ELECTRONICS TODAY INTERNATIONAL

electronics today international

SEPTEMBER 1975

30p

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£500 MUST BE WON IN THE ETI/DORAM **DESIGN COMPETITION**

BUILD THE INTERNATIONAL FM TUNER FOR UNDER £30!

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UNWANTED AUDIO
CERAMIC PREAMP
THE PHOTOPHONE
PROJECT BUILDING GUIDE

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electronics today international

SEPTEMBER 1975 Vol. 4. No. 9

Main Features

Projects

News & Information

Cover: The international FM Tuner is not only a first-class deisn, it is easy to build. See page 26.

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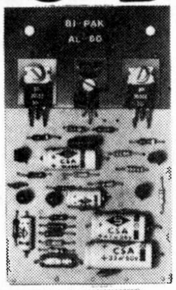
ETI PULSAR DIGITAL CLOCK OFFER — PAGE 57

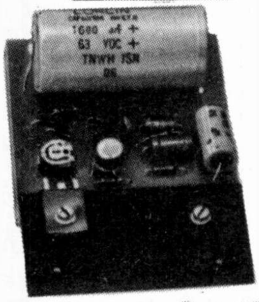
PO BOX 6 WARE HERTS



AL 60 — ONLY £3.95

50w. PEAK (25w. R.M.S.)

● Max Heat Sink temp 90°C ● Frequency Response 20Hz to 100K Hz ● Distortion better than 0.1 at 1KHz ● Supply voltage 15-50 volts ● Thermal Feedback ● Latest Design Improvements ● Load — 3, 4, 5 or 16 ohms ● Signal to noise ratio 80dH ● Overall size 63mm x 105mm x 13mm. Especially designed to a strict specification. Only the finest components have been used and the latest solid state circuitry incorporated in this powerful little amplifier which should satisfy the most critical A.F. enthusiast.

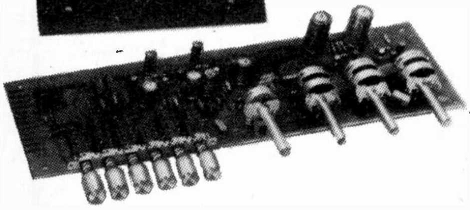


STABILISED POWER MODULE SPM80

SPM80 is especially designed to power 2 of the AL60 Amplifiers, up to 15 watt (r.m.s.) per channel simultaneously. This module embodies the latest components and circuit techniques incorporating complete short circuit protection. With the addition of the Mains Transformer BMT80, the unit will provide outputs of up to 1.5 amps at 35 volts. Size: 63mm x 105mm x 30mm.

These units enable you to build Audio Systems of the highest quality at a hitherto unobtainable price. Also ideal for many other applications including:—Disco Systems. Public Address Intercom Units, etc. Handbook available 10p.

TRANSFORMER BMT80 £2.60 — **PRICE £3.00**



STEREO PRE-AMPLIFIER TYPE PA100

Built to a specification and NOT a price, and yet still the greatest value on the market, the PA100 stereo pre-amplifier has been conceived from the latest circuit techniques. Designed for use with the AL50 power amplifier system, this quality made unit incorporates no less than eight silicon planar transistors, two of these are specially selected low noise NPN devices for use in the input stages.

Three switched stereo inputs, and rumble and scratch filters are features of the PA100 which also has a STEREO/MONO switch, volume, balance and continuously variable bass and treble controls.

£13.20

MK 60 AUDIO KIT

Comprising: 2 x AL60, 1 x SPM80, 1 x BTM80, 1 x PA100, 1 front panel, 1 kit of parts to include on-off switch, neon indicator, stereo headphone sockets plus instruction booklets.

COMPLETE PRICE: **£27.55** plus 45p postage.

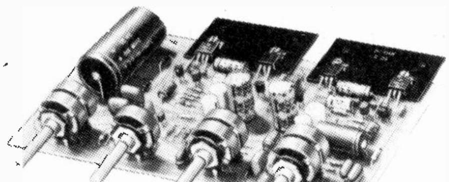
TEAK 60 AUDIO KIT

Comprising: Teak veneered cabinet size 16¾" x 11½" x 3¾", other parts include aluminium chassis, heatsink and front panel bracket, plus back panel and appropriate sockets, etc.

KIT PRICE: **£9.20** plus 45p postage.

STEREO 30 COMPLETE AUDIO CHASSIS

7 + 7 WATTS R.M.S.



The Stereo 30 comprises a complete stereo pre-amplifier, power amplifiers and power supply. This with only the addition of a transformer or overwind, will produce a high quality audio unit suitable for use with a wide range of inputs, i.e. high quality ceramic pickup, stereo tuner, stereo tape deck, etc.

Simple to install, capable of producing really first-class results, this unit is supplied with full instructions, black front panel, knobs, mains switch, fuse & fuse holder and universal mounting bracket, enabling it to be installed in a record plinth, cabinets of your own construction or the cabinet available.

Ideal for the beginner or advanced constructor who requires Hi-Fi performance with a minimum of installation difficulty. Can be installed in 30 mins.

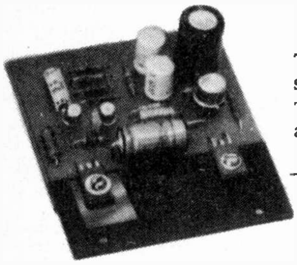
PRICE £15.75 Plus 45p postage & packing

TRANSFORMER £2.45 plus 45p postage & packing — **TEAK CASE £3.65** plus 45p postage & packing

PLEASE ADD V.A.T.
AT 25% TO ALL
ITEMS EXCEPT
✻ ADD 8%
NO V.A.T.

GIRO NUMBER
388-7006

AL 10/AL 20/AL 30



The AL10, AL20 and AL30 units are similar in their appearance and in their general specification. However, careful selection of the plastic power devices has resulted in a range of output powers from 3 to 10 watts R.M.S.

The versatility of their design makes them ideal for use in record players, tape recorders, stereo amplifiers and cassette and cartridge tape players in the car and at home.

AL10 £2.30, AL20 £2.65, AL30 £2.95

SPEAKERS

E.M.I. LEK 350 Loudspeakers Enclosure kit in teak veneer, including speakers. Rec. retail price £4.50 per pair.
OUR SPECIAL PRICE
ONLY £27.75 per pair P&P £3
WHILE STOCKS LAST!

HEADPHONES

4-16 ohms impedance frequency response 20 to 20,000 Hz stereo/mono switch and Volume Control £4 55

FRONT PANEL

FOR PA100. Attractive matt silver. Finish with black trim and lettering. Adds that professional touch. £1.10 only.

M.P.A.30

Enjoy the quality of a magnetic cartridge with your existing ceramic equipment using the new Bi-Pak M.P.A.30 which is a high quality pre-amplifier exist for the use of ceramic cartridges only.

Used in the construction are 4 low noise, high gain, silicon transistors and it is provided with a standard DIN input socket for ease of connection.

Supplied with full, easy to follow instructions.

PRICE £2.65

STORAGE-CARRY CASES

RECORD CASES
7 in E.P. 18 3/8th in. x 7 in x 8 in (50 records) *£2.48
12 in L.P. 13¾in x 7 3/8th in x 12¾ in (50 records) *£3.30

CASSETTE CASES
Holds 15. 10in x 3¾in x 5in. Lock and handle *£1.50

8-TRACK CARTRIDGE CASES
Holds 14. 13in x 5in x 6in. Lock and handle *£2.20
Holds 24. 13 3/8th in x 8 in x 5 3/8th in Lock and handle *£3.20

CARTRIDGES

ACOS	GP91-1SC	200mV at 1.2cms/sec	£1.11
	GP93-1	280mV at 1cm/sec	£1.43
	GP96-1	100mV at 1cm/sec	£2.31
TTC	J—2005	Crystal/Hi Output	£0.97
	J—2010C	Crystal/Hi Output Compatible	£1.11 £1.52
	J—2006S	Stereo/Hi Output	£1.81
	J—2105	Ceramic/Med Output	
	J—2203	Magnetic 5mV/5cm/sec including stylus	£4.78 £2.88
	J—22038	Replacement stylus for above	
	AT—55	Audio-technica magnetic cartridge 4mV/5cm/sec	£3.06

DYNAMIC MICROPHONE

TYPE B1223 200 ohms impedance. Complete with stand, on/off switch and 2.5mm and 3.5mm plugs. Suitable for cassette tape recorders.
PRICE £1.67

JUST OUT!

STEREO FM TUNER

WRITE *NOW* FOR FULL DETAILS

news digest

ATTENTION BRISTOL

ETI readers who take this copy of the magazine to Marshall's new Bristol components shop will get 10% off advertised prices for a limited period.

The new shop at 1 Straits Parade, Fishpools, Bristol was originally intended to open towards the end of August but Marshall's now expect the opening to be just before this issue is published.

In London since 1953, Marshall's have expanded rapidly recently. Their Glasgow office opened two years ago but a shop was almost forced to open a year later due to the pressure of callers. In November last year the company entered the EEC with a large shop in Paris.

CIGARETTE PACK TV CAMERA

A tubeless television camera -- potentially no larger than a pack of cigarettes -- for possible use in advanced space missions is being developed by RCA.

The prototype monochrome camera will employ a charge-coupled device (CCD) and will be designed under a contract from NASA.
The CCDs will make possible an ultra-small, lightweight camera capable of operating in space on very low power. Those planned for use in the space camera are 512 x 320 element devices, the largest and highest resolution CCD television image sensors announced to date. A scanning technique will be developed for the space camera that will assure its compatibility with the 525-line U.S. TV standard.

CALCULATOR PRICES - WHERE NEXT?

Exactly a year ago ETI carried a major survey of hand-held calculators - the cheapest was a very basic model at £10.95 and that had only just been announced. The Sinclair Cambridge was £22 - now available built from some discount houses for under £10 inclusive.

Today one CBM calculator retails widely at £5.95 and we are told is available for under £5.00! The manufacturers and importers all deny that they are interested in the low price end but sooner or later they cut their prices.

There has probably never been a product that has fallen so rapidly in price. We predict that within six months the range of calculators under £8 will be substantial with the cheapest selling for under £4 but with companies going all out for very sophisticated models in the £12-£20 range.

SINCLAIR PROGRAMMABLE CALCULATOR

Just as we were closing this issue for press, we received details of the Sinclair Calculator that we said last month was imminent.

Using only a single chip, the programmes, of up to 24 steps, are entered directly through the keyboard, are then stored ready to operate on any numbers which are subsequently entered. A full library of programmes covering a wide range of specialist applications is supplied.

Apart from its obvious appeal on account of the facilities, the big attraction is the price: £29.95 inc. VAT.

According to a spokesman for Sinclair, the company will be marketing directly for about three months after which it will be available through retail outlets.

PAGING RECEIVER ADDRESS CODE STANDARDISATION STUDY

The increasing interest in area paging and the variety of codes used by the interested manufacturers has resulted in an attempt to reach standardisation.

Eight European manufacturers are involved in this study, the object being to enable area paging operators, such as post and telegraph authorities, to simplify their central equipment and engineering services when designing and operating the systems.

The British Post Office has already announced that London will have a paging system in early 1976.

NEW SYSTEM AIDS SATELLITE COMMUNICATIONS

A new system for the suppression of unwanted signals which interfere with transmission from communications satellites has been developed by Plessey and commissioned at the Satellite Earth Terminal Station, Goonhilly Downs, Cornwall.

Goonhilly forms part of the INTELSAT network which links virtually every major country in the world via satellites maintained in fixed positions over the Atlantic, Indian and Pacific Oceans.

The Indian Ocean satellite appears at a low angle from Goonhilly, just above the horizon, and the PO aerial working to it has to be aimed across France nearly in direct line with a French radio-relay station. This station transmits on frequencies in 4000 MHz band which can interfere with signals received from the satellite. During periods of anomalous propagation the power of the interfering signals has sometimes exceeded the power of the wanted signals by as much as 30 dB.

Under a preliminary study contract, Plessey proposed that the Post Office should consider use of a cancellation technique which has been used experimentally in radar applications. The prime attraction of this solution is its fundamental simplicity. A small auxiliary aerial is installed which receives a significant level of the interfering signal only. By feeding a controlled amount of the signal from the auxiliary aerial into the main aerial receiver the interference can be cancelled.

It is believed that this is the first time that such a system has been applied to civil radio communications and foresees considerable potential for its further application in all fields of communications where interference is a growing problem.

AUDIO FAIR LOOKS PROMISING

This year's Audio Fair (Olympia, October 20-26th) seems as though it will be an improvement on the mediocre affairs of the 1973 and 1974.

For the past two years Hi-Fi companies have been riding the crest of a wave and only lip-service had to be paid to exhibitions, etc. Times have been hard for most of this year however with 25% VAT kicking the trade when it was down (with the exception of the enormous pre-VAT rise boom).

Organisers of the Audio Fair report stand bookings 80% ahead of the corresponding period before last year's event.

We think there will also be some excellent products at reasonable prices the VAT increase may put some sanity back into the race for the 'fanciest cabinet' award!

CMOS PLL

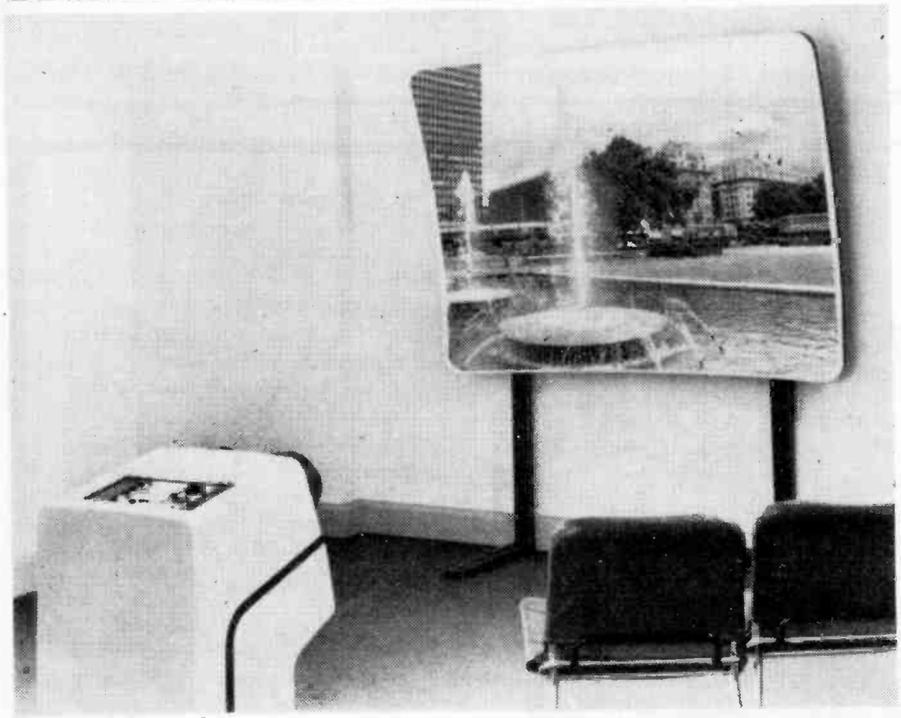
Designated the MC14046, a new Motorola device contains two phase comparators, a voltage controlled oscillator (VCO) and a zener diode to assist in supply voltage regulation. It operates at a VCO frequency up to 1.4MHz. Power dissipation is in the microwatt region for all typical applications.

The new IC compares the frequency and phase of the incoming data with the output of a VCO. If the two signals differ in frequency and/or phase, an error voltage is generated and applied to the VCO, causing it to correct in the direction required for decreasing the difference. The correction procedure continues until lock is achieved, after which the VCO will continue to track the incoming signal.

The medium speed and lower power of the CMOS PLL are important in such applications as frequency synthesis and multiplication, voltage-to-frequency conversion, and data synchronization and conditioning.

FAIRCHILD SEE BRIGHT FUTURE FOR SEMICONDUCTOR INDUSTRY

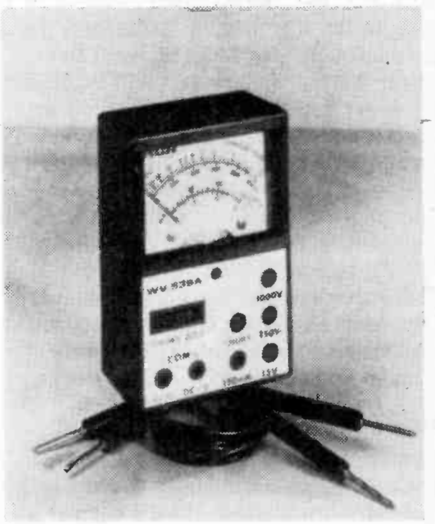
Despite the depressed economic situation, Fairchild has announced that it will invest between $20 and $25 million in capital expansion this year. Semiconductor industry sales are expected to decline by 22 per cent this year, but *"could see a growth of 37 per cent in 1976"* worldwide according to W.J. Corrigan President of Fairchild. He estimated that world semiconductor consumption would increase by a further 21 per cent in 1977.



American-designed projection television system, capable of beaming a 69-inch wide image onto a special screen, is being launched in Britain. Known as the Advent VideoBeam Projection Colour Television, the equipment is to be marketed by Crown Cassette Communications Ltd. Although a tenth of the price of previous similar systems, the Advent is unlikely to be your next choice for your home with a price tag of over £4,300.

The Advent can however be viewed comfortably by forty or more people seated within a 60 degree arc from the screen so it is ideal for use in a wide variety of applications including education, entertainment, training and commerce.

R.C.A. METER



We have received details of a new multimeter - nothing unusual in that. What *is* extraordinary is the manufacturer: R.C.A. What is even more surprising is the type - a 1000Ω/V, ultra-basic spec design aimed at the handyman - indeed that is what they have named it: Handyman. The price at over £5 can hardly be called cheap either.

Normally the news we get of R.C.A. is exciting and at the forefront of technology which makes this a very surprising departure. Does this herald a new era with major international companies catering for the lowest end of the market? We shall keep you informed!

SLOW-SCAN TV CONVENTION

A special Slow-Scan TV Convention organised by the British Amateur Television Club, will take place at Aston University, Birmingham, on Saturday, October 11th, from 1000 to 1800 hrs.

This convention is open to all who are interested in this fascinating topic whether they belong to the B.A.T.C. or not. There will be lectures and display of equipment and plenty of opportunity for the exchange of ideas. There is a charge of 50p to cover expenses, and tickets may be obtained from Mike Crampion G8DLX, 16 Percival Road, Rugby CV22 5JS.

news digest

ORACLE ON AIR

ORACLE, ITV's Teletext system (see ETI, July 1975) began an on-air experiment on the ITV network on 30th June. Operating the experiment are two editorial teams and three computer systems. At ITN there is an editorial team (plus computer) for news and associated information. At London Weekend Television there will be an editorial team preparing public service and similar information pages, and the second computer. At Thames Television the third computer will be used to insert data into the network during the Monday to Friday broadcasting period with LWT taking over for the weekend transmissions. It is hoped that there will soon be sets with decoders in the main entrace lobbies of ITN House, London Weekend Television's South Bank Studios and Thames Television's Euston Studios, so that visitors can interrogate the system and see how ORACLE works.

DABS GO ON COMPUTER

Scotland Yard has just placed an order for a £2 million computer to store and compare fingerprints. In 10 years it is expected that 3.5 million sets of fingerprints will need to be filed.

The new computer, based on the Ampex Video file information system, will store the fingerprint impressions on video tape — the computer will then be able to produce possible matches for analysis by experts.

A similar but much smaller system has been operating in Canada for the past four years. The Scotland Yard system is expected to start operation late in 1976.

CUTTING ELECTRICITY COSTS

Considerable savings can be made by industry by the installation of capacitors, it is claimed in a new publication "Capacitors for Power Factor Improvements", issued by Bryce Capacitors Limited, of Helsby, Cheshire. Because, in the average factory, electricity charges represent a high proportion of the running costs, significant savings can be made by the installation of power factor improvement capacitors. Experience has shown that this equipment can cut up to 15 per cent from electricity bills and, in most cases, capital costs can be recouped in less than two years.

The new publication explains power factor and its measurement, describes the design of power factor improvement schemes and gives examples of savings achieved in a quarry, a mill and an office block.

NEW SOLAR CELL

A new gallium-arsenide thin-film solar cell has recently been announced by NASA. The cells are said to have longer lifetimes than conventional cells, to have higher efficiencies and potentially, much lower fabrication costs than the silicon cells now commonly used.

Sample cells have shown efficiencies of up to 15% in sunlight (compared to 8 to 9% for silicon) plus 30% less radiation damage for a longer lifetime. The Jet Propulsion Laboratory team (who developed the device) predict that within three to four months they will have cells suitable for production which have an efficiency of 19%.

The new cells called AMOS for antireflection, coated metal-oxide semiconductor, are economically promising because the gallium arsenide layer is only 5 microns thick. This allows the use of less material than in any other competing technology.

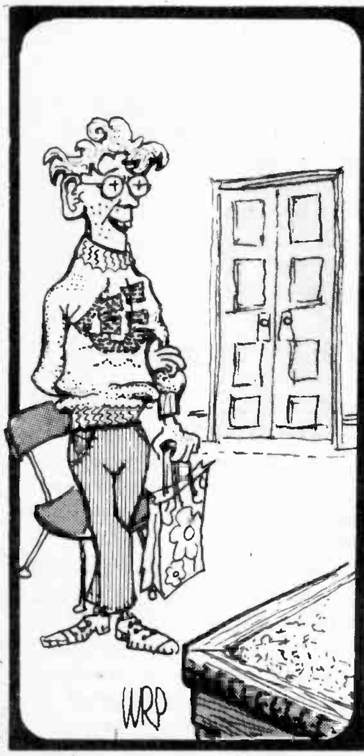
275 VOLT FETs

Siliconix have annouced a new family of high voltage JFETs with interchangeable sources and drains, and a guaranteed minimum break-down voltage of 275V (U328, U330) and 200V (U329, U331).

These devices open a new range of FET applications in high voltage, low frequency amplifiers; a symmetrical high voltage current sources; in high level signal handling involving low speed switching. The breakdown ratings offer a high degree of protection in systems where high voltage transients occur.

Siliconix Limited, 30a High Street, Thatcham, Newbury, Berks RG13 4JG.

TWO STUDIES IN INTERVIEW TECHNIQUES



'No, I've never actually handled a £60 million missile contract — but there's a first time for everyone —isn't there!'

'Well finally, before you go, do you mind if we ask you one or two questions, Mr. Er — ?!!'

ETI AND RNID TO COOPERATE IN SOLVING PROBLEMS OF THE DEAF

ETI has carried several excellent competitions and offers in the past and the response to these has been enormous. We are looking for a similar response to a new competition.

Both individuals and groups will be asked to research and design equipment which will overcome defined problems facing deaf people. The ingenuity of readers is of an extraordinary level and it is not impossible that some major improvement in the way of life of deaf people might result. ETI is working closely with the Royal National Institute for the Deaf in this competition – indeed they have set the problems for us. The prizes will be a specially designed trophy for the best entries with a donation from ETI to the RNID to help with the development of the ideas.

The competition to be known as 'Helping Hand' will start in the October issue when full details will be given. It will remain open for six months.

COSMOS NOW CHEAPER THAN TTL FOR MAJORITY OF DIGITAL SYSTEMS

RCA has announced further price reductions in its CD4000 range of COS/MOS integrated circuits. The reductions range from 35% to 50%. The biggest price reductions have affected the more established MSI devices of the CD4000 range, with many types being reduced by over 50%.

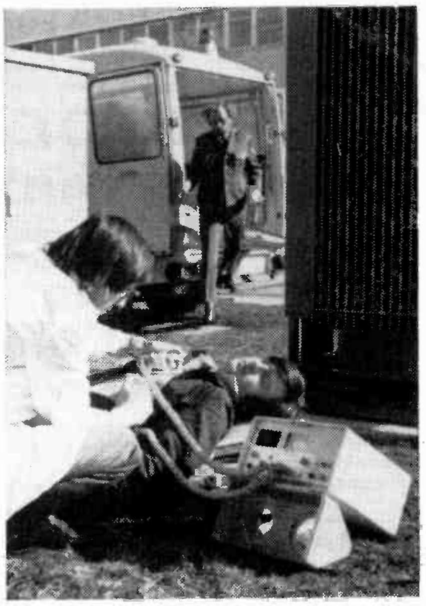
As a result of the price cuts, many of the popular TTL devices are currently more expensive than the equivalent COS/MOS functions.

NEW CONCEPT IN MICRO–PROCESSORS

Motorola have just divulged that they have a new high-speed microprocessor family in an advanced state of development at Phoenix, USA and that deliveries of these devices will commence in the early part of 1976. The new set of parts will be members of Motorola's ultra high-speed logic family MECL 10,000 (Motorola Emitter Coupled Logic type 10,000) and will enable engineers to construct computing systems that will operate with programmes that have been written for other machines. System speed will be up to ten times faster than NMOS microprocessors with a cycle time of 5 nsec.

There are five components in the new family which are designated MC10800 to MC10804. These are a 4-bit processor slice, a control chip, a timing chip, a memory interface chip and a look-ahead chip. They may be connected together to form a processor of any word length. Ten of the devices, plus external memory components, form a minimum 16-bit system. However, expansion to any word length is possible.

The new circuits are for high-performance applications such as top-of-the-range minicomputers, high-speed instrumentation, digital communication processors, real time analysis, main frame computers, time sharing and the like. Motorola feel that this LSI approach to high-speed system building makes more sense than developing sub-nanosecond logic functions, since the potential speed of such logic functions is seldom realised in practice due to the propagation delay of the interconnecting wiring.



A portable defibrillator, Sirecard P/PM, developed by Siemens can be quickly on the scene and ready for instant use. With the aid of this device, cases of ventricular fibrillation or flutter can be treated by applying a brief electric shock to restore the normal heart beat. The built-in cardioscope immediately indicates the response to the measure.

ONE-HOUR TV CASSETTE

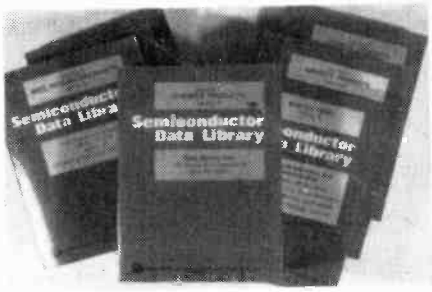
Japan's Sony Corporation have introduced a new video tape recorder and playback system using ½ inch width tapes with playing times of 30 minutes to one hour.

The tape deck called Betamex, sells in Japan for the equivalent of £350. The system complete with receiver is about £750; cassettes cost about £4 and £7 each.

DATA LIBRARY

Jermyn have just announced the introduction of the new Motorola Data Library.

This comprehensive publication consists of seven volumes containing detailed technical information on all Motorola's Semiconductor Products, plus a cross reference to industry Standard Jedec Discretes.

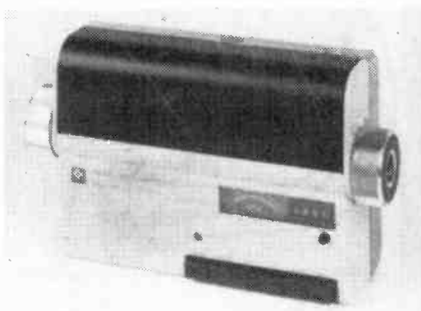


Cost is £14.50. Jermyn, Sevenoaks, Kent.

AIR POLLUTION CONTROL MONITOR

Latest addition to the range of air monitoring equipment is the Model Type P3 Digital Dust Indicator from Rothroe and Mitchell using the light-scattering principle. Pushbuttons select either a meter giving instantaneous readings of contamination expressed as counts per minute, or a 4-digit counter giving the count per unit time.

The device is one of the first in the UK to employ the technique of detecting scattered light. Air is sucked into the instrument by a tiny fan and conveyed across a beam of light whose intensity is stabilized by a photoelectric feedback circuit. Dust particles present in the beam scatter the light through 90 degrees onto a photomultiplier which gives an output proportional to the amount of dust in the beam - the more particles there are, the more light gets scattered onto the photomultiplier and the larger is the output. The output is fed to a capacitor and when the charge builds up to a predetermined level, it is suddenly discharged, giving a pulse.

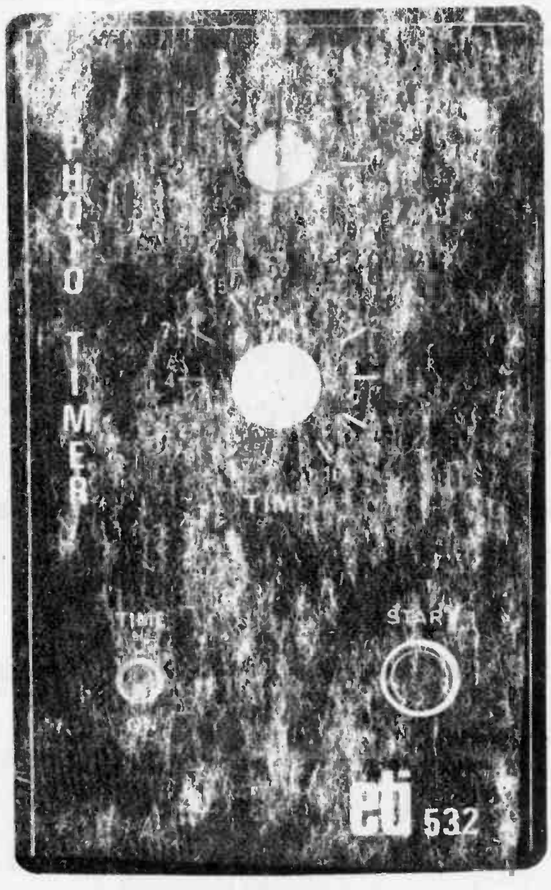


Rotheroe & Mitchell, 6/8 Aintree Road, Greenford, Middlesex UB6 7LJ.

Continued on page 69.

satile and accurate unit that displays progress through the timing cycle.

PHOTO TIMER



WHEN making multiple photographic prints the repeatability of exposure timing is considerably improved by using an accurate timer.

Mechanical timers, give excellent results but must be set for every exposure. Conventional electronic timers, do not need resetting but give no indication of the time remaining in the selected interval – as do mechanical timers.

Indication of progress within the selected time interval is very helpful, particularly if parts of a print need burning in. Such indication also helps co-ordinate other activities which may be carried out during the exposure period.

The electronic timer described here divides the total selected time into eight equal periods and indicates the elapse of each portion of the interval via light emitting diodes.

Eight LEDs are arranged in a vertical row. When the timing interval is initiated all LEDs light up. As time elapses the lights go out progessively, until all are out and the timing is complete. An internal relay is held on until the last of the LEDs is extinguished. This relay controls the mains output to the enlarger, or other device, via a standard three-pin power outlet.

The timing interval can be varied from one second to sixteen minutes in eleven switched ranges. Starting from the lowest, each range covers twice the time interval of the preceding one. Thus the exposure may be increased or decreased, by one stop simply by switching up one range or down one range respectively. A variable potentiometer allows the range-selected time to be adjusted by half a stop either side.

As a further aid to timing another LED is provided which flashes once per second, regardless of selected range. This once-per-second pulse may be fed to a small loudspeaker, if desired, to provide an audible one-per-second tick.

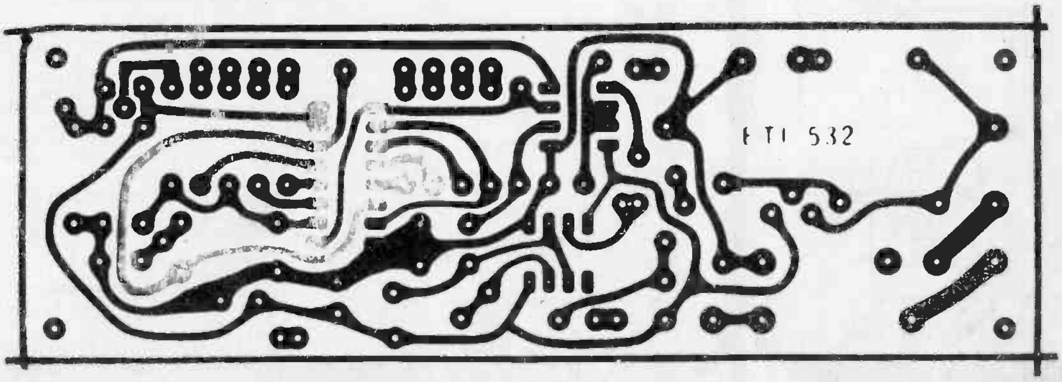


Fig. 4. Printed circuit layout. Full size 133 x 44 mm.

