment, each speaker also doubles up as a sort of moving coil microphone. In order to obtain a good frequency response from these the amplifier must have a low input impedance, the actual value required being approximately equal to the impedance of the speakers used. Although FETS have extremely high input impedances, and are usually associated with high input impedance amplifiers, a low input impedance can be attained by simply using a low value gate bias resistor. The actual input impedance is approximately equal to the value given to this resistor. One advantage of this type of circuit is that there is no need to use a capacitor at the input, as there is no significant d.c. potential to block here.

TR2 is used in the common emitter mode, and is used to boost the output of TR1 to a level that will fully drive the output stage, even with only a fairly weak input at TR1 g1. This stage is quite conventional except for the unbypassed emitter resistor, R7. This introduces a degree of negative feedback to the circuit, and reduces the voltage gain of TR2 to the required level (about 26dB).

C6 filters out any r.f. signals that might be picked up in the connecting cable, and could otherwise break through to appear as an audio signal from the speaker. It also slightly reduces the upper frequency response of the circuit which results in an improved signal to noise ratio.

OUTPUT STAGE

An LM380 i.c. is used in the output stage, and when used in its most simple form, as it is here, the only discrete components that are needed to complete a practical amplifier are the input and output coupling capacitors. These are C7 and C9 respectively. An internal feedback network sets the gain of the i.c. at typically 50 times.

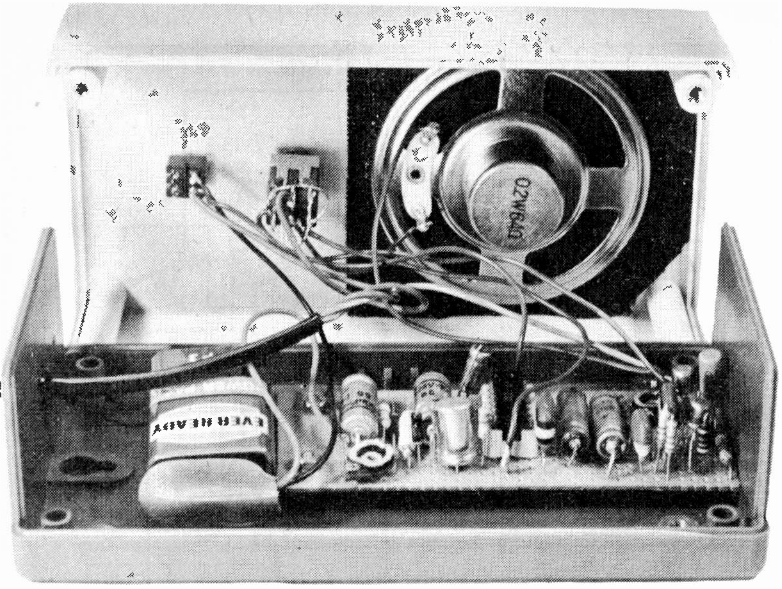
Although this is a 2 watt i.c., at the supply voltage and speaker impedance used here it is limited to an output power of about 100mW r.m.s. This is more than adequate for an intercom, and the quality of the output is quite good for this type of equipment.

A.V.C. ACTION

Some of the output signal of the LM380 is fed via C10 and VR2 to the rectification and smoothing network. C10 provides d.c. blocking and VR2 sets the level of compression. D1, D2, C11, R9 and C2 are the rectifying and smoothing network.

This network produces a negative bias at the g2 terminal of TR1, and the level of this bias is proportional to the amplifier's output signal amplitude. On strong signals a large bias voltage is developed, the gain greatly diminishing. Low level signals produce only a very small bias voltage which does not greatly affect the gain of TR1. Intermediate output amplitudes produce an intermediate bias level and circuit gain.

As a result of this the circuit has a low gain on strong signals, medium gain on average signals, and high gain on weak signals. This produces a level of volume from the intercom that is relatively constant over a wide range of input levels, and thus is very simple but effective.



Interior view of the master unit showing component board mounting position and wiring to the control switches and loudspeaker

This a.v.c. action has a quite fast attack time, but the decay time has purposely been made comparatively long (about 2 seconds). This is to avoid the undesirable effects of the a.v.c. bias falling away during the brief pauses that occur during normal speech. The decay time is set by the values given to C11 and R10.

SWITCHING

Normally S1 is left in the position shown in the circuit diagram, with the master unit set to receive any call from the remote unit. For the remote unit to call the master one, S3 is pressed while the operator talks into the microphone. Then anyone hearing the call at the master unit switches the unit on by closing S2. "Send/Receive" switching is then controlled at the master unit using S1.

The master station can call the remote one by S2 being closed, and the position of S1 being reversed (set to the "Send" position). The operator then speaks into the microphone and talks through to the remote unit.

Ideally S1 would be a biased type so that it would automatically return to the "Receive" position when a conversation had been completed. Unfortunately, biased switches are not easily obtained, and it will probably be necessary to use an ordinary unbiased type. It is then essential that this switch is always manually returned to the receive position, as otherwise it will be impossible for the remote unit to call the main one.

As the circuit is extremely sensitive, it is important in the interest of good low frequency stability that the supply lines are well decoupled. This is the purpose of C1, C5, C8, R4 and R8.

COMPONENT PANEL

All the small components are mounted on a 0·1in pitch Veroboard panel. Details of this panel are shown in Fig. 2.

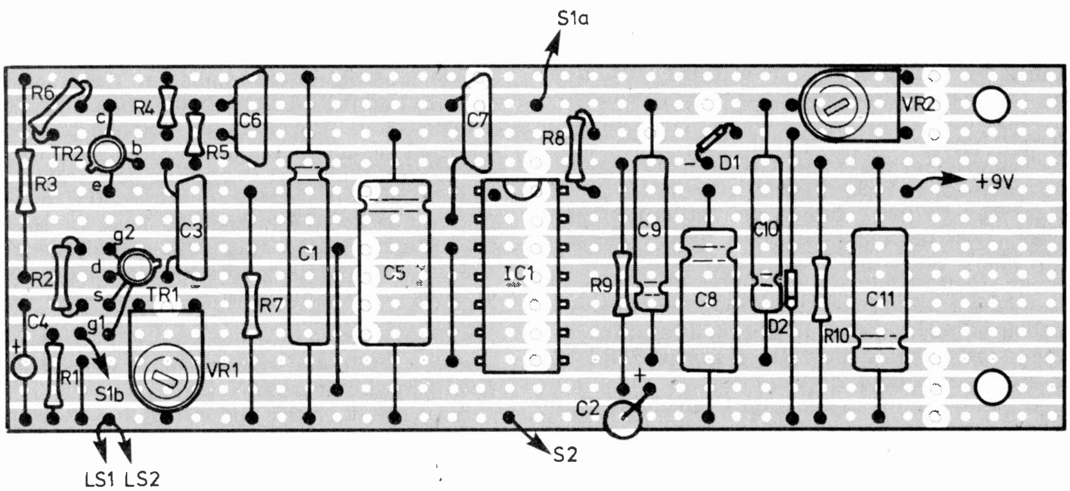
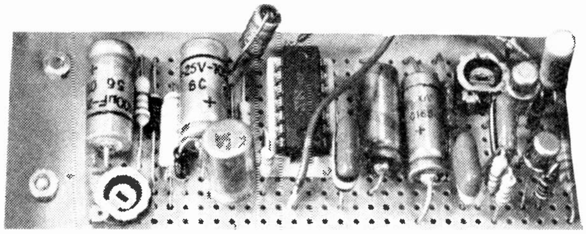


Fig. 2. Component layout and Veroboard cutting details

Physically small resistors and capacitors must be used if they are to fit into this very compact layout. Alternatively a slightly longer board could be used so that a slightly more spaced out layout can be adopted.

The mounting holes are drilled for 6BA clearance using a 3·2mm drill. Construction will be easier if the three link wires are soldered in before the other components. The LM380 is mounted in a 14-pin d.i.l. socket. 0·1in Veropins are used at the points where leads from the speakers, switches, etc. will eventually connect to the panel.



Components mounted on the circuit board

CASE

A plastics case measuring about 150 × 80 × 50mm is used for the master unit. An oblong 45 × 30mm cutout for the speaker is made towards the left hand side of the front panel using a fretsaw. A piece of speaker fret or cloth is glued in place behind the cutout, and then the speaker is carefully glued in place behind this. S1 and S2 are mounted to the right of the speaker. A hole for the connecting cable is cut in the right hand side of the case. Sub-miniature mains cable is ideal for use as the connecting cable. The panel is mounted on the base of the case using a couple of 13mm 6BA bolts, and it is advisable to space it a little way off the case using a few washers or short spacers, as otherwise there is a risk of the panel cracking as the mounting nuts are tightened.

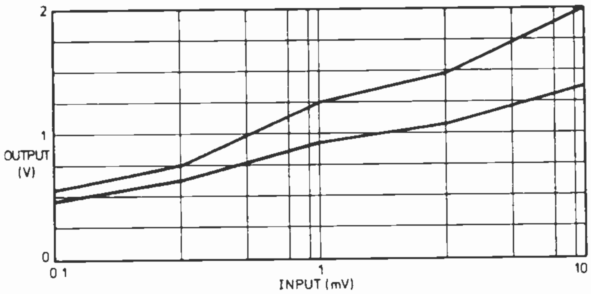


Fig. 3. Rough chart showing the compression given by two settings of VR2. (Input and output values are r.m.s., 1kHz sinewave)

REMOTE UNIT

This is built into a small plastics case measuring about 115 × 75 × 36mm, and uses much the same panel layout as the master unit, as can be seen from the photographs.

ADJUSTMENT

At the outset VR1 is set with its slider at about the centre of its track, and VR2 is adjusted for minimum resistance (fully anti-clockwise). With the units placed in different rooms so as to avoid acoustic feedback, turn the unit on. Connect a sensitive test meter set to read 10V f.s.d. across R3, and adjust VR1 for a reading of 4·5V. Adjusting VR1 in a clockwise direction results in an increased reading, and vice versa.

Set S1 to the "Receive" position and feed a fairly loud sound into the remote unit. If no helper is available to speak into the microphone and provide this test signal, an operating radio placed near the remote unit will do.

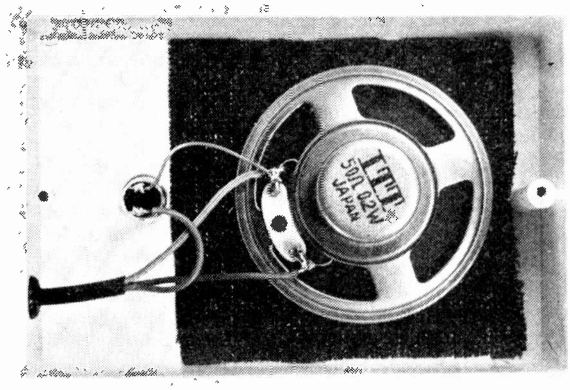
VOLUME

The volume from the master unit should be fairly low with VR2 set at minimum resistance, and adjusting it for increased resistance should result in an increase in the volume level. VR2 is set to the position that gives the most satisfactory volume. The greater the resistance VR2 inserts into circuit, the less effective will be the a.v.c. action. This can be seen from the rough chart shown in Fig. 3 which shows input versus output level at two settings of VR2. Also if it is set too high, there will be considerable distortion on strong signals. For this reason care must be taken not to adjust it for too high a level of resistance, and it is worthwhile experimenting a little with various settings in order to find the optimum one.

The unit has a fairly high background noise level, and this is partly due to the use of a MOSFET input stage, but is mainly because of the high sensitivity of the circuit. It should be found that when someone speaks into the microphone, the background noise level goes down as the a.v.c. action reduces the circuit gain.

On the prototype the a.g.c. action is highly effective, and talking anything between about 2m and 200mm away from the microphone produces a fairly constant output volume. ★

Interior view of the remote unit showing interwiring



BY FRANK W. HYDE

CLOSER INSPECTION OF THE SUN

The date of the Sun mission has been put back three times. The original plan was to launch in 1979 but this was later put back to 1981 and now to 1983. Any further delays would be limited to 1984 and possibly 1985. After that the mission would have to be shelved. From the scientific point of view this mission is an exciting one for this is an opportunity to study space away from the ecliptic.

First thoughts in this direction were made in 1974. It was last year that ESA (European Space Agency) and NASA (National Aeronautics and Space Administration) agreed that each should provide a spacecraft for the mission. Early studies were made with the idea that the highly successful *Pioneer 10* and *11* type of spacecraft with suitable modification would be used. However, as the responsibility for all deep space probes had been transferred by NASA from the Ames centre to the Jet Propulsion Laboratory a new situation arose. It was then agreed that ESA would build both spacecraft and during the design stage examine the possibility for a single craft project. The increased cost of the project would be shared by NASA.

THE MISSION

The basic mission would be two spacecraft launched toward Jupiter in 1983 by a four stage vehicle. The assembly would be taken to low Earth orbit by shuttle. The gravitational field of Jupiter would then swing both spacecraft round so that one passed over the north pole of the Sun and the other over the south pole in October 1986. The northern craft would pass at a distance of 1·5 AU (AU is one astronomical unit and is equal to the mean distance between the Earth and the Sun: 93 million miles). The southern craft would pass over the pole at 1 AU.

FIRST TIME

For the first time information would be gathered from an area outside the ecliptic. The ecliptic is the plane in which all the planets rotate and within which all probes have so far travelled. The space characteristics outside this plane would be investigated. This is an area where there could be considerable differences between the activity in that region as compared with activity within the gravitational field of the ecliptic.

TOWARD THE OUTER PLANETS

Plans for 1977 missions called MJS (*Mariner*, Jupiter, Saturn) are scheduled for launch in August or September. These vehicles are spin stabilised and weigh about 1,600lb.

They will fly past Jupiter in 1979. The planet's gravitational field will accelerate them on to a rendezvous with the planet Saturn in 1981. The vehicles are a new design and take advantage of the previous techniques explored with *Mariner* and *Pioneer* spacecraft.

DIFFERENT APPROACH

Journeys to the outer planets require a different approach from that needed for the inner planets. For one thing the greater distance from the Sun involved means that solar cell techniques are not satisfactory. The size of the sails required to carry enough cells to achieve the power necessary would take up too much of the payload. The power supplies are therefore similar to those on *Pioneer 10* and *11*. These were isotope generators which have already been described in *Spacewatch*. In order to isolate them from the experiments and instruments on board they are carried on booms sticking out from the vehicle. These generators are called RTGs (Radio Isotope Generators) using Plutonium 238. The thermal heat is converted by thermocouples to electrical power.

Another departure for these vehicles is the use of spin rotation at four to five revolutions per minute with a radio antenna locked to the Earth. Thus the Sun is no longer needed for control. The precessing of the spin axis is achieved by firing attitude control adjusters to maintain Earth lock by the antenna.

Launch vehicles will be *Titan IIIE/Centaurs*. These vehicles are similar to the launch vehicles for Mars but have an additional booster using solid propellant.

STUDY PROGRAMME

The programme for these two spacecraft will take them to Jupiter and Saturn on the first part of the journey. There will be studies of several of the satellites with a resolution of 1 kilometre. In the case of Io, the Jupiter satellite, the emission of the sodium radiation will be measured. The satellites of Saturn will also be surveyed.

The two cameras aboard each spacecraft will have lenses of 1,500 millimetres, and 200 millimetres focal length to provide a format of 800 lines with 800 pixels per line. The data from the cameras will be at the rate of 115,200 bits per second. With each pixel composed of 8 binary digits there will be a complete picture built up in 44·5 seconds. The data can be fed back to Earth at the 115,200 bits rate without an intermediate tape system. The transmission is via a 12 foot dish using a 26 watt transmitter. Storage is available if needed by tape with accommodation for 100 pictures. There will be 11 scientific experiments on each vehicle with a weight of 190lb. Three Plutonium generators will deliver 450 watts for power.

After the vehicles have studied the Saturn area in 1981 they may be sent on to Uranus as a target for 1985.

COMET INTERCEPT

In the period 1984 to 1986 the programme may include two fly-by vehicles to Saturn accompanied by a Saturn *Orbiter* probe. It could be that there will also be a detachable probe to go to Titan, a moon of Saturn known to have an atmosphere. By 1982 there is a possibility of a Jupiter mission with a sounding probe for study of the atmosphere by penetration by a vehicle. One event that also is a possibility in 1980 is the interception or fly-by of Encke's Comet. This would be a major step toward settling the controversial question of the structure of comets.

SELLING MICROPROCESSORS

FAMILIARISATION, education, and sales promotion are today three dominant and interlinked aims of microprocessor manufacturers. At present, there are more than thirty different types of microprocessors on the market. Will they all survive the intense campaigning now directed towards the customers that really count—the designers employed by makers of electronic equipments? These professional engineers will by their patronage of particular devices decide the ultimate survivors in this battle of the chips where large volume production wins over all.

Thus we have during the past months been witnessing a rash of Seminars for professional users (or potential users) of microprocessors. Reading (or rather listening) between the lines, there is quite a lot that could prove of great significance to the amateur in the not too distant future. Here we report briefly on two recent "happenings" that PE attended.

MOTOROLA: CONFIDENT AND ASSURED

In the next five years, completely committed on-board microprocessors will be in all automobiles. This spectacular use of microprocessors was confidently predicted by Colin Crook, Operations Manager, Motorola NMOS Products, from Austin, Texas.

As the opening speaker at the Motorola Seminar "Designing With Microprocessors" held at London's Royal Garden Hotel last November, Colin Crook explained Motorola's position in the microprocessor market and indicated future trends. Hardware costs will continue to fall, although, unfortunately, software costs will rise; the volume of 8-bit microprocessors will build up; the US hobby market will expand, from 25,000 systems sold in 1976 to double in 1977. Current development at Motorola includes work on the 4-bit single chip microprocessor for small computers and for single application purposes. Looking even further ahead—the big challenge is very large scale integration, where the entire system will be produced directly on to the chip. Within a few years we will see production of large scale integrated circuits containing a million and more transistor cells.