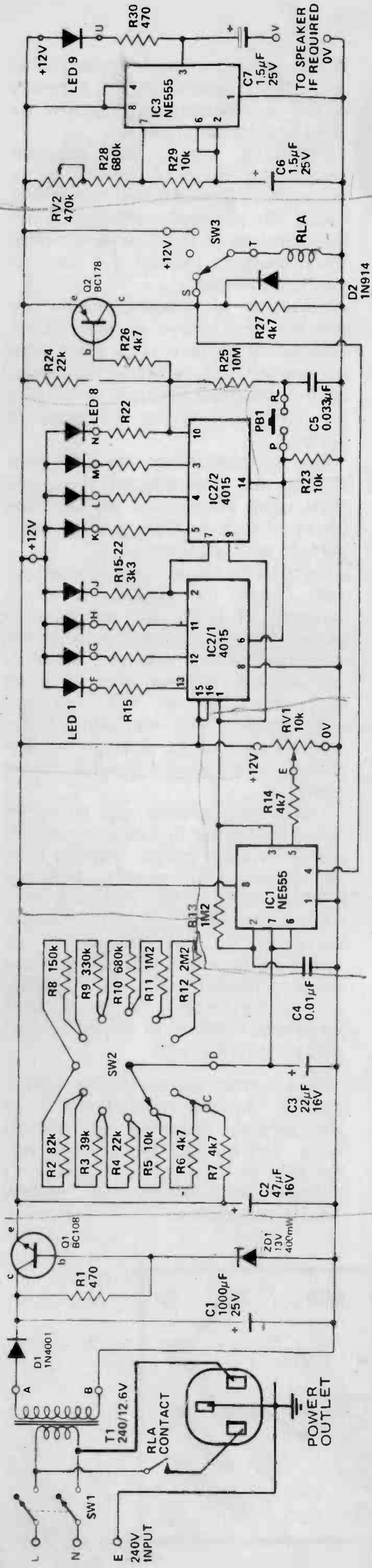


Fig. 1. Circuit diagram of the timer.

HOW IT WORKS

The basic timing is performed by an NE555 timer, IC1. The timing is varied by selecting a charging resistor via the range switch SW2. The range may then be varied around the SW2-selected period by providing a variable threshold voltage, (normally two-thirds supply) to pin 5 from RV1. Resistor R13 and capacitor C4 are used to ensure that C3 is completely discharged at the end of each charge cycle thus ensuring accurate timing.

Integrated circuit IC2 is a dual, four-bit shift register connected as an eight-bit shift register. For those unfamiliar with shift registers a brief explanation follows. There are eight outputs (labelled 1-8) a clock input, a data input, and a reset. When the unit is clocked the information at the data input is transferred into the '1' output. The information which was at the '1' output transfers to the '2' output, and so on., so that the information, at outputs 1-8, shifts along sequentially one place on each clock pulse – hence the name shift register.

The clock input to the shift register is the output from the 555 timer and the data input is connected directly to the +12 volt rail. Hence after eight clock pulses all outputs will be high. An LED is connected between each shift register output and +12 volts such that they are only illuminated when the associated shift-register output is low.

If push button PB1 is pressed all outputs of the shift register are set to zero and all LEDs will light. These then go out one at a time as the 'high' at the data input is clocked through the shift register.

The relay is driven by transistor Q2 which, in turn, is driven from the last LED. The relay can be switched out by SW3 and the LED display may then be used without the relay. Alternatively the relay may be switched on or off, without using the timer, again by SW2. When the shift register is reset the relay closes and when the last light goes out the relay opens.

The output of Q2 also controls the reset line of IC1 thus ensuring accurate timing in the first cycle.

The third IC is also a 555 timer which provides an output of one 10 millisecond pulse per second. This pulse drives LED 9 and a speaker if required.

A 12.6 volt transformer, rectifier D1, and filter capacitor C1 feeds a regulator consisting of Q1 and ZD1 to provide an output of 12 volt dc.

If required an external push button, or foot switch, may be paralleled across the local one to enable the start. Another may be used between the relay (point T) and +12 volts to allow the relay to be closed remotely.

PARTS LIST

R1,30	Resistor	470	¼ or ½W	5%
R15,16, 17,18	"	3 k3	"	"
R19,20 21,22	"	3 k3	"	"
R,6,7, 14	"	4 k7	"	"
R26,27	"	4 k7	"	"
R5,23, 29	"	10 k	"	"
R4,24	"	22 k	"	"
R3	"	39 k	"	"
R2	"	82 k	"	"
R8	"	150 k	"	"
R9	"	330 k	"	"
R10,28	"	680 k	"	"
R11,13	"	1 M2	"	"
R12	"	2 M2	"	"
R25	"	10 M	"	"
RV1	Potentiometer	10 k lin rotary		
RV2	"	470 k trim		
C4	Capacitor	0.01 µF	Polyester	
C5	"	0.033µF	"	
C6,7	"	1.5µF 25V electrolytic		
C3	"	22µF 16V Tantalum		

C2	"	47µF 16V electrolytic
C1	"	1000 µF 25V
Q1	Transistor	BC108 or similar
Q2	"	BC178 "
		1N4001 or similar
D1	Diode	1N914 "
D2	"	13V, 400mW
ZD1	Zener Diode	
LED 1-9	Light Emitting Diode	
IC1,3	Integrated Circuit	NE555
IC2	"	" 4015,14015
SW1	Switch	DPDT switch 240V toggle
SW2	"	11 position 1 pole rotary
Sw3	"	SPDT, with centre off, toggle
RLA	Relay	12V coil, 240 Vac 6 amp contacts
T1	Transformer	240V/12.6V 500mA
PB1	Push Button	Press to make.
Plastic Box		
240V outlet Clipsal 415 or similar		
3 core flex & plug.		

PHOTO TIMER

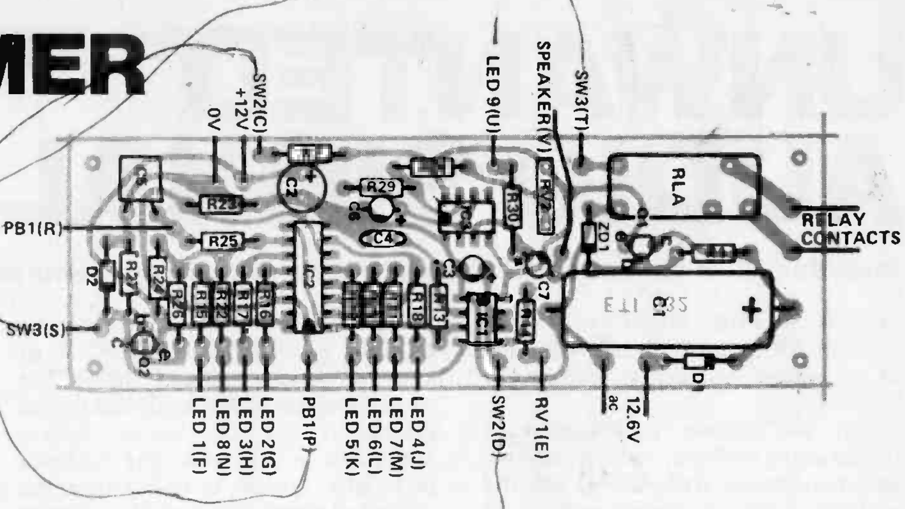


Fig. 2. Component overlay.

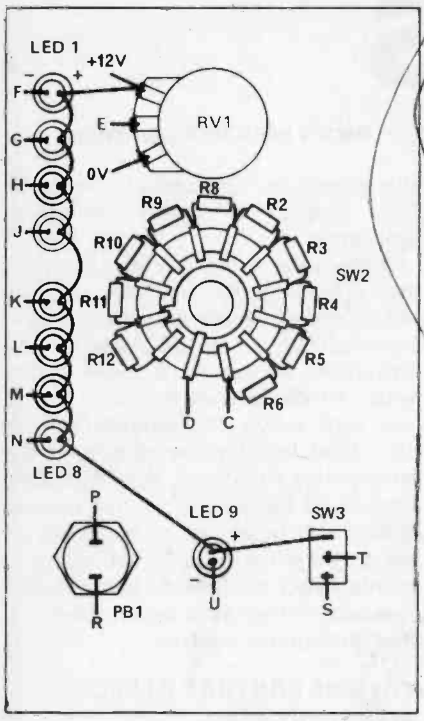


Fig. 3. Front panel wiring details.

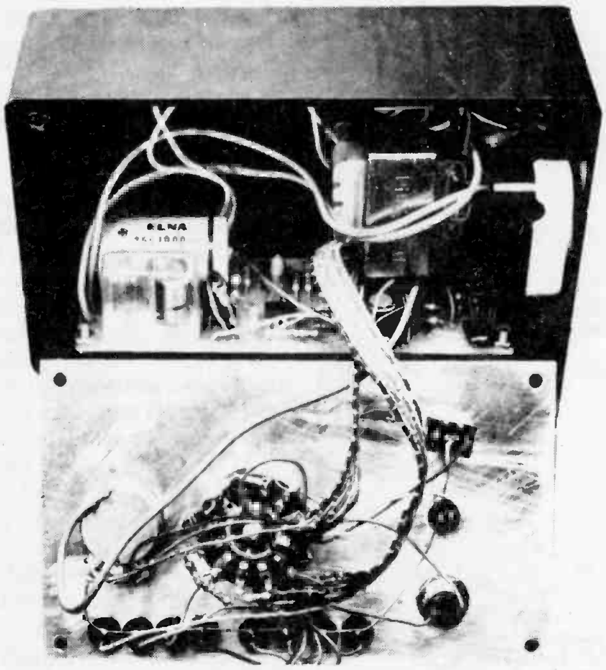


Fig. 5. This internal view shows how the components are mounted within the box. If the size of box specified is used watch component clearances — there is not much room.

CONSTRUCTION

Our prototype was built into a small plastic box, 160 x 95 x 50 mm. The front panel shown in Fig. 6 is designed to suit that box. All the electronics apart from switches and LEDs are mounted on a single printed circuit board. It is recommended that this board be used as construction would otherwise be much more difficult.

Assemble components to the printed circuit board with the aid of component overlay Fig. 2. Make sure that the polarities of transistors, diodes and capacitors are correct and that integrated circuits are correctly orientated. Note also that IC2 is a CMOS device and should therefore be the last component to be fitted. The pins of this device should not be handled unneccessarily and an earthed soldering iron should be used. Solder the supply pins (16 and 8) first.

Capacitor C5 and transistor Q2 should be mounted such that they are flat on the printed circuit board otherwise they may touch the power-outlet socket.

The components, mounted on the lid of the box, should be wired as illustrated in Fig. 3. Note that resistors 2 to 12 (with exception of R7) are mounted on SW2.

Before drilling any holes in the box for the transformer etc, make sure that all components are clear when the lid is in place as there is not a great deal of room in the box. The photograph of the box shows where components should be located.

All 240 volt ac wiring should be 23/0076 wire rated for 240 volts ac, and any bare terminals should be well covered with insulation tape to prevent accidental shorts or personal contact.

The range of timing available — one second to 16 minutes makes this timer suitable for a variety of applications other than photographic printing — it is an extremely versatile and useful device. ●

UNWANTED AUDIO SIGNALS

Breakthrough of unwanted broadcasts into audio systems can be infuriating — here's how to stop them.

PERHAPS THE MOST infuriating form of RF pollution is breakthrough of unwanted broadcasts into audio systems.

With the current proliferation of broadcasting stations, radio amateurs, taxi companies, walki-talkies etc the problem is now a major headache to manufacturers and users of hi-fi systems, public address systems, hearing aids — even electronic musical instruments may be affected from time to time.

The 'fault' that results in audio breakthrough is almost invariably within the 'interferees' audio equipment. It is hardly ever caused by a fault within the transmitter or even faulty operational procedures.

The phenomenon is now becoming generally known as 'audio rectification'. In essence the unwanted RF energy is picked up by some part of an audio system — which acts as an antenna. The energy is then rectified by an element operating non-linearly in the equipment. This can take the form of a valve, transistor, IC — or even a poorly soldered joint! The rectified signal is then amplified by the remainder of the audio system (although in at least one instance personally known to the author the unwanted signal was picked up on the leads between the power amplifier and speakers on a large PA installation — and then rectified by a faulty connection on one of the speakers).

Hopefully audio rectification will be only a short term problem because cases are now becoming so numerous that audio equipment may soon have to be designed with suitable rejection circuitry included.

In the meantime the USA's Federal Communications Commission and the Electronics Industries Association have devised a number of procedures for identifying the specific part of the circuit into which the signal is introduced — and a number of ways by which the interference may be eliminated or substantially reduced. This article is based on these procedures.

Ninety nine times out of a hundred the offending RF content will be introduced into the early stages of a pre-amplifier, or will be picked up and introduced by the mains power supply leads. To check that this is in fact so just turn down the volume control next time interference occurs. If the interference *is* reduced then it is being introduced before the volume control (which will be in the output stage of the pre-amplifier — or its equivalent in an integrated unit). If the level remains constant — then it is being picked up *after* the volume control.

VOLUME CONTROL AFFECTS INTERFERENCE

The most common causes of this type of interference are signals introduced via the mains power leads, via interconnecting cables between main amplifier and auxiliary equipment, or via the speaker leads themselves.

It may also be caused by a poor or non-existent earth connection and this should be checked before looking any further.

Having checked out the earth connections it is advisable to next check the speaker leads. At first sight it might seem that RF picked up by the speaker leads would produce a constant level signal — or that the level itself would be very low because of the low impedances involved. But this is not *necessarily* so, for the RF signal is fed back via the negative feedback loop. And whilst feedback is applied *after* the volume control, some of the RF signal may be radiated into the earlier stages of the pre-amplifier.

It is not unknown for speaker leads to be of such a length that they actually resonate at the interfering frequency — in which case an instant cure can often be effected merely by lengthening or shortening them. Murphy's Law can operate here, though. One person we know eliminated interference from a local TV station that way — only to pick up his local taxi radio service at Strength 9!

Twisting the speaker leads or using shielded cable is also generally effective. Connecting a capacitor across the amplifier output terminals

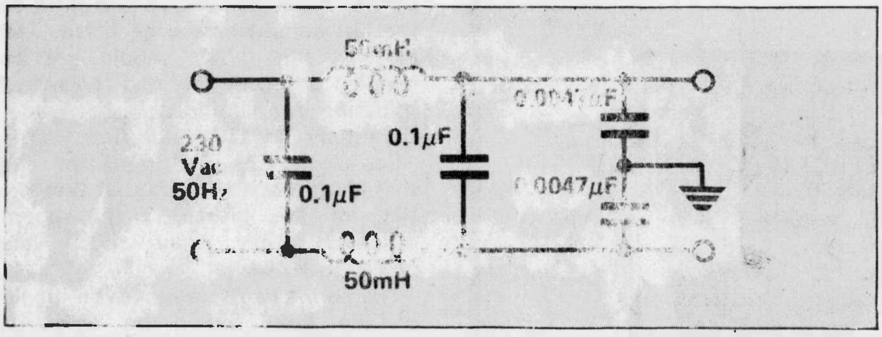
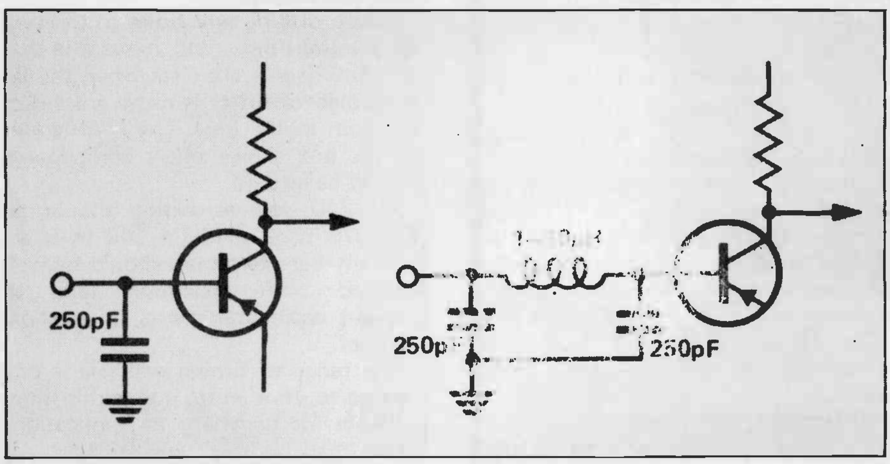


Fig. 1. Mains filter, available commercially or can be home-constructed. If you make it yourself it is essential to use capacitors rated for ac mains operation.



Figs. 2/3. These simple filters, connected in series with the pre-amplifier input, will prove effective in many cases.

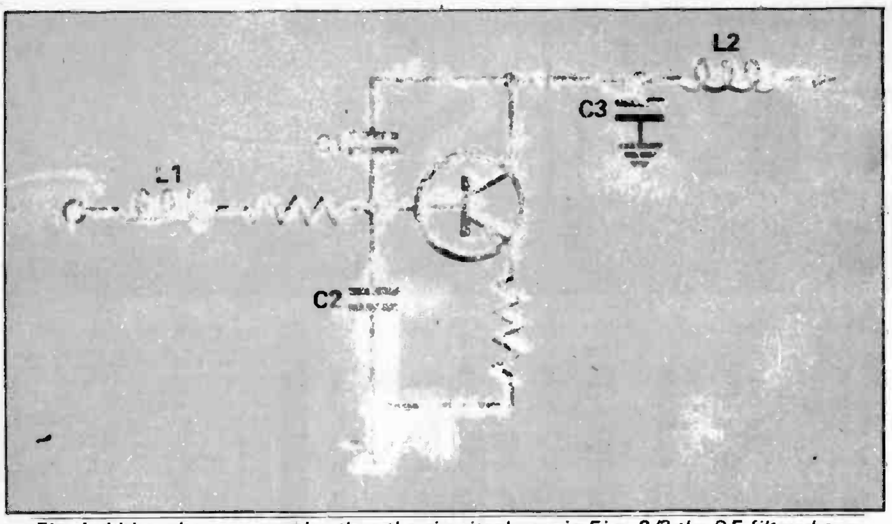


Fig. 4. Although more complex than the circuits shown in Figs. 2/3 the RF filter shown here will almost invariably eliminate unwanted signals. We regret that it is impracticable to show component values as they depend totally on the circuitry of the amplifier to which it is to be installed. Note two similar filters are required — one for each channel. The filters should be wired in series with the input to the power amplifiers.

or from each terminal to earth is also effective. Note that high frequency response will not be degraded as impedance is very low at this point in the circuit.

A capacitance of about 0.1 μF is generally sufficient to remove most RF. Use the smallest value that fixes the problem and always use a ceramic capacitor for the purpose.

If the above checks don't cure the problem the next thing to check is whether or not the signal is being introduced via the signal leads. Here the quickest check is to disconnect all externally connected units — such as the turntable, cassette recorder, radio tuner etc. If disconnecting a unit eliminates the interference then the cable connecting that unit to the amplifier is not properly screened Lastly check for mains-borne interference by connecting a line filter in series with the incoming power line. These filters are made commercially by R.S. Components and are available from their distributors or their subsidiary Doram or can readily be made as shown in Fig. 1. If you make this filter yourself do not under any circumstances increase the values of the capacitors shown — and make absolutely sure that the capacitors are rated for 250 volt ac operation.

In areas where the strength of the unwanted signal is very high (as it may well be if, for instance, you live close to a TV transmitting antenna) the signal may still find its way into the input circuitry despite the precautions suggested. This is particularly likely if the amplifier has a non-metallic case — or if it has a metal case that is not earthed satisfactorily. The cure here is obvious — aluminium foil makes a good shield — make sure it's earthed correctly.

If, despite all the precautions outlined, the RF signal is still finding its way into the pre-amplifier, more drastic treatment will be necessary.

Firstly check that there are no poorly soldered joints — for a dry joint can act as an almost perfect rectifier. Resolder any joints that look at all suspicious.

Electrolytic capacitors tend to have high inductive reactance at RF frequencies thus preventing them by-passing unwanted RF to ground. Check them out by temporarily wiring an 0.01 μF ceramic in parallel. Wire in permanently if this cures the problem. If the problem still remains it will be necessary to modify the amplifier as outlined below.

VOLUME CONTROL DOES NOT AFFECT INTERFERENCE

Sometimes unwanted level signals will be heard at a constant level — not affected at all by volume control settings. If this is your problem (or if unwanted signals are breaking through in the manner described in the last paragraph) it will be necessary to use RF filtering at the input to the power amplifier. Figure 4 shows one way of doing this that has proved very satisfactory. Unfortunately it is impossible to quote actual component values as these will be determined by the circuitry of the individual amplifier. The main thing to remember is that the components should be selected so as to cause no significant change in audio frequency response. (In really severe cases however it may be necessary to trade off frequency response against interference removal).

The capacitors used for this purpose should be ceramics — not paper types. Inductor L1 may be a ferrite bead.

If despite all the foregoing you *still* have problems there seem to be only two remaining solutions.

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SN456	0.80	2N3390	0.45	2N5295	0.48	AF116	0.35	BC207	0.12	BF159	0.27	LM309K	1.88	OC42	0.50
2N456A	0.85	2N3391	0.28	2N5296	0.48	AF117	0.35	BC208	0.11	BF160	0.23	LM5TI	1.50	OC45	0.32
2N457A	1.20	2N3391A	0.29	2N5298	0.50	AF118	0.35	BC212K	0.16	BF163	0.32	LM380	1.10	OC71	0.17
2N490	3.16	2N3392	0.15	2N5457	0.49	AF124	0.30	BC212L	0.16	BF166	0.40	LM381	2.20	OC72	0.25
2N491	4.38	2N3393	0.15	2N5458	0.45	AF125	0.30	BC214L	0.18	BF167	0.25	LM702C	0.75	OC81	0.25
2N492	3.00	2N3394	0.15	2N5459	0.49	AF126	0.28	BC237	0.16	BF173	0.27	LM709TO99	0.48	OC83	0.24
2N493	5.20	2N3402	0.18	2N5492	0.58	AF127	0.28	BC238	0.15	BF177	0.29	8DIL	0.38	ORP12	0.55
2N696	0.22	2N3403	0.19	2N5494	0.58	AF139	0.65	BC239	0.15	BF178	0.35	14DIL	0.40	R53	1.80
2N697	0.16	2N3440	0.59	2N5496	0.61	AF186	0.46	BC251	0.25	BF179	0.43	LM710	0.47	SL414A	1.80
2N698	0.82	2N3441	0.97	2N6027	0.45	AF200	0.65	BC253	0.25	BF180	0.35	LM3900	0.70	SL610C	1.70
2N699	0.59	2N3442	1.40	2N5777	0.45	AF239	0.65	BC257	0.15	BF181	0.36	LM723C	0.90	SL611C	1.70
2N706	0.14	2N3414	0.10	3N128	0.73	AF240	0.90	BC258	0.16	BF182	0.35	LM741TO99	0.40	SL612C	1.70
2N706A	0.16	2N3415	0.10	3N139	1.42	AF279	0.70	BC259	0.17	BF183	0.55	8DIL	0.40	SL620C	2.60
2N708	0.17	2N3416	0.15	3N140	1.00	AF280	0.79	BC261	0.25	BF184	0.30	14DIL	0.38	SL621C	2.60
2N709	0.42	2N3417	0.21	3N141	0.81	AL102	1.00	BC262	0.25	BF185	0.30	LM747	1.00	SL623	4.59
2N711	0.50	2N3638	0.15	3N200	2.49	AL103	1.00	BC263	0.25	BF194	0.12	LM7488DIL	0.60	SL640C	3.10
2N718	0.23	2N3638A	0.15	40361	0.40	BC107	0.14	BC300	0.38	BF195	0.12	LM7805	2.00	SL641C	3.10
2N718A	0.28	2N3639	0.27	40362	0.45	BC108	0.14	BC301	0.34	BF196	0.13	14DIL	0.73	SN76003N	2.92
2N720	0.57	2N3641	0.17	40363	0.88	BC109	0.14	BC302	0.29	BF197	0.15	LM7805	2.50	SN76013N	1.95
2N914	0.39	2N3702	0.11	40389	0.46	BC113	0.15	BC303	0.54	BF198	0.18	LM7812	2.50	SN76023N	1.60
2N916	0.28	2N3703	0.12	40394	0.56	BC115	0.17	BC307	0.17	BF200	0.40	LM7815	2.50	SN76033N	2.92
2N918	0.32	2N3704	0.15	40395	0.65	BC116	0.17	BC308A	0.15	BF225J	0.23	LM7824	2.50	ST2	0.20
2N929	0.37	2N3705	0.15	40406	0.44	BC116A	0.18	BC309C	0.20	BF244	0.21	MC1303	1.50	TAA300	1.80
2N930	0.22	2N3706	0.15	40407	0.35	BC117	0.21	BC327	0.27	BF245	0.45	MC1310	2.92	TAA263	1.10
2N1302	0.19	2N3707	0.18	40408	0.50	BC118	0.14	BC328	0.28	BF246	0.58	MC1330OP	0.90	TAA350	2.10
2N1303	0.19	2N3708	0.14	40409	0.52	BC119	0.29	BC337	0.20	BF247	0.65	MC135IP	0.80	TAA550	0.60
2N1304	0.26	2N3709	0.15	40410	0.52	BC121	0.35	BC338	0.20	BF254	0.19	MC1352P	0.80	TAA611C	2.18
2N1305	0.24	2N3710	0.15	40411	2.25	BC125	0.16	BCY30	0.80	BF255	0.19	MC1466	3.50	TAA621	2.03
2N1306	0.31	2N3711	0.15	40594	0.74	BC126	0.23	BCY31	0.85	BF257	0.47	MC1469	2.75	TAA661B	1.32
2N1307	0.30	2N3712	1.20	40595	0.84	BC132	0.30	BCY32	1.15	BF258	0.53	ME0402	0.20	TBA641B	2.25
2N1308	0.47	2N3713	1.20	40601	0.67	BC134	0.13	BCY33	0.85	BF259	0.55	ME0404	0.13	TBA651	1.69
2N1309	0.47	2N3714	1.38	40602	0.61	BC135	0.13	BCY34	0.79	BFR39	0.24	ME0412	0.18	TBA810	1.50
2N1671	1.54	2N3715	1.50	40603	0.58	BC136	0.17	BCY38	1.00	BFR79	0.24	ME4102	0.11	TBA820	1.15
2N1671A	1.67	2N3716	1.80	40604	0.56	BC137	0.17	BCY39	1.50	BFS21A	2.30	ME4104	0.11	TBA920	4.00
2N1671B	1.85	2N3771	2.20	40636	1.10	BC138	0.24	BCY40	0.97	BFS28	0.92	MJ480	0.95	TIL209	0.30
2N1711	0.45	2N3772	1.80	40669	1.00	BC140	0.68	BCY42	0.28	BFS61	0.27	MJ4B1	1.20	TIP29A	0.49
2N1907	5.50	2N3773	2.65	40673	0.73	BC141	0.68	BCY58	0.30	BFS98	0.25	MJ490	1.05	TIP30A	0.58
2N2102	0.66	2N3779	3.15	AC126	0.20	BC142	0.23	BCY59	0.32	BFX29	0.30	MJ491	1.45	TIP31A	0.62
2N2147	0.78	2N3790	2.40	AC127	0.20	BC143	0.25	BCY70	0.17	BFX30	0.27	MJ2955	1.00	TIP32A	0.74
2N2148	0.94	2N3791	2.35	AC128	0.20	BC145	0.21	BCY71	0.22	BFX84	0.24	MJE340	0.48	TIP33A	1.01
2N2160	0.90	2N3792	2.60	AC151V	0.27	BC147	0.14	BCY72	0.15	BFX85	0.30	MJE370	0.65	TIP34A	1.51
2N2218A	0.22	2N3794	0.10	AC152V	0.49	BC148	0.14	BD115	0.75	BFX87	0.28	MJE371	0.75	TIP35A	2.90
2N2219	0.24	2N3819	0.37	AC153	0.35	BC149	0.15	BD116	0.75	BFX88	0.25	MJE520	0.60	TIP36A	3.70
2N2219A	0.26	2N3820	0.38	AC153K	0.40	BC153	0.18	BD121	1.00	BFX89	0.90	MJE521	0.70	TIP41A	0.79
2N2220	0.25	2N3823	1.42	AC154	0.25	BC154	0.18	BD123	0.82	BFY50	0.23	MJE2955	1.20	TIP42A	0.90
2N2221	0.18	2N3904	0.27	AC176	0.30	BC157	0.16	BD124	0.67	BFY51	0.23	MJE3055	0.75	TIP29c	0.80
2N2221A	0.21	2N3906	0.27	AC176K	0.40	BC158	0.16	BD131	0.40	BFY52	0.21	MP8111	0.32	TIP30c	0.85
2N2222	0.20	2N4036	0.67	AC187K	0.35	BC160	0.60	BD132	0.50	BFY53	0.18	MP8112	0.40	TIP31c	1.00
2N2222A	0.25	2N4037	0.42	AC188K	0.40	BC167B	0.15	BD135	0.43	BFY90	0.75	MP8113	0.47	TIP32c	1.25
2N2368	0.25	2N4058	0.18	ACY18	0.24	BC168B	0.15	BD136	0.49	BRY39	0.48	MPF102	0.30	TIP33c	1.45
2N2369	0.20	2N4059	0.15	ACY19	0.27	BC168C	0.15	BO137	0.55	BSX20	0.21	MPSA05	0.25	TIP34c	2.60
2N2369	0.22	2N4060	0.15	ACY20	0.22	BC169B	0.15	BD138	0.63	BSX20	0.21	MPSA06	0.31	TIP41c	1.40
2N2646	0.55	2N4061	0.15	ACY21	0.26	BC169C	0.15	BD139	0.71	BSX21	0.29	MPSA12	0.35	TIP42c	1.60
2N2647	0.98	2N4062	0.15	ACY28	0.20	BC170	0.15	BD140	0.87	BU104	2.00	MPSA55	0.26	TIP49	0.70
2N2904	0.22	2N4126	0.21	ACY30	0.58	BC171	0.16	BD529	0.80	BU105	2.25	MPSA56	0.31	TIP53	0.53
2N2904A	0.24	2N4289	0.34	AD142	0.57	BC172	0.17	BD530	0.80	C106D	0.65	MPSU05	0.65	TIP2955	0.98
2N2905	0.25	2N4919	0.95	A0143	0.68	BC177	0.28	BFR39	0.24	CA3180A	0.85	MPSU06	0.58	TIP3055	0.50
2N2905A	0.26	2N4920	1.10	AD149V	1.20	BC178	0.27	BFR79	0.24	CA3020A	1.80	MPSU55	0.63	TIS43	0.28
2N2906	0.19	2N4921	0.80	AD150	0.63	BC179	0.30	BDY20	1.05	CA3028A	0.79	MPSU56	0.80	ZTX300	0.13
2N2906A	0.21	2N4922	0.83	AD161	1.15	BC182	0.12	BF115	0.36	CA3035	1.37	NE555V	0.70	ZTX301	0.13
2N2907	0.22	2N4923	1.00	AD162	1.15	BC182L	0.12	BF117	0.55	CA3D52	1.62	NE556	1.30	ZTX302	0.20
2N2907A	0.24	2N5190	0.92	A0161	pr	BC183	0.12	BF121	0.35	CA3046	0.70	NE560	4.48	ZTX500	0.15
2N2924	0.20	2N5191	0.96	AD162	1.05	BC183L	0.12	BF123	0.35	CA3048	2.11	NE561	4.48	ZTX501	0.13
2N2926	0.20	2N5192	1.24	AF106	0.40	BC184	0.13	BF125	0.35	CA3089E	1.96	NE565A	4.48	ZTX502	0.18
2N3053	0.25	2N5195	1.46	AF109R	0.40	BC184L	0.13	BF152	0.20	CA3090Q	4.23	OC23	1.35	ZTX530	0.23
2N3054	0.60	2N5245	0.47	AF114	0.35	BC186	0.25	BF153	0.25	LM301A	0.48	OC28	0.76		
2N3055	0.75	2N5294	0.48	AF115	0.35	BC187	0.27	BF154	0.16	LM308	2.50	OC35	0.60		

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SN7401	0.16	SN7411	0.25	SN7437	0.37	SN7453	0.16	SN7482	0.75	SN74100	1.25	SN74154	1.50	SN74180	1.40
SN7401AN	0.38	SN7412	0.28	SN7438	0.35	SN7454	0.16	SN7483	0.95	SN74107	0.36	SN74155	1.50	SN74181	1.95
SN7402	0.16	SN7413	0.35	SN7440	0.16	SN7460	0.16	SN7484	0.95	SN74118	1.00	SN74157	0.95	SN74190	2.30
SN7403	0.16	SN7416	0.35	SN7441AN	0.85	SN7470	0.33	SN7485	1.25	SN74119	1.92	SN74160	1.10	SN74191	2.30
SN7404	0.19	SN7417	0.35	SN7442	0.65	SN7472	0.26	SN7486	0.32	SN74121	0.37	SN74161	1.10	SN74192	1.15
SN7405	0.19	SN7420	0.16	SN7445	0.90	SN7473	0.36	SN7490	0.45	SN74122	0.50	SN74162	1.10	SN74193	1.15
SN7406	0.45	SN7423	0.29	SN7446	0.95	SN7474	0.36	SN7491	0.85	SN74123	0.60	SN74163	1.10	SN74196	1.60
SN7407	0.45	SN7425	0.29	SN7447	0.95	SN7475	0.50	SN7492	0.45	SN74141	0.85	SN74164	2.01	SN74197	1.58
SN7408	0.19	SN7427	0.29	SN7448	0.90	SN7476	0.35	SN7493	0.45	SN74145	0.90	SN74165	2.01	SN74198	2.25
SN7409	0.22	SN7430	0.16	SN7450	0.16	SN748D	0.50	SN7494	0.82	SN74150	1.50	SN74167	4.10	SN74199	2.25

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P.C. Marker Pen Dalo 33PC **0.87p** **Zeners** 400MW—**11p**; lW — **17p**
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4002	0.36	4018	2.55	4037	1.93
4006	1.58	4019	0.86	4041	1.86
4007	0.36	4020	1.91	4042	1.38
4008	1.63	4021	1.72	4043	1.80
4009	1.18	4022	1.66	4044	1.80
4010	1.18	4023	0.36	4045	2.65
4011	0.36	4024	1.24	4046	2.84
4012	0.36	4025	0.32	4047	1.65
4013	0.66	4027	0.43	4049	0.81
4014	1.72	4028	1.50	4050	0.66
4015	1.72	4029	3.50		

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	Copper 0.1 £ p	Copper 0.15 £ p	Plain 0.1 £ p	Plain 0.15 £ p
2.5x3¾in	36	26	—	17
2.5x5in	40	39	—	19
3¾x3¾in	40	39	—	—
3¾x5in	45	47	—	32
3¾x17in	1.61	1.26	1.00	1.92
PINSx36	30	30		
x200	1.16	1.16		

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RESISTOR COLOUR CODE

(standard carbon series)

To read the colour code, hold resistor with code ring nearest to end at left hand side.