During the day other speakers elaborated on specific Motorola products, including the new M10800 Bipolar Processor Family, and a formidable range of Development Tools and other aids for system design and evaluation.

Industrial applications discussed included a proposed microprocessor control system for lifts. This application provides a good example of the considerable operational and cost advantages microprocessors offer over traditional control systems based on relays. Current uses of microprocessors—mainly in the US—include: all types of instrumentation, c.r.t. terminals (at airports), machine tool control, giant scoreboards, and petrol pumps.

G.I. MICROELECTRONICS: A STRONG TRIO

In the Scottish factory of General Instrument Microelectronics 400,000 MOS l.s.i. devices are produced every month. They include a range of microprocessor chips introduced and described by technical representatives of this company at a Seminar organised by the well known distributors Semiconductor Specialists Ltd. This was a whole-day function held at the Bloomsbury Centre, London, in December last.

Three GIM microprocessor systems were featured in this presentation and brief details follow.

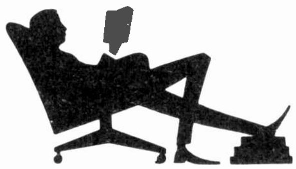
The Series 1600 Microprocessor System: Centred on a 16-bit single-chip *n*-channel device, this is designed for high speed data processing and real time applications. A complete minicomputer system is available already assembled on one 14in × 16in board, costing less than £500. This could be an interesting proposition for schools and amateur computer societies.

The Series 8000 Microprocessor System: This incorporates an 8-bit single chip *p*-channel microprocessor (developed and manufactured in Britain) and is designed to perform any digital function using far fewer packages than a TTL or CMOS implementation. A minimum system can be devised with two chips. The 8000 offers an ideal "one-off" approach: for use in test equipment, for system evaluation and also for amateur use. It can be supplied complete and wired up on one board, or as separate chips—suitable for home construction. A complete minicomputer can be realised with the addition of ROM, RAM, clock and A/D chips.

The Series 1650 Programmable Intelligent Controller: A single d.i.l. package containing an 8-bit *n*-channel central processing unit, ROM, RAM, clock and I/O. Suitable for consumer products (e.g. sewing machines, cine cameras) and for telecommunications applications, this purpose designed one-chip microprocessor is already in large scale production. The cost in quantity (500 plus) is £3.

Also described was another device which has a large consumer market application potential. This is the electrically alterable read only memory (EAROM). This device is *p*-channel, non volatile, low cost and easy to use. Already incorporated in TV tuners in Germany, other likely uses are: phase locked tuner for v.h.f., telephone repertory dialer, electronic doorlock, and waveform generator—storing digital information of analogue waveforms.

In microprocessor systems, the EAROM can be used for data storage; this was the original application for which it was invented by NCR.



BOOK REVIEWS

VIDEO YEARBOOK 1977
Published by The Dolphin Press
286 pages, 215 × 137mm. Price £4.75

THIS is the first edition of a new reference work prepared by the staff of *Video and Audio Visual Review*.

Equipment directly related to television use is given full coverage with technical descriptions and prices. This includes such items as cameras, monitors, video recording, control and effects equipment and lighting equipment.

Equipment indirectly related to television, such as audio equipment, is covered more briefly, generally only the company name and an indication of product range being given. Companies offering services in the video field are listed, and reference sections cover such items as video discs, TV standards and projection techniques. A comprehensive address directory rounds off the book. All in all, a most useful volume for anyone concerned with TV systems.

G.C.A.

SEMICONDUCTOR UPDATE... By R.W. COLES

ZNA103E

8748

MC14451

VIDEO GEN

It's nice to see that at long last the full potential of the domestic television set is being recognised by the electronics industry. By utilising spare lines and clever encoding, many pages of text are transmitted by the "Ceefax" and "Oracle" systems, demonstrating the suitability of the humble "telly" for the display of textual information of the computer-output type, and making it a natural candidate for use as a microprocessor output device in future domestic data-processing systems.

TV tennis games are already available at low cost, thanks to LSI technology, and in the future we can expect to see more sophisticated, perhaps (dare I say it) intellectual games, thanks once more to the microprocessor. With all these good things made possible by advancing electronic technology I am certain that home constructors will, as usual, be wanting to try out their own skills.

If you have grown tired of "Coronation Street" and feel the urge to cook-up a "Tele-Chess" game, or a microprocessor VDU, you may be interested in the Ferranti **ZNA103E** which is described as a "Monolithic digital video timing generator". This is a bipolar LSI circuit in a 24 pin package designed to provide all the horizontal, vertical, mixed blanking, and synchronising pulses required for raster generation in a 625 line, interlaced television system. Chip timing is derived from an external 656·25 kHz reference oscillator which would ideally be crystal controlled, and ten pulse waveform outputs are provided in all, making this new chip capable of handling the most demanding video generation tasks in closed circuit TV systems, video tape recorders and text generators. Inside the chip there is a divide by twenty one counter, a divide by six hundred and twenty five counter, and extensive decoding and addition circuitry which would require dozens of standard TTL circuits.

The ZNA103E runs from a five volt supply and has mainly TTL compatible inputs and outputs making it easy to use in that microprocessor game or CCTV camera you may have been dreaming about.

SNEAK PREVIEW

Microprocessors are in their infancy, and like all infant electronic products, new developments and price reductions can be expected to flow thick and fast as semiconductor manufacturers ascend the "learning curve". Let's face it, in these hard times we of the electronics fraternity are better off than most because we see exciting new components come along and we can be sure that before long we will be able to afford them no matter how sophisticated they may be. If you are ruefully passing microprocessors over because they are too expensive at present, you will be interested in a sneak preview of a future Intel chip, the **8748**, which will surely bring a microprocessor system within everyone's reach in a year or two.

This device is part of a new Intel family called MCS-48 which is an eight bit family incorporating a complete microprocessor system on a single chip including the program memory!

"Ah!" I can hear you say, "That must mean a mask defined program, and that's only of interest to the big boys," but it's not so with the 8748, because the microprocessor itself can be programmed, erased, and reprogrammed in the same way as the u.v. erasable PROMs which are now so common. To let your ingenuity run riot, and to control your electric toaster or lawn sprinkler, all you will need is a programmer, and simple programs can certainly be made at low cost if the programming operation is anything like that employed on the Intel 2107 and 2108 PROMs, as would seem very likely. With the 8748, when you get fed up with your pseudo-random lawn sprinkler you can pull the chip, erase it with ultra violet light, and start all over again.

The sneaky bit is that these chips are not due for release until well into 1977, and of course it will be a while before they appear in the PE ads at giveaway prices, but it *will* come, you can be sure of that!

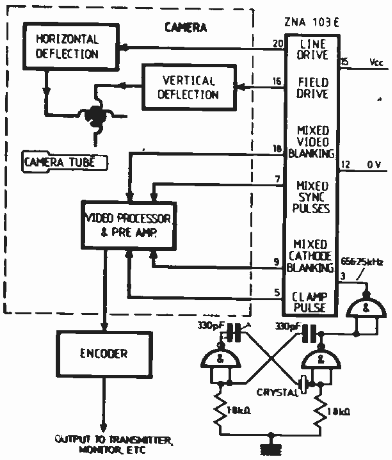


Fig. 1. The ZNA103E being used in a TV system

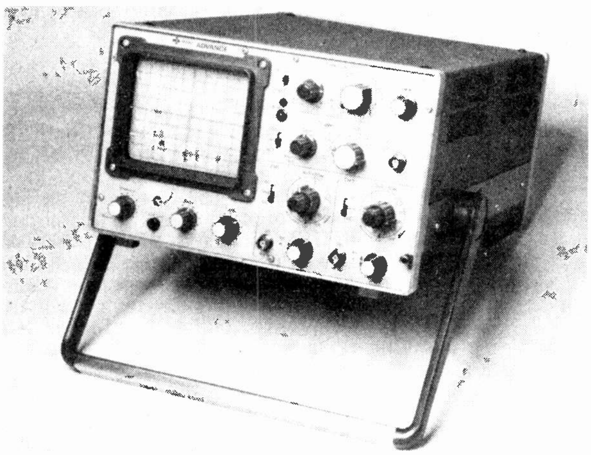
CMOS DIVIDER

Among many new additions to the Motorola 14000 CMOS family is an interesting device designed for low power timing applications, the **MC14451.**

The MC14451 contains the active inverters for use as part of a crystal oscillator, no less than eighteen flip flops arranged as a frequency divider chain, and a buffered output flip flop which can be set and reset by any of the last eight divider stages to give a user controlled pulse width. An interesting thing about this chip is that it is designed to run from voltages between 1·3 volts and 3 volts, and to consume no more than about 20 microwatts of power, making long life, pen cell powered timers easy to implement.

The MC14451 is housed in a standard 16 pin d.i.l. and is a natural choice for miniature, low power equipment which needs an accurate time reference. Using a 32·768 kHz crystal eight output frequencies of 16 Hz to 0·125 Hz are simultaneously available, and if a CR oscillator can be used timing periods of several hours would be possible with the very minimum of components.

NEWS BRIEFS



The new OS260 15MHz oscilloscope from Gould Advance incorporates a 10kV high brightness split-beam tube which gives true dual-trace operation.

Airborne

At a recent handing-over ceremony at the company's Airadio Division plant at Basildon, Essex, Marconi-Elliott Avionic Systems have just delivered to the British Army the first production model of the ARC 340 airborne communications and homing system. This system is claimed to be the most advanced of its kind ever produced.

The ARC 340, which is for installation in the British Army's new *Gazelle* and *Lynx* helicopters and other helicopters already in service, enables the pilot and crew to keep in constant contact with troops on a battlefield, by operating several communications channels from the same helicopter simultaneously. The system also enables the helicopter to "home" on to a desired objective with great accuracy and without impairing the system's use as a multi-station communication system.

A Call from New Zealand

A highspeed method which has halved the production time of UK telephone directories is to be used by the New Zealand Post Office.

The computer-controlled compiling process, developed by the UK Post Office and Her Majesty's Stationery Office, put Britain into the world lead when it went into operation in 1970.

Integrated with computerised photo-composition, it enables the average 'phone book to be prepared from scratch ready for printing in about four weeks, compared with the previous time of eight weeks working from standing type.

The UK Post Office computer programs and complete documentary back-up have been bought by the NZ Post Office under licence.

Fibre Links

The UK Post Office recently ordered 21 kilometres (km) of two-fibre cable to link two telephone exchanges in East Anglia. The total distance to be spanned by the optical cable is 12km. One link will cover 5km, another, 7km, with a repeater station between the two sections.

The Post Office claim that the installation will be the longest optical communications link in Britain and possibly in the world. Some of the optical cable will be used in a variety of experimental systems and equipment. The two-fibre glass cable is manufactured by the Corning Glass Works.

Russian First

Under a contract worth over $550,000, EMI Medical Ltd., is to equip the Academy of Medical Sciences, USSR with one of its advanced EMI-Scanner diagnostic systems for brain examinations. The machine will be operated by the Academy's Institute of Neurology located in Moscow.

The Institute will become the first Russian hospital ever to utilise computerised axial tomography X-ray technology pioneered by EMI. This new technology has revolutionised the diagnosis of cerebral diseases and other disorders in the Western world since its introduction in 1972.

MICROPROCESSOR FORUM

The meeting for February 26 has been fully subscribed.

This Forum will be repeated on March 5 and at the time of going to press bookings for this second date were well in advance. Tickets are being allocated strictly in order of application. See February issue for details and coupon.

SC/MP REVIEWED

By R. W. COLES

This is an eight-bit PMOS microprocessor which is *different*. It is different because it has been produced with small-system applications and low cost as prime design requirements, and it is different because from the outset the packaging and marketing have been arranged so that the emerging microprocessor hobby market can have a fair crack of the whip.

The SC/MP microprocessor (or to be more precise, ISP-8A/500D, which is the chip part number) has 46 very powerful instructions and has a clock generator on the chip to reduce the external chip count to the absolute minimum; in fact to a minimum of just a single PROM for a very simple system with limited input/output capability.

POWERFUL CHIP

The chip comes in a 40-pin package and has ample control inputs and outputs to allow use in very large systems too, when required, with a total memory address range of no less than 65 kilobytes, and provision for such sophisticated techniques as direct memory access, interrupt driven input/output and distributed intelligence in a multiprocessor system.

However, SC/MP is much more than just a semiconductor chip: it is a whole technology, and consequently not as easy to use as, say, a calculator or clock chip, where most of the thinking has already been done for us. To use SC/MP (or any other microprocessor for that matter) *you* have to create the program, and possibly the interface hardware, to make it work in your system, whether the application is a powerful general purpose computer system or just a control system for a model railway. *This is the attraction of microprocessors really, the fact that the user has to do some thinking himself, and is not at the mercy of the LSI producers, as has been the general trend of late.*

KNOWLEDGE REQUIRED

The knowledge required to make SC/MP jump through the hoop does *not* include a B.Sc. in computer science, or an A level in maths (or even, as some wags would have it, an O level in Swahili!).

Microprocessing is a subject which, while new and loaded with jargon can be readily assimilated by anyone who has some knowledge of logic systems or of using computers in a programming sense, or both.

To aid budding users and programmers of the SC/MP chip, National have produced an introductory kit called the SC/MP INTROKIT which is easy to assemble and can be used for running and modifying simple programs written by the user without the need for a PROM programmer.

Communication with the INTROKIT has to be carried out under the control of a program (supplied in a ROM), called KITBUG, and KITBUG will only talk to ASCII coded TTYs such as the Teletype ASR3320/JC or T.U. which, of course, is rather a problem for amateur users.

KEYBOARD KIT

National recognise that the small user is not going to be very happy about spending £500 or more on a Teletype, and so they have produced a companion to INTROKIT called KEYBOARD KIT, which uses a calculator keyboard and display to provide the necessary user communication with the INTROKIT, under the control of a replacement INTROKIT program called SCMP/KB, also in a ROM and supplied with the KEYBOARD KIT.

Unlike another National innovation, TELEKIT, KEYBOARD KIT is not a direct substitute for a TTY and operates in a rather different way but with equal effectiveness.

INTROKIT

Our INTROKIT arrived in a handsome and sturdy ring-binder which contained all the electronic components on a well laid out "Bubble-Pack" card, in addition to an impressive supply of "Software" in the form of data sheets for all kit components, a comprehensive programming manual, an SC/MP technical manual, and an INTROKIT user's manual. Also included was a useful pocket sized SC/MP instruction guide and a card informing us that we were entitled to a year's free membership of "Compute" SC/MP users' club, and its newsletter the "Bit-Bucket" (Ugghh!).

This club promises to be of great help to SC/MP users because it is fostering a software program library to which all members have access, and we are eagerly looking forward to our first issue of the newsletter which we hope will tell us more.

COMPONENTS

We were surprised at just how few components were required to make a working computer, only six i.c.s in all, including the SC/MP chip, the others being the KITBUG ROM (5214), two 2101 RAM chips, a hex TTL Schmitt trigger (7414), and an eight-bit TTL tristate bus buffer, DM81LS95N.

The INTROKIT p.c.b. is a high quality, glass fibre, double-sided board with plated-through holes, and less than half of its 160mm × 100mm Eurocard size is actually used for INTROKIT components, with the rest being laid out as a matrix board to house wire-wrap sockets provided by the user for his specific applications.

A 64-way wire wrappable edge-plug of the two-part variety is provided in the kit, although it is by no means essential to use it, and no matching socket is provided anyway.

A 40-pin i.c. wire-wrap socket is provided for the SC/MP chip which is very useful because it gives ready access to all the important busses and control pins when adding extra facilities or expanding the capability of the basic kit. A socket of the solder-tail variety is provided for the ROM so that you can change operating programs at will.

REGULATOR

The INTROKIT requires 5V and −12V supplies, but actually generates a third (−7V) internally by means of a LM 320 negative regulator which also goes on the p.c.b. and does not require a heat sink.

Consumption is 350mA at 5V and 200mA at −12V, but remember that this will increase if the KEYBOARD KIT is used, or any other user circuitry added.

CONSTRUCTION

The INTROKIT USER'S MANUAL is quite comprehensive and easy to follow, and we followed Chapter 2, "Kit Assembly and Checkout" religiously without incident, even section 2.2 which is quaintly titled "Stuffing Procedures"!

We mounted the RAM and TTL chips on Soldercon pins for flexibility and because, as pointed out in the manual, once you have soldered an i.c. into place on a p.t.h. type board, it is extremely difficult to remove it!

KIT EXPANSION

When all the INTROKIT wiring was complete we moved straight on to wire up the KEYBOARD KIT because, like most readers we did not have a TTY of the right type to start running programs using KITBUG. While still with INTROKIT however, it is worth drawing attention to Chapter 3 of the User's Manual which covers kit expansion, because not everybody will want to accept INTROKIT as it stands.)

We examined the possibility of using the INTROKIT as part of a more comprehensive "Development System" with extra PROM and RAM memory on additional Eurocards. This would seem to be quite possible providing that buffers are provided for system busses, and of course these can be housed on the matrix section of the INTROKIT board.

The National DM81LS95 series of tri-state buffers would be ideal for this purpose, and you would need to use about six or seven of them to cover all requirements. In this case the board interconnections could use the edge connector to advantage.

SC/MP KEYBOARD KIT

Our SC/MP KEYBOARD KIT arrived packed on a similar vacuum "Bubble Pack" card to the INTROKIT, but with no ring binder. Another mound of software was included, but with some relief we realised that much of this duplicated manuals already received with INTROKIT!

There is no circuit board with this kit because the components have to be mounted on the matrix area of INTROKIT, of which the KEYBOARD circuitry becomes an intimate part. The implication here is of course that the KEYBOARD KIT is not a stand-alone peripheral, but is in effect an extension of the INTROKIT system which treats it as a series of memory addresses to which data can be sent (Display) and from which data can be retrieved (Keyboard).