Colour	1st ring; 1st figure	2nd ring 2nd figure	3rd ring multiplier	4th ring tolerance
black	—	0	1	—
brown	1	1	10	±1%
red	1	2	10^2	±2%
orange	3	3	10^3	—
yellow	4	4	10^4	—
green	5	5	10^5	—
blue	6	6	10^6	—
violet	7	7	10^7	—
grey	8	8	10^8	—
white	9	9	10^9	—
silver	—	—	10^{-2}	±10%
gold	—	—	10^{-1}	±5%

No fourth colour indicates ±20% tolerance

Grade 1 ('high-stability') resistors are distinguished by a salmon-pink fifth ring or body colour.

RESISTORS of 1% tolerance sometimes have a five band code. The same colour codes are used but the first three bands represent the first three digits and the fourth band is the multiplier. With these resistors only a few of the standard values coincide with those of the four band coded resistors. For example 220 k is standard in four band code but 221 k is standard in five band code.

Example: Resistor coded as A – grey, B–red, C–orange, D–gold indicates a value of 82 kilohms ±5%.

STANDARD VALUES

This table shows the preferred series of values in a decade.

RESISTORS and capacitors are generally made with the values and tolerances shown. For example 20% tolerance resistors are usually made in values of 10, 15, 22, 33, 47 and 68 – whether ohms, kilohms or megohms. Thus a (nominally) 47 k, 20% resistor may have an actual value somewhere between 37.6 k and 56.4 k. A (nominally) 33 k, 20% resistor may in fact be as low as 26.4 k or as high as 39.6 k.

Closer tolerance resistors such as 10% or 5% are not necessarily better resistors – merely that the manufacturers have weeded out products falling outside the tolerance limits.

VALUES IN A DECADE

20%	10%	5 or 2%	1%							
10	10	10	100	133	178	237	316	422	562	750
		11								
	12	12	102	137	182	243	324	432	576	768
		13								
15	15	15	105	140	187	249	332	442	590	787
		16								
	18	18	107	143	191	255	340	453	604	806
		20								
22	22	22	110	147	196	261	348	464	619	825
		24								
	27	27	113	150	200	267	357	475	634	845
		30								
33	33	33	115	154	205	274	365	487	649	866
		36								
	39	39	118	158	215	287	383	511	681	909
		51								
	56	56	124	165	221	294	392	523	698	931
		62								
68	68	68	127	169	226	301	402	536	715	953
		75								
	82	82	130	174	232	309	412	549	732	976
		91								

POTENTIOMETERS

POTENTIOMETERS are made in many different forms for a vast number of applications. Factors which affect design are, for example, wattage and resistance range, whether the control is to be continually or intermittently adjustable, the 'law' of resistance and the variety of mechanical arrangements required.

POWER RATING

The maximum power which may be dissipated is specified for the condition where a voltage is applied across the end terminals continuously. However under certain conditions power dissipations much lower than this can cause damage. This is because the resistive element also has a maximum *current* limitation. Thus a potentiometer set to its lowest resistance could be damaged if excessive current were drawn via the slider terminal.

LAW

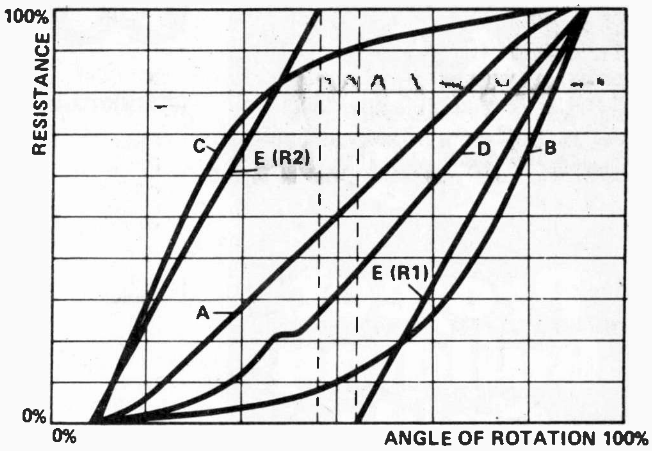
Potentiometers are constructed with various relationships of resistance versus rotation. Those most commonly used are:—

- A linear
- B logarithmic
- C reversed logarithmic
- D tapped
- E balance

The type of relationship (law) used is indicated by stamping the appropriate letter symbol on the body of potentiometer.
eg. 10 kC is a 10 k ohm reversed — logarithmic potentiometer.

LOG OR LINEAR?

Most human perception is of a logarithmic nature (eg hearing, where a doubling of power is just perceivable). Hence logarithmic potentiometers are frequently used for volume controls as the logarithmic change in resistance (versus rotation) is 'heard' as a linear level-change versus rotation. Logarithmic — potentiometers are not accurate, so, where an accurate mid-point setting is required, (for example in tone controls) they are seldom used except in cheaper equipment.



Resistance/rotation curves for commonly used potentiometers.

TAPPED POTENTIOMETERS

Tapped potentiometers are generally used where some form of frequency compensation versus rotation is required. They are often used in 'loudness' controls, (bass and treble frequencies boosted at low volume levels). Tapped potentiometers are usually specially made for a specific application. Because of this they are not generally available from hobbyist supply sources.

BALANCE CONTROLS

Balance controls are built with two separate elements connected such that each alters resistance in the opposite sense. Such controls are used where it is required accurately to balance the gain of a pair of amplifiers. Such accurate balance is not required in domestic stereo amplifiers and hence in this application a single gang potentiometer is generally used.

GANGING

Potentiometers may be obtained with two or three resistance elements driven by a common shaft. These are commonly used for volume and tone controls for stereo amplifiers.

SERIES AND PARALLEL CONNECTIONS

Resistors in series

$$R_{total} = R1 + R2 + R3 + \dots$$

Resistors in parallel

$$R_{total} = \frac{R1 \times R2}{R1 + R2}$$

Capacitors in series

$$\frac{1}{C_{total}} = \frac{1}{C1} + \frac{1}{C2} + \frac{1}{C3} + \dots$$

Capacitors in parallel

$$C_{total} = C1 + C2 + C3 + \dots\dots$$

TAG TANTALUM CAPACITORS

Because of their small physical size tag tantalum capacitors are ideal for miniature electronic work. They are more expensive than standard electrolytics though.

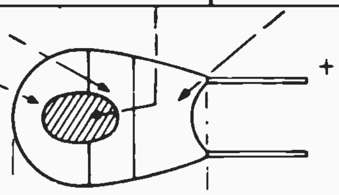
WORKING VOLTS	CAPACITANCE RANGE AVAILABLE
3	10 — 100 μF
6.3	6.8 — 47 μF
10	4.7 — 33 μF
16	2.2 — 22 μF
25	3.3 — 10 μF
35	0.1 — 6.8 μF

Tolerance ± 20%

PROJECT BUILDING GUIDE

TAG TANTALUM CAPACITORS

CAPACITANCE IN μF				D.C. WORKING VOLTAGE	
COLOUR	1st RING	2nd RING	POLARITY and MULTIPLIER	COLOUR	VOLTS
Black	—	0	x 1	White	3
Brown	1	1	x 10	Yellow	6.3
Red	2	2		Black	10
Orange	3	3		Green	16
Yellow	4	4		Blue	20
Green	5	5		Grey	25
Blue	6	6		Pink	35
Violet	7	7			
Grey	8	8	x 0.01		
White	9	9	x 0.1		

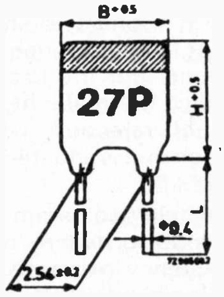


N.B. — The above sketch shows the position of the coloured spot which serves both as multiplier and anode indicator.

EXAMPLE
6.8μF/25 volts

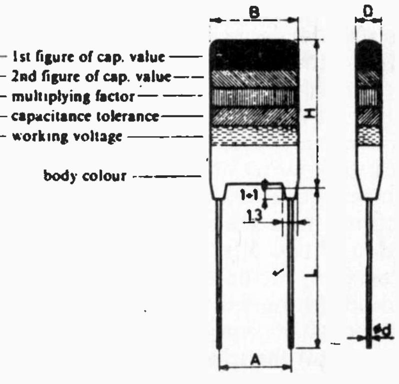
CERAMIC CAPACITORS

capacitance (pF)	marking	capacitance (pF)	marking	capacitance (pF)	marking
0.68	p68	5.6	5p6	47	47p
0.82	p82	6.8	6p8	56	56p
1.0	1p0	8.2	8p2	68	68p
1.2	1p2	10	10p	82	82p
1.5	1p5	12	12p	100	n10
1.8	1p8	15	15p	120	n10
2.2	2p2	18	18p	150	n15
2.7	2p7	22	22p	180	n18
3.3	303	27	27p	220	n22
3.9	3p9	33	33p	270	n27
4.7	4p7	39	39p		



POLY-CARBONATE CAPACITORS

colour					
black	–	0	1	±20%	
brown	1	1	10		
red	2	2	10^2		250 V
orange	3	3	10^3		
yellow	4	4	10^4		400 V
green	5	5	10^5		
blue	6	6			630 V
violet	7	7			
grey	8	8			
white	9	9		±10%	



MODERN FM RECEIVING TECHNIQUES PART TWO

Last month Brian Dance discussed VHF receiver front-ends. In this article he will cover some high performance 10.7MHz amplifier/demodulator circuits. Conventional tuned circuits cannot normally be integrated on a silicon IC chip and in any case they are inconvenient to use and to align. However, ceramic filters provide a satisfactory solution to these problems:

CERAMIC FILTERS

Miniature 10.7MHz ceramic filters are manufactured by Toko (type CFS), Vernitron (type FM-4) and Murata. They can be used to replace the tuned circuits formerly used in FM receivers and have the advantage that no alignment is required. These filters have three connections; the centre one should always be earthed, whilst the other two interchangeable connections are the input and output.

A single ceramic resonator is employed in the filters. This is equivalent to a co plex multi-section LC filter and provide excellent selectivity. The frequency response of Vernitron FM-4 filters is shown in Fig. 7. A single filter is adequate for most locations, but the use of two filters provides the really high adjacent channel rejection which is valuable when one is situated near to a transmitter.

Unfortunately two ceramic filters cannot be coupled *directly* together or their frequency response will be affected. An amplifier of moderate gain is normally inserted between two filters. The external circuit on each side of the filter should present an impedance of about 330 ohms, the parallel capacitance being under 10pF. Although these values are not very critical, the selectivity curve will suffer if they are not within 20%.

Ceramic filters cannot be manufactured with extremely narrow centre frequency tolerances. Manufactured filters are therefore colour coded. If two filters are to be used in a receiver, the colour coding of each should be the same, but it does not matter which colour is used. Manufacturers will supply matched pairs.

Ceramic filters are almost immune to shock. They are compact and light in weight, easy to mount and require no adjustment. The change of the centre frequency with temperature is around -40kHz for a change from -10°C to $+50^\circ$C. The loss in the pass band is only about 5 or 6dB. The price of 10.7MHz ceramic filters is about 50p each.

CFK FILTERS

The Toko CFK 10.7MHz filter contains a single tuned input circuit which is coupled to a ceramic filter. The imput impedance is about 5k, so it is suitable for use following circuits of a relatively high output impedance. It is, however, necessary to adjust the tuned input circuit.

AMPLIFICATION

The earlier FM demodulator ICs did not incorporate a high gain internal 10.7MHz amplifier. It is necessary to amplify the incoming signal from the front-end before feeding it to one of these circuits. Although only modern high gain demodulator ICs will be covered by this article, many readers will be interested in details of FM amplifiers.

THE μA753

The Fairchild μA753 device is especially suited to receivers using ceramic filters since it has input and output impedances of 330 ohms. The device has two outputs: the normal one at pin 5 is taken from the third amplifier stage where the overall voltage gain is about 300 (50dB). A lower level output is available from pin 7 where the overall gain is about 50 (34dB).

A circuit using the μA753 is shown in Fig. 8. Two ceramic filters, F1 and F2, are used. If the output impedance of the front-end is 75 ohms, the value of R1 should be about (330 - 75) = 255 ohms (so that the input of F1 is matched to the correct impedance). In practice, a 270 ohm resistor of 10% tolerance is quite suitable.

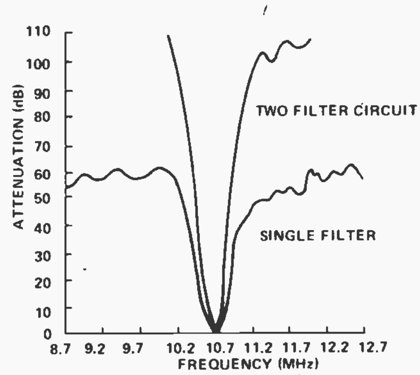


Fig. 7. Typical response of circuits employing one and two Vernitron type FM-4 ceramic filters.

The output of F1 is matched by the internal 330 ohm resistor of the μA753. Similarly, the output of the μA753 provides the required 330 ohm impedance for the input of F2, whilst the output of F2 requires the matching resistor R2. The value of R2 should be selected to provide a 330mΩ output impedance when it is in parallel with the input impedance of the succeeding stage. For example, if the output feeds a circuit with an imput impedance of over 3k ohm, the value of R2 should be about 330 ohms. If the following circuit has an input impedance of 660 ohms, the value of R2 should be about 660 ohms also. (A 680 ohm resistor would be quite satisfactory.)

The μA753 provides a stabilised output of 7.8V from pin 6. This can be used as the power supply to a front-end unit, as in Fig. 8. The total current consumption of the circuit in

Fig. 8 is around 16mA plus any current taken from pin 6. The µA735 is an 8-pin dual-in-line IC and costs around £1.

OTHER AMPLIFIERS

Quite a number of other integrated circuits are suitable for use as 10.7MHz amplifiers. The RCA CA3076 can be used in the simple circuit of Fig. 9. R1 and R2 are the filter matching resistors. A gain of about 80dB at 10.7MHz can be obtained using this device if the load is about 2k. In the circuit shown the gain will be reduced by the filter matching resistor R2 and the loss in the two filters. However, it should still exceed 50dB.

THE TDA 1200/CA3089E

The SGS-Ates TDA 1200 and the RCA CA3089E are equivalent 16-pin dual-in-line devices which form a complete FM IF and demodulation system. They contain over 80 transistors. The connections are shown in Fig.10, and the internal circuit is shown in block form in Fig. 11.

The devices include a three-stage high-gain differential amplifier which drives the level detector circuits. The latter feed the field strength meter circuit, whilst the first level detector also provides delayed AGC for the RF stage in the front-end. The last stage of the differential amplifier also drives the quadrature detector. This provides signals to the audio amplifier, the AFC amplifier and the muting circuit.

Fig. 12 shows a typical high-performance tuner using a normal front-end (gain about 26dB), a transistor 10.7MHz amplifier, one ceramic filter (marked F) and a TDA 1200 circuit. R5 and R7 are the filter matching resistors. The value of R10 should be chosen so that a suitable AFC characteristic is obtained.

Two coils are employed in the circuit. L1 is a 22µH choke which can be obtained as a very neat Toko coil (type 144 LZ 220K). The coil L2 with the parallel capacitor C9 is available under the Toko type numbers KACS-K-586HM and 94AES 30465N. The former type includes an 82pF capacitor for C9 and the latter a 120pF capacitor. The Q factors are quoted as 100 and 65 respectively, but R8 reduces this. The value of this resistor has been chosen to give a suitable compromise between the distortion level and the amplitude of the audio output signal. In the case of all three coil types, the connections are taken

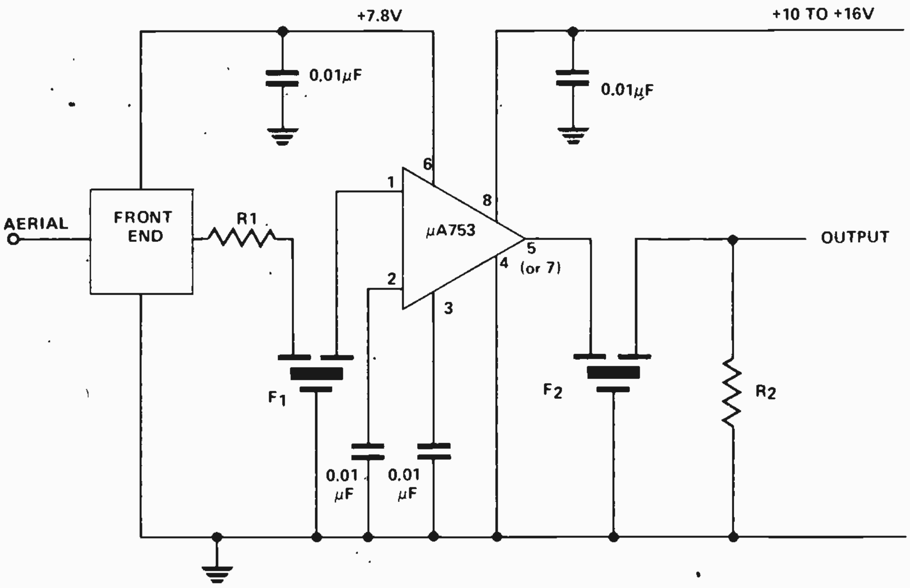


Fig. 8. Amplifier circuit using the Fairchild µA753 with two ceramic filters.

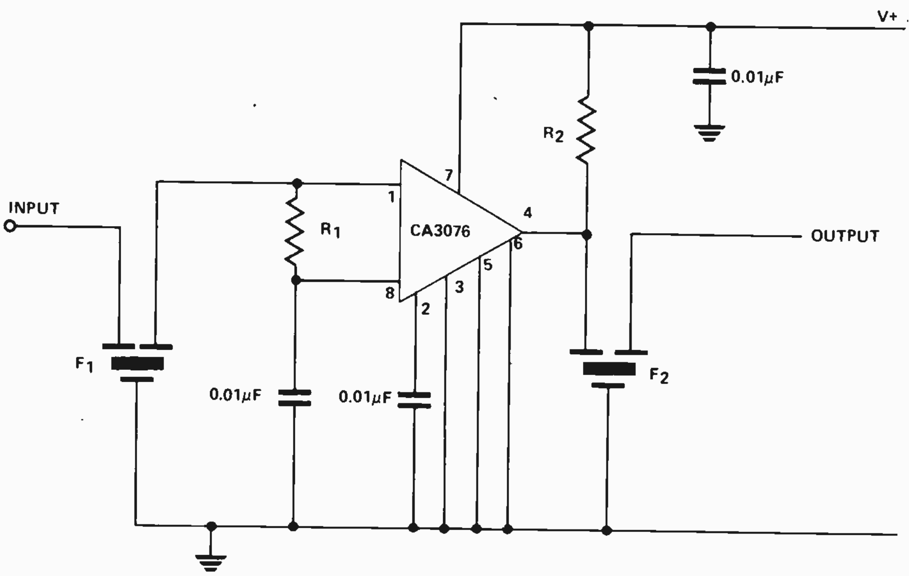


Fig. 9. A CA3076 amplifier stage.

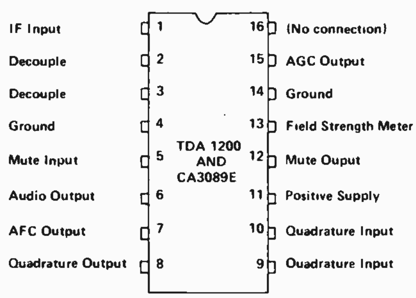


Fig. 10. Connections of the TDA 1200/CA3089E devices.

from the outer pair of the row of three connections, the other leads remaining unused. (The 94AES 30465N has an additional coupling coil which is not used in this application.)

The coil L2 can be roughly aligned by tuning it for maximum audio output. If no wobbulator is available, reasonable alignment of L2 can be effected by adjustment of the core until the meter M2 swings almost symmetrically from one side through the centre to the other side as one tunes the receiver through a station. Correct tuning is, of course, obtained when M2 is at the centre null point.

The circuit of Fig. 12 provides a total harmonic distortion at the output of around 0.5%. Lower distortion can be obtained by using the double tuned circuit shown in Fig. 13(a) as a modification. This double-tuned circuit is claimed to have a distortion of around 0.1%. In addition it provides a lower capture ratio.

MODERN FM RECEIVER TECHNIQUES

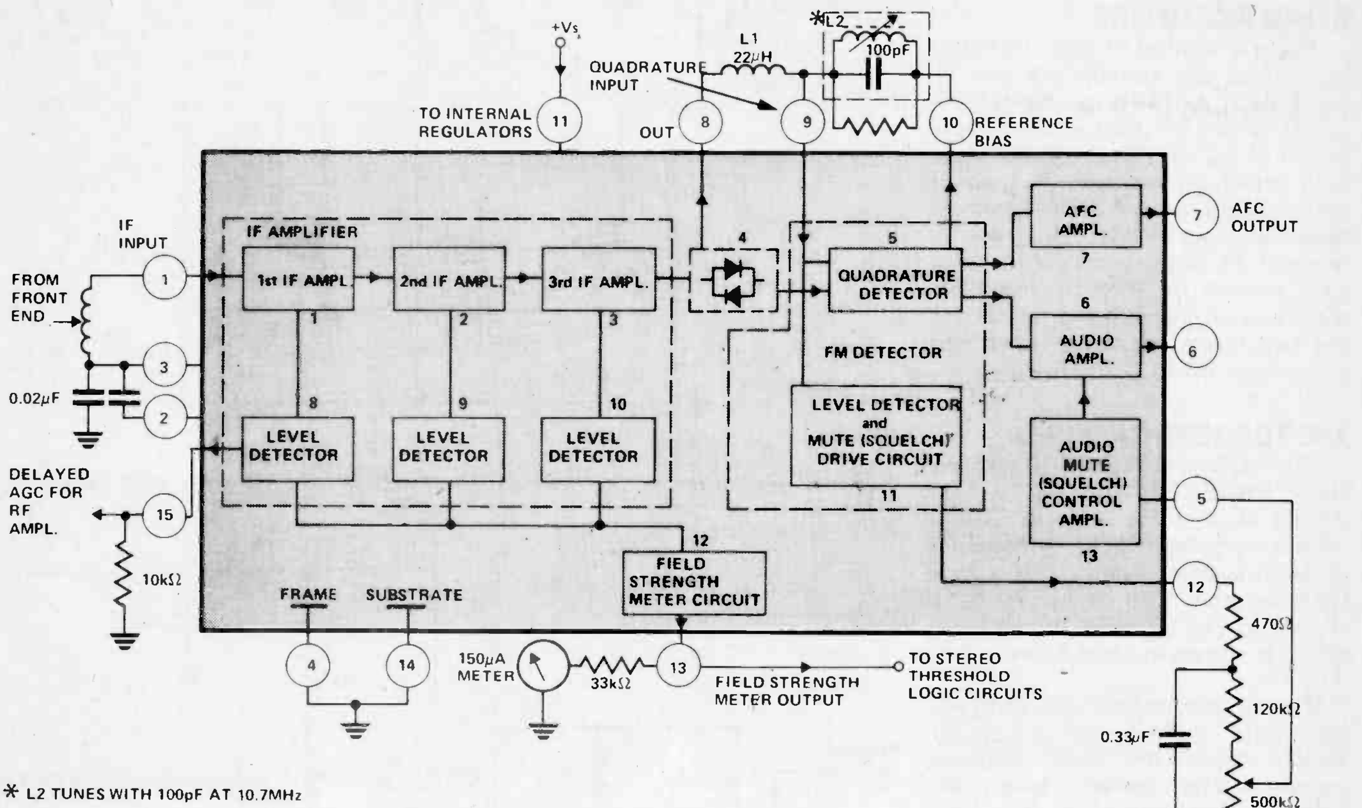


Fig. 11. Internal circuit of the TDA 1200/CA3089E in block form with basic external circuit.

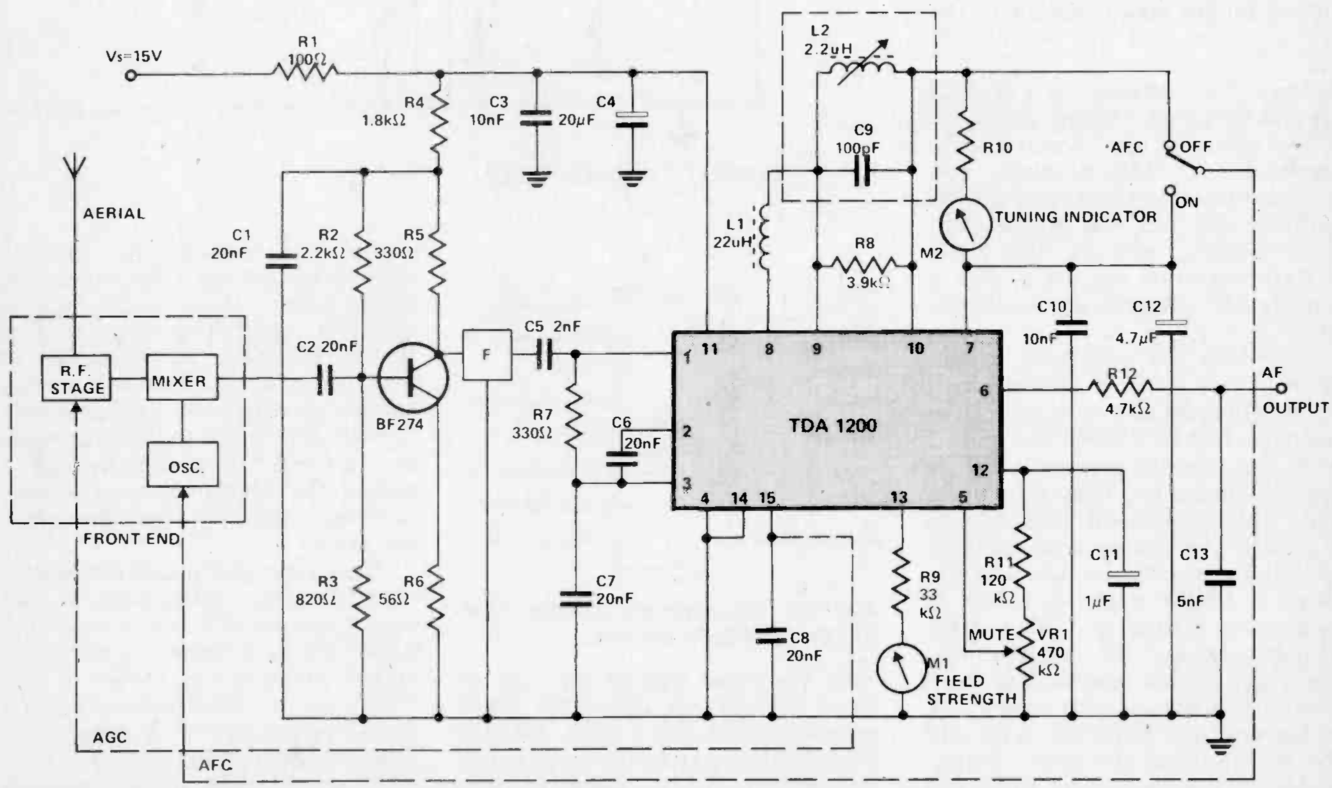


Fig. 12. A typical FM tuner using the TDA 1200.

MODERN FM RECEIVER TECHNIQUES

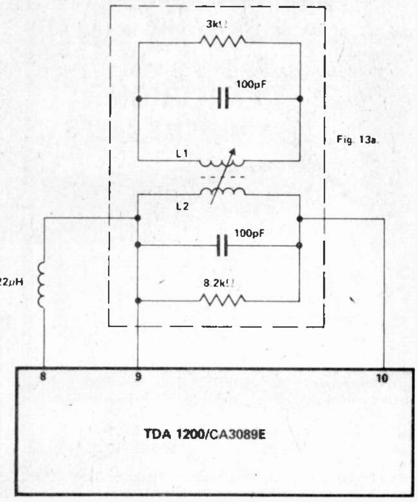


Fig. 13. Low distortion circuit using a double tuned quadrature coil.

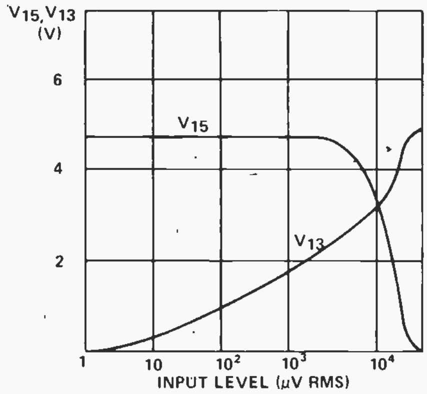


Fig. 14. Variation of the pin 13 and pin 15 potentials with input signal level.

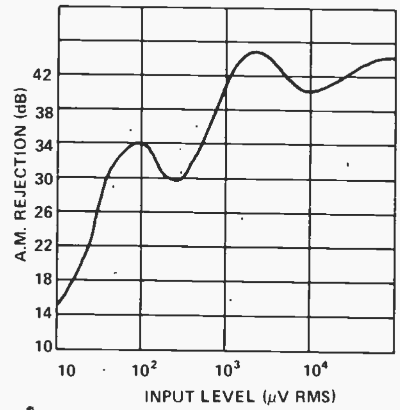


Fig. 15. A.M. rejection provided by the CA3089E/TDA 1200.

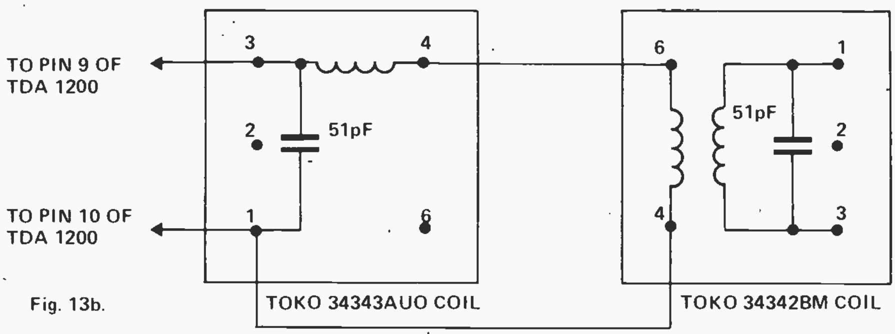


Fig. 13b.

A suitable double-tuned circuit can be made by using the Toko type 34342BM coil with a separate Toko 34343AUO coil connected as shown in Fig. 13(b). This circuit is electrically equivalent to that of Fig. 13(a). Although these coils for the double-tuned circuit are readily available, a wobbulator is required to align them, since any change in the sitting of the core of either coil affects the tuning of the other coil. Many readers will therefore prefer to use the simpler single tuned demodulator circuit of Fig. 12.

All of the Toko coils mentioned for both the signal and double tuned circuits are housed in miniature 10mm square cans.

The capacitor C13 in the Fig. 12 circuit provides the normal 50µs de-emphasis in conjunction with the sum of the resistance of R12 and the 5k ohm output impedance of the pin 6 circuit. If the output is fed to a

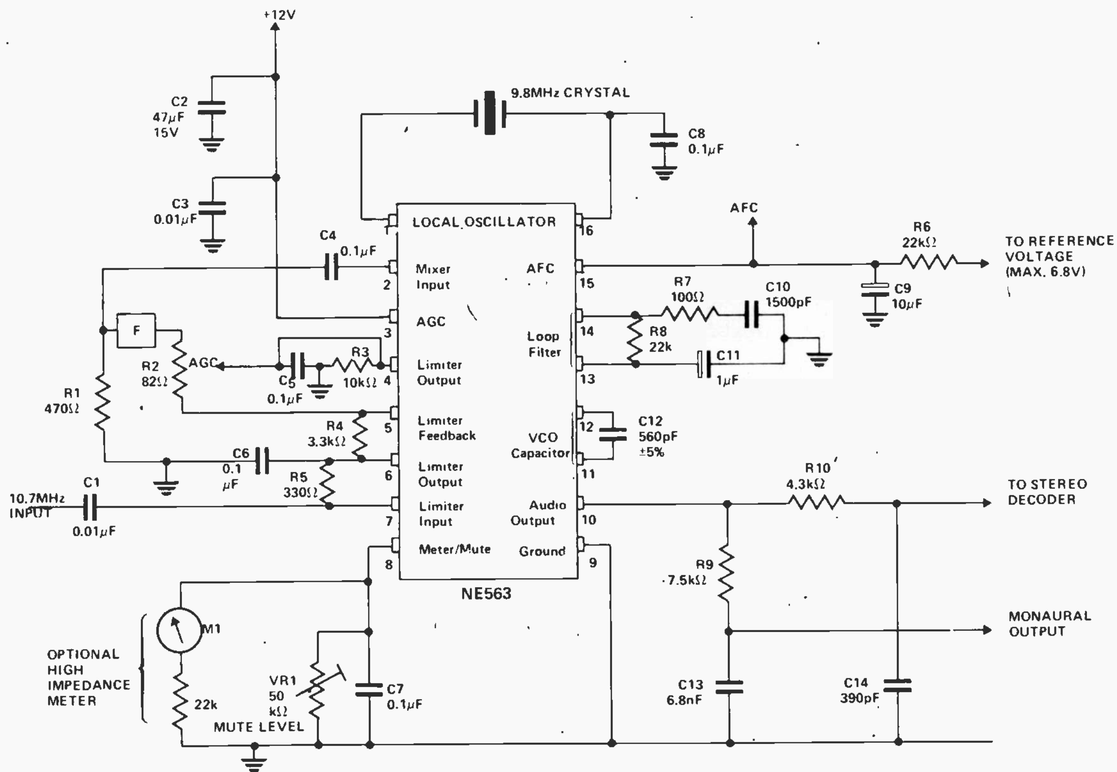


Fig. 16. A typical NE563 amplifier, mixer and phase locked loop demodulator circuit.

stereo decoder circuit, R12 and C13 should be omitted. The de-emphasis components must be placed at the output of the stereo decoder.

The variation in the potentials of pins 13 and 15 with the input signal level is shown in Fig. 14. It can be seen that the AGC output from pin 15 remains almost constant at about +4.7V until the input signal to pin 1 reaches a level of about 3mV. Then the potential at this pin falls with increasing signal level. The front-end circuit must not impose a load of less than 10k ohms on the AGC output from pin 15.

It can be seen from Fig. 14 that the potential of pin 13 rises almost as the logarithm of the input signal strength over much of the working range of input levels. Thus the meter M1 can indicate a very wide range of input signal levels.

The AM rejection provided by the type of circuit shown in Fig. 12 is plotted in Fig. 15. It can be seen that for signal levels exceeding about 1mV the rejection of unwanted AM signals (including car ignition noise) exceeds 40db. The circuit can handle inputs of over 500mV without any deterioration of the AM rejection factor. A signal to noise ratio at the audio output of over 20dB can be obtained with input signals to pin 1 of the order of 12μV RMS.

If the AFC facility is not used, it is advisable to link pin 7 with a 4.7k ohm resistor to pin 10 to avoid the possibility of added distortion at the audio output.

The CA3089E and the TDA1200 incorporate circuitry which enables inter-station noise to be muted. When a signal is tuned in correctly, the potential of pin 12 is approximately zero volts. If, however, only noise is present, this potential will rise and a portion of it is tapped off by VR1 of Fig. 12. If the potential of pin 5 exceeds about +1.5V, the circuit is muted and little signal reaches the output. If a high gain front-end unit is employed, it may be necessary to employ a capacitive attenuator between the front-end and the TDA 1200/CA3089E in order to achieve satisfactory muting.

A detailed report entitled 'TDA 1200 FM-IF System for High Performance Radio Receivers' is available from SGS-Ates.

THE NE563

Phase locked loops are very attractive for use in FM receivers, since they can replace a complete IF circuit and they require no coils. Unfortunately the phase locked loops available until recently have been suitable for communications receivers but not for high fidelity work. However, the recent development of the NE563 device by Signetics has greatly changed the position. The 563 is a new device containing about 180 transistors which can be used in the circuit shown in Fig. 16.

The incoming 10.7MHz signal from the front-end unit is fed to pin 7 of the NE563. It is then amplified by up to 60dB in a high gain amplifier/limiter circuit which has a bandwidth of 22MHz. The output of the limiter at pin 5 has an impedance of about 270 ohms, so the additional series resistor R2 increases this to the value required by the ceramic filter F for correct matching. On the output side of this filter, R1 in parallel with the input resistance at pin 2 (about 1250 ohms) makes a suitable impedance match for the filter.

The 9.8MHz quartz crystal connected between pins 1 and 16 forms part of a 9.8MHz local oscillator circuit. The signal from the latter is mixed with the incoming 10.7MHz and the resulting difference frequency of 900kHz is fed by an internal connection to the phase locked loop section of the device.

The voltage controlled oscillator of the phase locked loop will free run at a frequency determined by the value of C12. If this free running frequency is reasonably close to the 900kHz input frequency, the loop will lock onto the frequency of the input signal. The error voltage which keeps the loop in lock will vary with the frequency of the incoming signal. Thus this error signal is the required audio voltage when the incoming signal is a frequency modulated one.

The audio output appears at pin 10 superimposed on a steady voltage. The filter R9-C13 provides the normal de-emphasis of 50μs time constant, whilst R10 and C14 provide some attenuation of RF frequencies. A series capacitor must be employed in both the stereo and monaural output circuits to block the steady voltage at pin 10.

The loop filter connected to pins 13 and 14 controls the bandwidth of the demodulator circuit. The impedance at these pins is typically 6.2k. If R8 is reduced in value the bandwidth — and hence the noise level at the output — will be reduced, but the centre frequency must then be more carefully matched to the input frequency.

To be continued next month . . .

INTERNATIONAL·

PART 1

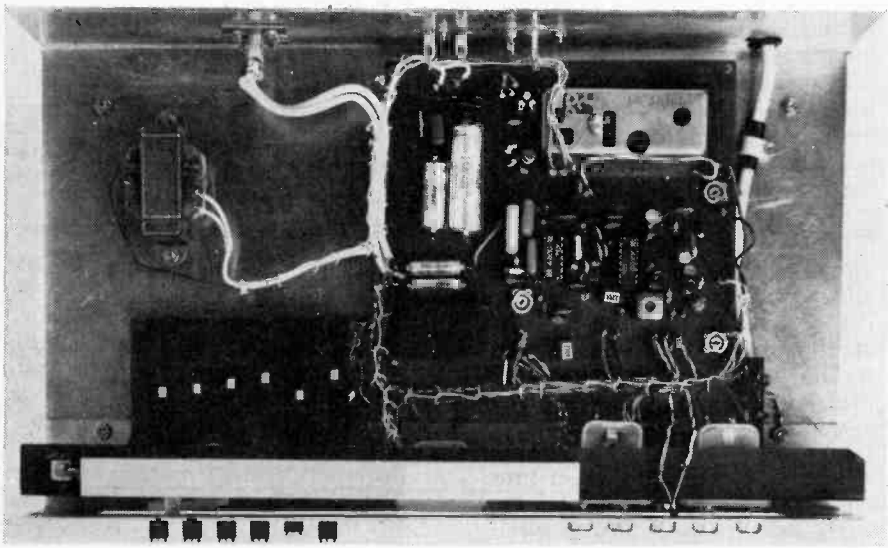
The International FM Tuner is a first class design with an excellent specification. It is designed as the 'brother' of the International 25 — a Hi-Fi amplifier which will be described next month. ETI have worked closely with Ambit International in designing this Project and a kit will be available from them (see their advertisement on page 47. Without the metalwork and cabinet the cost of this project is well under £30.

INTERNATIONAL FM TUNER: SPECIFICATION

Sensitivity (75kHz, 26dB, 75Ω)	1.2μV
Signal plus noise to noise ratio (1mV, 75kHz, 400Hz)	67dB
Stereo channel separation (1mV, 75kHz, 1kHz)	40dB typical
Alternate channel selectivity (±400kHz)	55dB
AM suppression (FM–75kHz, AM–30%, 1mV)	60dB
Total harmonic distortion (1mV, 75kHz, 400Hz)	1%
AFC pulling range (>10μV, 75Ω)	±400kHz
Aerial input impedance	75 and 300Ω
Audio output impedance (both channels)	4.7kΩ
Audio output level (>2μV, 75kHz)	150mV RMS
Operating Voltage (ground neg.)	12V
Operating current	50mA

The design of an FM tuner was, until quite recently, a major problem: numerous coils and i.f. cans were required and the component count, if one had a stereo decoder, was high.

The components now available to the constructor however, make the building of an FM tuner, even with a very high specification, hardly more complex than for a simple amplifier. Alignment was also a major problem and for decent quality, sophisticated equipment was necessary. Our design, the International FM Tuner has an excellent specification and is easy to build and can be lined up literally in seconds using only the meters which are an integral part of our design.



The design is greatly simplified by the use of a single p.c. board which carries all the components other than the transformer and the operator controls. These carry only d.c. (except of course the transformer) and so wires to the front panel are in no way critical. It would not be correct to say that layout is not critical — it is — but if the p.c. board layout is used, all this work is done for you already.

We have not attempted to build the tuner head, although the number of components included is not high, the construction is highly critical and special techniques are needed to align it.

The International FM has facilities way beyond those normally found in any but the most expensive designs. Stations can be tuned in using the cursor in the usual way but also included is a preset module enabling any six stations to be preselected. A disadvantage with multi-turn presets of the type used here is that it is often difficult to know whereabouts in the FM band you are tuning: our design includes a frequency meter which registers the approximate frequency of each push-button. Also included in the design are a tuning meter — to tell you when are right on tune and a signal strength meter to register the relative strengths of the stations heard. These meters are also used in the very simple alignment procedure.

A set of push buttons can select other facilities. There is of course AFC in the circuit and its capture ratio is so good that it has to be switched out for the reception of weak stations adjacent to strong local ones. Inter-station noise is annoying so a MUTE switch is included; once again this can be disabled for the reception of weak stations.

The 19kHz (and residual 38kHz) on stereo transmissions can cause a

FM TUNER

ETI PROJECT 751

whistle if it beats with the bias oscillator of a tape recorder but more serious, if there is a reasonable level of it, it can overload some amplifiers. It will not be heard at these frequencies but the amplifier can be overloaded and cause distortion as a result. To overcome this a pilot tone filter is included on the output.

We felt that this circuit design was so good that to cut corners in the final appearance could not be justified so considerable thought was put to the final shape and general appearance. There is a fair bit of metal bashing we admit but we think most readers will be happy to spend a hour or two to make the final product acceptable in the living room. A specially long slider pot has been chosen to give good resolution.

The International FM Tuner has been designed in conjunction with the International 25, an excellent 25W r.m.s. stereo amplifier that will be described in the next issue. The chassis sizes are identical and the two look very attractive together.

CONSTRUCTION

As we have already said, the layout of the components is critical and we therefore strongly recommend the p.c.b. design shown. This carries the power supply (except the transformer) and all the active components. The need for a properly designed layout will be appreciated when one considers that there is over 80dB of i.f. amplification in the main signal processing IC.

Room has been left on the p.c. board for the use of IC sockets and these are strongly recommended unless you always get things to work first time!

The components specified are all readily available from Ambit International who have cooperated closely with ETI in the circuit design.

A number of presets are used on the board: these should be the horizontal types to fit onto the board. Ceramic filters are used in the i.f. stage. These come with various colour codings but this does not matter as long as the colours of both are the same.

A voltage regulator (IC3) is used in the power supply. This is almost essential as the tuner relies on a stable and hum-free supply for the varicap diodes.

Note the lead-out connections of the BF224 — this is given on the circuit: as will be seen the lead-outs

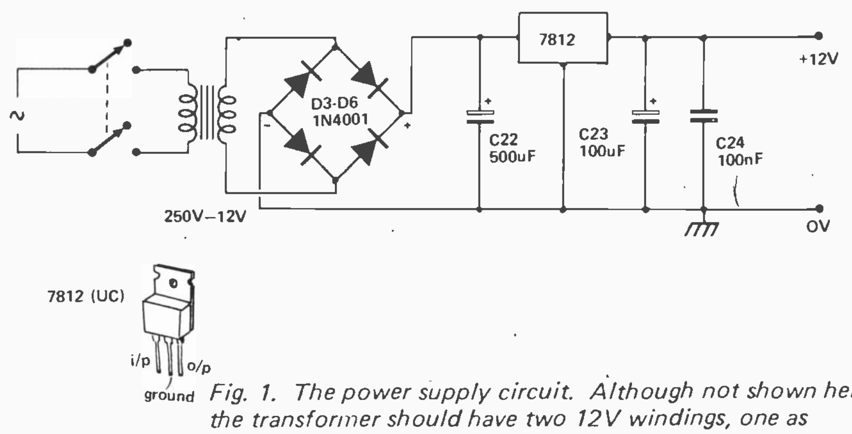


Fig. 1. The power supply circuit. Although not shown here the transformer should have two 12V windings, one as shown, the other for applying 12V a.c. to the panel and meter lights. The use of a voltage regulator is essential as varicap tuning is employed.

HOW IT WORKS

The system is basically a single superhet VHF receiver. Signals in the range of 88-104MHz are tuned at the R.F. stage of the front end, by means of the varicap diodes. These varicaps are simply silicon diodes whose capacity changes when a reverse bias voltage is applied.

Following the R.F. stage, the mixer converts the R.F. signal to the intermediate frequency of 10.7MHz, by combining it with the signal from the local oscillator — which operates at the R.F. signal frequency plus 10.7MHz.

After amplication provided by QI the resultant signals are then fed through the ceramic filter to provide the necessary selectivity to prevent interference from nearby transmissions, and thence to the main IF amplifier and detector I.C. — the KB4402 (a cheaper but direct equivalent of the CA3089).

The KB4402 contains some ninety transistors that amplify the signal from an input level of 12 microvolts, to a suitable level for the quadrature detector to operate. The amplification is 'limiting', i.e. amplitude variations are removed, since it is only the frequency variations that convey the necessary intelligence. In fact, by the time the signal is ready for detecting, it is almost a square wave — so extensive capacitive decoupling is employed around the device to prevent unwanted R.F. feedback.

The quadrature detector compares with the IF signal with itself — by feeding a signal which has been shifted through a phase network known as the quadrature coil. The effect is similar to the mixer in an DSB generator, though in this instance the frequency variations are converted to the original amplitude variations, and thence fed via the muting circuit to the AF output pin. The muting circuit quietens the noise that appears when tuning between stations, by simply rectifying part of that noise and using it as the control for the audio gate.

A peak detector provides an output for the signal strength meter that is proportional to the signal level of the incoming signal. After the audio detector, the multiplex stereo decoder selects the 19kHz subcarrier, around which the basic stereo information of the L—R channel is encoded at the transmitter.

By matrixing the resultant signals, the decoder output returns the program to its original discrete form of left and right channels. The simplest analogy is to consider the decoder as switching at a rate of 38,000 times a second between left and right. A certain amount of the 19 and 38kHz signal remains in the audio and has to be removed to prevent distortion in subsequent audio amplification — and also to prevent mixing with tape recorder bias oscillators, and thereby producing an audible whistle. A 19kHz pilot presence detector provides a switch for the 'stereo-on' indicator.

Outside the main p.c.b., all the functions are strictly D.C. control voltages (other than audio). This permits flexibility in mounting, since no R.F. sensitive paths exist outside the main unit.

PARTS LIST

R1,7,9,16,21	resistor	10k
R2	"	2k2
R3,26	"	33k
R4,31	"	330 ohm
R5,8	"	390 ohm
R6	"	100 ohm
R10,29	"	3k3
R11	"	470 ohm
R12	"	68k
R13,24	"	100k
R14	"	2k2
R15	"	5k6
R17	"	1k2
R18	"	3k9
R19,27	"	1k5
R20	"	22k
R22	"	15k
R23	"	2k7
R25,28,30,33,34	"	4k7
R32	"	1k

All resistors ¼W, 5% types.

RV1	Slider pot.	50k linear-Rivlin
RV2-RV7		Preset, six position station selector module (Ambit)
RV8,RV11	Preset	10k skeleton type
RV9	"	100k skeleton type
RV10	"	25k skeleton type

C1,2,3,4,6,19	capacitor	22nF ceramic disc
C5,12	"	4.7μF,12V electrolytic
C7,8,17,18	"	10nF ceramic disc
C9,10	"	1μF,12V electrolytic
C11	"	47nF ceramic disc
C13	"	470pF ceramic or polyester
C14,15	"	220nF polyester
C16	"	470nF polyester
C20,21	"	10μF,12V electrolytic
C22	"	500μF,25V electrolytic
C23	"	100μF,16V electrolytic
C24	"	100nF ceramic disc
Q1	transistor	BF224 etc
Q 2,4	"	BC108 etc
Q3	"	BC178 etc
ICI	integrated circuit	KB4402 (CA3089)
IC2	"	KB4400 (MC1310)
IC3	"	7812 (UC) voltage regulator
D1,2	diode	1N4148
D3-D6	"	1N4001 (50V, 1A)
LED		TIL209 etc
F1,2	ceramic filter	CFS-10.7 (matched pair)
F3	pilot tone filter	BLR-3107N
L1,2	inductor	22μH choke
Quadrature Coil		KACS-K586
Tuner Head		EC3302 Toko (Ambit)
M1	400μA	Frequency Meter scaled 88-104
M2	400μA	Signal Strength Meter scaled 0-10
M3	50-0-50μA	Tuning Meter, centre zero, scaled 3-0-0 3-0-3
Transformer		250V:12V,12V, 250mA each (one winding for panel and meter lights)
Push-button Assembly		One mains On-off, 4 single pole change-overs, all individually operated (Ambit)
Coax socket,		
Balanced feeder terminals		
Stereo phono sockets (or DIN socket)		
PCB		
Metalwork — details next month.		

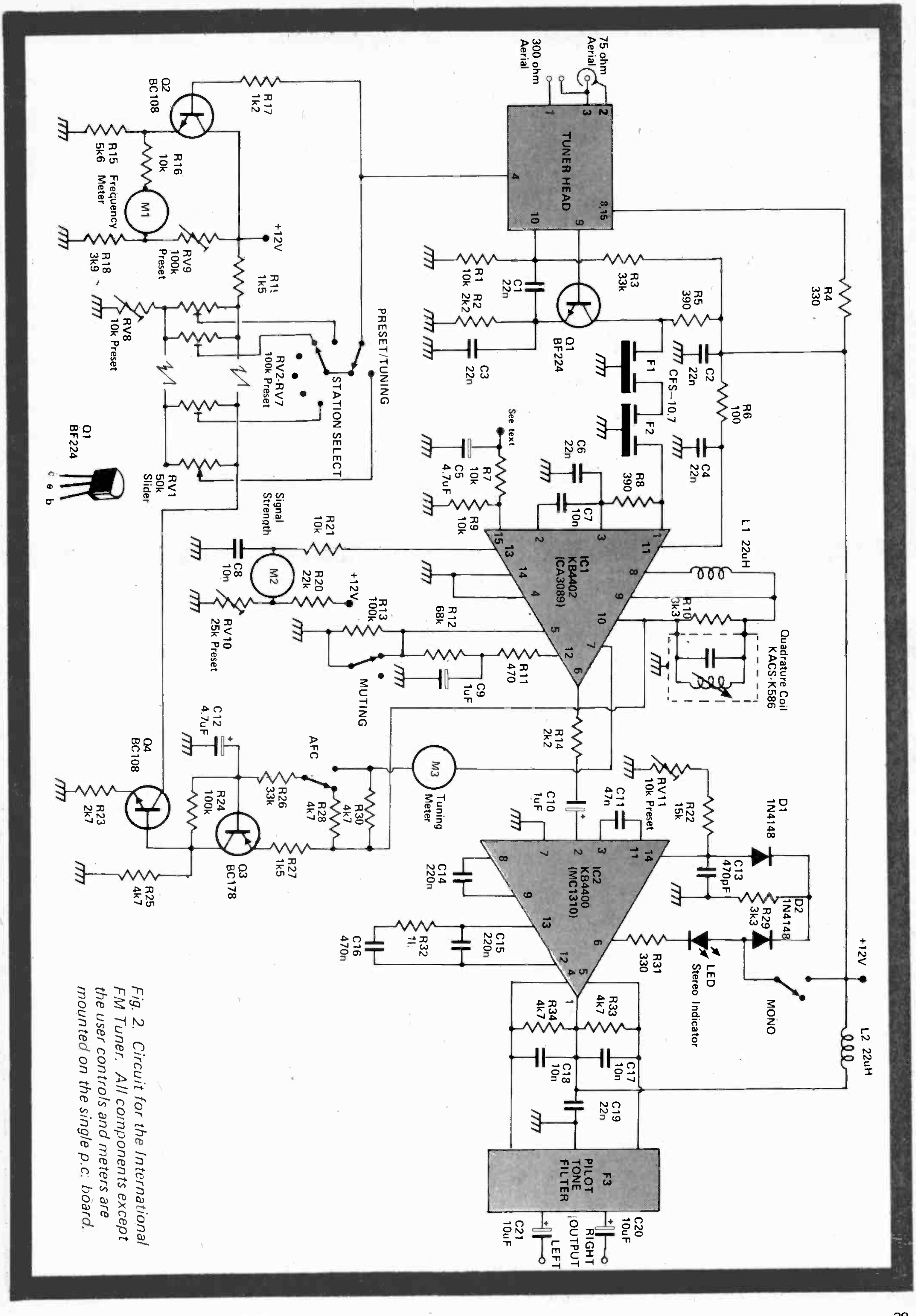


Fig. 2. Circuit for the International FM Tuner. All components except the user controls and meters are mounted on the single p.c. board.

INTERNATIONAL-FM TUNER

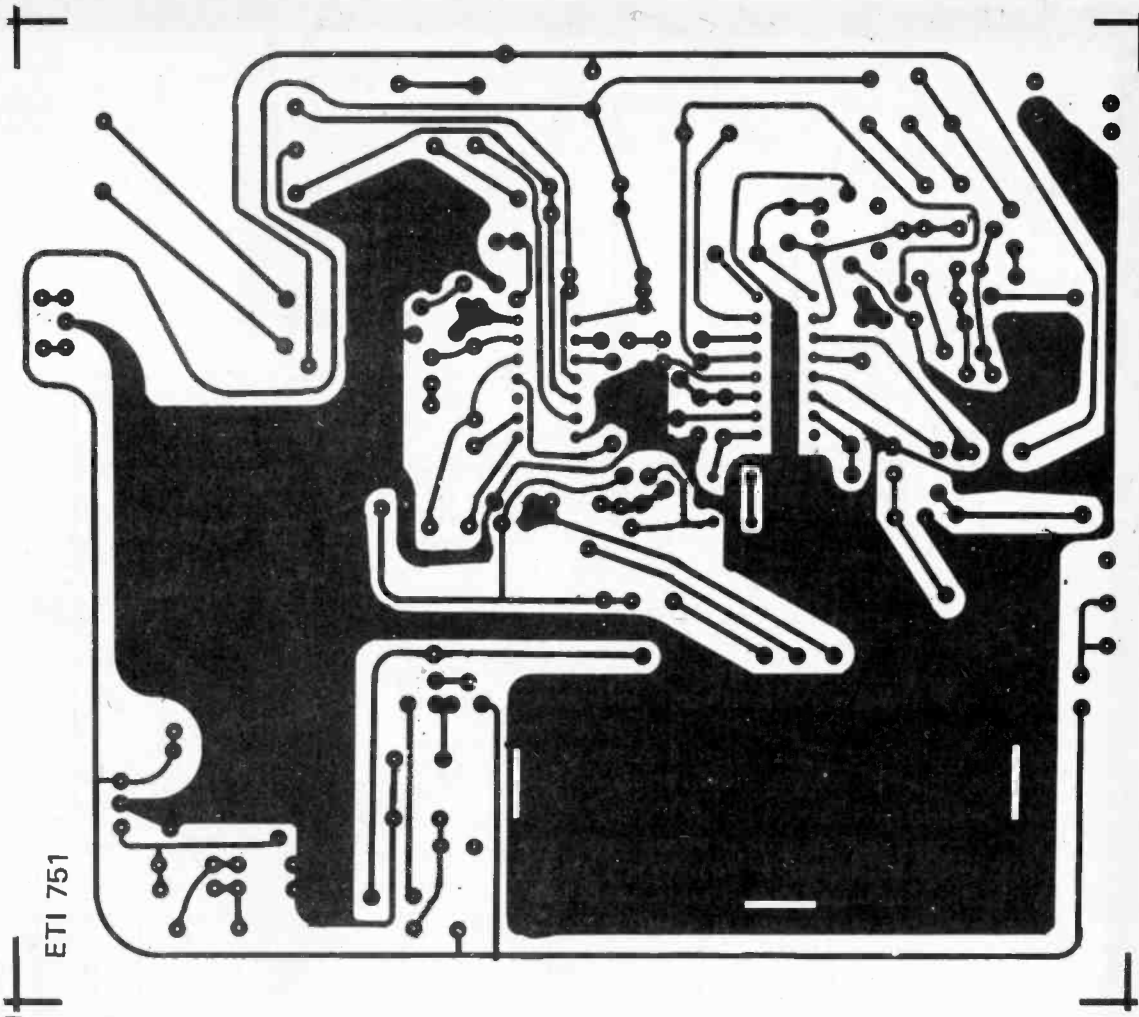


Fig. 3. PCB layout. Due to the high frequencies used this should not be changed.

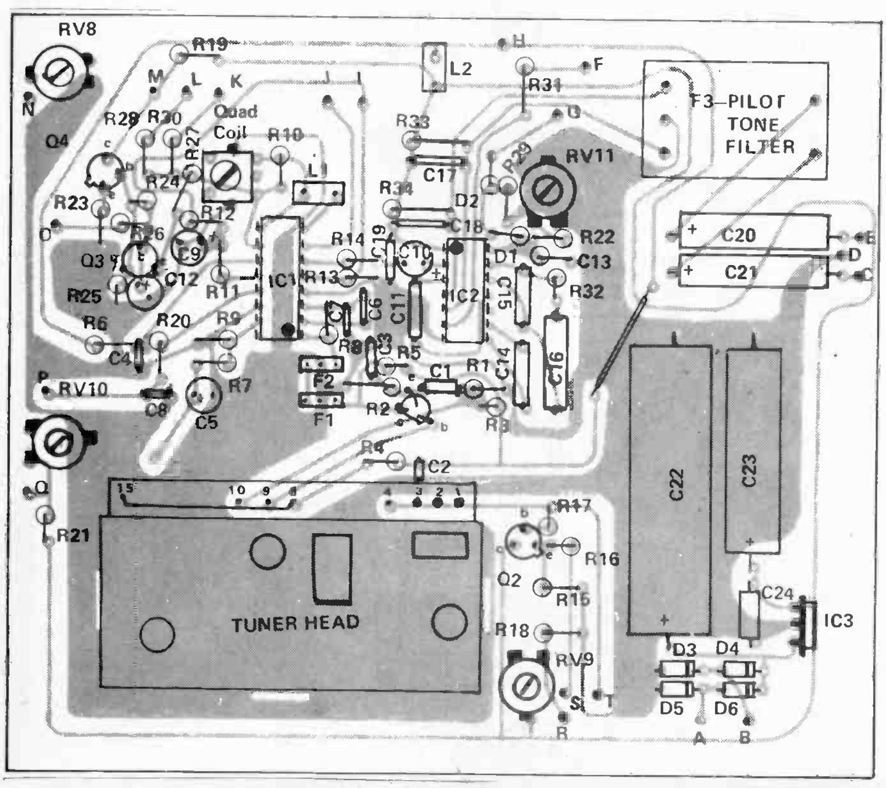


Fig. 4. The component layout on the p.c.b.

are far from standard. The other transistors have conventional lead-outs and should create no problems.

The Toko EC3302 Tuner Head has no provision for AGC but if an alternative is used, ICI has an output for AGC to tuners with such provision (pin 15). For use with the EC3302 R7 and C5 are unnecessary but R9 should be left in even if the EC3302 is used.

To keep the leads as short as possible, the tuner head is mounted on the p.c. board. This has its own board with 15 holes all in line, eight of which are used. Holes 8 and 15 should be connected together with a short wire. The p.c. board of the tuner head sits about 3mm above the main p.c.b. and four wires have to be run through both boards to carry the various connections. Three of the wires go directly to aerial connectors. If the p.c.b. pattern is followed exactly the holes in the two p.c.b.s will line up.

All take-off points on the boards are at the edges to neaten the wiring.

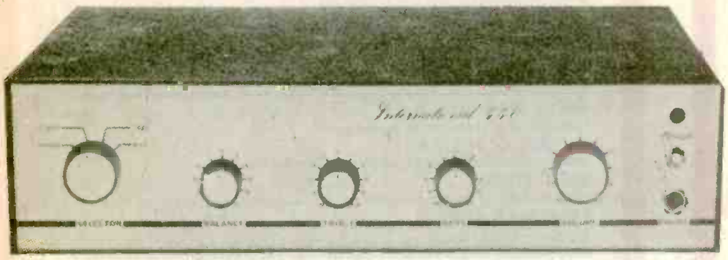
Continued next month . . .

OCTOBER ETI

A LOOK AT SOME OF NEXT MONTH'S MAIN FEATURES

NEW PUBLISHING DATE:
Starting with the October issue, we are advancing the publishing date of ETI to the first Friday in the month preceding the cover date.

BUILD THE INTERNATIONAL 25



HI-FI STEREO AMPLIFIER

A superb amplifier designed for really easy construction: simple metal work and virtually all components on one p.c. board. That doesn't mean that the spec is simple — far from it: Output is 25W r.m.s. per channel, frequency response 6Hz - 80kHz (+0dB, — 3dB), THD 0.12% (20W at 1kHz). Complete constructional details next month.

ELECTRONICS IN MEDICINE

Some of the most advanced electronic techniques are being used to fight disease. This major ETI feature describes the state-of-the-art.

WE'VE DONE IT AGAIN!

A year ago we offered you the fabulous Sinclair Scientific kit for £14.95 and 11,000 readers responded! We are repeating this offer at a new low price — and the built version for just £1 more. No orders before next month.

KIT £11.95
BUILT £12.95

HELPING HAND

Join with us to find solutions to some of the problems of the deaf

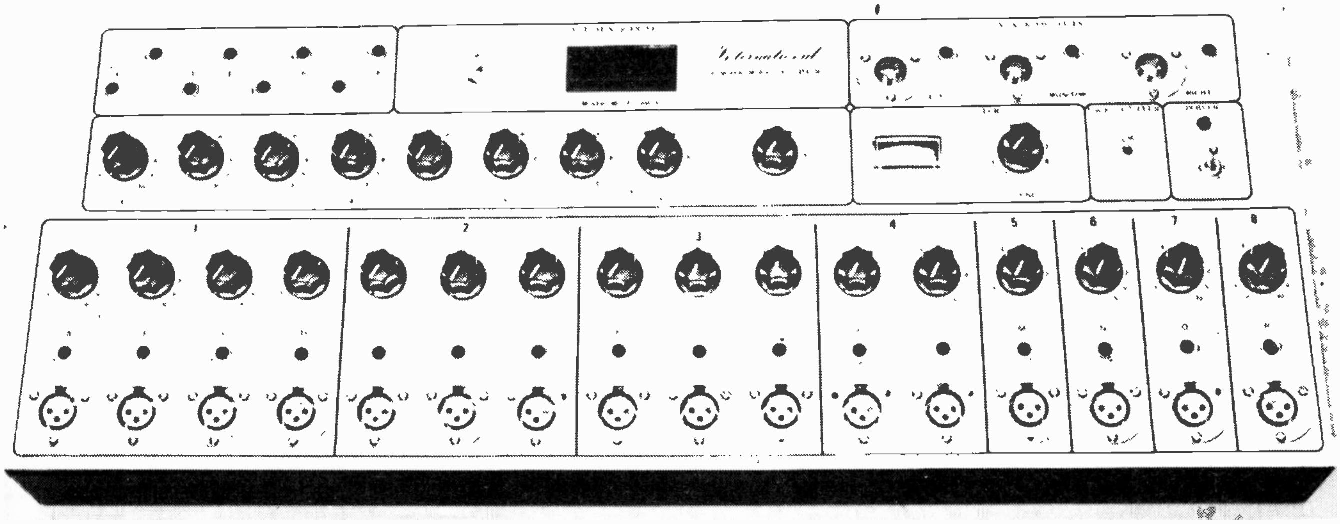
We are inviting individuals and groups of readers to take part in a competition to find solutions to three problems that confront the deaf: we believe that ETI readers have the ingenuity to solve these. This competition is being run with the full co-operation of the Royal National Institute for the Deaf. A trophy will be awarded to the best entries, ETI will donate the main cash prize to the RNID to develop the best idea.

NEW SERIES: DATA SHEET

Another first for ETI: condensed versions of manufacturers data sheets on popular I.C.'s and other semiconductors, arranged so that you can pull out and file.

electronics today international

At the time of this issue going to press, the articles mentioned here are in an advanced state of preparation. However, circumstances including highly topical features, may effect the final contents.