CALCULATOR

The keyboard and display unit uses the case of a National Calculator with an overlay to re-label the twenty keys as the 0 to F hexadecimal characters and the four control operators GO, ABT, TERM, and MEM. The old ON-OFF slider is now used as INIT, or reset, switch to clear the SC/MP chip when required.

The calculator part of the kit comes complete with a prewired 21-way flat-strip cable and socket and there is no need to do anything to this part of the kit at all, it is ready for use when received.

The electronic "Meat" of the kit comes in the form of eight TTL dual in line i.c.s which act as address decoders, data latches and l.e.d. display drivers, and are wired into the SC/MP system address and data busses.

WIRE WRAP

We were a little apprehensive about the fact that the TTL i.c.s had to be connected up using wire-wrapping techniques as opposed to the usual soldered connections, but wire-wrap sockets are provided, along with a simple wire-wrap tool and an adequate supply of prestripped, cut lengths, of 30 gauge Kynar wrapping wire; and in the event our apprehension was unnecessary because we found the tool and the wire easy to use, even a little boring!

Despite the ease of wiring up the KEYBOARD KIT, it is important to spend some hours studying the USER'S MANUAL before carrying it out—because mistakes could be difficult to rectify, and would of course require extra Kynar wire which is difficult to obtain, and expensive at the moment. We feel that an understanding of the circuit is important *before* construction, so that links can be crossed off on the circuit as well as the wiring list as construction proceeds.

USER MANUAL

We weren't quite so happy about the KEYBOARD KIT USER'S MANUAL as we were about the INTROKIT versions, because it refers to two different SC/MP kits: the SC/MP KIT (USA) and the SC/MP INTROKIT (EUROPE). The manual is written primarily for the former, with the extra information required for the latter listed as changes. This means a certain amount of cross-referencing and is rather annoying because at times you can get confused about which board you are dealing with!

PROBLEMS

We must also point out that there are *two* versions of the *European* INTROKIT, and the KEYBOARD KIT will only easily interface with one of these.

The first INTROKIT we received was of the old type on an s.r.b.p. circuit board with the crystal located on the top left-hand corner of the board as viewed from the edge connector; and we found that although the INTROKIT itself was perfectly satisfactory, adding the KEYBOARD KIT was difficult and required the addition of an extra CMOS gate package which is *not* supplied. The KEYBOARD KIT USER'S MANUAL does not recognise this earlier INTROKIT and so no instructions are listed for this combination, making this a situation to avoid if at all possible.

We later received the new INTROKIT on the glass fibre board and with the crystal on the bottom right-hand corner of the printed area of the board, and this proved to be perfectly satisfactory (as reviewed earlier).

We have been assured by Marshall's that INTROKITS now on sale are of the new type, but I advise anyone to specify—to the supplier—that he or she is only interested in the *new* INTROKIT, if they intend to use the KEYBOARD KIT with it.

Unfortunately there are no part number differences that we can detect, and so visual identification is best. The *new* INTROKIT is packed in a ring binder, the *old* INTROKIT comes in a "Shirt-box".

If you already have one of the older INTROKITS you can of course ask the supplier of the KEYBOARD KIT to supply details of the modifications necessary to combine them. The modifications are not too difficult for experienced constructors.

USING THE SC/MP INTROKIT AND KEYBOARD

When we finished the KEYBOARD KIT additions to the INTROKIT, we decided to build a special power supply for it to provide the well-regulated 5V and −12V supplies required. On the lid of the power supply case we mounted slide-in p.c.b. edge strips to hold the INTROKIT board securely while allowing free access to the circuit layout.

With the SC/MP system now ready to go we plugged in the SC/MPKB program ROM and switched on—Success!

With power applied the display shows dashes in the four-digit address field and the two-digit data field, which means that it awaits your command! A small step-by-step program is provided in the KEYBOARD KIT USER'S MANUAL and we entered this and ran it with the result that SC/MP announced on its display that we "Did Good"—which was very satisfying.

WHERE NEXT

At this stage, unless you have done your homework well, you may feel a little lost, like us. But we armed ourselves with the PROGRAMMING MANUAL and remembering that the SC/MPKB keyboard and display routine is a callable subroutine, we soon had some simple programs running using the display as an output device.

We found the system for entering a program using the keyboard was a bit tedious because between each data entry we had to press TERM then MEM then TERM again, a sequence which is easy to bodge if you try to enter a program rapidly. We felt that an automatic memory address incrementer and separate "Enter address" or "Enter data" keys would have made life much easier for the user!

If you will be using the SC/MP kits to discover microprocessing for the first time, you may find it a useful exercise to set the address field to 0000 and then step through the SC/MPKB program using MEM. This enables you to make notes on the program listing supplied with the KEYBOARD KIT which is a little difficult to decipher at first.

Once you have an understanding of the SC/MPKB program operation, writing new programs of your own should be child's play!

VERDICT

The INTROKIT is an excellent introduction to using the SC/MP microprocessor and is well presented and packaged. It can be used in a dedicated application or be expanded to form the heart of a capable development system if required. Adding the KEYBOARD KIT overcomes one of the main hurdles for the small user by providing the vital input/output interface at low cost, however, since it uses the INTROKIT matrix area, expansion of the INTROKIT is made correspondingly more difficult.

One last thing, the SC/MP chip runs quite hot to the touch, which is nothing to worry about and could come in handy for keeping your coffee mug warm during those long winter programming sessions!

MICROVISION POCKET TV

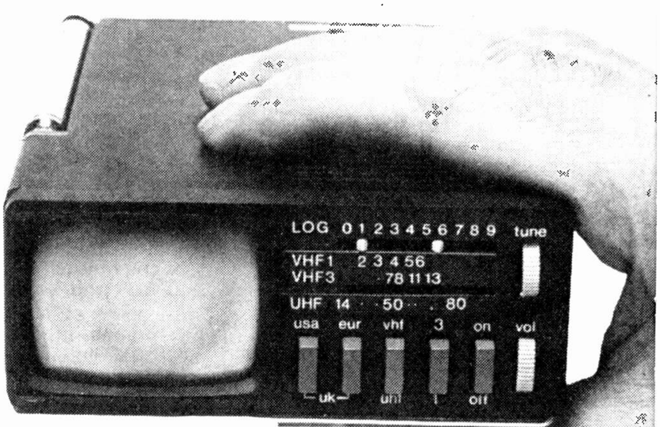
Gimmick?—or rich man's toy?

This 2in screen, black and white, pocketsize TV receiver with a price tag of nearly £200 has been called both by some less-than enraptured TV and radio distributors here in the UK.

But what if it is, so long as it brings in the dollars? For Clive Sinclair is confident that a big market awaits his invention in high-class stores throughout the USA.

From a technical stand point, this tiny receiver with world-wide reception capability must be acclaimed as a brilliant achievement. The culmination of 12 years of research and development, doggedly pursued by Clive Sinclair despite set-backs and disappointments along the way.

The *Microvision* uses an electrostatically deflected tube with a 2in screen, manufactured by Telefunken. The electronics have been designed entirely by Sinclair Radionics Ltd. Three of the five bipolar i.c.s used were specially designed by Sinclair, and without them the present model could not have been achieved.



MINI SPEC ON THE MICROVISION

Overall size:	**6 × 4 × 1½in**
Screen size:	**2in diagonal**
Tuning ranges:	**V.H.F. Bands I, III** **U.H.F. Bands IV, V**
Operating Standards:	**625 and 525 lines. (Covers UK, most W. Europe and USA transmissions).**
Power Consumption:	**750mW**
Batteries:	**4 AA-size nickel cadmium rechargeable. Life about four hours per charge.**

Part 1—INTRODUCTION

MICROPROCESSORS explained

By R. W. Coles

The very word "Microprocessor" can strike terror into the hearts of those of us who still mourn the passing of the beam-tetrode; it can just as readily bring forth squeals of ecstasy from the dynamic, avant garde brigade, who see in this new technology the dawning of an electronic Utopia where every conceivable gadget from an electric toothbrush to a motor car has at its heart a one-chip computer!

At present micro-madness grips the electronic industry, everyone is learning to speak Microprocessor-ese and, believe it or not, some people are actually ***using*** *these omnipotent devices in* ***practical*** *applications.*

Where will microprocessors be when the dust of the electronic industries' first emotional reactions settle? Are they really the universal component or are they too difficult for most engineers, let alone amateurs to use?

In this series we will attempt to put down on paper the essence of the microprocessor technology, and where necessary, take a hard look at how these remarkable devices can be employed by the amateur.

THE MICROPROCESSOR is not new, the first true example was introduced by Intel, still the market leaders, as long ago as 1971 in the shape of their 4004, a four-bit device which is still in full scale production. New developments followed thick and fast and today we see a broad spectrum of microprocessor (MPU) devices, available from all the major semiconductor manufacturers and catering for every possible application which can currently be envisaged, many of them approaching the sophistication of "full size" computers when supported by memory and interface components.

Microprocessors were made possible by the giant strides made in LSI production, spurred on by such consumer products as the one-chip calculator. But don't confuse the MPU with calculator chips because although similar operations take place inside the respective packages the application of the two devices is very different indeed.

The MPU is very much a general purpose device which can be used to replace the large number of TTL or other logic functions which might otherwise perform a particular task. The MPU is tailored to an application by means of a program, or sequence of simple instructions, which it carries out one after another.

It is well within the capability of an MPU for it to perform the tasks of a common or garden calculator, including keyboard processing and display driving, but the point is that simply by changing the program, which is usually held external to the MPU chip, it can also perform the tasks of a pig feed dispenser control system, a washing machine controller, or a TV tennis game. The versatility of an MPU chip can be summed up in the two words "Deferred Design".

DEFERRED DESIGN

Deferred design means that when the hardware of an MPU system is assembled the operations it is going to perform need not be known in detail since these will be controlled by the software, or program, which can be created or developed later on.

In the design process the question "Which resistor shall I solder in?" is replaced by "Which instruction shall I enter in the program?" Of course, hardware is still very much involved, the MPU itself is hardware, and to make it work it is necessary to surround it with a number of other devices to provide program storage and the means to communicate with the outside world.

This external logic will vary from application to application but really it is only a small part of the microprocessor system because the lion's share of the circuitry is hidden inside the MPU chip itself.

APPLICATIONS

Applications for these amazing devices are legion. All you need is a creative mind, a grasp of the instruction set or rudimentary "language" of the MPU, and the hardware to try out the resulting programs.

While programs are being tried out on a general purpose microprocessor, or "development system" as it is usually called, it will often be unnecessary to add any application hardware to the system because l.e.d.s can be used to simulate switched outputs such as relays or motors, and panel switches can simulate labelled control switches or sensor inputs.

When you are happy that the program operates correctly and have made improvements where necessary, the program can be "frozen" in a PROM (Programmable Read Only Memory) chip and the development system reused over and over again for designing and debugging other new systems.

The PROM or "Firmware" programs are then plugged into a minimal microprocessor hardware circuit where only sufficient circuitry external to the MPU to perform the particular application is used.

This entire sequence of events is shown graphically in the flow chart Fig. 1.1.

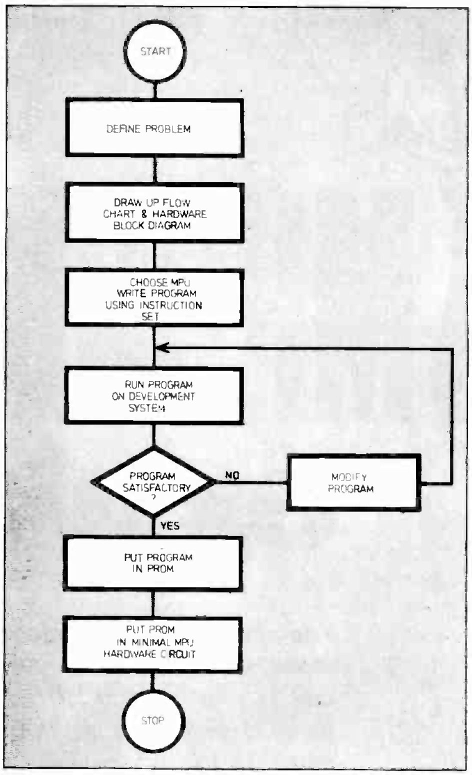


Fig. 1.1 Example of a flow chart as used for developing a microprocessor system

Glossary of Terms

BCD—Binary Coded Decimal. A method of representing numerical values where each decimal digit is replaced by its binary equivalent.

BIPOLAR—Descriptive of the junction transistor, which is dependent on both types of charge carrier electrons and holes. One of the technologies used in i.c. manufacture. Has speed and drive capability advantages over MOS. Frequently used to buffer MOS I/P and O/P devices.

BIT—BInary digiT. A single binary digit which may be either logic "1" or logic "0". In an MPU system these logic states are represented by voltage levels.

BUS—A collection of wires carrying parallel binary data. Several bus users can send or receive data along the bus; generally only one "Sender" and one "Receiver" active at any one instant.

BYTE—See "Word".

CMOS—Complementary MOS. A semiconductor technology. Uses both *n*- and *p*-channel devices on the same chip. Has great advantages of power, but has both speed and packing density limitations.

DATA STORE—Memory that contains data. Usually a RAM.

DEBUGGING—The procedure of checking a program and eliminating any errors.

DEDICATED—A type of application where a microprocessor is programmed to perform one particular set of operations, and so is committed exclusively to one application.

DEVELOPMENT SYSTEM—An apparatus which normally includes the MPU in question in combination with sufficient memory and peripherals to enable development of MPU programs and hardware systems.

FIRMWARE—Instructions or data permanently stored within a ROM.

FLOW CHART—A diagrammatic way of expressing program operation using boxes to represent "operations" and lines for execution sequence.

HARDWARE—The electronic components or equipment of a computing system.

HARD WIRED LOGIC—Systems built up with TTL or similar logic i.c.s (or relays) and involving hand-wired connections, the interconnection pattern determining the operation—rather than the contents of a memory as in the case of MPUs.

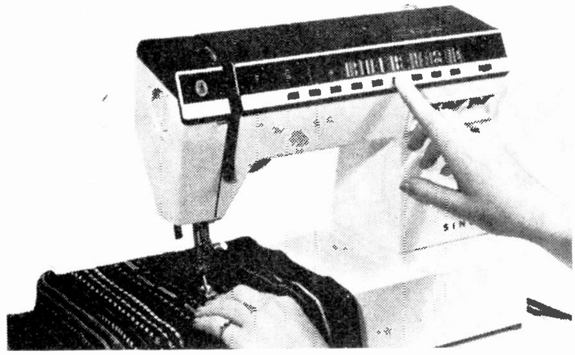
INSTRUCTION—A binary "word" which is interpreted by the MPU instruction decoder as a command to open gates, generate shift pulses and increment counters. Typical MPU instructions would be: ADD, SHIFT LEFT, CLEAR REGISTER.

INSTRUCTION SET—The set of instructions that the microprocessor is able to perform. Unique to a given type of MPU.

LSI—Large-Scale Integration. Solid state microelectronics technology that permits very high densities of circuit functions on a single chip.

IN THE HOME . . .

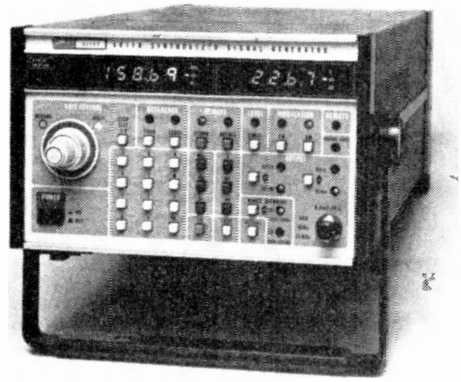
The Singer Futura Sewing Machine, introduced to the domestic market last autumn. This is the first truly electronic sewing machine. The conventional stitch formation mechanism, involving some 300 parts in all, has been replaced by electronic controls. The "brain" is a microprocessor which is programmed to provide 25 patterns, including straight stitch and two buttonholes, at the touch of a button. There is some unused memory capacity available for future alterations or additions to the patterns.



IN INDUSTRY . . .

The Fluke 6010A Synthesised Signal Generator, a versatile 7-digit 10Hz to 11MHz instrument with exceptional capabilities.

The 6010A is the first signal generator to incorporate a microprocessor (an Intel 4040). One of the unique features due to the use of a microprocessor is the instrument's ability to store and recall programmed data. Up to 10 frequencies, modulation and attenuator settings can be stored and recalled at the push of a button. The microprocessor also plays a part in several other operations, including automatic range selection.



MOS—Metal Oxide Silicon. Descriptive of the construction of insulated-gate field-effect semiconductor devices. One of the technologies used in i.c. manufacture.

MPU—Shorthand for Microprocessor, standing for Micro-Processor Unit, a collection of gates and flip-flops on a LSI chip which are arranged so that they will obey general purpose "Instructions" stored external to the MPU itself.

NMOS—*n*-channel MOS. A semiconductor technology. Has speed and power advantages over PMOS. Operates at lower voltage (5V). TTL compatible.

PERIPHERALS—Terminal Units or equipments for "talking" to, or reproducing outputs from, computers, e.g. Teletype, VDU, paper tape readers, or magnetic tape equipment.

PMOS—*p*-channel MOS. The first MOS technology evolved. Requires a high voltage (12–15V). Can be made TTL compatible.

PORT—A terminal which the MPU uses to communicate with the outside world. Ports can be input only, output only, or bidirectional, and would in general carry parallel data 4, 8, 12, or 16 bits wide.

PROGRAM—An assembly of MPU instructions which together instruct the processor to carry out a particular job.

PROM—Programmable Read Only Memory. Widely used to hold MPU programs in the form of "n" parallel binary words accessed by means of "Address" inputs and "Chip Select" inputs. PROMS are a special form of ROM which can be programmed by blowing fuse links, making links by migration, or storing a charge on the gate of a MOS device. Some PROMS can be erased with ultra-violet light and re-used, but all require special hardware for programming and so are not the equivalent of Read/Write RAM.
Programs committed to ROM or PROM are referred to as "Firmware".