STAGE MIXER

Constructional details.

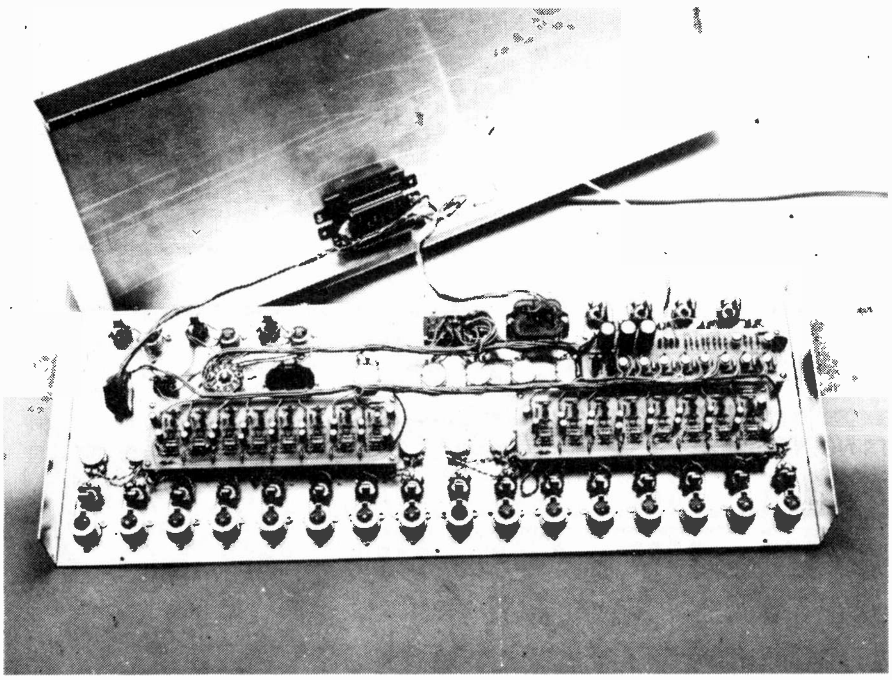
IN THE FIRST PART (July issue) we introduced the principle of our Stage Mixer and gave constructional details of the preamplifier boards. We continue now with details of the mixer board and interconnection wiring.

CONSTRUCTION

The mixer board (ETI 414E) should be assembled with the aid of the circuit diagram, Fig. 5, and the component overlay, Fig. 7. The parts list for this board was given in the last part issue. It is advisable to use terminal posts or pins for the eight input lines, the O V line and the +19.6 volt line. This makes later interconnection considerably easier.

Our prototype was constructed in a simple pan shaped chassis and cover. We suggest that the sides of the front panel be bent up (rather than the ends as shown in the photographs).This will strengthen the front panel and allow the transformer to be mounted on it rather than in the case as shown in our prototype unit.

Mount the spacers for the printed circuit boards, the multi-cable socket, VU meter and power outlet socket to the front panel with countersunk screws. It is suggested that the wires to the three-pin socket be attached before mounting – it is difficult later. All other front-panel components can now be mounted along with the escutcheon.



Internal view of the completed mixer.

HOW IT WORKS – ETI 414 MIXER/POWER SUPPLY

The signals from any number of line amplifiers may be summed by one of the sub mixers (eight per board ICI-IC8) the output from each mixer is taken directly via the output socket to the master mixer, and via a 22 k level control to the monitor mixer, IC9.

The output of the monitor mixer is taken to the master-monitor level control on the master mixer and then returned to a buffer amplifier in the stage mixer, IC10.

In an emergency (main mixer faulty) SW2 disconnects the outputs from the master mixer and connects the output of the monitor amplifier to the PA channels.

Power for the stage mixer is provided by a conventional supply which provides plus and minus 15 volts for the mixer amplifiers and plus 19.6 volts for the line amplifiers.

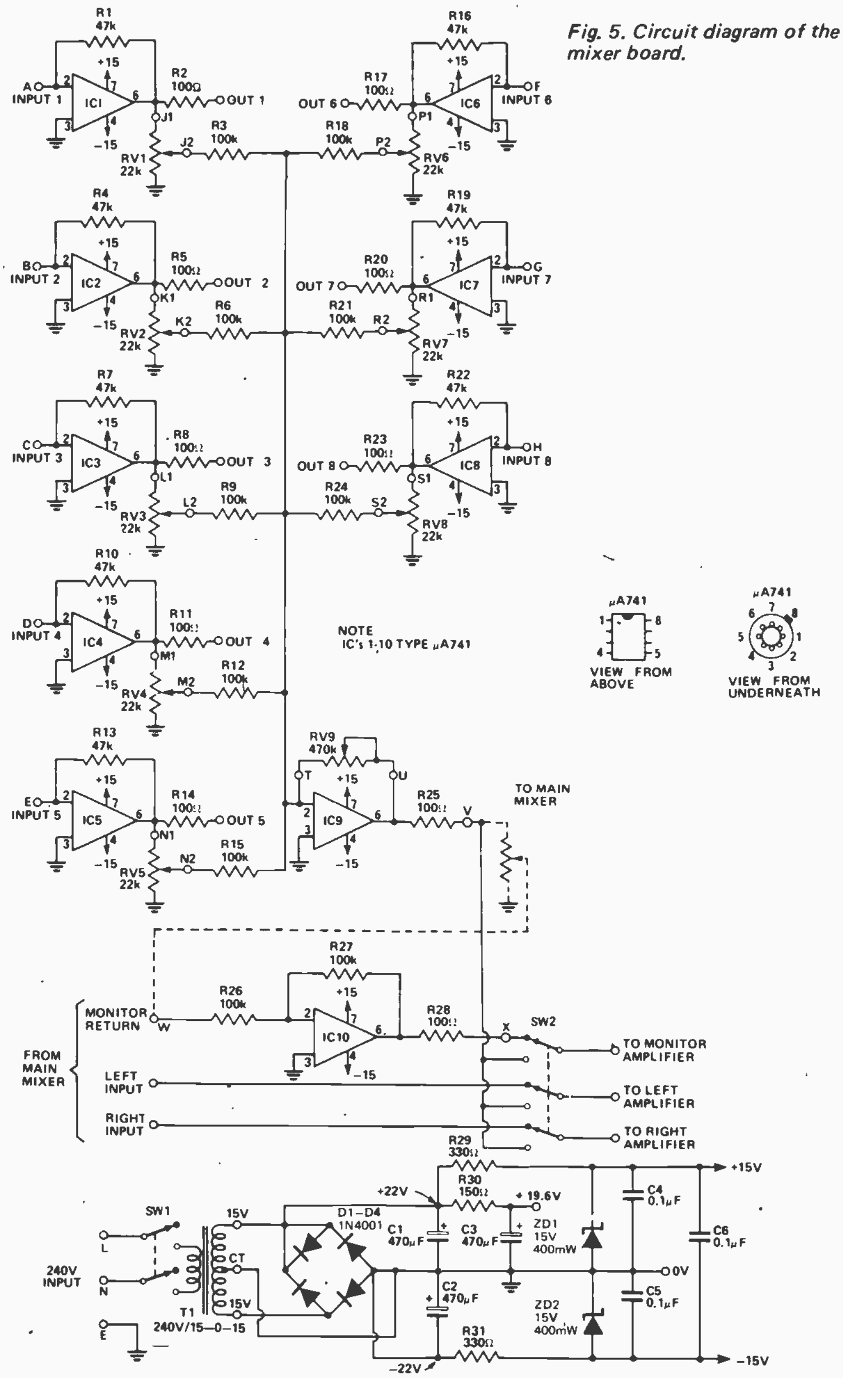


Fig. 5. Circuit diagram of the mixer board.

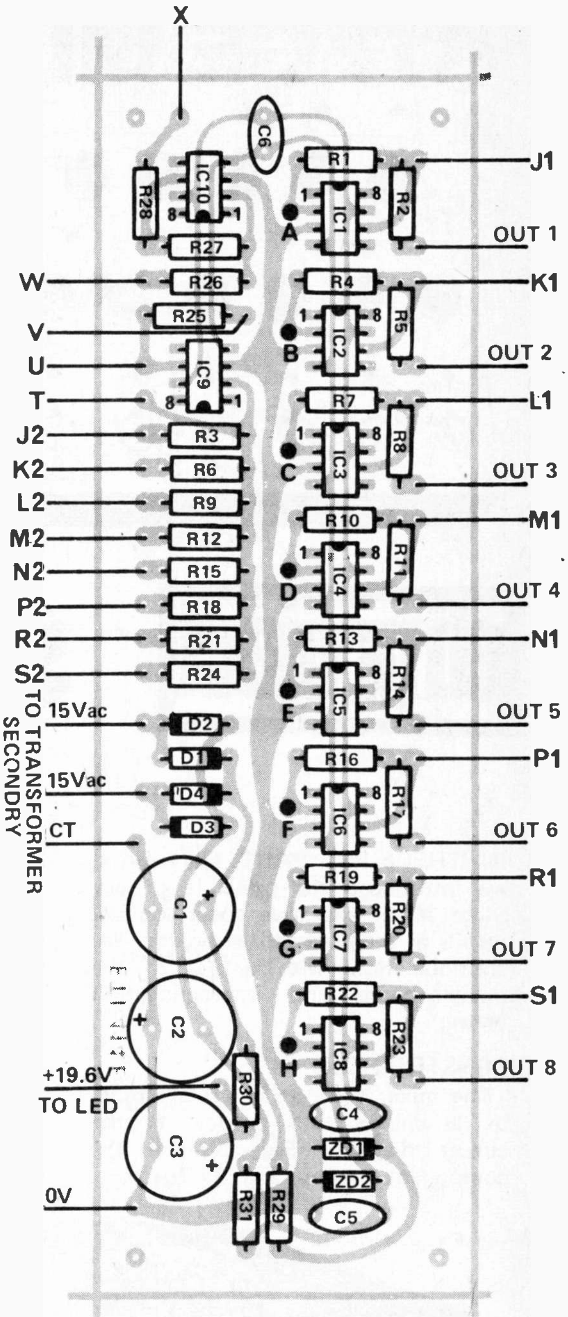


Fig. 7. Component overlay for the mixer/ power-supply board.

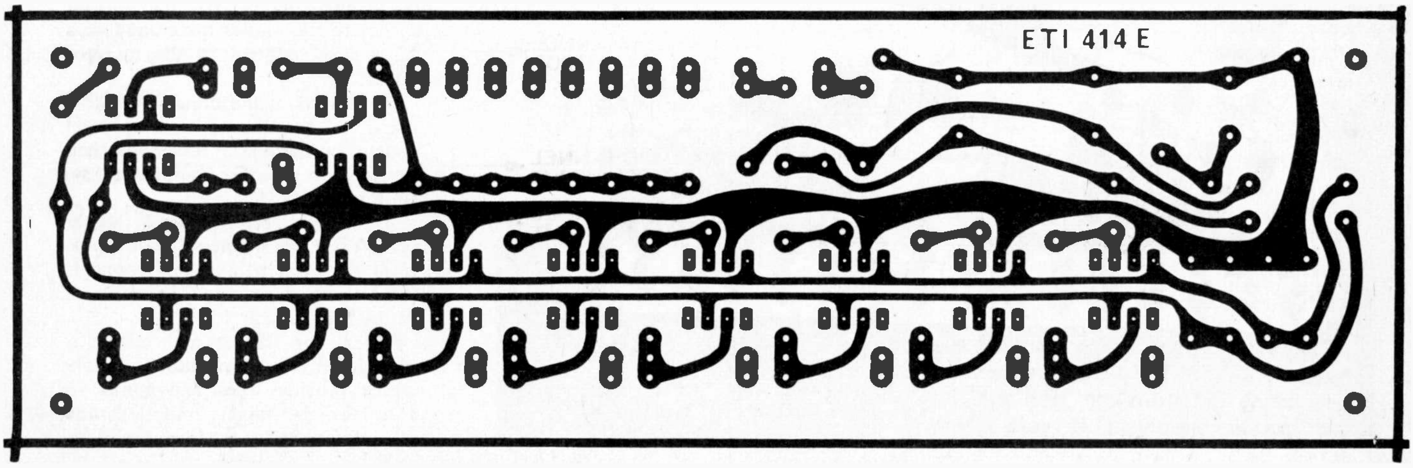
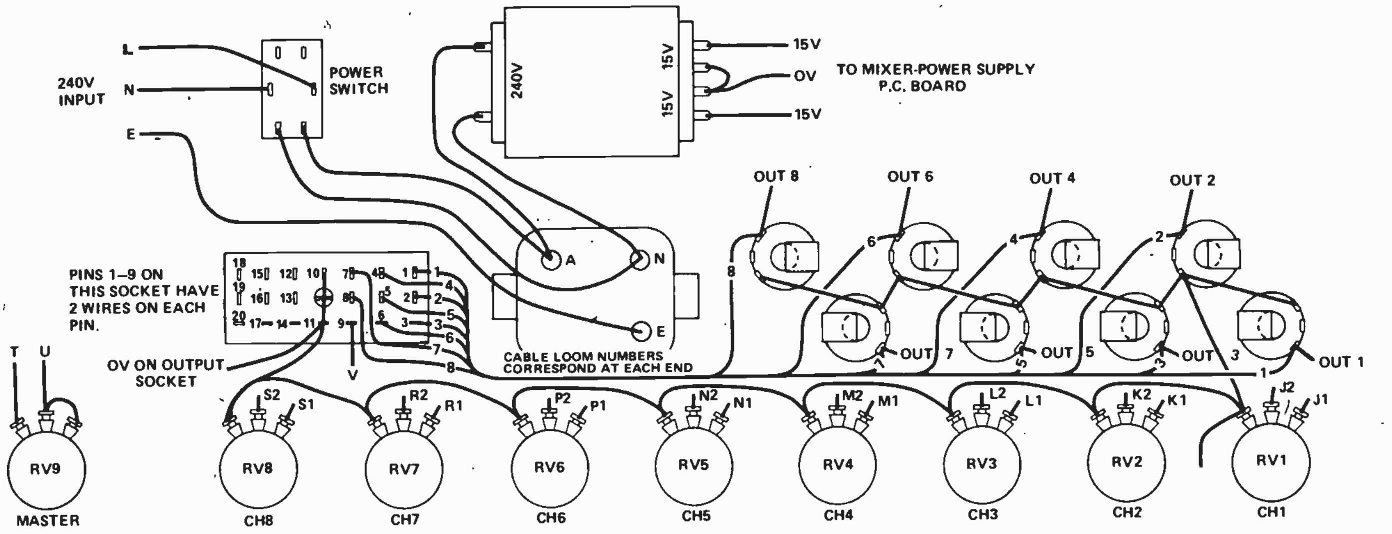


Fig. 6. Printed circuit layout for the mixer/power-supply board. Full size 182 x 57 mm.

STAGE MIXER

Fig. 9. Connection diagram for the mixer/power-supply board.



NOTE: ALL NUMBERING REFERS TO THE MIXER-POWER SUPPLY CIRCUIT DIAGRAM AND OVERLAY.

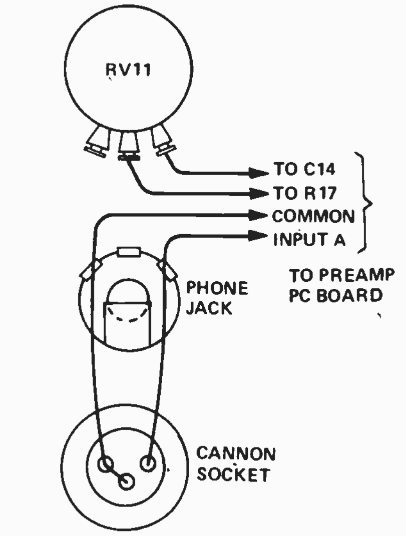


Fig. 8. Wiring to input sockets.

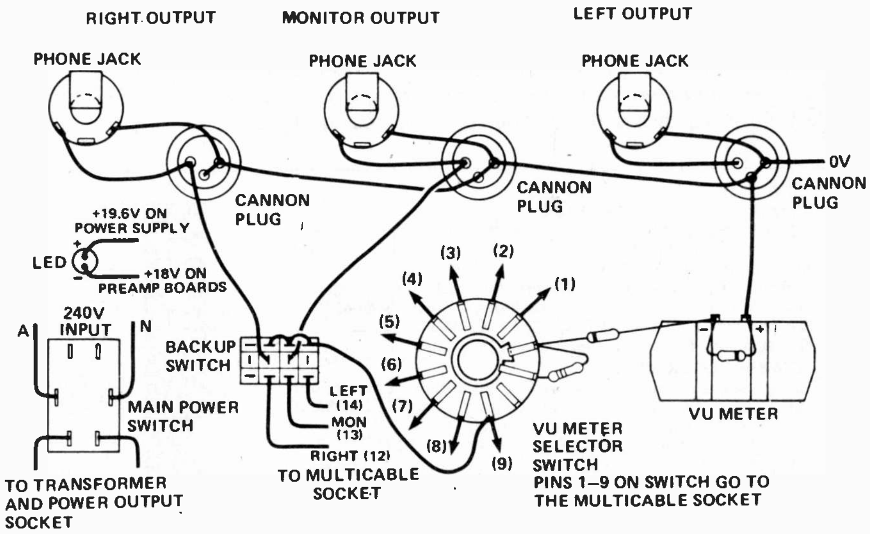


Fig. 10. Interconnection of output sockets VU meter and switch and backup switch.

Since the mixer may be subject to rough handling it is recommended that all screws be sealed in position with LOCTITE or similar compound.

Commence interconnection wiring by connecting the input sockets and potentiometers as shown in Fig. 8. This diagram shows connections to channel 1 of the preamplifiers — all other channels being similar. For neatness, we terminated these wires by soldering to the appropriate places on the underside of the board. Attach wires to the preamplifier outputs, on both boards, long enough to reach the appropriate mixer inputs. Similarly attach wires for the O volt and +18 volt supply lines.

The +18 volt supply comes from the negative side of the LED, the positive side being fed from the 19.6 volts of the power supply (1.6 volts drop across LED). When all these leads are attached, both boards may be

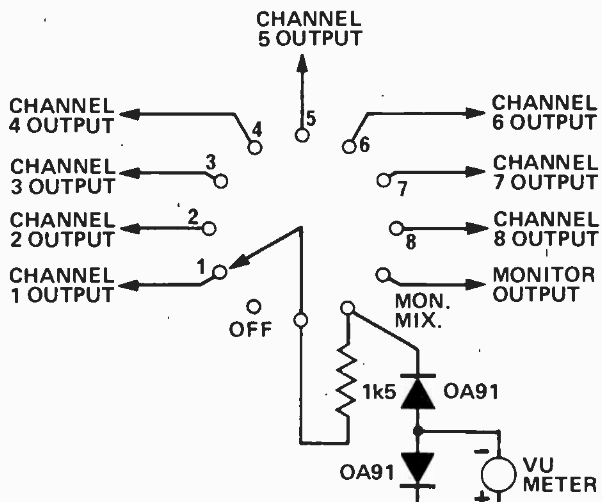


Fig. 11. Circuit diagram of the VU meter.

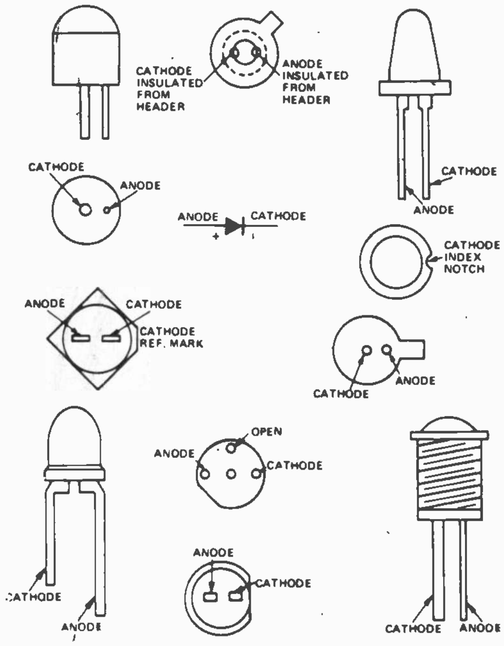
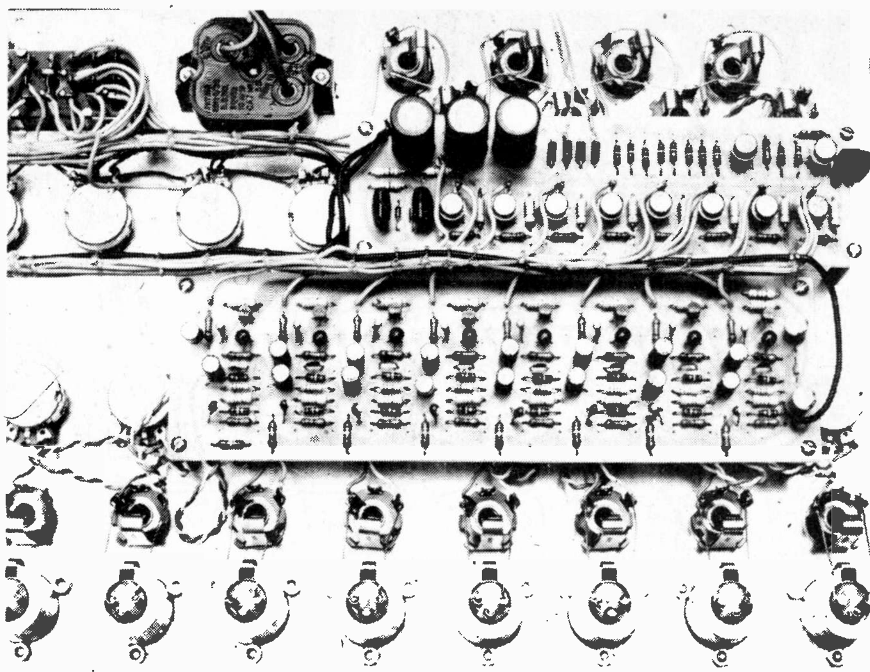


Fig. 1. Common lead connections for LED indicator lamps.

Fig. 12. Common lead connections for LED indicator lamps.



This picture shows the power supply/mixer board at top and one of the pre-amplifier boards (bottom) in position in the chassis.

mounted in position on the chassis.

The mixer/power-supply board may now be interconnected with the aid of Fig. 9. Figure 10 shows the wiring to output sockets and VU meter.

The selector switch and VU meter wiring is as shown in Fig.10 and 11. Note that pins 1 to 9 of the multi-cable socket will have 2 sets of leads, one set from the mixer outputs and one set from the VU meter selector switch. ●

£500 WORTH OF PRIZES MUST BE WON!

PRIZES

The first prize will be awarded to the design, irrespective of category, which is considered by the judges as best overall. This prize is £50 cash plus £50 worth of Doram £5 vouchers. The first prize includes the category prize.

CATEGORY PRIZES:

EACH £50 IN DORAM VOUCHERS

BEST AUDIO PROJECT
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BEST TEST EQUIPMENT PROJECT
BEST HOUSEHOLD PROJECT
BEST CAR ELECTRONIC PROJECT
BEST ELECTRONIC GAME OR TOY
BEST PROJECT IN OTHER CATEGORIES
BEST PROJECT USING I.C.'s.

RULES

1. The components used in design must all be listed in the new Doram Catalogue (Edition 2) but if necessary, common household items may also be incorporated.
2. The total cost of the project, based on the prices shown in Doram Catalogue (Edition 2) should not exceed £15.00 exclusive of VAT.
3. All designs should include at least one semiconductor.
4. Power supplies may be omitted.
5. Designs must not be of a 'critical' nature. That is, they must not depend for their operation on a critical set of component values. Devices must work as intended and within their specifications.
6. All entries must conform to details mentioned in 'How to Enter'.
7. Employees of Electronics Today International and the Electrocomponents Group are excluded from entry.
8. The judge's decision will be regarded as final.
9. There is no entry fee but all entries must be accompanied by the coupon and all entrants must have purchased the new Doram Catalogue (Edition 2).

ETI/DORAM Design Competition

Design a simple, effective and economical project and you could win one of nine prizes of £50 worth of Doram £5 vouchers — and if your entry is considered the best overall you will receive an additional £50 in cash!

All the components used (except common household objects) must be listed in the new Edition of the Doram Catalogue, but this is hardly a restriction because of the enormous range included. It is not necessary to buy any components, only to decide which to use.

The winning entries will be the most practical, ingenious and well designed in their group commensurate with the most economical use of components.

Any type of electronic or electromechanical design is eligible providing it has essentially practical value. Self contained designs will be preferred to sub-assemblies (but see note on power supplies).

ETI reserve the right to publish any of the winning entries but any material used will be paid for at our standard rates.

We know how ingenious many ETI readers are — now's your chance to prove it!

ENTRY PRESENTATION

Entries should consist of a clear circuit diagram, a full parts list and a description of the purpose and uses of the entry. A brief technical description explaining the operation and the reason for the particular design approach. The text in total should not exceed 300 words and need not be written in 'article' form but with the prime aim of giving information to the judges.

Photographs may be included if required. Entrants should keep a copy of all material submitted as ETI cannot undertake to return entries. Please ensure that every sheet of your entry and every photograph carries your name and address.

Do not send in the project; if it is necessary for the judges to see this, they will ask for it.

Each entry must be accompanied by an entry coupon and each entrant must have purchased the Doram Catalogue Edition 2 before the closing date of the competition. (Doram keep records of names and addresses of all catalogue purchases and the winners names will be checked against this before any announcement is made.)

JUDGING

Entries will be judged by a panel of three including a representative of the Electro-components Group and the Editor of Electronics Today International.

Marks will be awarded as follows:

Economical use of components	25
Practicality	25
Ingenuity	20
Engineering excellence	20
Clarity of presentation	10
	100

The prize in each category will be awarded to the entrant with the highest cumulative total. The additional £50 cash prize will be awarded to the entrant with the highest marks.

It is quite possible that when a short list of possible winners is drawn up, that the judges may wish to see the built-up project before making a final decision, readers should be prepared for this and also to give additional information. However, entrants should take no action on this until they are contacted.

To: ETI/DORAM DESIGN CONTEST
Electronics Today International
36 Ebury Street
London SW1W 0LW

Please find enclosed my entry for this competition.

Name (block letters) . . . .
ADDRESS . . . .
. . . .
. . . .
. . . .
. . . .

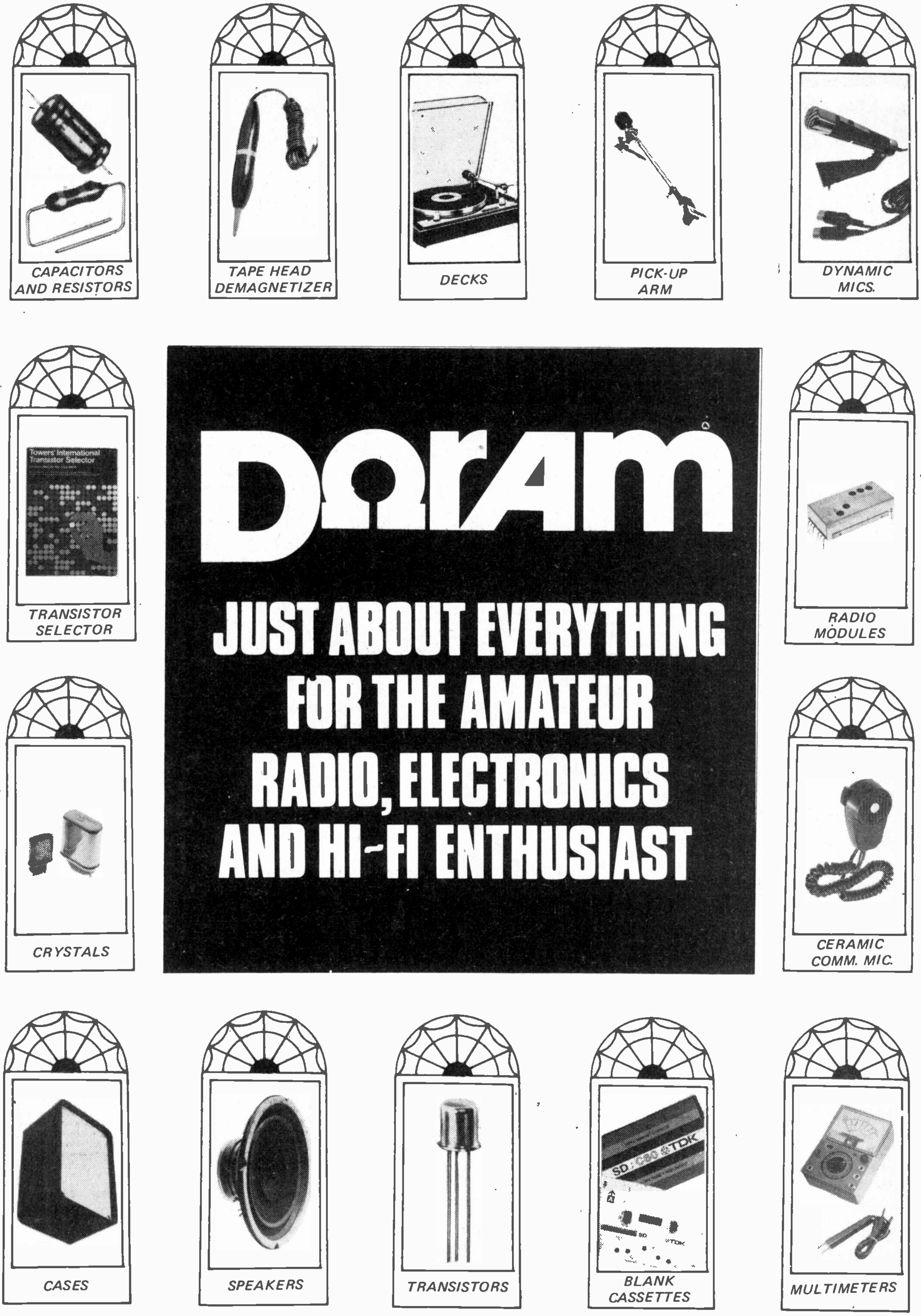
Day-time telephone number . . . .

I agree to abide by the rules and regard the judge's decision as final.

Signed . . . .

Closing date for the competition is October 31, 1975.

A separate coupon must accompany each entry — but readers may submit as many entries as they wish.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CERAMIC CARTRIDGE PREAMPLIFIER

Use of charge amplifier improves performance of ceramic cartridges.

MOST amplifiers of commercial design, including our own ETI designs, omit facilities for ceramic cartridges and allow only for the use of magnetic cartridges. This is because magnetic cartridges are capable of much better performance than ceramic although top line magnetics are much more expensive.

Magnetic cartridges are expensive to build whereas ceramic cartridges are relatively cheap to build so there is a crossover point, and many top line ceramic cartridges are much better value-for-money than are magnetic cartridges in the same price range. Hence many people with limited funds have asked for details of a preamplifier input stage specifically tailored for use with ceramic cartridges.

The two types of cartridge, ceramic and magnetic are entirely different in terms of electrical qualities. The ceramic cartridge has a much higher output, the working load impedances of the two are entirely different and the magnetic type requires equalization whereas the ceramic type does not (or does it?). The magnetic provides an output which is proportional to stylus velocity whilst the ceramic provides an output proportional to acceleration. This means that where a record is recorded with constant acceleration characteristic the output from a ceramic cartridge would be flat with frequency whereas the output from a magnetic cartridge would be a response rising with frequency at 6 dB/octave. Converseley if a constant velocity record characteristic were used the ceramic output would fall with frequency at 6 dB/octave.

Today all records are recorded to the RIAA standard of equalization. This attenuates bass and boosts treble to provide a characteristic very close to constant acceleration. This procedure gives best compromise between the conflicting requirements signal-to-noise ratio and of pickup trackability. To replay an RIAA equalized record with a magnetic cartridge we must use a preamplifier having the reverse characteristic, i.e, bass must be boosted and treble must be cut in order to obtain a flat frequency response. This process is used on all preamplifiers for magnetic cartridges and is loosely just known as equalization.

However a *perfect* ceramic cartridge, when replaying RIAA equalized material would give an unequalized response as shown in Fig. 1. In order the make ceramic cartridges easier to use manufacturers build in a broad mechanical resonance at the high frequency end to boost the response. At the low end, the rise in response below 50 Hz is cured by selecting a terminating impedance which causes a roll off at about 130 Hz. The response of such a cartridge would be as shown in Fig. 2. If the bass end were not corrected rumble of the turntable would be accentuated and this is clearly not desirable.

Thus clearly, the impedance into which a ceramic cartridge works is of great importance and with this in mind we investigated different methods of matching the cartridge to the amplifier with a view to obtaining the utmost from ceramic cartridges.

DESIGN APPROACH

The ceramic pickup may be simulated by a voltage source and a series capacitor.