RAM—Random Access Memory. A bad choice of title this because, of course, PROMS are also Randomly Accessible. RAM really refers to Read/Write Memory components which are used in MPU systems to store data words which can be erased or modified at will. Unlike PROM storage, RAM data is destroyed by removing the power.

ROM—Read Only Memory. A device containing information which is fixed and is unalterable.

SOFTWARE—Programs which can be changed and loaded at will. Resides in RAM and is entered from keyboard, paper tape, or magnetic tape.

TTL—Transistor-Transistor Logic. A form of logic circuit design where multi-emitter transistors provide all required logic functions. Common in logic i.c.s.

VDU—Video (Visual) Display Unit.

WORD—A Word is a parallel collection of binary digits and MPU chips are sometimes compared on the basis of their "Word-Length" or number of bits they can operate on at any one time. The particular case of an eight-bit word is often referred to by the special term "Byte".

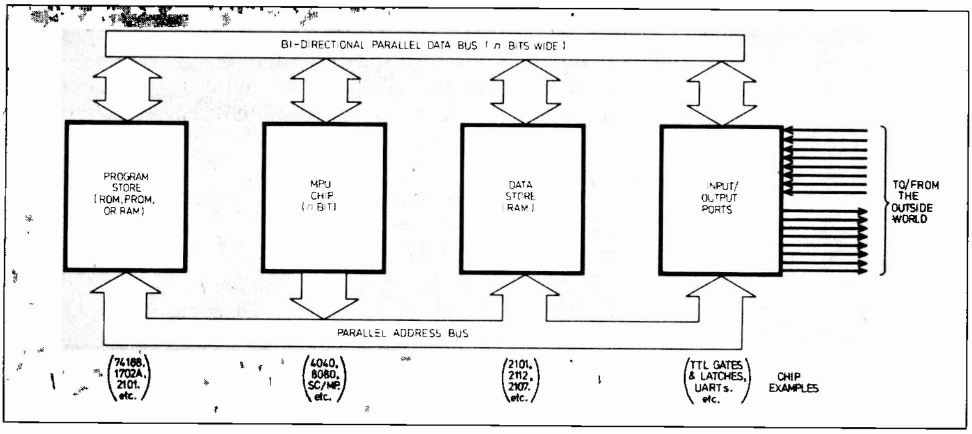


Fig. 1.2 A basic microprocessor system, comprising four chips

If you are fascinated by the creative possibilities of using microprocessors, then the starting point is acquiring a general purpose development system, and equally important, a means of communicating with it, e.g. keyboard and display.

AS A COMPONENT

If this creative use of MPUs with its requirement for learning a lot of "new tricks" is not for you and you prefer the wire-it-up-and-switch-it-on, well-defined type of project, don't *ignore* microprocessors because eventually there will be projects appearing in this magazine which will use microprocessors just as components.

In such cases construction will be just as it's always been, with the added interest of a "program diagram" in addition to the usual circuit diagram. A project like this might be titled "TV Game" or "Ignition Control" and the circuit and program presented would be dedicated to performing just one job.

It would be unnecessary in this case to understand fully the program, only how to get a blank PROM loaded with it, either by doing it yourself with the aid of a simple PROM programmer, or by post when you buy the PROM chip.

DEVELOPMENT SYSTEMS

If you *do* feel interested enough to invest in a general purpose system to try out your programming skills there are an increasing number of "Introductory Kits" (such as the SC/MP Introkit) appearing on the market which can usually be expanded to form quite capable development systems as your wings begin to spread.

Communicating with such a general purpose system is a bit of a headache because the most obvious way is to use a commercial teletypewriter or VDU, and these have prices which are unrealistic for our purpose to say the least!

The microprocessor itself can come to the rescue here though, because it can be programmed to imitate a Teletype, as in the National Telekit machine which provides most of the usual Teletype facilities but in a calculator case. This is quite a good idea, but unfortunately still a bit pricy in battered Britain at about £180.

The Telekit uses an extra MPU to do a dedicated job but it can be much cheaper to let the development system itself encode its own keyboard and drive its own display, and this is the approach used in certain microprocessor systems now under development.

Eventually it will be possible to construct low cost MPU peripherals such as VDUs using a standard television set, or program stores using cassette tape players, so that amateurs can build up a very powerful data processing system and enjoy all the benefits of the computer age in their own homes.

EVERYDAY USE

Commercially speaking, microprocessors are already in everyday use, and are to be seen in cars, cookers, washing machines, petrol pumps, weighing scales, juke boxes, signal generators, sewing machines and elsewhere.

In most of these applications the MPU chip is used to replace mechanical gadgets such as cam-timers or boards full of "random logic" (like TTL counters), but they provide new facilities into the bargain which were out of the question before the power of the microprocessor came along.

The microprocessor can be all things to all people, so versatile and powerful that seldom, if ever, are all the available facilities of a particular chip used in an application, and it is quite possible that the same device could be used in, say, a heart monitoring machine, and also turn up in a food-mixer. In the first case a sophisticated lengthy program, requiring many PROMS would be necessary, in the second a single PROM would probably suffice.

The nice thing about all this is, of course, that once the finer points of a particular MPU become familiar to the designer then it can be designed into almost any application that enters his head: there is no need to swop from MPU chip A to MPU chip B except in extreme circumstances.

THE PROGRAM

A basic microprocessor system is shown in Fig. 1.2. It will be noted that the system can be split into four main areas:

1. The MPU itself, which is capable of performing arithmetic, logical and manipulative operations on data with which it is provided, under the control of a sequence of program steps.

2. The Program Store which in its simplest form is a PROM but which could also be Read/Write memory (RAM) and which holds the sequence of instructions to control the action of the MPU.

3. The Data Store, which consists of an array of Read/Write memory and is used for storing input data, output data and intermediate results. (The Data Store is integrated with Read/Write program storage in some MPU designs, particularly development systems).

4. Input/Output Ports, which are simply the communications channels over which the MPU talks to the outside world. (These are of course binary channels, often four, eight, 12 or 16 bits wide for transferring parallel data words. An eight-bit port could represent 0—255 in binary, 0—99 in BCD, the state of eight separate and independent front panel switches, or the correct segment pattern to display the number "4" on a seven-segment display, for example.)

SYSTEM EXAMPLE

To see how these system components work together let us consider a simple example using an imaginary "one-bit" MPU to replace TTL which performs the following logical operation . . . $D = \overline{(A.B) + C}$.

The TTL implementation of this expression can be achieved with a single two-input AND gate followed by a two-input NOR gate as shown in Fig. 1.3 (a).

The same result can be achieved with a few program steps on our imaginary microprocessor by . . .

Using a READ 0 instruction to input the state of Port 0.

Using a STORE instruction to file this away in the data store.

Using a READ 1 instruction to input the state of Port 1.

Using an AND instruction to solve $A.B$.

Using a STORE instruction to file away the result.

Using a READ 2 instruction to input the state of Port 2.

Using an OR instruction to solve $(A.B) + C$.

Using a COMPLEMENT instruction to form $\overline{(A.B) + C}$.

Using a WRITE 3 instruction to output the result D on Port 3.

The above sequence of instructions is stored in the Program Store and after "system reset" the sequence is carried out sequentially by the MPU to achieve the same result as the two TTL gates would. (See Fig. 1.3 (b)).

This may seem a pretty futile exercise but of course in a real system this would be only a tiny part of a much larger program. Real world microprocessors handle not one bit at a time but four, eight, twelve or even sixteen!

WHICH MICRO?

Later on in this series, after we have become more familiar with the detailed workings of the microprocessor chips and systems, we will take a critical look at the various MPU chips available so that you can choose the one(s) which would be best for *your* sort of applications. But before going into that sort of detail it may be useful to think about two of the most fundamental, and often most confusing aspects of MPU selection, namely "Word length" and "Semiconductor Technology".

WORD LENGTH

Anyone who has come into contact with binary arithmetic knows that with (say) four bits there are 2^4 or 16 possible combinations and that with (say) 16 bits there are 2^{16} or 65,536 combinations possible. Applying this simple knowledge to MPU systems leads to the conclusion that with a four-bit answer the best definition possible is 1/16 or about 6 per cent, whereas with a 16-bit answer definition is: 1/65,536 or about 0·0015 per cent.

On this sort of comparison it looks obvious that "The bigger the word length the better". But this can be a trap to catch the unwary because another dimension must be added before genuine conclusions on word length can be drawn, and the extra dimension is "Time".

A four-bit MPU can process data to give 16-bit definition by simply cascading four, four-bit manipulations in its program; the only loss is in the time required to achieve an answer, and since even with slow MPUS 100,000 instructions can be implemented in one second, that may not be a limiting factor in *your* application!

Four-bit MPUS are ideal for handling decimal calculations where input and output are in BCD (Binary

(a)

(b)

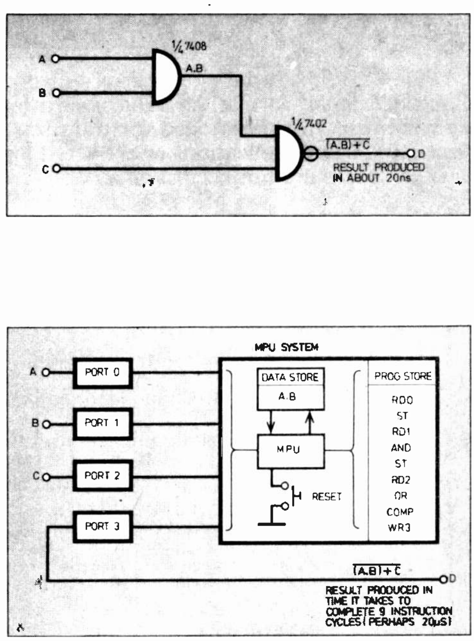


Fig. 1.3 Performing a logical operation
(a) the hard-wired logic approach
(b) the MPU programmed logic approach

HOW THEY COME . . .

The Intel SDK80 Microcomputer System Design Kit contains all components required to build a complete system based on the 8080A CPU Group. In addition, the board provides areas for expansion of the microcomputer system and for customised interfacing through a pre-drilled, wrapped-wire interconnection area.

ON ACTIVE SERVICE . . .

The RCA COSMAC Microprocessor Development System modified into a prototype for an automatic TV audience monitor unit.

Coded Decimal) format, straightforward logic control operations as may be needed for train sets or synthesizers, and most applications where very long programs or high speeds are not necessary.

Table 1.1: MICROPROCESSOR TECHNOLOGIES

	PMOS	NMOS	CMOS	Bipolar
Cost	Low	Medium	Medium	High
Speed	Low	Medium	Medium	High
Power	Low	Low	Very low	High
Usage	Wide	Wide	Medium	Specialised
Examples of commercial devices	4004 4040 8008 SC/MP TMS 1,000	8080 6800 2650 Z80	IM6100 Cosmac	3000 series

ALPHANUMERICS

Eight-bit MPUs are more expensive, but have the useful facility of being able to handle alphanumeric data (0 to 9, A to Z etc.) directly, because eight-bit words give more than enough combinations to handle all the characters to be found on a typewriter keyboard.

Eight-bit MPUs are therefore ideal for data-processing applications where output is to a Teletype or VDU as well as for those applications which can be also handled by the four-bit chips.

Twelve- and 16-bit microprocessors are more powerful than the eight-bit devices in that they have larger instructions sets and can give more precision in a shorter time, but needless to say you have to pay for these goodies, and in the author's opinion they are a little too complicated and expensive for use in present amateur projects.

SEMICONDUCTOR TECHNOLOGY

Microprocessor chips are made in all the currently popular semiconductor processes. Each of these has attendant advantages and disadvantages which are summarised in Table 1.1.

PMOS was the first LSI technology and it is likely to be cheaper per bit than the others for some time to come, which makes it a likely first choice for amateur use—unless special characteristics like low power consumption (choose CMOS) or high speed (choose NMOS or Bipolar) are important.

NEXT MONTH: How the MPU chip works.

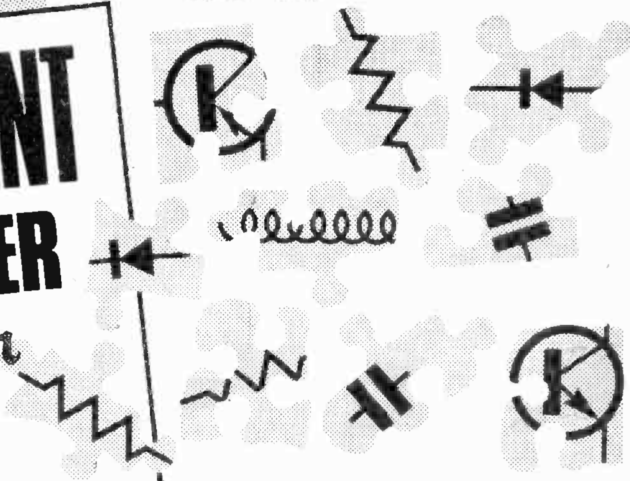
SPRING to life... with our APRIL issue

8 PAGE SUPPLEMENT

PUTTING IT TOGETHER

...A Practical Guide for Constructors

A look at wiring methods, prototyping systems, circuit boards, tools and aids.



DIGITAL VOLTMETER

A mains-powered $3\frac{1}{2}$-digit voltmeter based on the Ferranti ZNA116 dual-slope integration DVM chip. Four ranges cover 1·999 to 1999 volts d.c. full scale. Features include automatic polarity indication, overload indication and leading zero suppression.

TRANSIENT GENERATOR

An envelope shaper circuit designed to give keyboard triggered transient profiles for driving v.c.a.s and v.c.f.s. Also shown are various types of suitable trigger circuits.

pH METER - Part 2

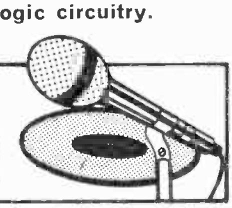
Construction, calibration and operation of this instrument will be dealt with, including a F.E.T. input stage version.

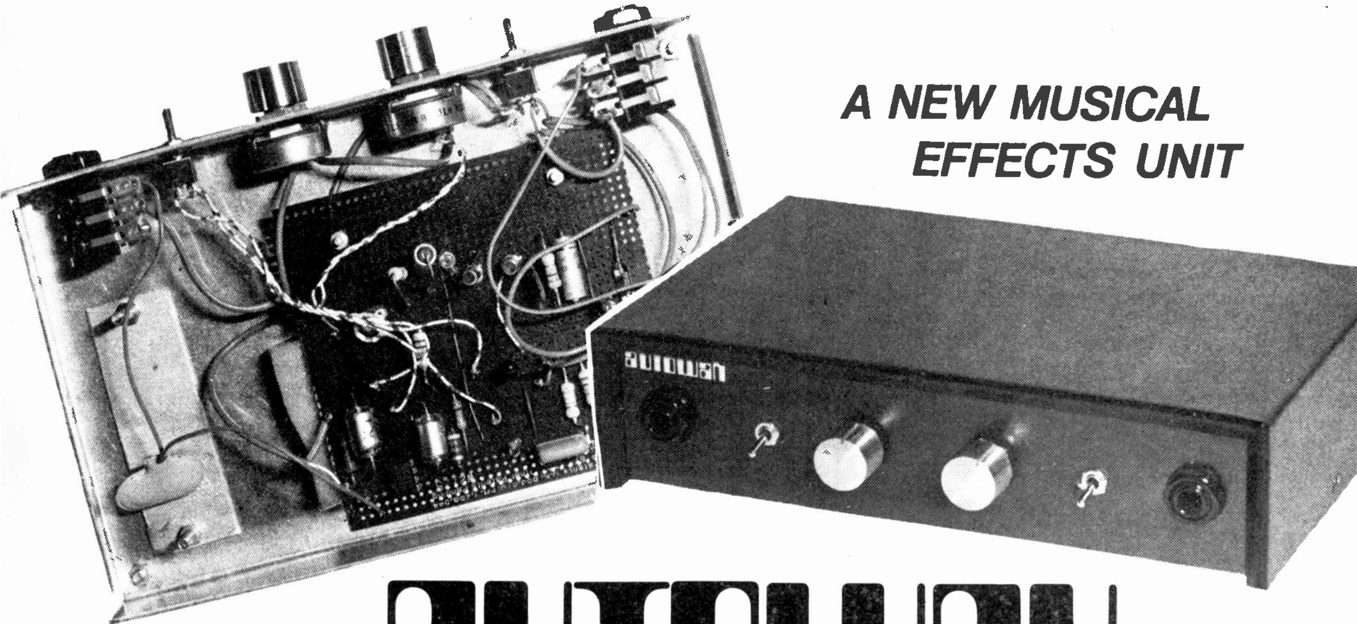
DAY INDICATOR

This unit will display the day of the week on a row of l.e.d.s for up to a year on manganese alkaline cells, by using CMOS logic circuitry.

GET ON THE RIGHT ROAD...

Mobile Disco Techniques—Part 1





A NEW MUSICAL EFFECTS UNIT

AUTOWAH

BY P. J. GOODWIN

THIS unit contains a novel guitar effects circuit which uses an operational amplifier as a filter and attenuator, to automatically generate either a wah-pedal, or swell-pedal sound. The wah-pedal mode makes use of the Voltage Controlled Filter (v.c.f.), and the swell-pedal makes use of the Voltage Controlled Attenuator (v.c.a.); the effect being triggered by the start of each new note played through the unit. This leaves the guitarist's foot free to operate other effects pedals and switches, and also, especially when used in the attenuation mode, produces an effect not easy to achieve by conventional means.

PRINCIPLE OF OPERATION

Referring to the block diagram in Fig. 1 it can be seen that the input signal is buffered by an amplifier, and fed to a rectification and pulse generator circuit. This fires a pulse to the ramp generator at the start of each note. The pulse has the effect of resetting the ramp (which normally rests high), then allowing the output voltage to climb back up to the high end again, at a rate set by the time control. This ramp voltage is fed to the signal processing circuit, which can be switched into either a v.c.f. or v.c.a. mode of operation. Thus each note produced by the guitar will initiate its own ramp, and consequently its own "wah" or "swell".