The value of the capacitor and the magnitude of the voltage source vary

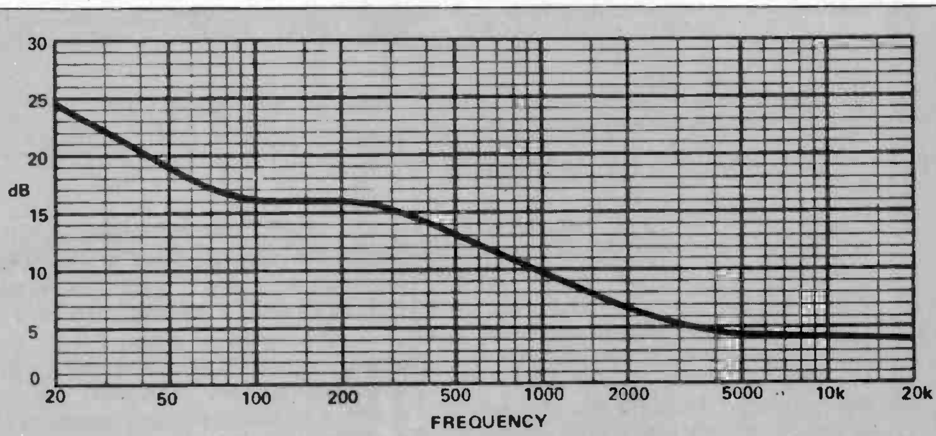

Fig. 1. Typical response of a ceramic pickup without mechanical equalization.

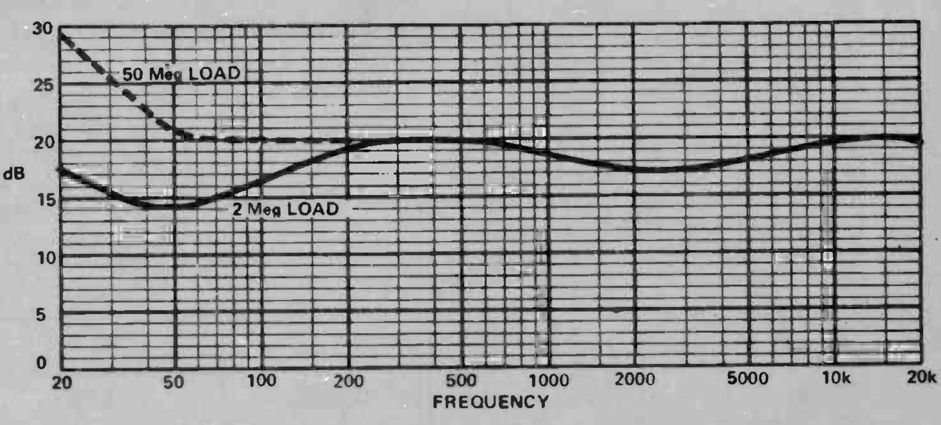

Fig. 2. Response of Decca Deram showing effect of terminating impedance at low end and of mechanical equalization at top end.

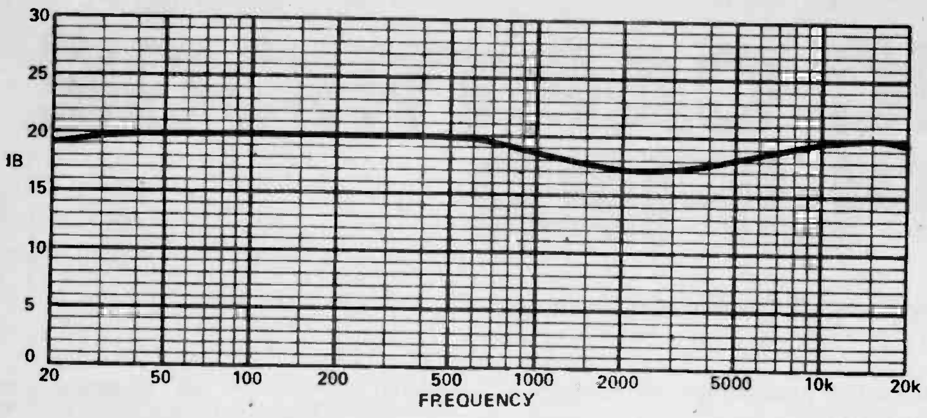

Fig. 3. Overall response of a Decca Deram into a charge amplifier.

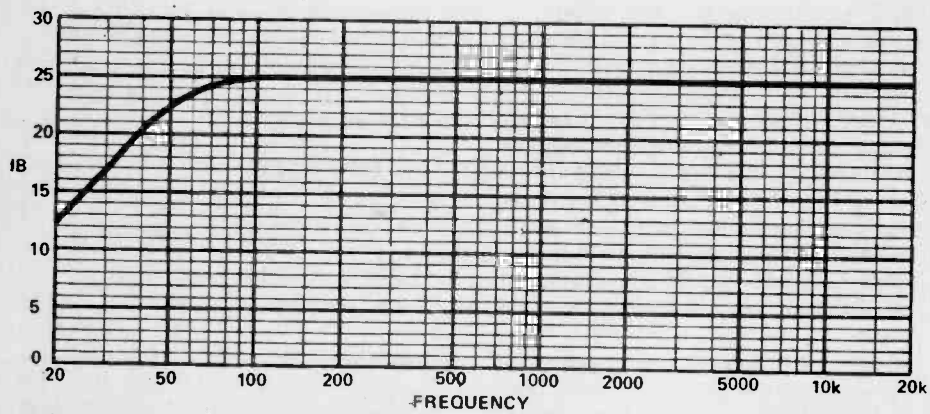

Fig. 4. Response of charge amplifier. Roll off at low end is designed to compensate for rising response of cartridge in this area.

from manufacturer to manufacturer but lie in the range 200-900 pF and 100 to 1000 mV at 1 kHz and 5cms/second.

One of the most popular and readily available cartridges is the Decca Deram and we performed all our tests with this cartridge. The unit has an output of about 150 mV and a capacitance of 600 pF. The recommended load impedance is 2 megohms and this gives the response as shown in Fig. 2. The bass response can be improved but only at the expense of greatly increasing the rumble. The dip at 2 kHz can readily be compensated for but we have not experimented in this area.

Another system commonly used is to load the unit with a low impedance (e.g. 75 k ohm) which causes a loss of bass below 3 kHz, and then boost the bass again electronically. This overcomes the need for a very high impedance. Such a technique combined with a rumble filter to cut the rising response below 50 Hz can give good results. However due to the large differences between various makes a different network needs to be designed to suit the bass roll-off characteristic of each cartridge type.

A third system which we propose, and to our knowledge this is the first time such a system has been described, is to use a "charge" amplifier.

CHARGE AMPLIFIER

With the charge amplifier the input impedance is zero — how then does it work? A conventional inverting amplifier is shown in Fig. 5. and, as anyone familiar with amplifiers will know, the output voltage will be:—

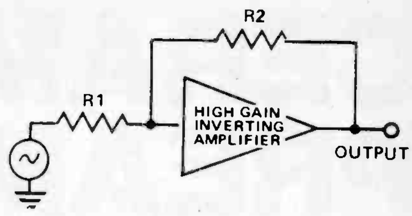

Fig. 5. Conventional inverting amplifier stage.

$$V_{out} = \frac{R2}{R1} \cdot Vin$$

What is not always realized by beginners is that R1 and R2 need not be resistive — they may be capacitors, inductors or combination of impedances. It is only the impedance that is important. Since the output of the ceramic pickup is a capacitor we may connect it directly to the input of an inverting amplifier and use a capacitor as the feedback element. The gain of the stage now becomes the ratio of the two capacitor impedances. Although the impedance of the capacitor drops with increasing frequency the ratio remains constant. Therefore, with a 'perfect' amplifier, the *frequency response is flat at* all frequencies.

In real circuits we generally need a bias resistor across the feedback capacitor. This causes a roll-off at the low end similar to that obtained when using a FET amplifier.

If a response down to 10 Hz is required a resistance of 50 megohm minimum is required. However this is

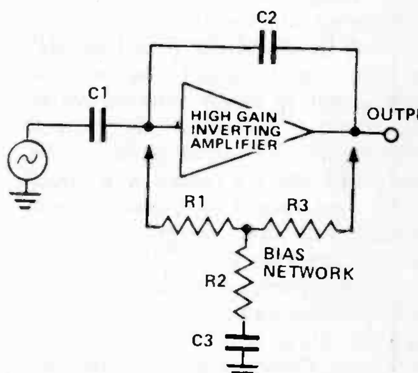

Fig. 6. Basic charge amplifier with bias and filter network. Gain control elements are capacitors. Bias network R1, 2, 3 and C3 are required for dc stability and to roll of bass response.

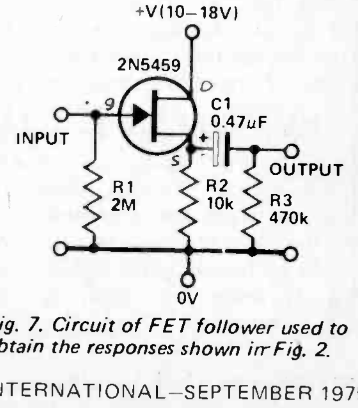

Fig. 7. Circuit of FET follower used to obtain the responses shown in Fig. 2.

TABLE 1

GAIN (600 pF cartridge)	C2	C3	R4
unity	560 pF	0.0082μF	390 k
6 dB	330 pF	0.015μF	180 k
12 dB	150 pF	0.039μF	47 k

much too high for correct biassing and a different technique is called for.

With the arrangement illustrated in Fig. 6, the effective resistance is:—

$$R_{eff} = \frac{R2 + R3}{R2} \cdot R1$$

provided R2 << R1, 3 and X_{C3} << R2

If the value of X_{C3} approaches R2 the effective resistance drops and, if the value of R2 and C3 are properly chosen, a 12 dB/octave cut-off at the low end can be obtained which effectively removes the rising low-end response due to the recording characteristic.

Other advantages of the charge amplifier are firstly that it is easy to obtain gain (unlike the source — follower FET approach) and secondly that cable capacitance does not affect the performance in any way. One disadvantage is that the cables are slightly microphonic and movement of the leads can cause an output — this however is not an insurmountable problem.

The overall response of the Decca Deram Cartridge into a charge amplifier is given in Fig. 3, and as can be seen the response at the low end is greatly improved. As said before the drop around 2 kHz could readily be compensated for but this was not considered necessary.

If a pickup having a different capacitance were to be used the only change would be in the gain of the amplifier — the frequency response (of the amplifier) remains the same. If the gain is too high then simply changing the feedback capacitor to a higher value will restore it. However, if the low frequency cut-off is to be maintained both R4 and C3 must also be altered. Table 1 illustrates the values required.

CONCLUSION

Cost for cost the ceramic cartridge is better value for money than the magnetic type. The use of a properly designed preamplifier can produce a substantially flat response.

However whilst an almost perfect frequency response can be obtained by properly processing the output from a cartridge like the Decca Deram it can *never* sound like the Shure V15 MK 3! Other factors such as transient response and channel separation are generally not as good as those of a magnetic cartridge. Whether the inbuilt mechanical resonance is actually responsible for the poor transient response is probably known only to the cartridge manufacturers — one feels that if it were done electronically it may well be better.

This has not been presented as a normal project but rather as a basis for experimentation. The circuit described has been built up and does give the response expected. Try it. The results may be surprising. ●

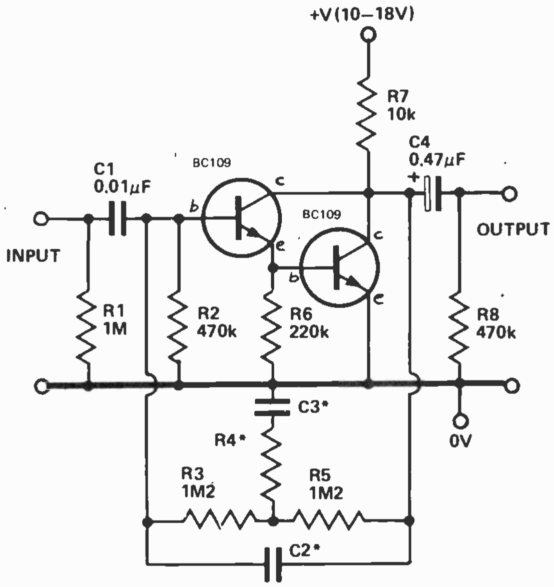

Fig. 8. Circuit of practical charge amplifier for ceramic cartridges which gave the overall response as in Fig. 4. For values of C2, 3 and R4 see table 1.

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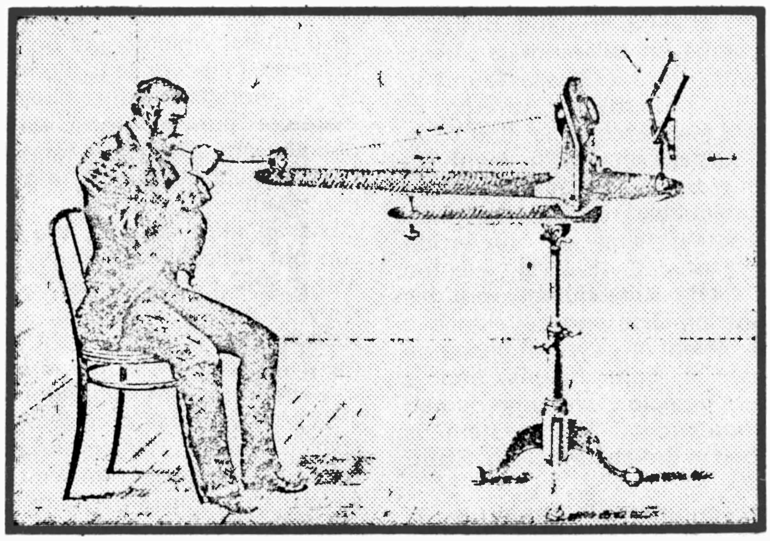
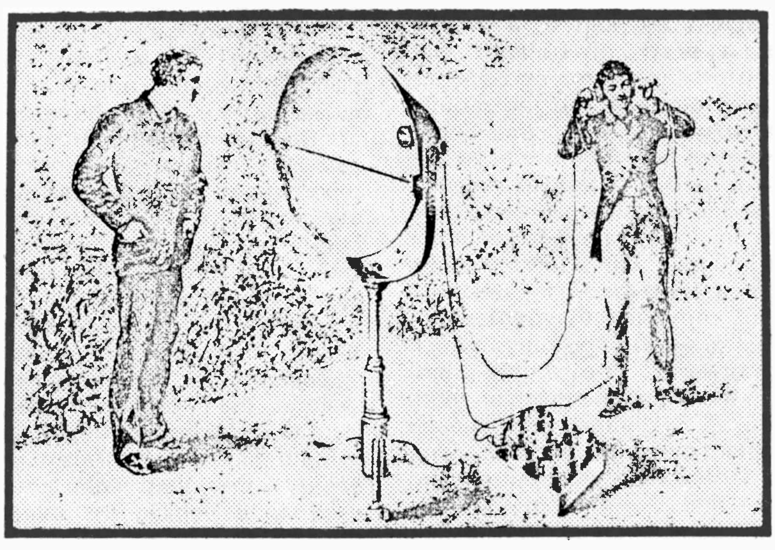
The Photophone

THE TERMS 'RADIO' AND 'WIRELESS' are now usually taken as referring to the transmission and reception of signals using 'radio waves'. In the early 1880s, more than 10 years before Marconi's first experiments, these terms were also used but had different connotations.

Wireless telegraphy, or the transmission of signals without using wires to link the transmitter and receiver, had long been an aim of mankind and by 1880 many such systems had been devised and tried out. There were, for example, electrical wireless systems relying on induction between spaced current carrying wires, and systems involving the use of the ground or waterways as electrical conductors. Some of these induction and 'earth leakage' systems were described in the article on Early Radio Patents in the June 1974 edition of ETI. There were also optical signalling systems using shuttered lights, and indeed a chain of optical relay stations was set up at the end of the 18th century and used to pass a daily time signal between London and Portsmouth.





OPTICAL COMMUNICATIONS

Optical signalling systems have always been particularly popular and perhaps one of the earliest examples of this is simply the candle in a window to guide the homecoming traveller! A system involving somewhat more sophisticated apparatus, if equally undiscriminating in its broadcasting of information, followed on the development of the electric light: a beam of light from a powerful arc lamp was projected on to a cloud and signals were transmitted by shuttering the beam. This is probably the only communication system which is dependent for good operation on poor weather!

SPEAKING ALONG SUN SUNBEAMS

All of the optical systems tried out by 1880 had however one thing in common, they could not be used to transmit continuously fluctuating signals such as speech and music; except, that is, for the system developed that year by the famous Scottish-American inventor, *Alexander Graham Bell*. With Bell's system it became possible at last to *"speak along a sun-beam"*, as a contemporary writer put it.

Bell had a profound interest in the mechanism of speech, arising out of his own and his father's work with deaf and dumb children, and this interest spread to a study of mechanical speech reproducing devices and his search for a device to convert speech into electrical signals which could be transmitted along a wire. He eventually solved this problem in 1875, when he was only 28, whilst experimenting with a harmonic telegraph: a telegraph system

The Photophone

using different tones to enable several messages to be transmitted simultaneously along the same wire. By accident he found that one of the tone generators, made from a thin metal diaphragm vibrating close to a solenoid, would transmit speech when wrongly adjusted; and the telephone was born.

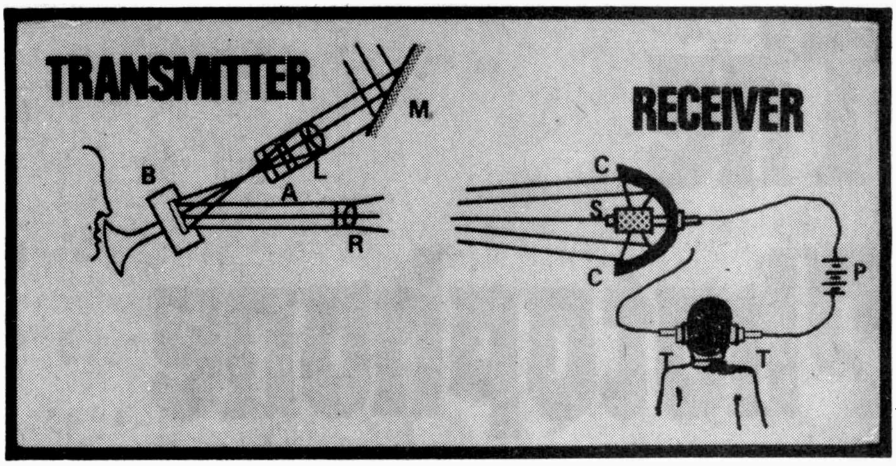
SELENIUM

Later, whilst in England, Bell saw experiments on selenium, a substance which in 1873 was found to have the property of varying in electrical resistance when illuminated. He was still preoccupied with his experiments on the telephone,and he immediately realised that here was another way of converting speech into fluctuating electric currents. He subsequently put his idea into practice and developed a wireless telephony system based on the use of light beams and a selenium detector, which he named the *Photophone*. This system is described in British Patent No. 3885 of 1880.

The original Photophone as described in Bell's Patent used as the transmitter a thin flexible mirror fixed across the end of a mouthpiece. A beam of sunlight was focused on the mirror and speech vibrations directed into the mouthpiece caused the mirror and hence the beam of light to vibrate. At the receiving end a parabolic reflector was used to focus the vibrating light beam on to a selenium detector wired in circuit with a battery and a telephone receiver. The selenium detector converted the light vibrations into electric currents which were converted into sound vibrations in the telephone receiver. With this set up Bell transmitted speech over short distances without using wires to link the transmitter and receiver and the Photophone may thus be considered to be the first telephonic wireless system.

FURTHER EXPERIMENTS

Bell did not restrict his researches to selenium but concerned himself more broadly with all substances which when exposed to radiant energy undergo *"changes which the sense of touch or the sense of sight has not been able to take notice of."* This changed condition he suggested *"may be fitly called a state of strain."* In addition to selenium he suggested the use of thin sheets of



hard rubber which could be caused to vibrate in response to illumination by a vibrating light beam and therefore convert light variations directly into sounds. A long list of other suitable materials is given in the Patent.

As an alternative to the use of sunlight reflected from a vibrated mirror, the Patent refers to a well known device used to convert speech into vibrating light — the manometric flame apparatus. With this apparatus, the supply of gas to a flame is varied in accordance with speech vibrations by passing the gas through a chamber, the volume of which can be varied by vibration of a diaphragm.

OTHER WORKERS

Bell was not the only person to be considering wireless transmissions using light beams, and in an article in *The Times* in 1881 the researches of Bell in conjunction with his associate Sumner Tainter were reported and reference was made to the similar work being done in Europe by Rontgen, Tyndall, Mercadier, and Preece. Mercadier was particularly active in this field and he derived the term *'radio'* from *'radiant energy'* to produce the generic term *'radiophone'* for telephonic wireless systems, the Photophone being one form of radiophone. Mercadier had in mind the fact that forms of radiant energy other than light could be used as a vehicle for telephonic transmissions although he was thinking more of the kind of devices which we now associate with the term 'radio'.

The article in *The Times* went on to refer to the work being done by Bell and Tainter as described in a paper submitted to the Academy of Arts and Sciences in the U.S.A. and this included the substitution of lamp black for selenium and the invention of a rather interesting device which Bell and Tainter called the *Spectrophone*.

THE INVISIBLE SPECTRUM

Contemporary laboratory instruments enabled scientists to examine the wavelengths absorbed by various substances in the visible spectrum. Bell and Tainter realised that an instrument capable of also operating outside the visible region would be an invaluable research aid and with this in mind they proposed a variation on the basic Photophone which was capable of scanning the *'invisible'* as well as the visible spectrum and would convert detected radiant energy into sounds. This enabled scientists to hear the characteristic absorption pattern of a substance.

Bell's Photophone raised a great deal of interest at first but was then quickly written off as being no more than a toy because the distance over which a light beam could be transmitted at a sufficent level of intensity to operate the receiver was very limited. The problem was that for effective long distance transmission a closely parallel high energy beam of light was required and as everyone knows a light beam of this kind is a sheer impossibility! Or rather it was before the laser was invented. Now, long distance photophonic communications is very much a practical proposition and indeed has important advantages in certain respects, particularly where a high security communications link is required.

Bell's original ideas on the Photophonic stemmed from his work on the telephone and a search for an alternative to the use of wires to link the transmitter and receiver. Ironically, history now repeats itself and, as reported for example in the April 1973 edition of ETI, laser beam photophonic communication systems have been developed as a consequence of a search for alternative ways of supplementing existing overload telephone cable links. ●

ELECTRONIC ONE-ARM BANDIT

PART TWO

The final part of our special project article gives all the constructional details.

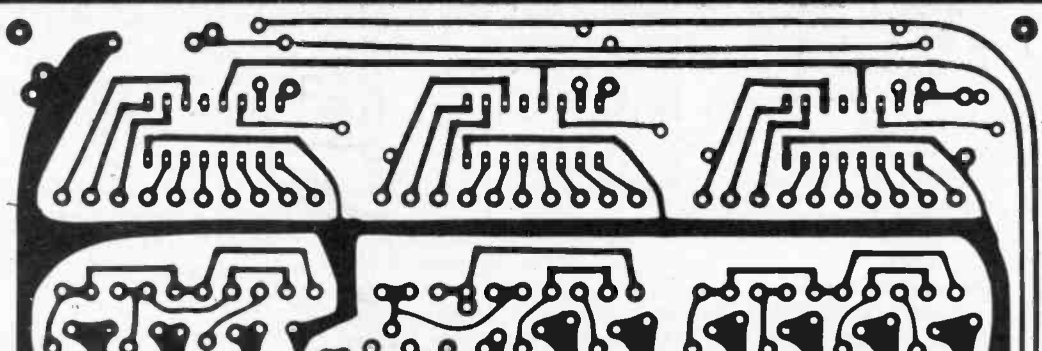


Fig. 1. Printed circuit design for the main logic board.

CONSTRUCTION

Because of circuit complexity it is recommended that printed-circuit boards be used as their use will greatly simplify construction.

When assembling components to the printed circuit boards take particular care to correctly orientate integrated circuits, electrolytic capacitors, diodes and transistors. Construction should commence by installing links to the logic board in accordance with overlay diagram Fig. 4. Make sure that the supply-rail decoupling capacitors C2, 3, 16, 17, 22 and 23 are ceramic types for best possible bypassing.

On the display board Q1, Q2 and C1 should be laid flat on the PC board so that there is sufficient clearance when the board is mounted to the front panel. The leads of the LEDs were bent to form the shape of a circle (don't bend close to the body of the LED or the lead will fracture) thus giving a spring action against the rear of the panel.

When assembling the main logic board, use care with integrated circuits IC11, 12, 13, 14 and 17. These are CMOS devices and are easily damaged by static discharges. Avoid handling the pins, insert them after all other components are mounted and insert them as quickly and cleanly as possible. Lastly with these ICs, and indeed all semiconductors avoid overheating the device when soldering. Apply the iron only long enough to obtain a good joint.

Interconnect the two boards as shown in Fig. 7. Keep the leads as short as possible especially power supply leads E, D and G as interference picked up on these leads could affect the operation of the machine. Also at this time attach leads to the outputs of the boards which are long enough to reach the switches and power supply.

Both boards may now be mounted on the rear of the sloping front panel. Making sure that the LEDs are aligned with the holes, mount the display panel (component side towards rear of panel) by means of 19 mm countersunk screws. Space the board from the front panel about 8 mm by means of a pair of nuts or plain spacers. Hold the board in position by screwing 12 mm spacers onto the protruding screws. Now attach the logic board by screwing to the 12 mm spacers (component side away from front panel).

The power supply is built into the bottom of the box and wired up as in Fig. 5. An eight-way tag strip being used to support all the components. Make sure that the polarities of the diodes and electrolytic capacitors are correct. The five volt regulator, IC 18, is bolted to the bottom of the box after first scratching away the paint so that good thermal conduction is obtained — a little silicon grease between tab and box will help. When mounting the tag strip make sure that both earth lugs have good electrical contact with the box.

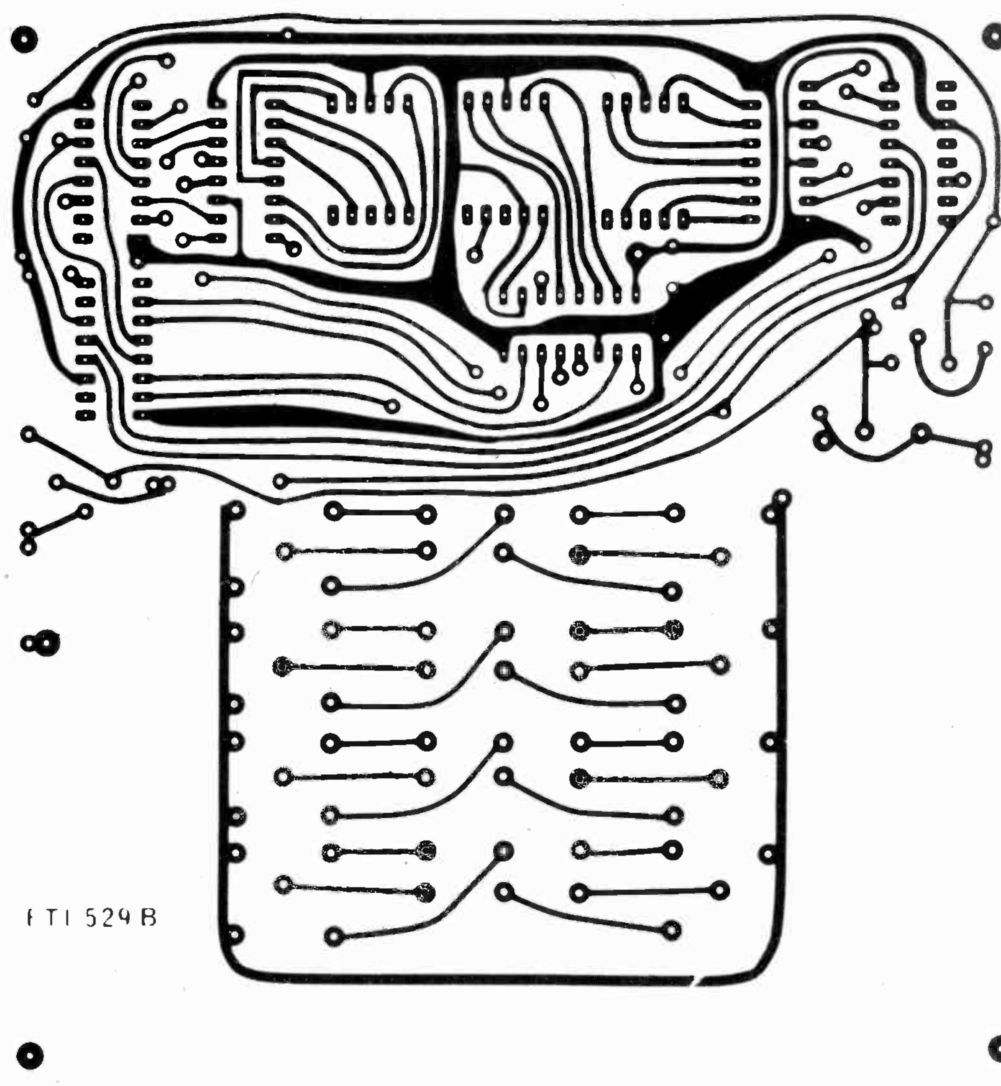


Fig. 2. Printed circuit design for the display board.

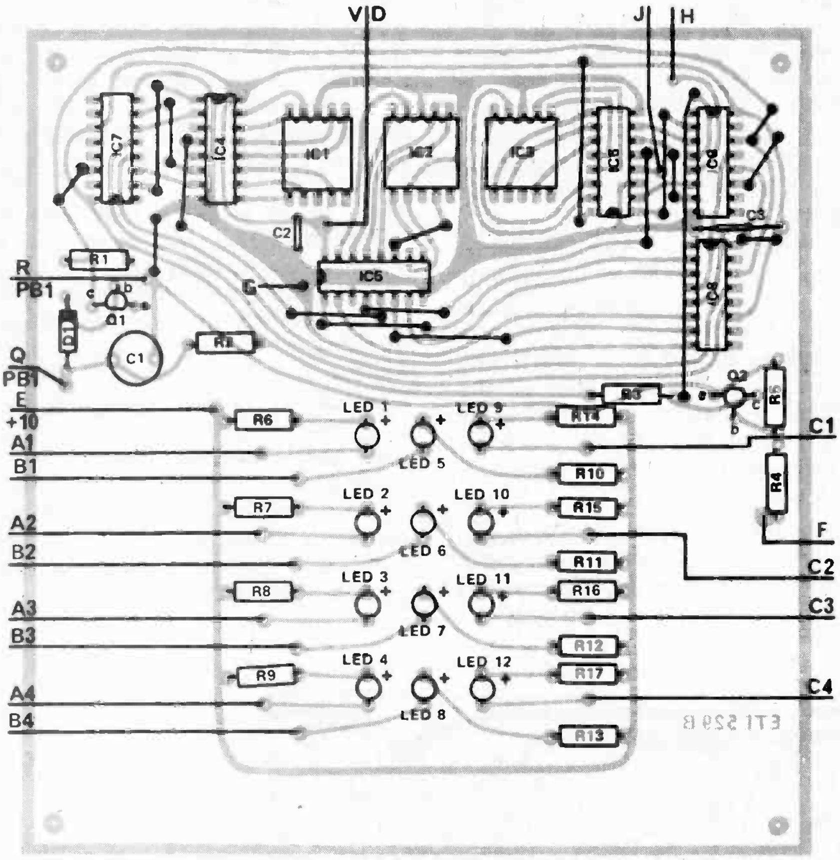
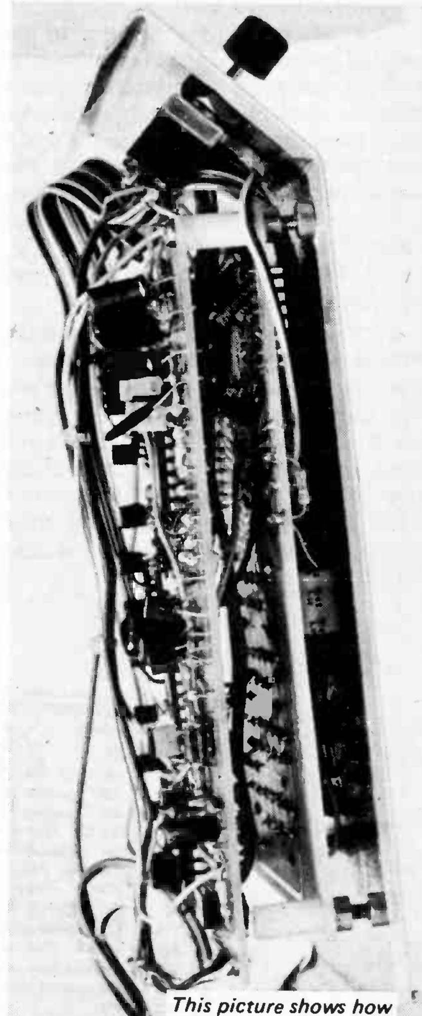


Fig. 3. Component overlay for display board.