A switch is also fitted to connect the input directly to the output, and so allow the signal to pass unchanged.

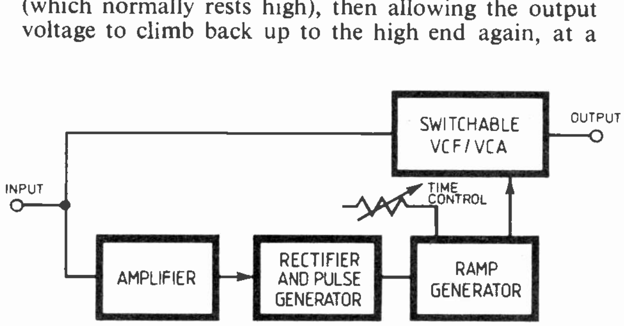


Fig. 1. Autowah block diagram

THE CIRCUIT

The v.c.f./v.c.a. is formed by IC1 and its associated components as illustrated in Fig. 2. Capacitors C1 and C2, and the field effect transistor TR1 form a "T" filter in the feedback path of IC1 when operating as a v.c.f., whilst for v.c.a. mode the f.e.t. becomes part of a purely resistive feedback path.

Amplification of the raw signal is required for the rectifier stage, and this is achieved through IC2. The gain of this pre-amp is set by R5 and R7, and the output is a.c. coupled (C4) to allow for the level shift generated by the diode pump rectifier, giving greater sensitivity. The components D1, D2 and C5 form the rectifier and smoothing circuit, with R8 providing a discharge path for C5. D3 provides a discharge path for C6. A d.c. voltage will appear across C5 throughout the duration of a note from the guitar, and due to the differentiating capacitor (C6), a pulse will be delivered to the base of TR2 at the onset of each note. Now C7 will be reset by TR2 and TR3, but because the pulse is very short, C7 will start to recharge almost instantly, at a rate set by VR2. It is this ramp, starting at the onset of each new note, that is used to control the v.c.f./v.c.a. via the gate of TR1.

Stereo jack sockets are used for input and output connections, to allow automatic connection of the batteries when the plugs are inserted.

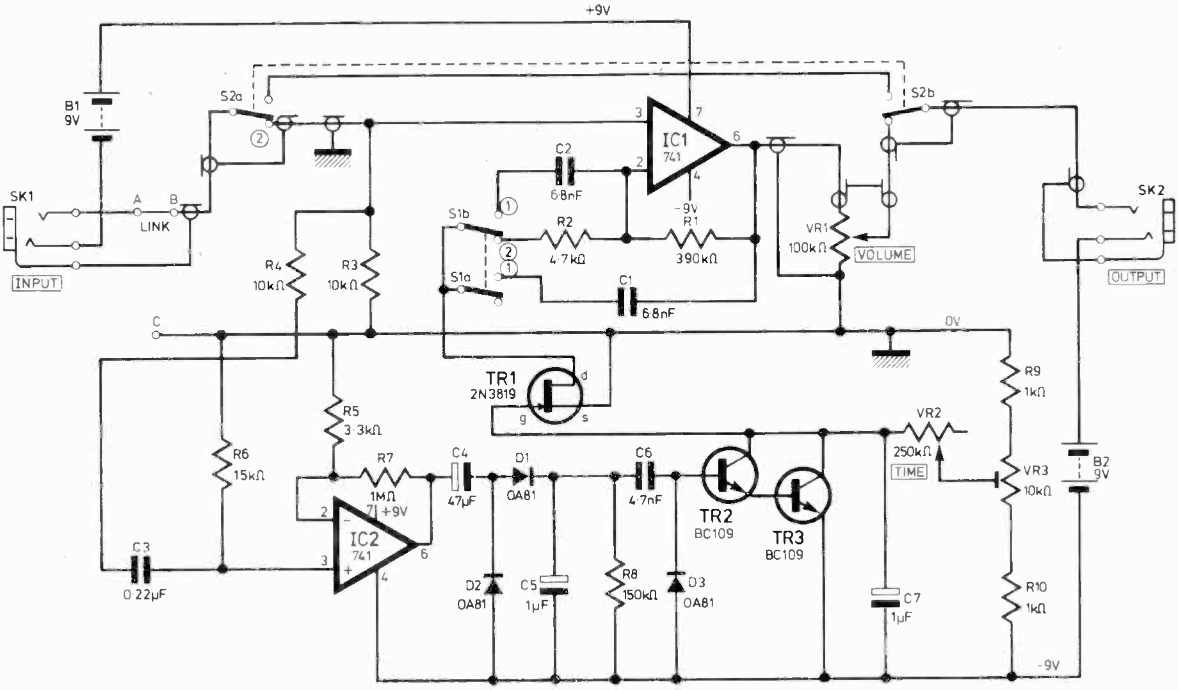


Fig. 2. Circuit diagram. All input and output leads to the jack sockets are screened, the screening providing an earth path

COMPONENTS . . .

Resistors

R1	390kΩ	R6	15kΩ
R2	4·7kΩ	R7	1MΩ
R3	10kΩ	R8	150kΩ
R4	10kΩ	R9	1kΩ
R5	3·3kΩ	R10	1kΩ

All ¼W 10% carbon

Potentiometers

VR1 100kΩ log
VR2 250kΩ log
VR3 10kΩ preset

Capacitors

C1 6·8nF
C2 6·8nF
C3 0·22μF
C4 47μF 25V elect
C5 1μF 10V elect
C6 4·7nF
C7 1μF 16V elect

Integrated Circuits

IC1 741
IC2 741

Semiconductors

TR1 2N3819 f.e.t.
TR2 BC109C
TR3 BC109C
D1 OA81
D2 OA81
D3 OA81

Miscellaneous

4BA+6BA nuts and bolts. Two-pole c/o switches (2 off). Knobs, and a plastic or metal case. Two stereo jack sockets. 0·1 inch matrix Veroboard, 90×100mm approx. Battery connectors (2 off), and wire.

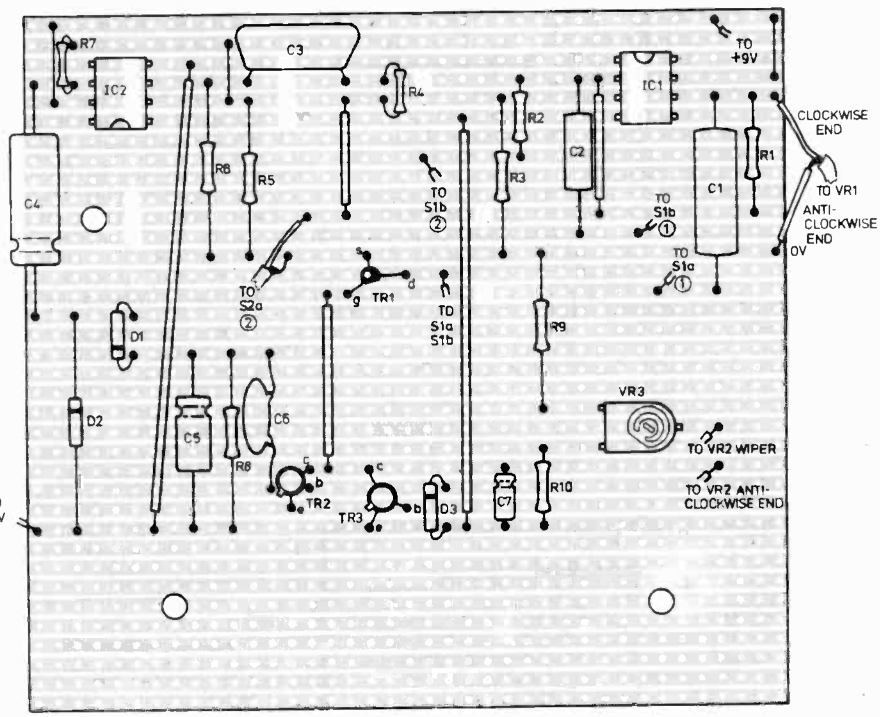
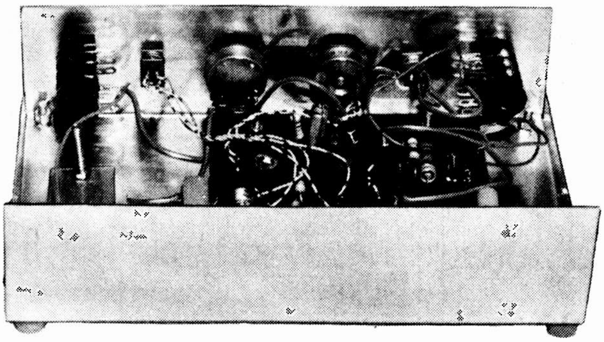


Fig. 3. Component layout. Switch positions are numbered to simplify wiring. Note: C4 is shown with incorrect polarity and should be reversed



Rear view showing wiring to front panel controls

CONSTRUCTION

The unit was constructed on 0·1in Veroboard as shown in the layout diagram (Fig. 3). The gate of TR1 may be left unconnected at the circuit board construction stage, to allow for a simple test later on.

A ready-made aluminium and steel box, 203 × 140 × 51mm, was used for the prototype, but any convenient case will do, although metal is preferable for both screening and robustness.

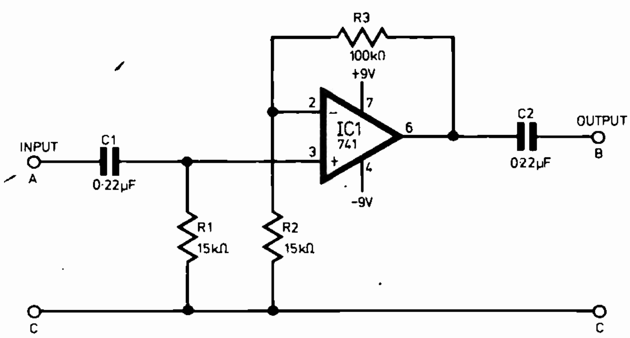


Fig. 4. Additional pre-amplifier for use with low output guitars

COMPONENTS . . .

OPTIONAL PRE-AMP

Resistors
R1 15kΩ
R2 15kΩ
R3 100kΩ
All ¼W 10% carbon

Capacitors
C1 0·22μF
C2 0·22μF

Integrated Circuits
IC1 741

Although a miniature two-pole changeover toggle-switch was used as the BYPASS switch on the prototype, a footswitch could be used and mounted in the lid of the box. However, suitable two-pole changeover footswitches do seem to be both expensive and difficult to obtain from electronic parts retailers.

Current consumption is around 4mA (measured in each supply rail), so PP3 or PP6 batteries can be used. The batteries were clamped into the prototype by an aluminium strip held by two long 6BA bolts.

The Veroboard was mounted on two 25mm × 4BA bolts using short lengths of plastic tube as spacers, and with additional support from a block of foam rubber glued to the floor of the box.

Letraset and Letrafilm were used on the front panel, and sprayed with Letracote gloss. This finish tends to be rather brittle, and so a coat of polyurethane varnish would give a more resilient finish.

TEST

A simple test can be carried out at this point to check the operation of the v.c.f./v.c.a. A fingertip brought close to the gate of TR1 should cause heavy 50Hz mains hum modulation of any note fed through the unit to an amplifier. There should be a clearly audible difference between the v.c.f. mode and the v.c.a. mode. After this check, the gate of TR1 can be connected to the circuit. The unit is sensitive enough to respond to most guitar pick-ups, although some low output guitars may give unreliable triggering.

ADDITIONAL PRE-AMPLIFIER

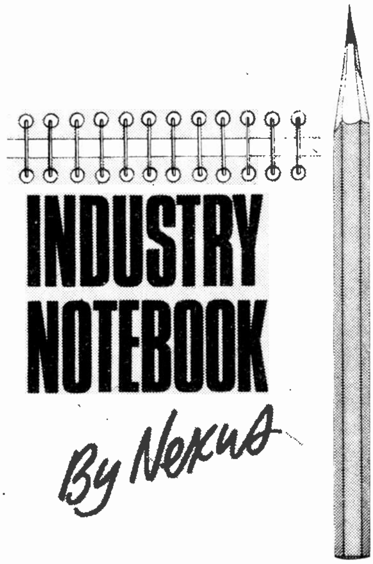
Should a low output guitar be used, the additional pre-amp shown in Fig. 4 can be employed to boost the low level signals. It may be fitted inside the Autowah Unit, or built as a separate item with its own case and batteries, so as to be a useful general purpose pre-amp. When used with normal guitar pick-ups, the pre-amp will cause a certain amount of clipping and distortion; but this does give the v.c.f. more harmonics to work on, and results in a stronger more aggressive sound, possibly preferred by some rock guitarists.

USING THE AUTOWAH

Since the trigger circuit responds to increases in the input level, it is not normally necessary to leave spaces between notes as with some circuits, and quite fast, fluid runs can be played after only limited experience with the unit. However, should the circuit not seem to respond quickly enough to successive notes, R8 may be slightly reduced in value.

For best results, some experimentation with the input levels may be necessary, compensating for any adjustments by a corresponding adjustment to the amplifier volume control.

The output volume of the Autowah is normally set to give no change in volume with the unit switched out of circuit. With the unit in circuit and switched to v.c.f. mode, the time control will vary the length of the "wah", from an extremely short "click" to something over one second. In the v.c.a. mode, most effective results are obtained when the time control is adjusted to just remove the sharp peak at the start of the guitar envelope, which changes the sound to a surprising extent. This produces something like a violin sound; or with fuzz, using the additional pre-amp, a harmonium sound is produced. ★



THE RECORD BREAKERS

British electronics companies are performing as never before. GEC is doing record business with sales in the current financial year certain to approach, if not surpass, £2,000 million with pre-tax profits of some £250 million. I base this forecast on first-half results of £963 million sales and profit of £120 million, an all-time record and the pace shows no sign of slackening. Moreover, GEC's liquidity position is remarkable with nearly £350 million cash in the bank which alone generated £15 million in interest.

Of course, GEC is also in heavy electrical engineering and consumer products but the telecommunications, electronics and automation sectors accounted for £273 million turnover in the first half and should top £550 million for the full year. Capital investment is running at some £80 million a year, hardly deserving the taunts of those who are never tired of saying that British industry lacks the will to invest.

Proportional to its size, Racal Electronics Group is doing even better than GEC and breaking every record in the book. Turnover is now over £100 million a year and when the financial year closes on March 31, pre-tax profits are forecast as being not less than £28 million compared with £19·65 million in the preceding year and £9·5 million the year before that.

Exports are better than ever, now running at 75 per cent of production for the whole group and 85 per cent in communications products. Chairman Ernest Harrison is not exaggerating when he claims that Racal is enjoying "exceptional years".

Having built up a dominating position with its communications products, spearheaded by military manpacks and mobile radios, in Africa, the Middle East and the Far East Racal's problem now is where to look for further expansion. Harrison sees it in the United States. First moves have already been made in securing a 15 per cent stake in Milgo Electronic Corporation. Racal has had a 50/50 share in Racal-Milgo which markets Milgo data modems outside the United States. Now Racal will have a direct interest in manufacturing and product development through representation on the Milgo board.

Additionally, Racal's own company in the United States, Racal Communications Inc. at Rockville, Maryland, has now received its biggest ever contract from the U.S. government for a new communications receiver designed in the U.S.A. This could be the big breakthrough for which Racal has been patiently waiting over the years.

By the standards of U.S. military spending the present contract is comparatively insignificant in cash terms but if the receiver is made standard U.S. forces equipment the flood gates could open. It is only by having a company based in the United States that one can hope to get military contracts. Outsiders are heavily penalised through the "Buy America" act which protects the home industry.

Meantime, the Racal Group with its buoyant financial position is actively looking for take-over possibilities at home. The Group now has 23 companies in the U.K. and 12 overseas.

Britain's data processing giant ICL continues to gain strength with 20 per cent growth of which very little is said to be due to inflation. Profits are up to £12·5 million from £9·5 million and overseas turnover is now 40 per cent of the total and expected to rise to 50 per cent. Nice work.

A NATIONAL ENTERPRISE

The cut-throat consumer market with ever-tumbling prices may be good for the customer but can be disastrous for manufacturers who can't stand the pace. Latest victim is Clive Sinclair's Sinclair Radionics, now baled out of trouble by the National Enterprise Board.

Whether we like it or not we are now all shareholders in Sinclair and therefore wish the company well. And Clive Sinclair has, in the end, seen his most cherished ambition, his miniature TV set project, come to fruition *(see page 198)*.

But whether such a project is much related to the "regeneration of British industry" with which the NEB is reputed to be connected, is quite another matter. It seems that in talks with other possible backers their commercial judgement in relation to such projects was lukewarm. One might have expected the NEB's response to have been in agreement with those with long professional experience.

The most astonishing aspect of the whole affair is that the key component, the miniature picture tube, is to be imported from overseas through a European supplier who will reap some of the benefit of the British tax-payers' investment in £650,000 of ordinary shares and 200,000 £1 preference shares.

ENTENTE CORDIALE?

Hard on the heels of an agreement between Plessey Semiconductors and Sescosem, the semiconductor division of the French giant Thomson-CSF, for mutual development and production of surface acoustic wave (SAW) devices came an announcement that the two companies were exploring a similar agreement on integrated circuits. Industry thinking is that only by mutual co-operation can European i.c. manufacturers stave off the enormous challenge of the big American producers who are only too anxious to capture the bulk of the important European market.