This picture shows how the two boards are mounted to the rear of the front panel

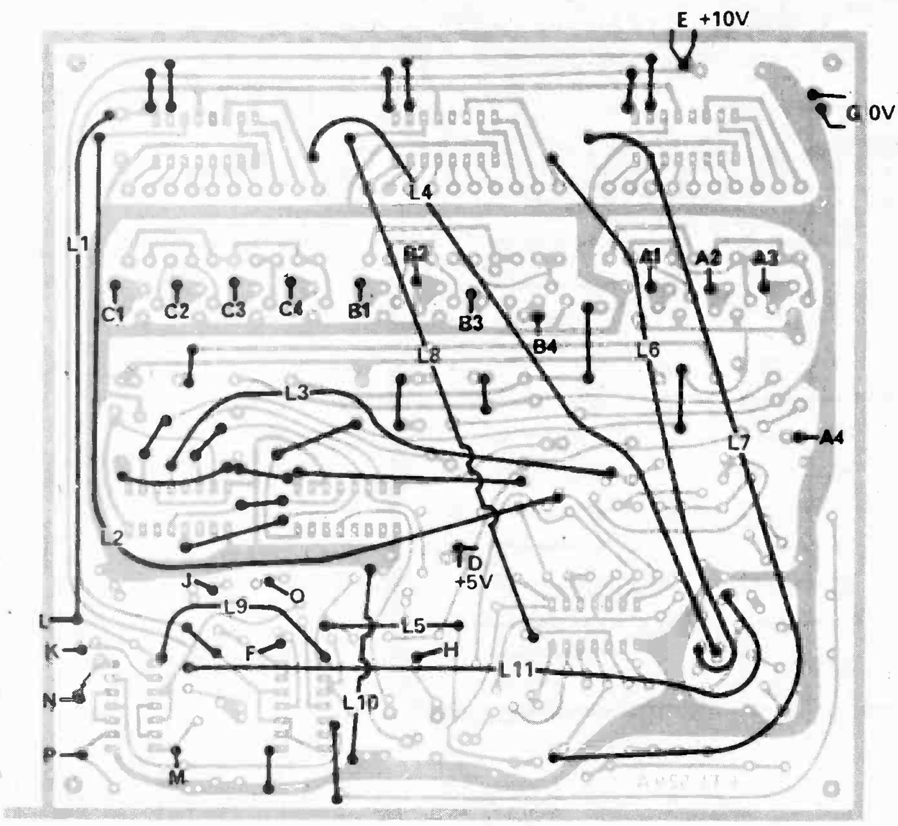


Fig. 4. Linking diagram for the logic board.

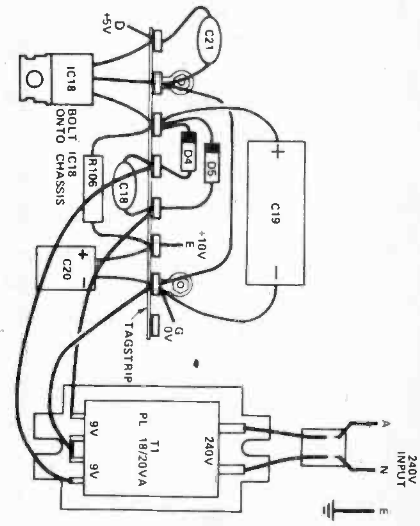


Fig. 5. Wiring of the power supply.

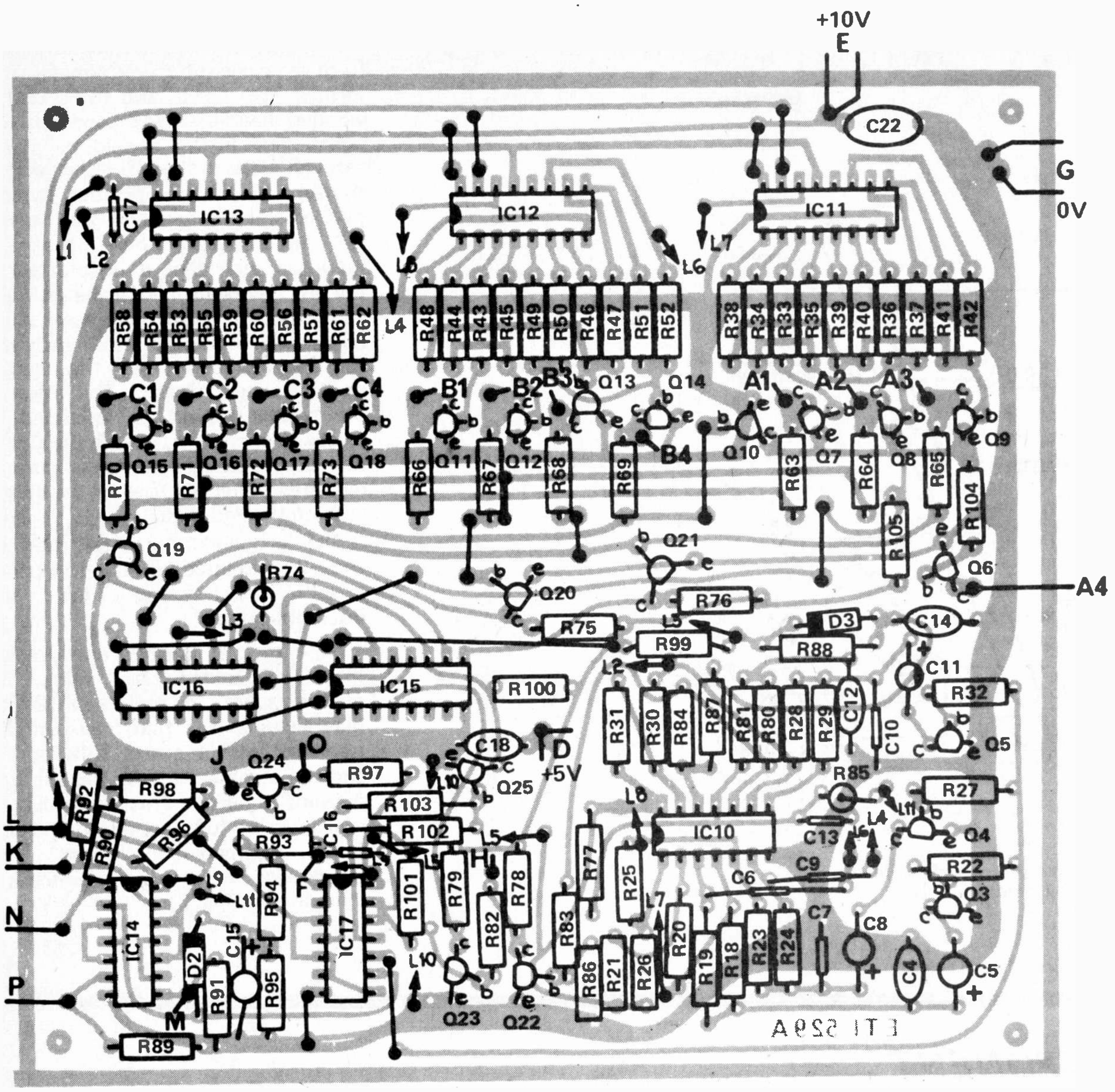


Fig. 6. Component overlay for the logic board.

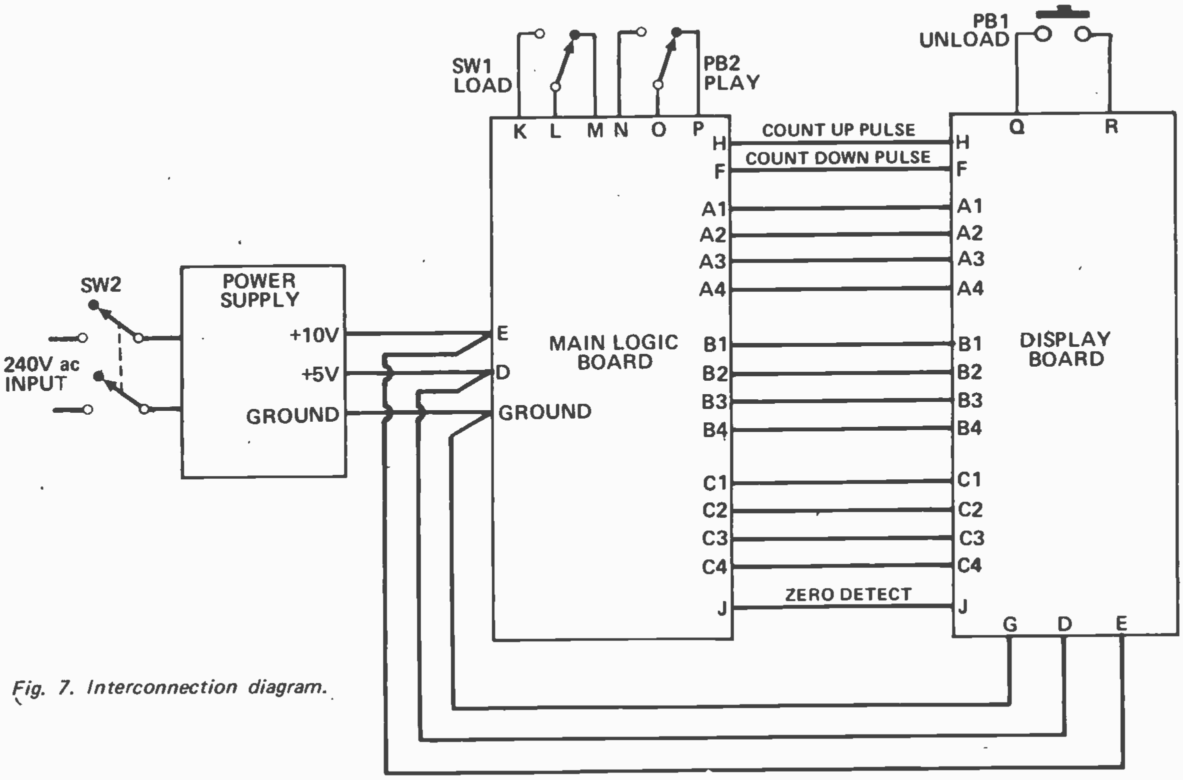


Fig. 7. Interconnection diagram.

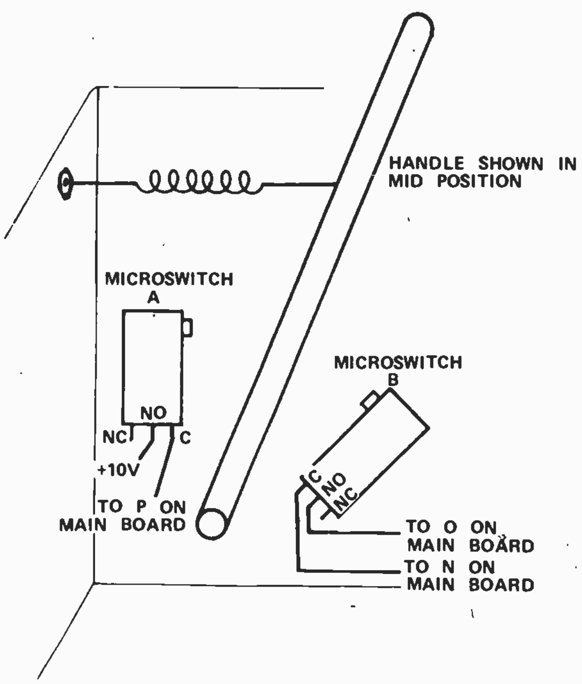


Fig. 8. Alternate arrangement of two micro-switches on the play handle.

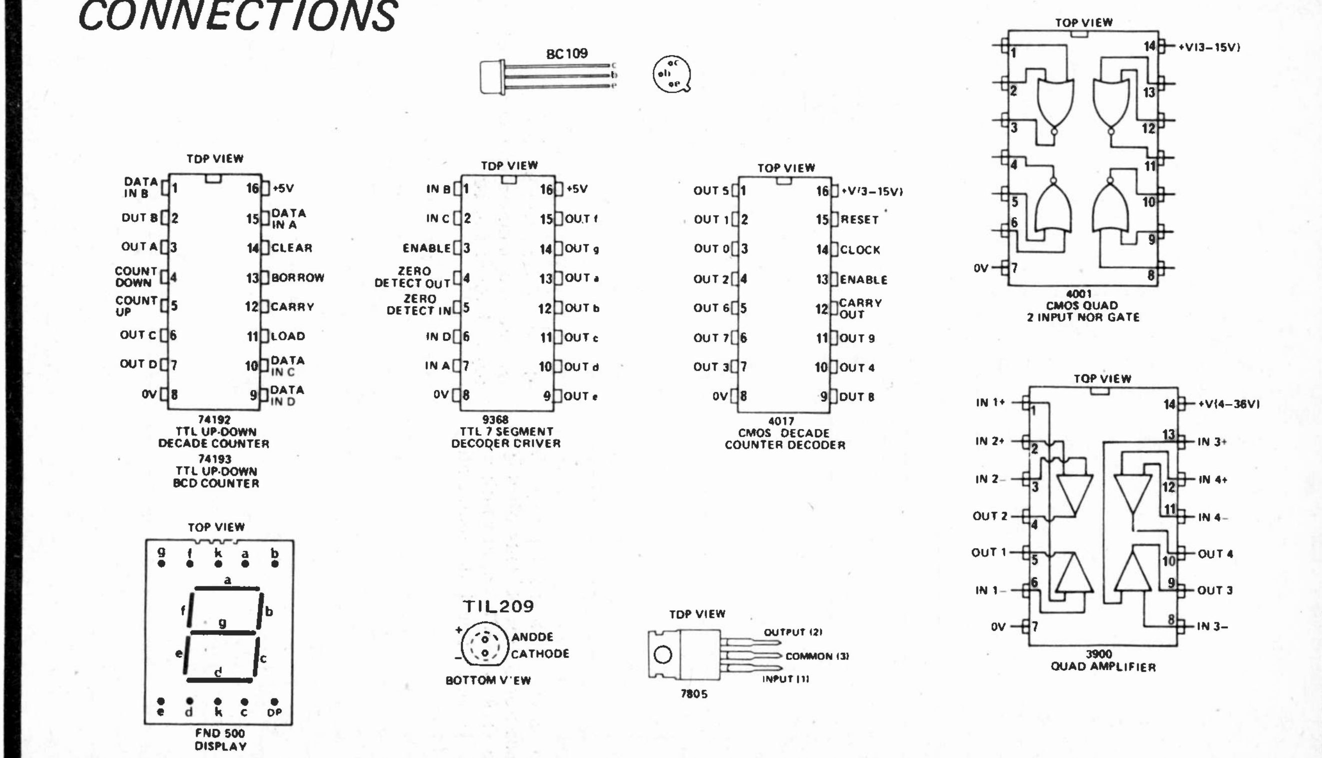
The play handle may be fashioned from a piece of 6 mm metal rod, formed into an 'L' and fitted with a wooden handle (a file handle is just right). The handle should be passed through holes drilled in either side of the box and held in position by split pins or small collars and grub screws.

A microswitch may then be mounted such that it is actuated by the grub screw (or end of the split pin) when the arm is pulled forward. A pin and spring should be fitted such that the handle returns to the upright position when released. The travel of the handle should be restricted by means of two bolts through the side of the case. Rubber grommets may be mounted under the head of the bolt to cushion the end stop.

The 'load' and 'unload' switches may then be mounted on the top of the front panel and the unit interconnected.

Note that, if desired, extra realism may be added by using two microswitches to replace SW2 (the play switch). The first microswitch is operated with the arm fully vertical and the second one with the arm fully forward as before. This means that the arm must be fully depressed and then fully returned for each play. Connection of the microswitches is illustrated in Fig. 8.

COMPONENT CONNECTIONS



HOW IT WORKS ETI 529

Before reading this section it is advisable to read last month's general description to obtain an understanding of the overall system used.

The roller counters IC11, 12 and 13 are CMOS decade counters and decoders. These counters provide a high output on only one of the ten output lines for each and, when enabled, this high will shift through the outputs at a rate determined by an oscillator (IC 10A, B and C respectively) associated with each counter. The oscillators run continuously but the counters are only enabled when pins 13 are taken low.

The outputs of the roller counters are taken via resistors R33 through R62 to the 'odds decoders' Q7, 8, 9, and 11 through 18. These transistors are wired as resistor/transistor NOR gates. Thus, for example, the collector of Q14 will be low when ever any of IC12 pins 5, 6, 9 or 11 are high. When the collector of Q14 is low the roller indicator LED, connected to B4, will be illuminated.

Note that the emitters of Q7, 8 and 9 are grounded via Q10. Therefore if Q10 is off Q7, 8 and 9 are disabled. Transistor Q10 is off only when Q14 and Q18 are both on, in which case Q6 is also turned on illuminating LED A4.

The four pay conditions are decoded by Q19, 20, 21 and Q10 which are all wired as NOR gates. For example, when a jackpot occurs, pins 3 on IC11, 12 and 13 all will be high causing Q7, 11 and 15 to conduct. Hence Q19 base will be at ground potential and its collector at +5 volts. This high will be transferred to the payout counters IC15 and 16. These ICs are up/down binary counters which can be preset to any desired count by applying a four line code to pins 1, 9, 10 and 15. Pin 15, 1, 10 and 9 have weights of 1, 2, 4 and 8 respectively on IC15 and, as IC15 drives IC16, will have weights of 16, 32, 64 and 128 on IC16.

Returning now to our jackpot conditions, the high from Q19 will appear at pin 10 of IC15 (weight 4) and pins 1 and 10 of IC16 (weight 32 and 64 respectively). Hence the counter will be loaded with 64 + 32 + 4 = 100. When the counters are not at zero the 'borrow' output pin 13 will be high. This high is delayed by R88 and C14 and passed to oscillator 4 (IC 10d) gating it on. A train of positive going pulses is generated which is inverted by Q22 and passed, via terminal H, to pin 5 of IC9 thus incrementing the display counter. At the same time IC15 and 16 are also decremented by the same pulse train via Q23. When IC15 and 16 reach zero the borrow output goes low stopping oscillator 4. Diode D3 discharges C14 rapidly ensuring no delay in switch off.

The switch-on delay allows time for the counters to be loaded before the oscillator starts – hence ensuring an accurate count. By this means the count loaded into IC15 and 16 is loaded into the display counters and simply adds to any count already displayed.

If no prize is decoded by Q10, 19, 20 and 21 zero will be loaded into the pay out counter and oscillator four will not be started.

THE PLAY SEQUENCE

The play switch SW1, and the load button, PB1, are both shown in the non-operated position. Both switches are connected to RS flip-flops (IC14) which eliminate any contact bounce.

When the handle is pulled SW1 sets the output of IC14-1 'high' charging C16 to 10 volts. This causes the output of IC17-1 to go 'low' and this low enables roller-counters IC11, 12 and 13. The same low gives a high at the output of IC17-2.

When the handle is released the IC14 latch resets and, as C15 discharges only slowly through R95, both inputs to IC17-3 will be low. Transistors Q3, 4 and 5 will therefore turn on switching capacitors C5, 8 and 11 in parallel with C4, 7 and 10 respectively. The oscillators 1, 2 and 3 therefore slow from 20 kHz, 2 kHz and 200 cycles respectively and continue at a much slower speed. This slow speed operation is maintained to give the appearance of wheels spinning to the roller indication LEDs and has little bearing on the final roller display. This being mainly determined by the period of high speed oscillation that is gated to the roller counters.

After a delay of several seconds C16 discharges to the threshold point of the Schmitt trigger formed by IC17-1 and IC17-2 causing IC17-1 output to go high thus disabling the roller counters IC11, 12 and 13. At the same time the output of IC17-2 goes low triggering the monostable formed by C16, R101 and IC17-4. The output of IC17-4 is a narrow positive pulse which turns on Q25 momentarily, loading IC15 and 16 with whatever is at the input terminals.

The output of IC17-2 also is connected to the down-count of the bank counters via the level translator and inverter Q2. Thus at the time the rollers stop one is also subtracted from the display. If a prize has been won this will immediately be added to the display and the one deduction will not be seen but still occurs.

Should the display counters all be at zero, after this pulse, the display decoders IC4, 5 and 6 will detect the all zero condition (by the leading edge zero suppression feature of IC6) and ground the emitter of Q24. Transistor Q24 will therefore conduct and ground the +10 volt supply to SW1 inhibiting any further play.

To restart playing, the load switch PB1 must be pressed. This resets counters IC11, 12 and 13 to the zero position and, since the zero position is also the jackpot position, Q19 will detect a jackpot. Pressing PB1 also generates a load pulse via R103 which causes 100 to be loaded into the payout counter. Whilst PB1 is pressed oscillator 4 is inhibited via R85. When PB1 is released oscillator 4 starts (because the payout counters are no longer at zero) and 100 counts are added to the display counters.

The three counters of the display section IC7, 8 and 9 are cascaded decade counters providing a maximum count of 999. The output of these counters is decoded to seven segment format by IC4, 5 and 6 to drive the displays (IC1, 2 and 3). On switch-on C1 charges slowly delaying the turn-on of Q1. Until Q1 turns on, IC7, 8 and 9 are held, reset to zero, the delay allowing the payout counters time to settle. To clear the machine pressing the unload button cuts of Q1 thus generating a positive going pulse which clears IC7, 8 and 9.

The power supply is a simple full wave rectifier and capacitor filter the output of which is regulated by IC18 to +5 volts. This IC has thermal cutout and overload protection. Resistor R1 provides an unregulated supply of 10 volts which is smoothed by C20.

The play switch SW1 was described previously as a single pole push button, or microswitch, activated by pulling the handle. A more realistic handle action may be obtained by using two microswitches to replace SW1. The first microswitch is actuated when the handle is at the rest position and the second when the handle is at the end of its forward travel. These switches should be interconnected as shown in Fig. 8, and such connection means that the handle must be pulled all the way forward, and then, all the way back to operate the machine.

THE OSCILLATORS

Oscillators 1, 2, 3 and 4 are based on the LM3900 IC which contains four, identical Norton operational amplifiers. These amplifiers operate a little differently from conventional devices.

Unlike the conventional op-amp both inputs of the Norton amplifier are about 0.6 volts above ground (one base-emitter junction) and the output is dependant upon the ratio of the currents into the two inputs. That is the output will remain centred if both currents are varied from say 10μA to 1 mA providing there is never any differential current between them. However if the current into the negative input is higher than that into the positive, the output will go low and vice versa. The amount of difference in the currents depends on the open-loop gain of the amplifier. We, at the moment, are only concerned with their operation as an oscillator.

Referring to the main circuit diagram and to IC10-1 we can assume that its output is low and C4 is discharged. (Ignore for the moment Q3 and C5). Under these circumstances a current of 4.5 μA flows into the positive input (10V/R21) and none into the negative input. This causes the output to go to +10 volts. As a result the current into the positive input rises to 9μA and C4 begins to charge via R18. As C4 charges R19 passes current into the negative input and when the voltage across C4 reaches about 7.5 volts the current in R19 will equal the current into the positive input thus forcing the output hard low (since the current through R20 is now lost).

The voltage across C4 will now drop and when it reaches about 3.5 volts it falls below the positive input and the output goes high again. This process continues producing square wave oscillation.

There are two ways to stop the oscillator. One is to remove the bias current into the positive input and the other is to swamp this bias current by adding a higher bias current into the negative input. Both these methods are used on oscillator 4.

UNDERSTANDING COLOUR TV

The line output stage

by Caleb Bradley B.Sc.

THE previous parts of this series have described every part of a colour receiver's circuitry except the stage which drives the horizontal deflection coils. This is known as the line output (LOP) stage. Its description has been left until now because its design is closely linked with the requirements of the shadowmask tube, described last month.

Both the vertical and horizontal deflection coils are fed with sawtooth-waveform currents to cause the focussed electron beam to scan in the raster pattern, but some ten times more power is needed to drive the horizontal coils because of the higher scanning frequency in this direction (i.e. 15 625 Hz compared to 50 Hz). It is especially difficult to obtain an adequately fast 'flyback' from the end of one line to the start of the next, demanding a near-instantaneous reversal of current in the deflection coils. The inductance of the coils becomes significant at this point and a large driving voltage is required. Because of this it would be impractical to design the line output stage along the same lines as the field scan circuit (described in Part 6) where a low-power sawtooth generator is followed by a linear output stage.

The same problem exists for monochrome receivers although here the scan power needed is less because the small-diameter neck of a monochrome cathode ray tube allows the deflection coils to be closer to the electron beam.

ENERGY RECOVERY

The solution is to turn the inductance of the horizontal deflection coils to advantage by making them part of a resonant circuit during the critical flyback period. This allows minimum driving voltage to cause the fast reversal of current which follows the 'up' slope of a sinusoidal waveshape. The next trick is to *recover*

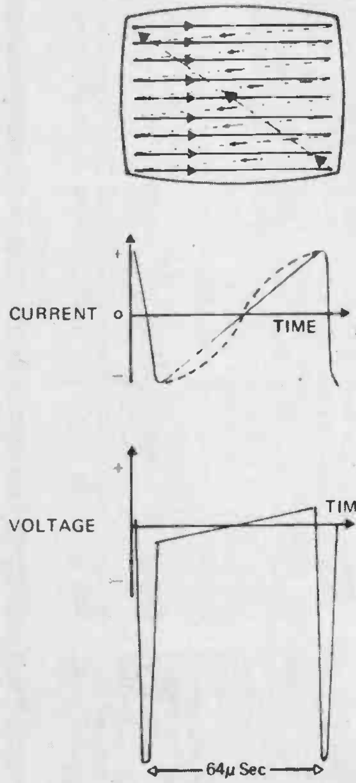


Fig. 43a. Idealized, line-deflection, current waveform. In practice some 'S' shape distortion (shown dotted) is added to compensate for the picture distortion caused on most CRTs by screen being nearly flat rather than section of a sphere centred on the deflection centre.
Fig. 43b. Voltage drive waveform needed to produce (a).

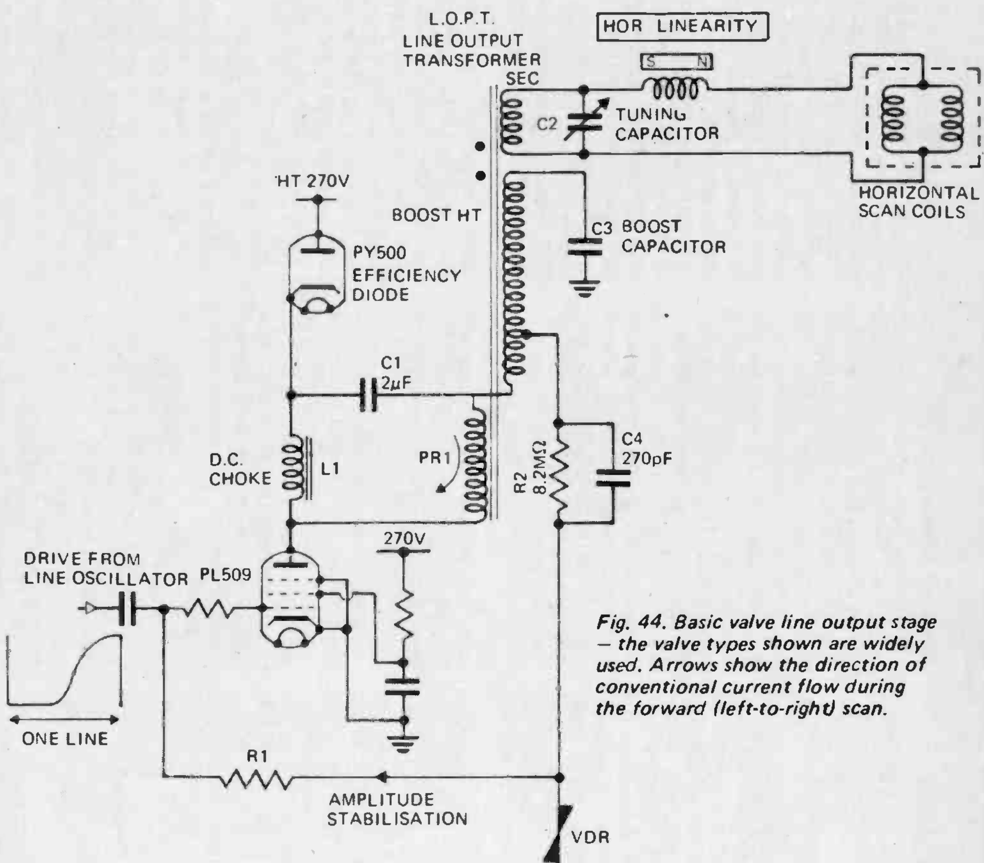


Fig. 44. Basic valve line output stage – the valve types shown are widely used. Arrows show the direction of conventional current flow during the forward (left-to-right) scan.

backswing energy from the resonant circuit (i.e. all the energy which was put into the circuit minus small resistive losses) for future use! This is achieved by an 'efficiency diode' which can be found in every modern television receiver. The circuit operation depends on whether a valve or a transistor driver is used, and since the former is still preferred by many manufacturers we shall describe both arrangements.

VALVE LINE OUTPUT

A typical stage, minus the frills, is shown in Fig. 44. It contains a high-power pentode valve (PL509) which switches current flowing in the primary of the line output transformer (LOPT). This transformer is wound on a high efficiency ferrite core and is heavily insulated to withstand high peak voltages.

Current flows into the circuit via the PY500 efficiency diode from the high tension rail – which can be merely the mains voltage rectified and smoothed. In monochrome circuits all the current passes through the transformer. Here, for greater scan power, a large choke L1 provides a dc route from ht to the pentode; the alternating voltage appearing across it is coupled into the transformer by C1. This removal of dc from the transformer allows the use of a smaller more efficient core.

The secondary of the LOPT drives the horizontal scan coils and the combined inductance of transformer and coils is tuned to about three times line scan frequency by C2. From an ac point of view it is convenient to regard L1 as an open circuit and C1 as a short circuit.

The sequence is best understood by starting half way through a line where the deflection current (Fig. 43a) is zero. At this point the pentode is switched on by positive drive to its control grid and current builds up in the LOPT primary, and therefore in the scan coils, in the direction shown by the arrows.

At the end of the scan the pentode is abruptly turned off by the negative swing at its control grid. The tuned secondary circuit has a large amount of energy stored in it in the form of forward current and this continues to flow into C2, decaying towards zero as C2 charges up and then reversing as C2 discharges back into the inductance. As C2 charges a large positive pulse appears at the pentode anode but no current flows in the primary. The energy recovery bit happens as C2 drives current in reverse direction through the secondary. By transformer action in reverse the upper (dotted) end of the primary is induced positive with respect to the tap connected via C1 and PY500 to ht. Therefore current is drawn from ht and the resonant energy is recovered by charging the 'boost reservoir' C3 to a voltage as much as 500 V *more positive* than the ht rail.

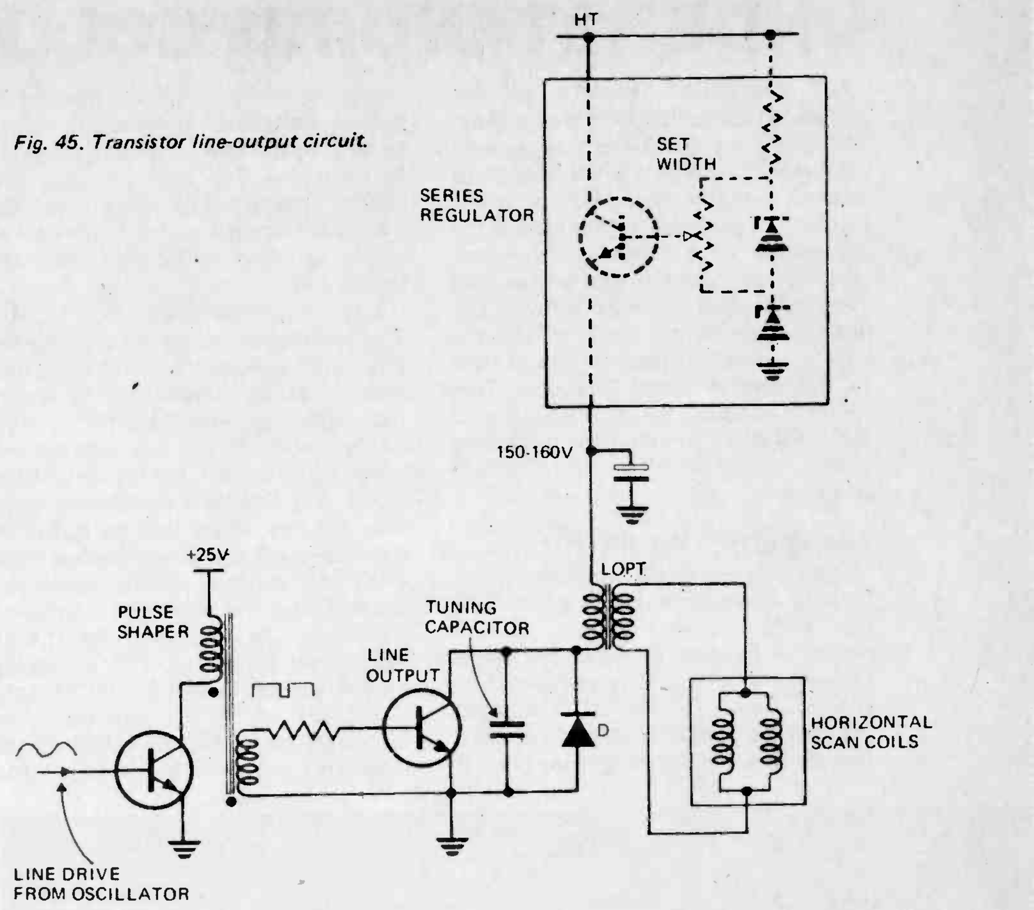


Fig. 45. Transistor line-output circuit.