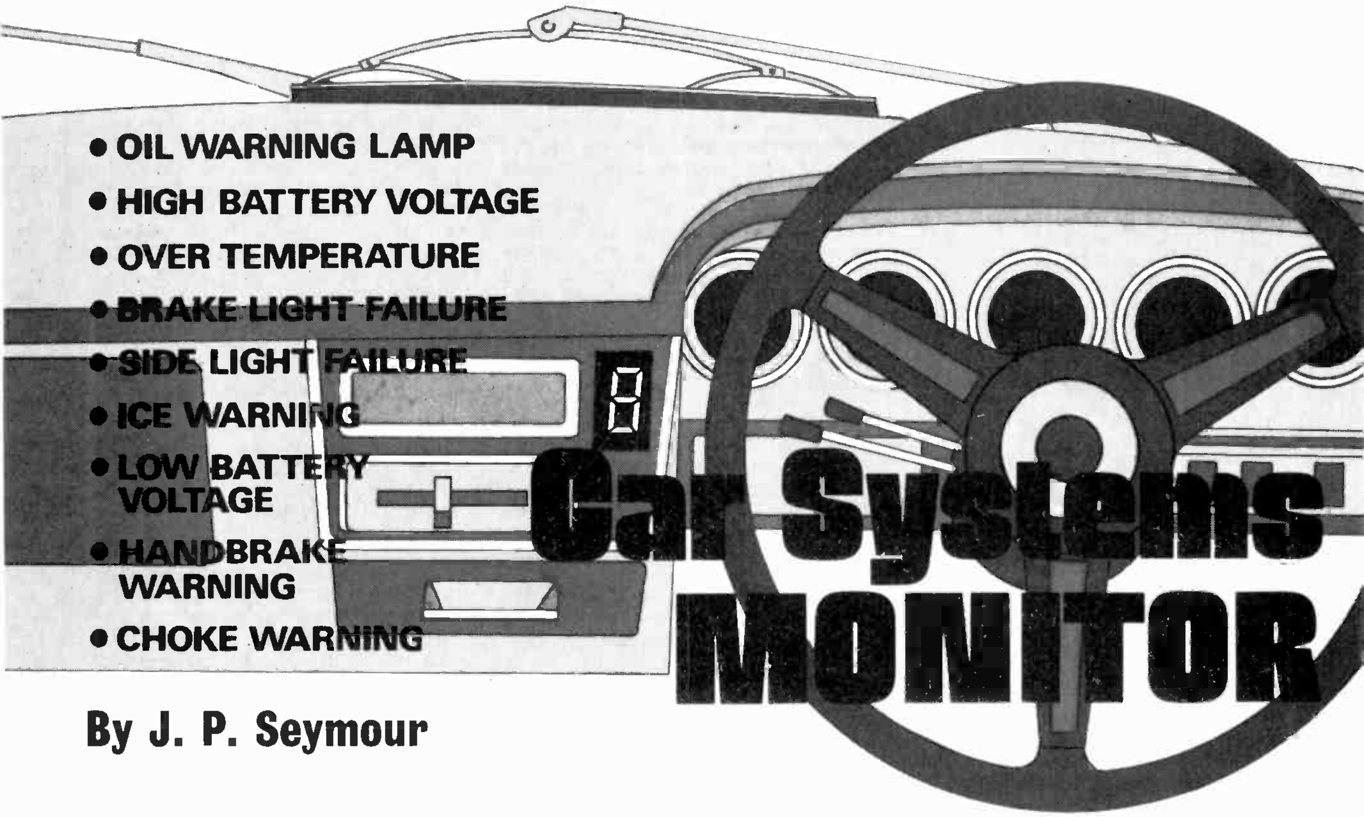
Recent successes in semiconductor exports have considerably strengthened Plessey's hand in negotiations. But co-operation agreements have proved difficult in the past in the semiconductor business. Attempts to re-group the British industry into larger units have always failed. Will an Anglo-French initiative prove more fruitful? Or an Anglo-German? Or an Anglo-French-German, because Siemens is said to have been a party to informal discussions?

If one is to share one's R and D secrets and production know-how there is clearly great commercial risk and that has always been the stumbling block.

DISPLAYS

The increasingly booming business in electronic displays is proving more and more attractive. Rank Optics is investing heavily in a plant in Leeds, claiming to be the first British company to go into mass production of professional quality liquid crystal displays.

The size of the LCD market can be gauged from the claim that this year Brown Boveri will be churning out watch-sized LCDs at the rate of five million a year. And production of LED displays from various manufacturers is of similar astronomical proportions. In fact, electronic displays are now a recognised specialist sector of electronics with its own exhibition and conference as an annual event.



Car Systems MONITOR

By J. P. Seymour

In any car there are a number of points which should be monitored by the driver. The number of instruments and warning lights fitted by the manufacturer varies widely according to model, and in many cases there is little dashboard space left to add any more.

The output of the self-diagnostic car systems monitor to be described is in the form of a single 7-segment l.e.d. display which may be fitted to even the most crowded of car instrument panels. The circuit is capable of displaying up to ten fault conditions, and will indicate the existence of any number of these faults occurring at the same time, and their seriousness.

The central unit uses one five volt regulator i.c., five TTL i.c.s and three CMOS i.c.s, with a few gates left over which could be used as part of the interface circuitry for the various inputs.

CIRCUIT DESCRIPTION

Two power supply lines are required for the unit. The +12V supply for the CMOS chips is taken direct from the car supply, while the +5V supply for the TTL is derived from a 7805 regulator, IC1. See Fig. 1.

An NE555, IC2, operates as a clock oscillator driving IC3, a BCD counter. The output of IC3 is applied to IC5 (of which more later) and to IC4, a 7-segment decoder/driver. The output from this i.c. to the display is blanked unless a fault occurs, in which event a preselected number corresponding to that fault will flash on and off with a mark/space ratio of 1:10. Should more faults occur simultaneously, more numbers will flash in sequence.

Scanning of the input lines is accomplished by connecting the outputs of IC5, a BCD to decimal decoder, via switches to the blanking input of IC4. Thus as the counter counts from zero to nine the switches are scanned one by one and the display is held off as long as the switch being scanned is closed. The switches take the form of CMOS devices, IC6—IC8, which are closed so long as the control input to each switch is held at +12V. Each package contains four switches.

The switch outputs are fed via two inverters contained in IC9. These act as a buffer amplifier, necessary because the maximum current rating of the CMOS switches is not sufficient to drive the blanking input of IC4. The car-driver is alerted to more serious faults by means of a "bleeper", based on IC10 which operates as a gated oscillator. When an alarm signal is output by IC9, AND the *A* output of IC3 is high (signifying an odd number) the oscillator is activated and its output is fed via amplifier TR1 to a small loudspeaker or earpiece insert.

CONSTRUCTION

The prototype was built on matrix board (Fig. 2), which seemed the best method allowing as it does complete flexibility in the wiring of the various input interface circuits required. The voltage regulator circuit was built up on a separate small piece of board, so that the heat sink tab of IC1 could be bolted to the car chassis. No insulation is required, since the tab is connected to the 0V line. Note that the circuit as designed is suitable for NEGATIVE EARTH electrical systems only.

If the assembly order follows the order in which the i.c.s are numbered, power supply followed by timer, etc., each section of the circuit may be tested as it is completed.

COMPONENTS . . .

Resistors

R1	4·7kΩ	R22, R23	2·2kΩ (2 off)
R2	1kΩ	R24	270Ω
R3–R9	270Ω (7 off)	R25	22Ω
R10	4·7kΩ	R26	4·7kΩ
R11	270Ω	*R27*	*1kΩ*
R12–R21	1kΩ $\frac{1}{8}$W (10 off)		

All 10% $\frac{1}{4}$W unless otherwise specified

Variable Resistors

VR1	100kΩ
VR2, VR3	*10kΩ (2 off)*

All min. presets

Capacitors

C1	0·22μF polyester
C2	0·47μF polyester
C3	10μF 16V electrolytic
C4, C5	0·22μF polyester (2 off)

Semiconductors

IC1	7805 5V 1A regulator
IC2	555 timer
IC3	7490
IC4	7447A
IC5	74145
IC6–IC8	4016 (3 off)
IC9	7404
IC10	7400
IC11, IC12	*741 (2 off)*
TR1	2N3704
D1	1N5401
D2	*BZY88 C4V7*

LED 1 Any 7-segment common anode l.e.d. display with I_F typical of about 10mA per segment

Note Items in italics are for the over/undervoltage input interface (Fig. 3)

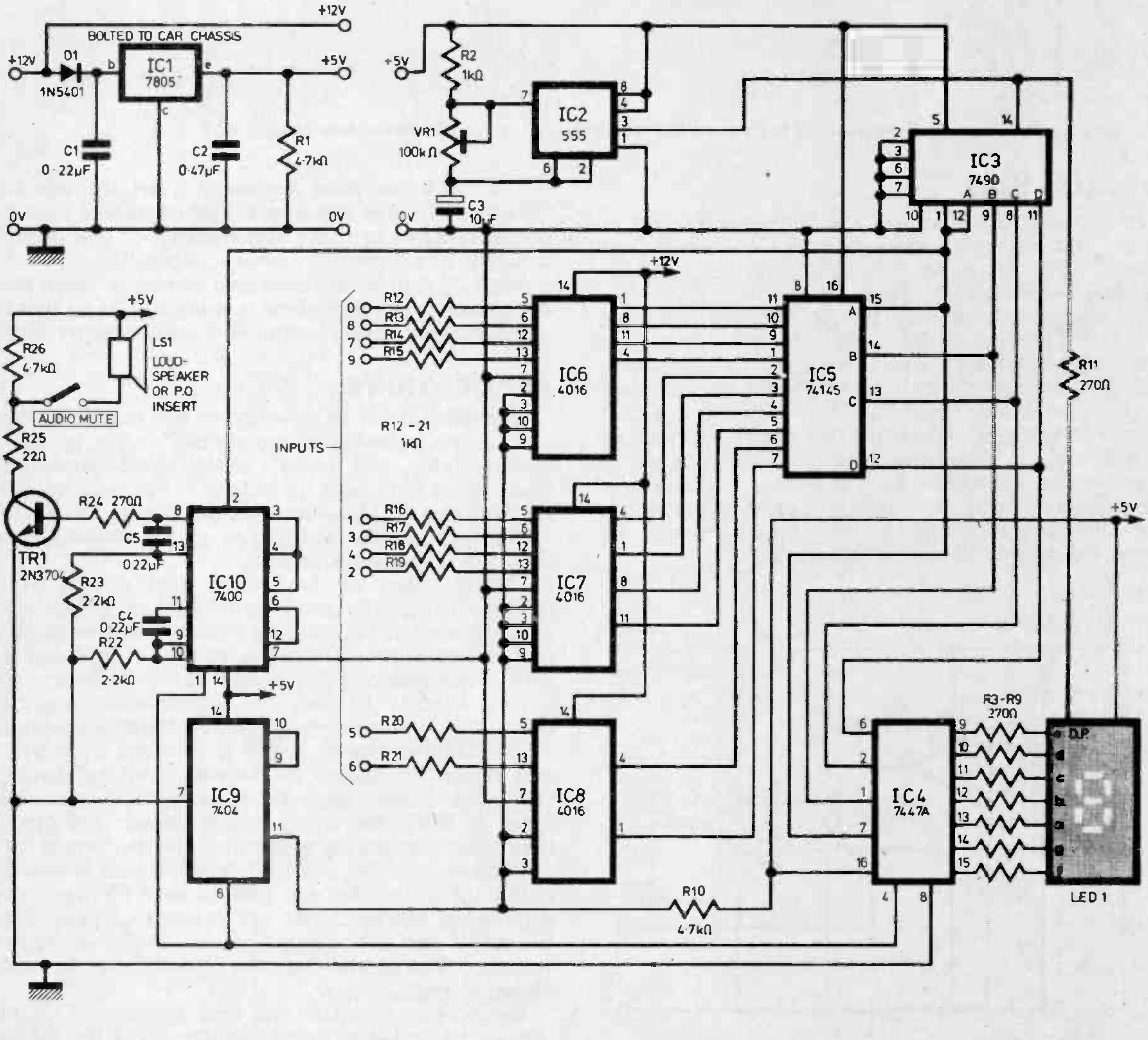


Fig. 1. Circuit diagram of the central unit of the monitor

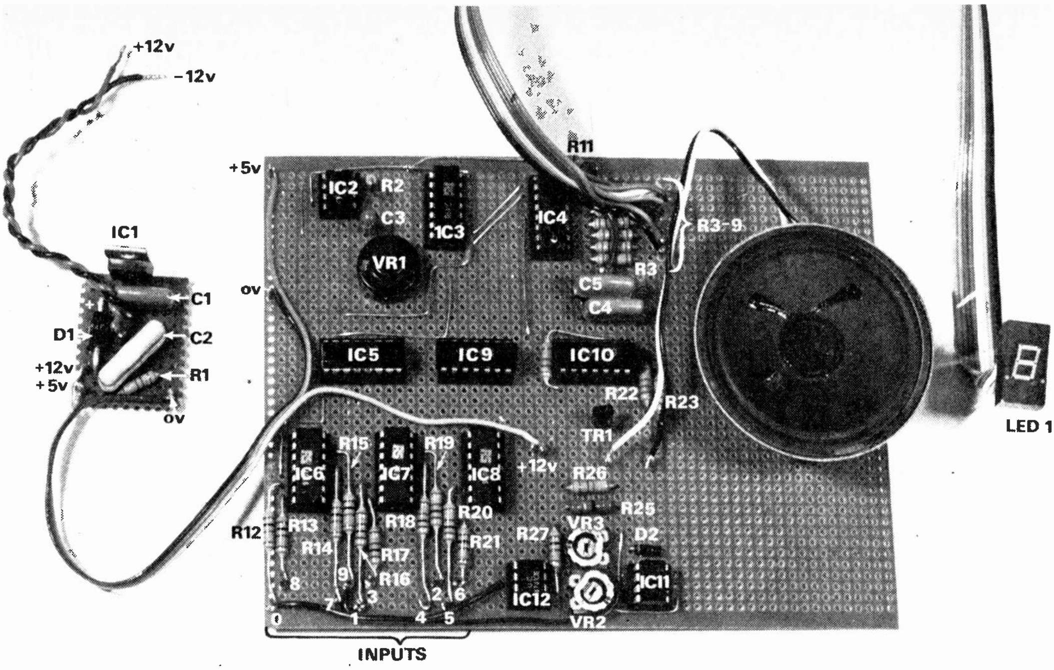


Fig. 2. Component layout of the central unit, plus the interface circuit of Fig. 3

INSTALLATION

In operation the alarm inputs are normally held at +12V and are taken down to near 0V when a fault occurs. The values for R12—R21 are the minimum required to protect the CMOS inputs from a low impedance source and may be increased considerably without affecting performance. Inputs which are being controlled by a s.p.s.t. normally closed switch, such as a mechanical thermostat, should be connected to one side of the switch and to +12V via a 4·7kΩ resistor. The other side of the thermostat is connected to chassis (0V). The extra resistor is to stop the input from floating when the switch is open. If a normally open switch is being monitored, the resistor and switch are interchanged. Any unused inputs should be connected directly to the +12V supply.

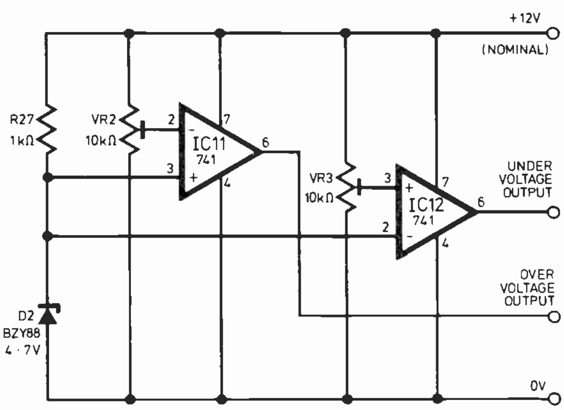


Fig. 3. An example of a suitable interface circuit, monitoring battery system voltage

The clock oscillator frequency is set by means of VR1 so as to give a reasonably fast scanning rate, but not so rapid as to make identification of two or more consecutively displayed numbers impossible.

The 12V supply for the system should be taken from the accessory position of the ignition switch, so that the unit is isolated during operation of the car starter motor.

APPLICATIONS

Suitable faults to be indicated by odd numbers, where the audible warning is operational, might be an oil warning lamp, high battery voltage, over-temperature, brake lights fault, side lights fault. For even numbers the faults could be an ice warning device, low battery voltage, handbrake warning or choke warning, since these are perhaps less urgent.

Clearly, many of these ideas (and others) would require further interface circuitry such as voltage comparators and current sensing circuits. An example of one of these types of circuit is shown in Fig. 3 and will provide a warning of low or high battery voltage. The circuit consists of two 741 operational amplifiers operating in the open loop mode as voltage comparators. A reference voltage of +4·7V is provided by R27/D2, and this is connected to the non-inverting input of IC11, the over-voltage sensor, and to the inverting input of IC12, the under-voltage sensor. Samples of the battery voltage are applied to the other inputs from potentiometers VR2 and VR3, which are set so that the output of the related i.c. falls to near 0V when predetermined voltage levels are reached. These might be +15V for over-voltage and +10·5V for under-voltage. This circuit has been included on the board shown in Fig. 2.

The prototype system was built for around £7, but this is not excessive when one considers the cost of repairing an engine damaged by overheating or similar fault. ★

PATENTS REVIEW...

GAIN COMPENSATING AMPLIFIER

A British company based in the Channel Islands, Television Research Ltd., patents, in BP 1 449 825, a novel audio amplifier system. The gain is automatically controlled, to compensate for changes in ambient background noise level, for instance to keep the level of reproduced speech, alarm signals or background music always audible.—Existing systems, which sense ambient level with a microphone, tend towards instability it is claimed.

The block diagram of the new patented system is shown in Fig. 1. The input signal (speech, music, warning alarm, etc.) is fed through a buffer amplifier to a variable gain amplifier for reproduction and also to a switching amplifier which detects periods when the input signal falls below a preset threshold.

The microphone senses the ambient sound level and feeds the detector circuit, via an amplifier, with a signal representive of total sound in the environment, i.e. reproduced sound plus ambient noise. An inhibitor circuit in the switching amplifier chain is used to control the detector so that its output is fed to the store during quiet periods only (i.e. when the switching amplifier detects that the signal level at the buffer amplifier is below the preset threshold).

The provision of the store between the detector and a variable gain amplifier effectively increases the normally short time constant of the detector during quiet periods. This prevents a sudden change in ambient noise level, as for instance produced by a dropped eating utensil or sudden laugh, from altering the gain of the microphone amplifier when the reproduced programme is quiet.

Details of suitable switching amplifier, inhibitor and an ambient noise level detector (with converter from analogue detector voltage to four-bit digital code storage) are given in the patent. Also, suitable digital stores are described.

BP 1 449 825

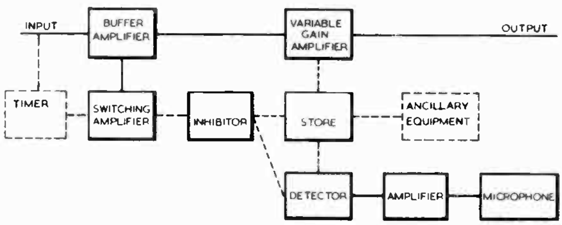


Fig. 1

IN BRIEF

BP 1 451 817—Chan Hue Yeh: *Electronic Data Processing of Chinese Characters*. A Chinese Teletype which functions without conventional code and decode means as so far employed for converting Oriental characters to electronic signals.

The characters are digitised by placing them under a grid formed as a 24 × 20 matrix, giving 480 grid portions. The digital results are converted to hexadecimal form, stored, retrieved, transmitted and, on reception, used to drive a conventional matrix printer corresponding to the matrix used for digitisation.

BP 1 451 969—Telub A.B.: *Apparatus for Converting Digital Information to Braille*. This invention is a calculator modified to provide a Braille output.

A memory register is used, which senses and is triggered to commence entry by the leading edge of a received pulse. The pulse trailing edge triggers transmission of the memory content, to a mechanical Braille format indicator.

Calculator clock pulses are used as the memory triggering pulses.

BP 1 449 371—Porsche AG: *Electrical Speed and Distance Indicator*. A simple, but apparently novel idea, because the patent has been accepted. A crossed pair of stationary reed switches lie adjacent to a single bar magnet on a rotating spindle, and produce sufficient discrete pulses, even at low rotational speeds, to provide a steady dial readout after integration.

BP 1 448 879—M. Demetrescu: *Generator*. A novel approach to the generation of electric power at mains frequencies. A mass and spring combination is tuned to a resonant frequency equal to the a.c. frequency to be generated. The mass is moved by mechanical power pulses, for instance in an IC engine, under electronic ignition control to keep the system resonating. Power at the frequency of resonance is generated electromagnetically by interaction of moving coils and magnets.

Copies of Patents can be obtained from the Patent Office Sales, St Mary Cray, Orpington, Kent Price 95p each

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Celestion G12/50TC 8 or 15 ohm	£20·00
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Decca London ribbon horn	£31·50
Decca London CO/1000/8 crossover	£6·95
Decca DK30 ribbon horn	£20·50
Decca CO/1/8 crossover (DK30)	£4·75
EMI 14×9in bass 8 ohms, 14A770	£14·95
EMI 8×5in, 10W, d/cone, roll surr.	£3·95
EMI 6½in d/cone, roll surr., 8 ohm	£3·95
EMI 8in roll surr. bass	£6·75
EMI 5in mid range	£3·50
Elac 59RM 109 (15 ohm), 59RM114 (8 ohm)	£3·50
Elac 6½in d/cone, roll surr., 8 ohm	£3·95
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Kef T27	£8·50
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Kef B110	£10·95
Kef B200	£11·95
Kef B139	£24·95
Kef DN8	£2·75
Kef DN12	£7·25
Kef DN13 SP1015 or SP1017	£4·95
Lowther PM6	£32·00
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Peerless KO10DT 4 or 8 ohm	£8·25
Peerless DT10HFC 8 ohm	£9·50
Peerless KO40MRF 8 ohm	£10·50
Peerless MT225HCF 8 ohm	£3·75
Richard Allan HP8B	£12·50
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Richard Allan Super Disco 60W 12in	£17·95
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Radford TD3	£8·25
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Peerless 2050	pair	£43·95
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Richard Allan Triple 12	each	£25·95
Richard Allan Super Triple	each	£29·50
Richard Allan RA8 Kit	pair	£37·80
Richard Allan RA82 Kit	pair	£59·40
Richard Allan RA82L Kit	pair	£65·70
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Wharfedale Linton 3XP kit	pair	£34·25
Wharfedale Glendale 3XP kit	pair	£49·50

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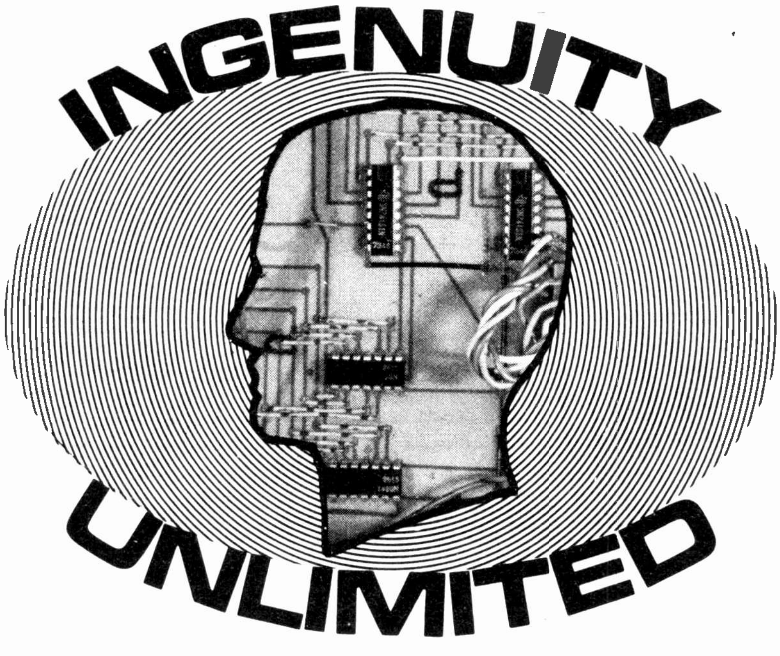

A selection of readers' original circuit ideas. It should be emphasised that these designs have not been proven by us. They will at any rate stimulate further thought.

Why not submit *your* idea? Any idea published will be awarded payment according to its merits.

Articles submitted for publication should conform to the usual practices of this journal, e.g. with regard to abbreviations and circuit symbols. Diagrams should be on separate sheets, not inserted in the text.

Each idea submitted must be accompanied by a declaration to the effect that it is the original work of the undersigned, and that it has not been accepted for publication elsewhere.

BENCH POWER SUPPLY

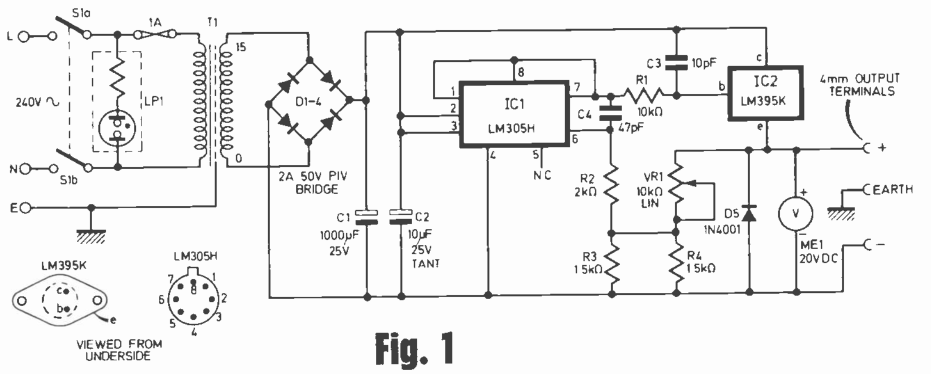

Fig. 1

THE circuit of Fig. 1 uses two National Semiconductor integrated circuits to provide a short-circuit-proof one amp variable d.c. power supply, variable from 3 to 20V.

Mains voltage is stepped down by transformer T1, type Douglas MT3, of which the 15V winding is used. The a.c. voltage is rectified and smoothed by D1–4 and C1 and passes to pin 3 of the i.c. regulator type LM305H. This i.c. comes in an 8-lead TO-5 can. The output from the LM305H is taken from pin 8 and drives the second i.c., the LM395K. This has three terminals like a normal transistor, but its internal circuitry limits the output current of the power supply to one ampere; thus the power supply is short-circuit-proof, as all that would happen if the output terminals were shorted would be that the i.c. would current-limit. The LM395K also thermal-limits if it gets too hot due, for example, to insufficient heat-sinking. The LM395K comes in a TO-3 case, but note that the case is connected to the emitter. Potentiometer VR1 controls the feedback to the regulator i.c., but need not be a simple pot. It could be replaced by a rotary switch selecting 10kΩ presets, or if the meter were omitted, could form a small power supply for intercoms, calculators etc., or radios—no hum appeared when used to power a radio.

Meter ME1 monitors the output voltage. Diode D5 shorts away any back e.m.f. which appears when a purely inductive load is connected and then disconnected from the output terminals. (Back e.m.f. destroyed an LM395K on the prototype.)

It may be worth noting that a higher voltage model could be built simply by adjusting the tapping on the secondary of T1 for a higher voltage. The LM395 can cope with 30V, but care must be taken not to exceed 36V absolute maximum. A higher current value can be achieved by placing two or more LM395s in parallel, one per ampere of output required.

The circuit was assembled on two pieces of Veroboard, one holding the rectification and smoothing components, the other the regulator. An 8-pin TO-5 i.c. socket was used for IC1. IC2 was mounted on the back panel using a mounting kit and a large heatsink. (The device got very hot under short-circuit conditions.)

A. R. Winstanley.
Brigg,
S. Humberside.

ACOUSTIC RELAY

This circuit (Fig. 1) is very useful for a simple alarm system. When a sound is made, the voltage generated as the sound hits the microphone, trips the simple transistor switch and lights the lamp. The sensitivity of the circuit should be adjusted very carefully to obtain maximum performance.

The light will stay lit until the circuit is reset with the switch, thus this is a tell-tale alarm by which you could tell if someone had been into the house, etc. The circuit may also be used in conjunction with a light triggered alarm.

T. Robinson,
Malton,
Yorks.

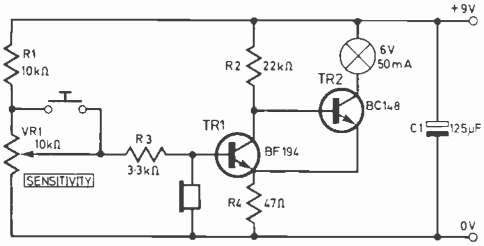

Fig. 1

SIMPLE POSITION SERVO

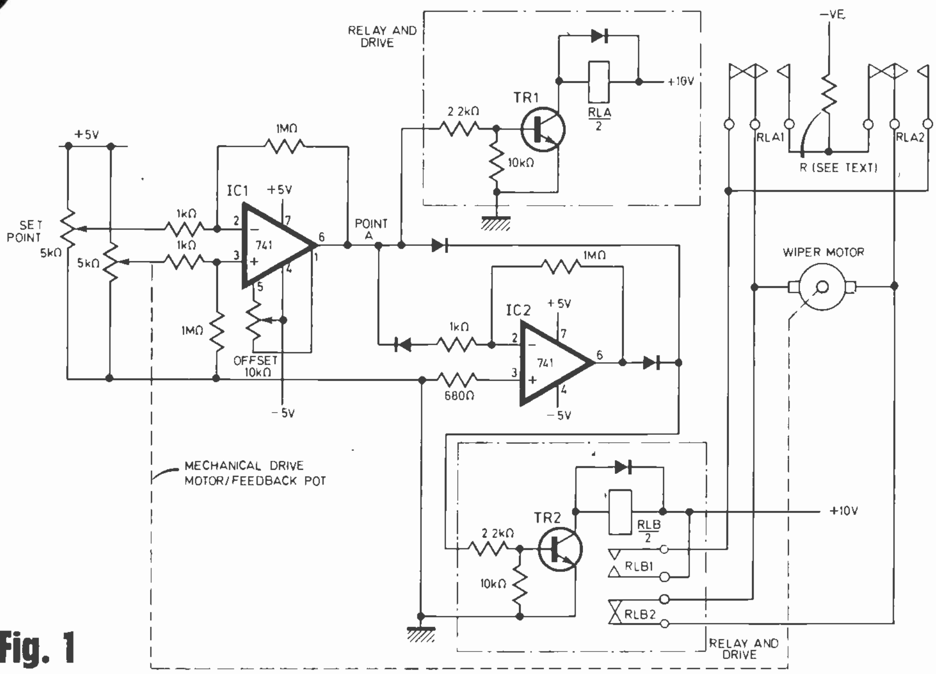

Fig. 1

The servo described is of a simple nature, and can be built at minimal cost. The system was designed primarily as an aerial rotator, although it can obviously be used in many other applications. The motor used, a surplus wiper motor, is readily available from most vehicle scrapyards, and is suitable as a drive where high starting torque coupled with low revs are required.

Any difference between the set-point and the feedback potentiometer is amplified by IC1. An out of balance signal of positive polarity at point A provides a signal to RLA causing it to energise, operating the change-over contacts. A signal is also given to RLB which energises the motor. The motor then rotates the feedback potentiometer until the out of balance signal is nulled, thus removing the feed to RLA and RLB. An out of balance of negative polarity is fed via IC2 to RLB, which energises the motor. RLA is not energised because TR1 is reverse biased, hence the motor is reversed.

The wiper motor drive to the feedback potentiometer should be made fail-safe to avoid damaging the pot, in case of failure to achieve a null. A probable cause would be the feed to the motor being reversed.

Helipots were used in the prototype to obtain a full 360° rotation. The motor supply voltage should be set at something less than the full 12 volts used for vehicle operation. The power resistor R in the order of five to ten ohms in series with the motor feed, should provide sufficient drop from a 12 volt source. This is best found by experiment, as it depends largely on the application. The same applies to the gain of IC1. The 1MΩ resistors can be reduced in value for less gain, in order to avoid hunting if it occurs.

J. C. Hardman,
Leyland,
Lancs.

COMPUTER VOICE OSCILLATOR

THE computer, or Dalek voice generator devised originally for theatrical purposes, and described in PE May, 1976, used a 555 oscillator to drive a reed relay for voice modulation. The circuit in Fig. 1 replaces both the 555 timer and the relay with a CD4016 CMOS switch package.

Switches S1 and S2, form an oscillator similar to the conventional CMOS NAND-gate oscillator arrangement. The output is taken from S1, and drives S3 which replaces the original reed relay.

W. H. Montgomery,
Belfast.

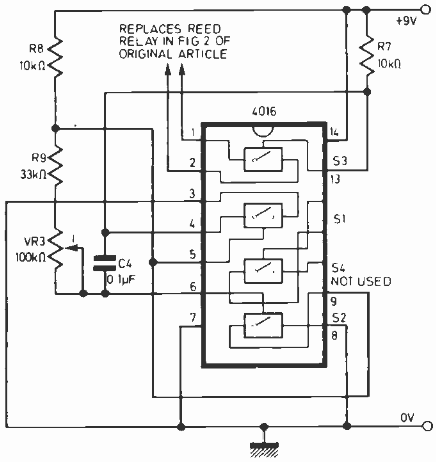

Fig. 1

SIMPLE TUNING FORK

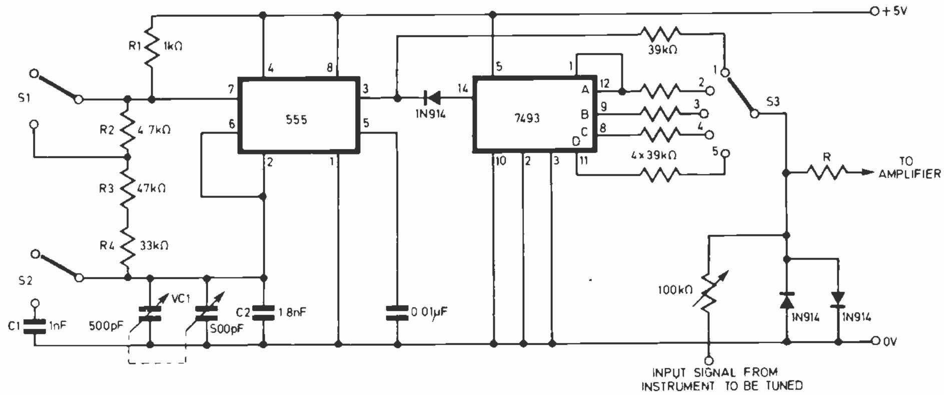

Fig. 1

THE circuit in Fig. 1 uses a NE555 i.c. timer, and a SN7493N i.c. The 555 is used as an astable multivibrator, and in this mode the output frequency is given by·

$$f_1 = \frac{1{\cdot}44}{[R_1 + 2(R_3 + R_4)]\,C} \quad \text{with S1 closed.}$$

$$f_2 = \frac{1{\cdot}44}{[R_1 + 2(R_2 + R_3 + R_4)]\,C} \quad \text{with S1 open.}$$

Therefore the ratio $f_1/f_2 =$

$$\frac{R_1 + 2(R_2 + R_3 + R_4)}{R_1 + 2(R_3 + R_4)} = \frac{170{\cdot}4}{161{\cdot}0} = 1{\cdot}0584$$

This is a good approximation of the musical interval of 1·0595. Since this ratio depends greatly upon R3 and R4, close tolerance of 2 per cent or better must be used for these two resistors. Resistor R2 should be of 5 per cent or better.

In conjunction with S2, tuning with VC1 will give about 2·1 to 4·2kHz with S3 at position 1. With S3 at position 2, the range of frequency will be divided by two (i.e. about 1·05 to 2·1kHz) and similarly, positions 3, 4 and 5 each give further binary divisions.

To tune a musical instrument such as a home made electronic organ, starting with say note C which is known to be at the correct frequency, first connect the output of the organ to the input of the circuit and set S3 to the appropriate range. Then with the key C depressed and S1 open, adjust VC1 until there is a zero beat in the detector, also using S2 if necessary. Now the tuning fork circuit is at the same frequency as the C note. Next close S1 to short out R2, and press on the C # key and tune the organ for zero beat. When this is done, still with C # key down, open S1 and adjust VC1 for zero beat. Next close S1 again and press on the D key, and tune the organ for zero beat. Then with D key still down, open S1 and adjust VC1 for zero beat. Then close S1 to tune the D # note. Following this systematic procedure the rest of the notes can be tuned.

If a zero beat cannot be obtained after closing S2, and with S3 correctly set, a 500pF capacitor temporarily connected across VC1 should cure the problem.

Pek Yaw Kee,
East Malaysia.

ECONOMICAL RELAY

WANTING to use a number of 700 ohm miniature relays, each drawing a current of 36mA from a 25 volt supply, it was found that their combined load exceeded the rating of the available power source. Some way was needed of reducing the running current of each relay.

It was found that although the minimum pull-in voltage at room temperature was 11·5 volts, the relay would hold in down to about 3·5 volts, at a current of only 5mA. A considerable saving in power was possible if the relay could first be energised.

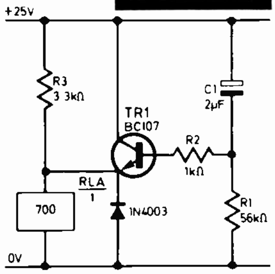

Fig. 1

The circuit in Fig. 1 was devised to allow the relay to receive sufficient current to energise, and then restrict it to just above the minimum hold-in value. When voltage is first applied, TR1 switches on for a brief period, governed by the time constant of C1.R1, to allow the relay to energise. After TR1 switches off, the necessary hold-in current flows through R3.

The circuit works well with other relays, although it will be necessary to make some adjustment to the value of R3, which should be chosen to allow slightly more than the minimum hold-in current to flow.

A. A. Farman,
Biggin Hill,
Kent.

LOGIC PROBE

THIS logic probe uses a conventional 7447 decoder with a seven-segment readout to indicate logic states. The circuit is in three parts:

1. Logic 0 and 1 detection.
2. Pulse detection and BCD coding circuit (Fig. 1(a)).
3. BCD decoder and character formation (Fig. 1(b)).

1. This can be any circuit giving the required *x* and *y* outputs of the voltage levels given in Table 1, such as the circuit used in the PE *Digiprobe*.

2. Here, the *y* output is allowed to pass directly to the *A* output, unless either IC1 or IC2 is operating, by means of IC3a and IC3b. IC3c is used to drive the decimal point of the display, to provide continual monitoring of the probe input when the edge and pulse outputs are observed. If a transition edge or a single pulse appears at the probe input, IC1 is clocked by the *x* output. This forces the *A* and *B* lines high, presenting BCD-3 to IC4. If a series of pulses is present, IC2 being retriggerable forces the *A* and *D* lines high and the *B* line low, giving BCD-9. Should the pulses be of low frequency, erratic operation of IC1 will occur. However, such an input condition can easily be seen by the flashing of the decimal point.

3. An important feature of this part of the circuit is that the *c* and *e*, and the *b* and *f* connections are reversed between the decoder and display. This means that the 0 and 1 are unchanged, but the 3 becomes an "E" and the 9 becomes a "P". The ripple blanking input is connected to the *x* output, so that when the *x* and *y* ouputs are low, the display is blanked.

The time for which the "E" is displayed is set by VR1, and can be varied from approximately 300ms to one second. The value of C2 will depend upon the clock frequency of the equipment being tested. For general use it should be 2·2 µF, as shown, or a selection of switched values provided.

Fig. 1a

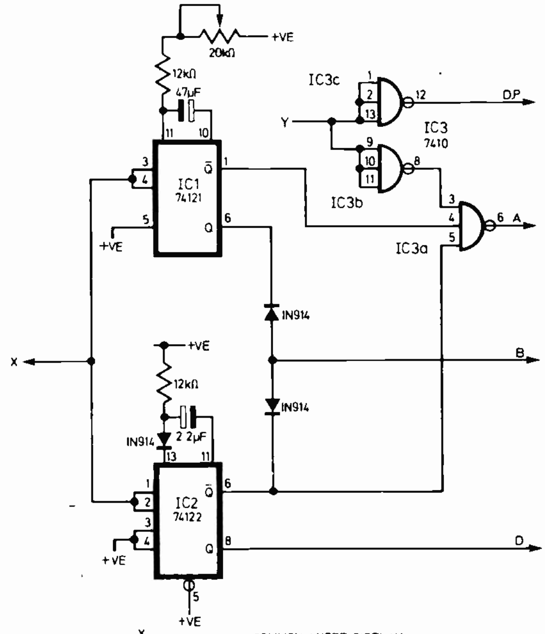

Fig. 1b

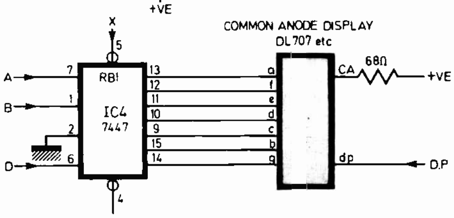

Table 1:

PROBE INPUT	X	Y	BCD	DISPLAY	FUNCTION
<0 4V	1	0	0	0	LOGIC ZERO
0 4 – 2 4V	0	0	RB		INVALID STATE
>2·4V	0	1	1	1	LOGIC ONE
5V 0V			3	E	0-1 TRANSITION
or			3	E	SHORT PULSE
			9	P	CLOCK PULSES

J. Froggatt,
Edwinstowe,
Notts.

DIGITAL ANALOGUE CONVERTER

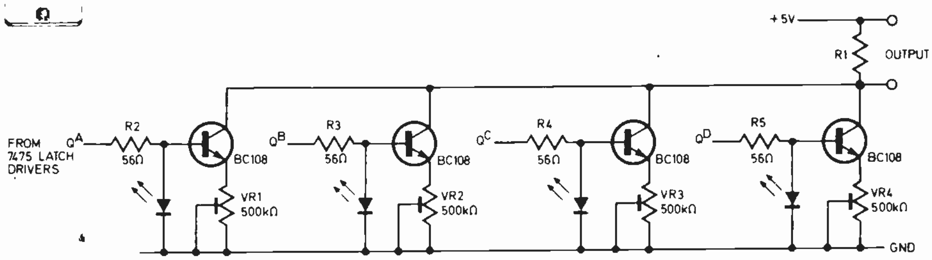

Fig. 1

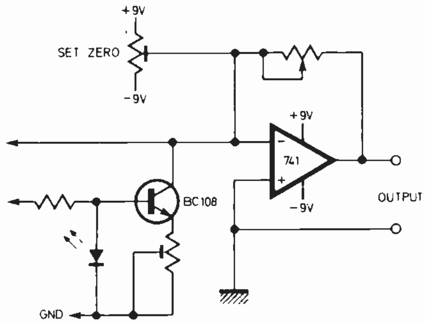

Fig. 2

A CIRCUIT is shown in Fig. 1 which will visually indicate the state of a four bit binary counter, and simultaneously provide an output suitable for driving a chart recorder.

The design consists of four constant current generators connected in parallel. Each supplies current according to its position in the binary series when switched on by a logical 1 from the Q output of a 7475 latch. The output voltage obtained across R1 is directly proportional to the sum of currents flowing through it, and therefore to the binary state of the latch. The l.e.d.s give a visual indication of the logical states. With the values shown, a forward current of three milliamps was measured in the l.e.d.s, making them easily visible.

A 741 buffer working as a current to voltage converter allows continuously variable adjustment of the output voltage whilst maintaining the correct ratios, and such an addition is shown in Fig. 2. It also enables the zero point to be set at any desired level.

Ten turn trimpots were used for the emitter resistors, and the unit is stable when delivering a maximim output of less than one millivolt.

J. P. Fitzgerald,
Ealing, London.

SIMPLE POWER SUPPLY REGULATOR

THIS circuit (Fig. 1) was originally developed from M. J. Meaken's Low Voltage Regulator, which appeared in *Ingenuity Unlimited* in March 1976, to power a cassette player from a car battery. It has, however, proved much more useful as a general purpose bench power supply.

When used in a car, where the battery voltage may vary between 12 and 15 volts, there is no perceptible variation in output voltage. If the unit is connected to the output of a battery charger, the result is a hum-free output at 6, 7·5 or 9 volts for indoor use. The series transistor TR2 should be mounted on a suitable heatsink.

R. Scott,
Morpeth.

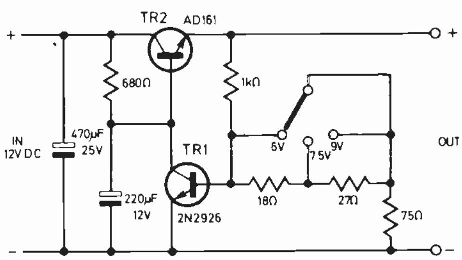

Fig. 1

SAWTOOTH TRIANGLE CONVERTER

THIS circuit will turn a sawtooth waveform into a triangle using two 741 op. amps. or both halves of a single 747 dual op. amp. i.c.

An ideal full-wave rectifier is formed by IC1 and its associated components. For positive input excursions the output of IC1 swings fully negative because D1 effectively isolates it from the rest of the circuit, including the feedback path. The positive half of the input waveform does, however, find its way to pin 3 of IC2, attenuated slightly by the presence of R3. For negative input excursions IC1 acts like an inverting amplifier, where D1 is forward biased. R1 and R2 are chosen to give the same attenuation as for positive excursions. Provided that the input waveform is balanced about zero volts, a triangle will be generated at the input to IC2.

The triangle waveform is buffered by IC2, which is a straightforward non-inverting amplifier with its gain set to give the same output voltage as the converter input. Also, a level shift facility is provided by VR1 which can be used to eliminate any d.c. offset at the output. R7 should be chosen to give approximately the same voltage at point "x" as the peak to peak input voltage. Close tolerance resistors should be used for R1, R2 and R3, to maintain a symmetrical output. Other components are not critical. The peak to peak input voltage should lie between 250mV and 5 volts for offset and slew rate reasons. If the input is not balanced about zero volts, an input capacitor of a few microfarads can be used.

D. F. Bowers,
Chesterfield.

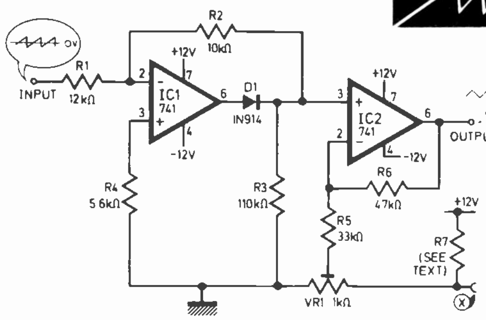

Fig. 1

THERMAL A.G.C. FOR TRANSISTOR POWER AMPLIFIERS

THIS is a simple and effective method of preventing overheating, thermal runaway and breakdown of expensive power transistors due to prolonged overdriving of the power amplifier.

Unlike more conventional thermal cutout devices, which abruptly switch off the h.t. rail as soon as a predetermined temperature is reached, this method works on the feedback principle, and gradually reduces the drive to the power amplifier as soon as dangerous temperatures are approached. A safe maximum output/safe maximum heatsink temperature compromise can be achieved by including a sensitivity control in the circuit (Fig. 1).

The circuit operation is self-explanatory. Preset resistors VR1 and VR2 and thermistor R1 form a potential divider across the output of the pre-amplifier. The thermistor is mounted in close thermal contact with the power amplifier heatsink, so that as output stage dissipation increases and heatsink temperature rises, the resistance of the thermistor decreases, reducing the drive to the power amplifier, and so limiting the increase in dissipation. A typical value for VR2, the sensitivity control is 5 kilohms. All connections should be made using screened leads.

Some experimentation will be required in the selection of R1, depending on the input impedance of the power amplifier being used. As an example, an amplifier with an input impedance of 20 kilohms would require a thermistor type RA24 (R at 25°C = 20kΩ, R at 220°C = 150Ω). A cheaper compromise would be type VA1055s (R at 25°C = 15kΩ, R at 150°C = 540Ω).

The circuit has been proved on a well known make of 70 watt amplifier. This was run for several hours into a load impedance of 4 ohms instead of the recommended 8 ohms, and very good thermal tracking was achieved.

R. Walsh,
Aldershot.

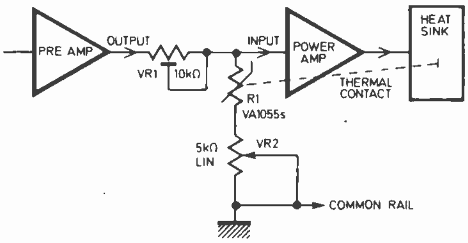

Fig. 1

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Tuner	100mV	>70dB	10kΩ
Tape	100mV	>70dB	10kΩ
Auxiliary	1-100mV	60dB-70dB	200kΩ

Magnetic i/p overload: 33dB. **Distortion:** 0 04% at 1kHz; **Output:** 1V r.m.s. into 10kΩ; **Supply voltage:** ± 18V nominal; **Tone controls:** Bass ±12dB at 100Hz. Treble ±12dB at 10kHz.

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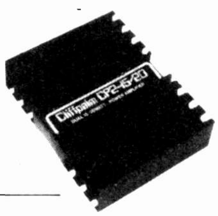
Input sensitivity: 1V r m.s.; **Frequency response:** 20Hz-20kHz, at −3dB; **Distortion:** 0 04% at 15W; **Supply Voltage:** ± 18V nominal; **Size:** 5·1 x 4 x 1·25in. (130 x 102 x 32mm).



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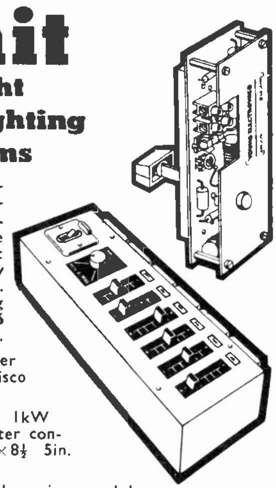

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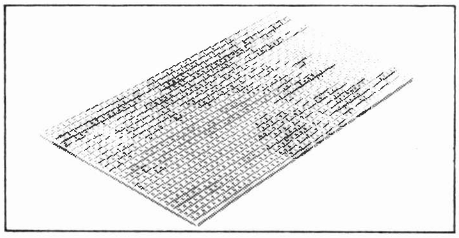

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912–950	Single PCB for building 2 digit CMOS counter with latch. Takes 2 × TIL322 or FND500, 2 × CD4511, 1 × CD4518, R's and C's, etc. (please order components separately). Size 67mm × 71mm	£2·10
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TIL321	Texas Instr.	Red	Common Anode LED	0·5in	£1·30
TIL322	Texas Instr	Red	Common Cathode LED	0·5in	£1·20
XAN652	Xciton	Green	Common Anode LED	0·6in	£2·45
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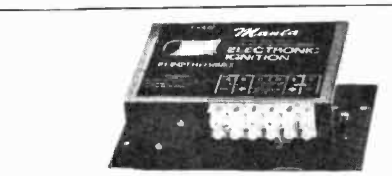

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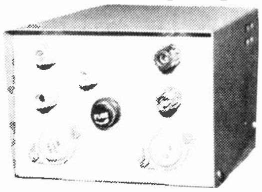

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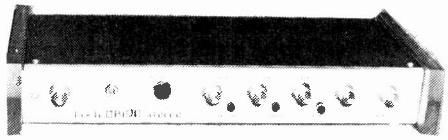

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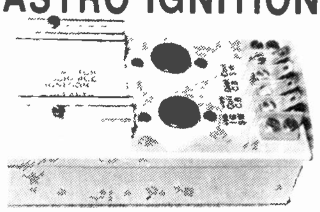

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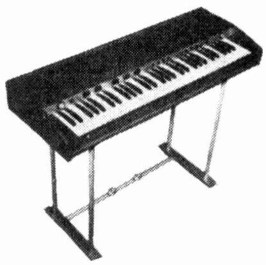

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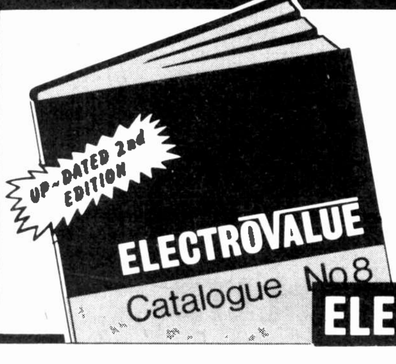

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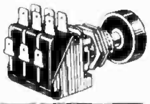
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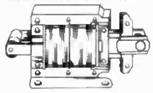

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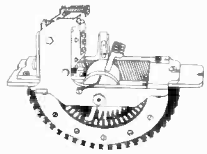
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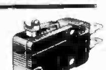
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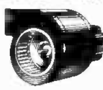
Mfg by Smiths Industries. 230/240V a.c. Miniature Model. Series SE/200. Size 95mm × 82mm × 82mm. Aperture 38mm × 31mm. 12 c.f.m., **£2·75.** Post 50p.
Mfg. by Fracmo 115/230V a.c. 2800/3400 r.p.m. Fan type aperture 3″ × 2½″ VBL4 25/L. Price **£12.** Post £1.
Also available extremely powerful blower mfg. by Fracmo.

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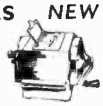
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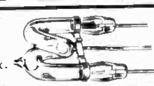
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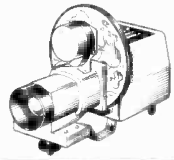
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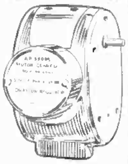
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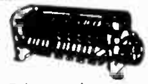
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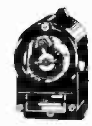
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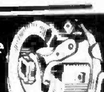
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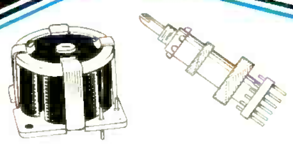

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