Thus at the end of flyback the correct current (opposite to the arrows) is flowing in the scan coils and a 'bonus' packet of high voltage energy has been accumulated on C3. As the first half of the scan proceeds, the primary current into C3, and hence the reverse current in the scan coils, linearly decays to zero to reach the point where we began. However it can now be seen that when the pentode turns on, the source of current will be the high voltage and C3 and the efficiency diode serves to prevent C3 discharging back into the ht rail. In short, the efficiency diode conducts during the left half of the picture, the pentode during the right half.

Also, C3 is a useful source of high voltage, albeit at low current, for other circuits in the receiver. The 'boost ht' rail usually feeds one end of the potentiometers which set the voltages of the tube first anodes, and may also be the charging source for the vertical scan sawtooth generator.

SCAN STABILISATION

The field scan circuit contained a thermistor to stabilise the picture height against supply voltage changes and component ageing. Valve line output stages are also stabilised by means of a special component – a Voltage Dependent Resistor (VDR in Fig. 44). This is a non-linear resistor which passes virtually no current until several hundreds of volts are applied across it whereupon its resistance drops and current flows. It behaves like a high-voltage (950 V approx.) zener diode except that it is not polarity sensitive.

In Fig. 44 *positive*-going flyback pulses are applied to VDR by C4 from a tapping on the transformer. VDR conducts only on the tips of the pulses causing C4 to charge. This causes the pentode control grid to be held further negative via R1 during the next scan line. It therefore switches on *later* on the positive swing of the drive waveform so less energy is stored in the tuned circuit on this line and the width is reduced. To prevent the valve eventually cutting off entirely the negative supply due to the VDR is opposed by positive current from R2 and the circuit stabilises at a particular scan width. The effectiveness (gain) of the stabilisation feedback depends on the drive waveform having a fairly steep rising edge. The 500 kΩ control (variously labelled 'width', 'set eht' or 'line amplitude') allows the VDR conduction to be reduced by inserting resistance in series with it, which results in *increased* width.

UNDERSTANDING COLOUR TV

The horizontal linearity of the picture is controlled in a simple way. The control (L2) consists of a small coil wound on a core small enough to saturate at the deflection currents involved. Before saturation occurs the inductance of L2 restricts the scan current; as saturation occurs its inductance falls towards zero. A bar magnet is mounted close to L2 and can be rotated to apply a steady field to the core in either direction. This renders unequal the critical currents for saturation in opposite directions with a useful effect on picture linearity.

TRANSISTOR LINE OUTPUT

The efficiency diode principle cannot be used in the same way in a transistor line output stage because of the excessive flyback voltage. Also it is undesirable to stabilise transistor line output stages by the VDR method because the transistor should receive a base drive waveform with near vertical edges to minimise power dissipation during switching. Because of this a pulse shaper stage is usually included between the line oscillator and line output stages. The only available means of stabilising the width against mains variation is by regulating the supply rail.

A typical circuit is shown in Fig. 45. The rectangular switching drive to the line output transistor is transformer coupled at low impedance to ensure fast switching. The transistor is held *on* for most of the line and current builds up linearly in the primary of the LOPT and therefore in the scan coils. Near the end of the line the transistor is switched off and a high voltage pulse (1000 V) appears at its collector, necessitating a specially designed transistor. As before, the LOPT inductance resonates with a tuning capacitor (connected in the primary this time) which first charges, then discharges back into the LOPT. As the resonant current backswings into reverse the diode D conducts. It is interesting to note that D can be omitted (and sometimes is) because the base-collector junction of the line output transistor also forms a route by which current can flow from earth to the LOPT. There is no boost ht rail in Fig. 45 although auxiliary supplies can easily be obtained by tapping off flyback pulses from the LOPT, rectifying and smoothing them. In some receivers quite remote circuits are powered in this way, e.g. the IF strip, and this can lead to some misleading fault symptoms.

Width adjustment is by setting the ht regulator output. The regulator may be a conventional series type as shown in Fig. 45 or it may be the 'chopper' type where the incoming mains is rectified and passed to an integrating filter via a series switching transistor or SCR (thyristor) which is driven by pulses of controlled mark/space ratio.

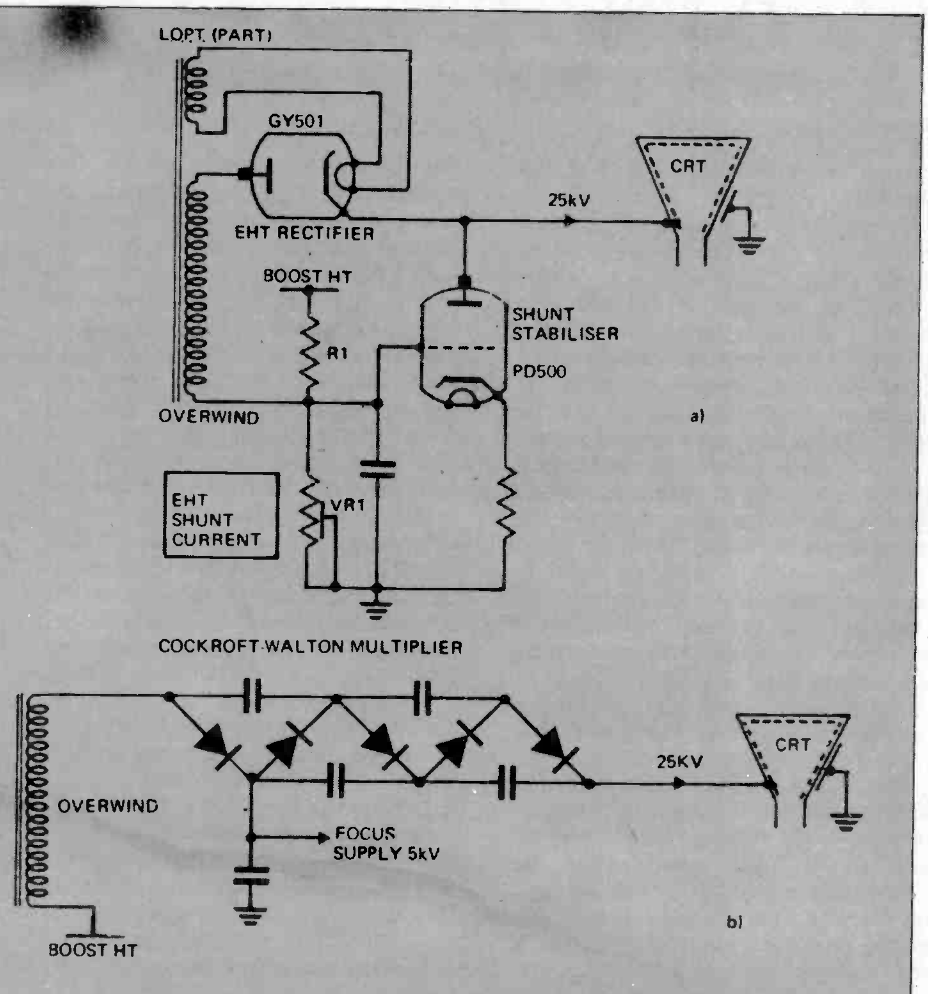


Fig. 46. Old (a) and new (b) methods of obtaining 25 kV third-anode supply from the line output stage.

HORIZONTAL SHIFT

Neither of the simplified line output circuits include a means for shifting the picture horizontally – which is often necessary after setting the purity magnets. Arrangements for this vary, but all basically involve breaking the dc continuity between the LOPT and the scan coils by inserting a capacitor at some point and setting a dc bleed current through the coils by means of a potentiometer. The source of current may be rectified flyback pulses or the cathode current of the line output valve. Often a two-position link is found which must be set according to whether shift to the right or left is required.

EHT

The shadowmask tube requires an extraordinarily high eht supply (25 kV) to its third anode and this is normally obtained by rectifying pulses from an extra many-turn overwinding on the LOPT. Early colour receivers used simple valve rectification as in Fig. 46a. Here the stepped up pulses are rectified by the GY501 diode whose heater is supplied by an isolated winding on the LOPT to avoid impossible demands on its heater-cathode insulation. The capacity between the inner and outer (earthed) conductive coatings on the tube makes a reservoir capacitor unnecessary.

The inherent output impedance of this simple supply is rather high and would allow the eht level to vary with changing beam current (picture brightness). This would upset the critical focus, purity and registration settings for the tube. Therefore a shunt stabiliser employing a special high-voltage triode PD500 is used to reduce the output impedance. Its operation is simple:

With no beam current (black picture) the divider R1/VR1 is adjusted to bias the PD500 to draw a specified current (1.2 mA) from the eht line, checked by a voltmeter connected to its cathode resistor. After this, any beam current flowing in the overwind will drive the PD500 grid in a negative direction which reduces its cathode current and counteracts the voltage drop in eht.

While the performance of this circuit is hard to match it has the shortcomings of (1) needing a massively insulated overwinding, which can be a source of expensive burnouts, and (2) running two valves at such high voltage that they emit dangerous X-rays and *must* be shielded for safety. These disadvantages are overcome by using a voltage multiplier to provide eht from a relatively small overwind (typically 7 to 8.5 kV pulse output) as in Fig. 46b. Both tripler and quadrupler multipliers are used. The first multipliers using selenium stick rectifiers were sometimes unreliable (the bad-egg odour of a burnt-out selenium stick is once-smelt, never forgotten!) but silicon diode multipliers are more satisfactory. The first stage of the multiplier is a convenient takeoff point for the tube focus (A2) supply which would otherwise be obtained from line pulses by a separate rectifier and reservoir capacitor.

FRILLS

This part has shown that the line output stage does much more than just drive the scan coils. For example it generates radio interference at short range, and magnetostriction of the LOPT core produces a whistle at line frequency (15 625 Hz) — deafness to which separates men from boys! The line output circuit of a commercial receiver always appears complex with a multiplicity of windings and tappings on the LOPT. The reason is that line pulses are tapped off the LOPT and shaped if necessary for a variety of odd jobs throughout the receiver. These jobs include:

- driving the line flywheel discriminator,
- operating gated a.g.c. in the IF strip,
- blanking the luminance signal during line flyback

and in the decoder department:

- gating the burst,
- 'toggling' the PAL bistable,
- and clamping the decoder outputs.

. . . to be continued

ELECTRONICS -it's easy! PART 19

Generating non-sinusoidal waveforms.

THE UNIJUNCTION TRANSISTOR

The unijunction transistor, UJT for short is a three terminal semi-conductor device somewhat akin to the normal transistor. The exception is that by appropriate choice of the manufacturing placement and thickness of material, it has entirely different characteristics between the currents and voltages of its three terminals. It becomes a device in which a current flows once it is triggered on. It features a stable triggering voltage Vp, a very low value of firing current Ip, a negative resistance region (where a rise in voltage between terminals is related to a fall not a rise in current) and a high current carrying capacity once it has been pulsed on. As there are 50 different kinds we can only give a general impression of their operation here. The symbol is shown in Fig. 1.

When the emitter, E, is reverse-biased no current can flow between B_1 and B_2 bases. When V_E rises sufficiently it alters the state between the bases and, quite sharply, I_{B2} commences to flow. This is seen by studying the representative static emitter characteristic curve given in Fig. 2.

Until V_E rises to close to Vp (the actual value depends upon the standing value of V_{BB} and ranges typically from 3 V to 20 V for V_{bb} of 4 V – 30 V) I_E remains virtually zero. After the I_{EO} value, emitter current can be absorbed and V_E drops back exhibiting a negative resistance region. In the unijunction, therefore, the equivalent of the collector-emitter current flow of normal transistors takes place between the emitter and base 1; base 2 acting as the input that decides at which point the circuit goes into the conduction state.

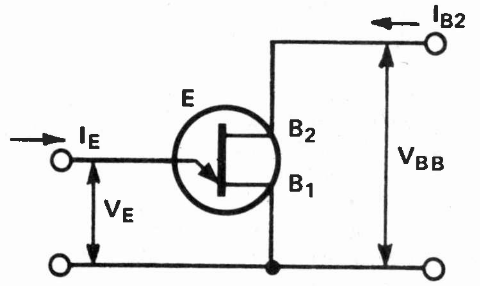


Fig. 1. The basic unijunction symbol.

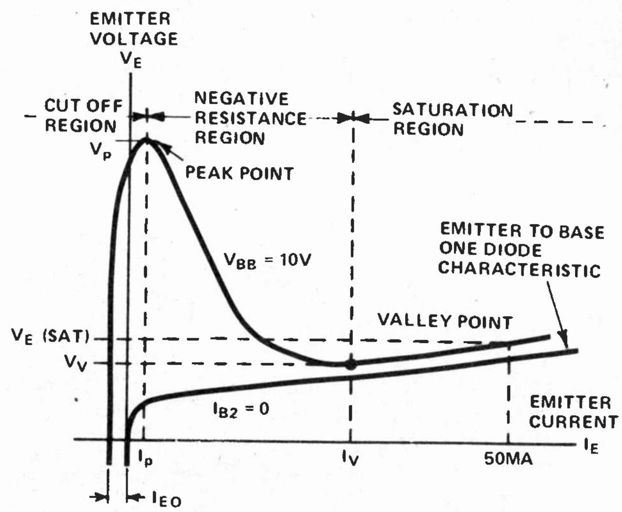


Fig. 2. The unijunction characteristics.

A BRIEF description of how a cathode ray oscilloscope operates was given in part 4 of this course. There we saw how a sweep generator is used to provide a signal that causes the spot to sweep across the screen thus tracing the waveform. A television receiver uses the same principle as indeed, does a television camera also. This effect is achieved by steadily increasing the voltage applied to a deflection plate (or deflection coil in a TV system).

When the spot reaches the limit of travel needed it is swept back again, by reversing the voltage change, so that it eventually arrives back at the original level. If the rise and return of such a waveform are both at the same rate the resultant waveform is triangular; if the waveform returns to the starting point virtually instantaneously – it is a saw-tooth. Sweep times required vary from hours down to a few nanoseconds depending upon the particular application.

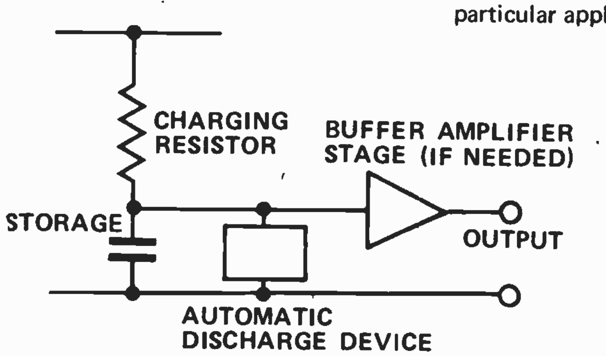
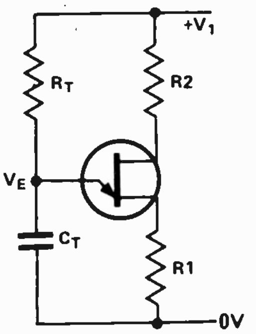


Fig. 1. Functional block diagram of basic relaxation oscillator.

A common use of saw-tooth-like signals is in the modulation of tones – eg, the rise and rapid fall of modern police sirens. The tones used in some telephone systems and in organs and electronic music synthesizers are other well known examples of the application of saw-tooth waveforms.

Most simple sawtooth generators are based upon what is known as the relaxation principle. In this method a capacitor is charged (Fig. 1) though resistor, R, which limits the current and hence the rate of rise of voltage across the capacitor. When the voltage across the capacitor reaches a preset limit, some form of device is actuated that discharges the capacitor back to its initial point. Inductors could also be used in a similar manner but the use of capacitors is more usual. Once the capacitor is discharged the device becomes inoperative and the voltage rises again to repeat the cycle. The simplest form of relaxation oscillator



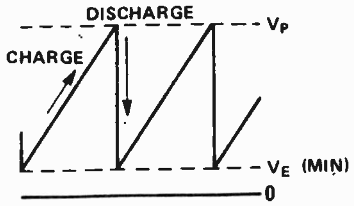


Fig.2. The unijunction transistor together with three resistors and one capacitor makes a simple sawtooth generator.

uses no more than a capacitor, a resistor and a neon lamp as the device to discharge the capacitor. The details of this method were given in Part 7.

As with most electronic techniques (and life in general) the simplest method is not necessarily the best. The neon method requires a high voltage supply, by today's standards, and the charge and discharge slopes are exponential rather than straight linear rises and falls.

Improvement can be made by making the charge process more linear, that is, by using a method that gives a purer integration. The first steps toward improvement are to use a much smaller part of the exponential charge curve of a capacitor, for this will be more linear, alternatively we can provide a more linear charge technique. These methods however, usually call for a more sensitive trigger to discharge the capacitor, that is, an active trigger element. Whereas it is quite feasible to use transistors as discharge elements the more practical method, usually employed, in relaxation designs, is based upon a device known as the unijunction transistor.

The unijunction transistor has three terminals labelled base 1, base 2 and emitter. The emitter to base 1 resistance of a unijunction is normally very high, however, when the emitter is raised to a voltage known as the peak point, emitter to base 1 resistance drops to a very low value. This property may be used quite effectively to discharge a capacitor once it has reached the peak point voltage of the unijunction.

In the circuit of Fig. 2, capacitor C1 charges through R_T from source V_1 therefore, no emitter to base circuit is made. When V_E reaches the peak emitter voltage V_p of the unijunction (decided by the circuit values R_1, R_2) the unijunction changes state and the emitter to base-one resistance falls to a low value. This discharges C_T through R_1. When the voltage has fallen to V_E(min) the emitter to base 1 discharge circuit becomes a high resistance again and the cycle repeats. Provided R_1, R_2 have small values compared to R_T the oscillation frequency is given by

$$f = \frac{1}{R_T C_T \, ln \left(\frac{1}{1-\eta}\right)}$$

where η is the intrinsic stand-off ratio quoted for the unijunction device. It has values typically around 0.6.

If V is kept large compared with V_P the capacitor is charged from a more constant-current source improving linearity. With this technique the linearity, however, still has an error of 10% or so. Using a separate, even-higher charging voltage further improves linearity but at the expense of a more complex supply. Another method is to use a transistor in the charging path to provide constant-current flow to the capacitor.

A much superior circuit is given in Fig. 3. The capacitor C_2 and the output buffer stage improve the linearity by stabilising the voltage across the charging resistor feeding the 100 nF capacitor. Components R_1 and C_1 are added as an integrating compensating network that further improves the linearity of the charge process. Variation in R_1 is provided to trim the wave shape rise characteristic from concave through linear to convex. As shown, the circuit generates a 1 kHz sawtooth. Note the ability to provide two anti-phase signals and the input that enables the system to be started in synchronism with an external event – as is required to trigger, say, a CRO trace upon demand.

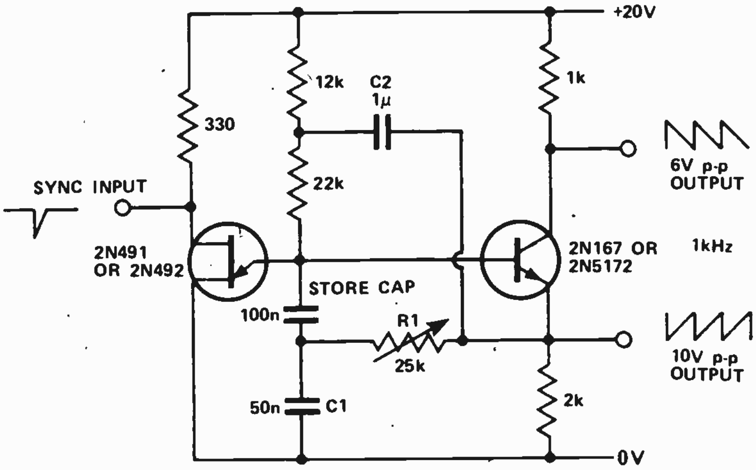


Fig.3. This generator adjusts the sawtooth to a high degree of linearity.

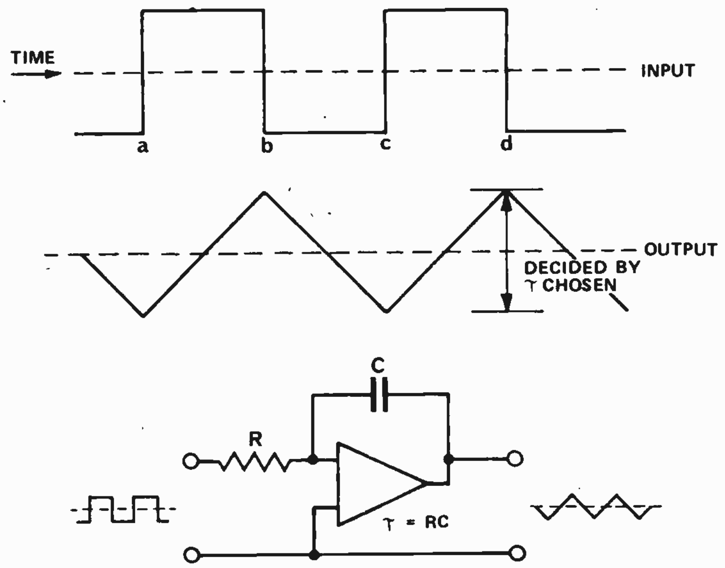


Fig.4. A symmetrical triangular wave may be generated by integrating a square wave.

ELECTRONICS -it's easy!

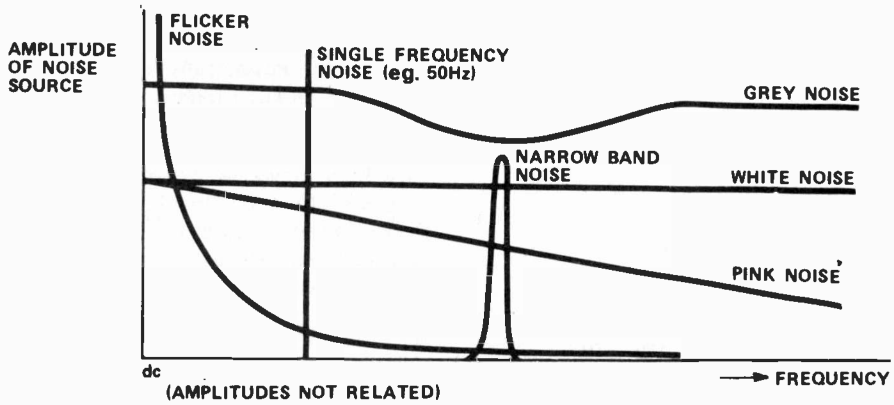


Fig.5. Frequency spectra of commonly encountered noise sources.

NOISE GENERATION

So far we have said little about noise, that generally unwanted signal that must (usually) be kept to a satisfactory minimum in circuit design. Indeed, it might seem strange that we should sometimes want to *generate* it, when the usual aim in design is to eliminate it.

By appropriate design, relaxation oscillators can be made to provide sawtooth, triangular and pulse wave shapes. They are also the basis of timing circuits — for the time-constant of the capacitor and the trigger relaxation level effectively defines a time interval.

Yet another way to produce a sawtooth is to generate a number of sinewave signals of chosen frequencies and amplitudes covering the spectrum of the sawtooth. These can then be combined to produce the sawtooth. This method is suitable for synthesizers or other precision generators but would normally be prohibitively expensive — over ten generators would be needed to provide a reasonably accurate waveshape.

A symmetrical triangular waveform may be generated by starting with a square-wave source and integrating it with an op-amp type of integrator.

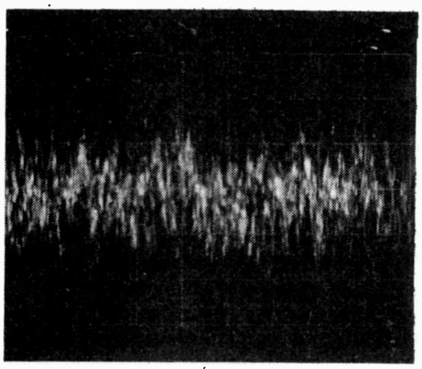


Fig.6. How random noise looks on a CRO screen.

This is shown diagrammatically in Fig. 4. At point 'a' the integrator output starts to rise in the positive direction. When the square wave reaches 'b' the integrator input reverses and the output starts to fall until 'c' is reached. It is, however, not fundamentally possible to have different rise and fall times if the amplitude is to be held constant: different rates require different integration time constants for both directions of signal change.

Although noise may be any unwanted signal and, therefore, can consist of any combination of an enormous variety of waveforms, the noise usually referred to will be what is known as random noise. Random noise is a signal that has the interesting, but frustrating property that one cannot predict the exact level of signal at any particular instance. We can only characterise it by the use of random statistics that will tell us, if we know the type of noise, the *chances* of certain levels occurring at a given time.

Various kinds of noise are termed white, pink and grey. Each is typified by the nature of its frequency spectrum. White noise, the usual one considered (but in reality not always the one that really occurs) has equal energy at all frequencies. The energy level of the signal will be the same at 1 kHz as it is at 100 kHz. There is equal noise energy at all frequencies with white noise. In practice noise energy may fall off uniformly with rising frequency (pink noise), or it might not be quite white in that there may be variation in energy at various points of the spectrum (grey noise).

Unwanted white noise mainly arises due to thermal agitation in resistors. This effect is called Johnson noise. It is a basic effect that can only be reduced by reducing resistance values, or by operation at lower temperatures.

As noise exists at all frequencies, reducing the band-width of a system reduces the total noise power occurring at the output.

Another noise phenonemon is known as excess or flicker noise. It is also sometimes called 1/f or hyperbolic noise. This is noise that rises in level as the frequency is reduced. It occurs in all semi-conductors. It is usually less than the resistor-generated white noise (above 1 kHz) so is not a problem at high operating frequencies. The various types of noise are depicted by a representative plot of their frequency spectra as in Fig. 5. In contrast to noise of the random kind the spectrum of induced 50 Hz hum is a single line. Random noise, usually presumed to approximate white noise, appears as shown in Fig. 6 on an oscilloscope screen. Audibly it sounds like hiss because the ear is most sensitive to frequencies in the 1.5 — 6 kHz region, thus the ear subjectively attenuates frequencies above and below these rough limits.

The amount of noise generated internally in an electronic system is a limiting factor. The noise performance is usually specified as the *noise figure* of the system. Noise figure is the ratio of signal-to-noise at the output to signal-to-noise at the input expressed in decibels. Thus a noise figure of 2 dB is much better than one of 6 dB.

One way of ascertaining the noise contributed by a system is to measure the total output power of the system under test with a suitable driving (wanted) signal and then without the test signal. The residue is noise power. The usual method of stating noise power is as the RMS level of the random process.

In another class of tests, noise of a known level and character is added until the noise output of the system is doubled. The amount added then equals the amount internally generated.

White noise generators can be built using a wide-band amplifier to raise the signal level of Johnson resistor noise. This method, however, is seldom used in practice due to the comparatively lower noise output from resistors compared to other alternatives.

For example, a Zener diode generates much more intense internal noise than does a resistor. Two simple noise generating circuits are given in Fig. 7. One, Fig. 7a, will provide white noise suitable for audio work. Capacitor C_2 (if added) filters the output reducing the noise level as the frequency rises — thus providing pink noise. The other, Fig. 7b, is suited to VHF work as the bandwidth extends beyond 150 MHz. Resistor R is adjusted to pass about 6 mA through the circuit. Capacitor C_2 should be a ceramic capacitor. Output

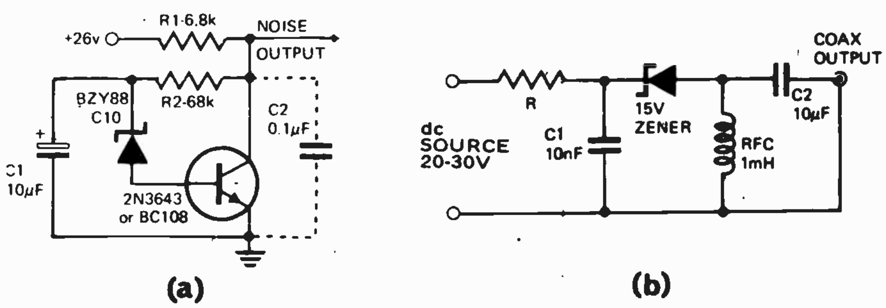


Fig.7. Two noise generators. (a) noise generator suitable for audio work. (b) for VHF use.

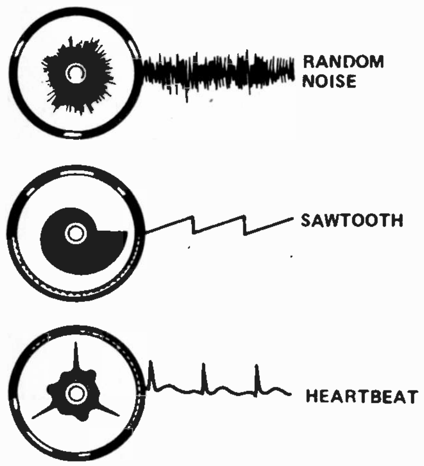


Fig. 8. Complicated wave shapes may be generated by opto-mechanical methods. A specially masked disc, as it rotates, is used to vary the amount of light transmitted to a photocell.

via a coaxial cable, in this case, is essential to preserve the bandwidth of the signal.

Another noise source sometimes encountered relies on the variation of contact resistance in an electro-chemical cell — this produces a good signal at relatively low frequencies. It is also possible to approximate noise in certain cases as a binary (that is, two-state only) signal that switches between states in an apparently random fashion — such generators are called pseudo-random binary sequence generators, PRBS for short. These generate their signal by virtue of specially connected ring-counters, a technique we will study later in the series. The output of these can be averaged with a CR filter to provide analogue noise.

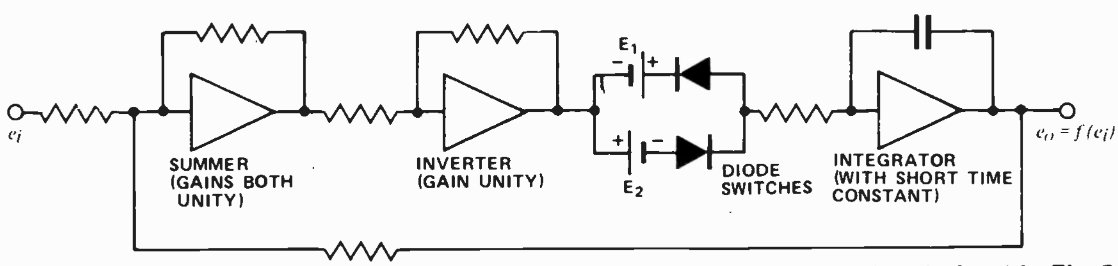
NON LINEAR AND NON-REPETITIVE ANALOGUE WAVE SHAPES

The waveform producing circuits considered so far generate sinewaves or linear ramps. In some instances the need may be for a special shape other than those producable by standard circuits. If you are lucky the distortion of some oscillators may be the waveform needed — the exponential rise of single relaxation oscillators can sometimes suit the non-linear characteristics of CRO tube deflection systems.

Provided the cyclic frequency needed is not too high, that is, up to about 10 kHz, it is possible to make use of an optical-disk generator. In this method a transparent disk, on which is placed a mask of the required signal shape rotates at a controlled speed. Light passing through a portion of the disk is integrated by a photo-detector and collection system providing an output proportional to the degree of masking at each point. Figure 8 shows disks suitably masked to provide random noise, sawtooths and heart beats. This method is admirably suited to the generation of very low frequency complex waveshapes — down to 0.001 Hz but suffers from the possible disadvantage that the waveshape period is rigidly related to frequency. It is not possible to retain a fixed cycle time with changing repetition rate.

Given a mini-computer facility it is possible to generate any waveshape as a repetitive event, or as a "one-shot" event, by controlling the signal flow with time. In hybrid computer operations (those combining analogue with digital methods) the mini-computer operates switches that gate voltages to the output. Each change in the circuit alters the rate of rise of the output, that is, the instantaneous slope is controlled. It is, therefore, possible to create a waveshape by successive linearisation of the originally smooth curve into one made up of a string of different slopes joined end to end. The number of stages used decides the degree of accuracy of generation.

It is also possible to generate unusual voltage-versus-time functions using diodes in conjunction with op-amps. Figure 9 shows the schematic diagram of an analogue, op-amp set-up that generates an output voltage as would come from, say, a potentiometer driven back and fourth by a badly worn mechanical linkage. It also simulates gear backlash and a crude approximation to magnetic hysteresis. All resistors are equal and the integrator time-constant is very small. As it rises from zero there is no change in I_o initially, as there is no current flow into the integrator because of the reversed-biased state of the diodes. When the input reaches, say E_2 a diode conducts, starting the integrator which operates until the output causes the same diode to cut off. If e_i now decreases, the output is held high since the integrator cannot discharge until e_i falls to a value which causes the other diode to conduct. The functional relationship between input and output



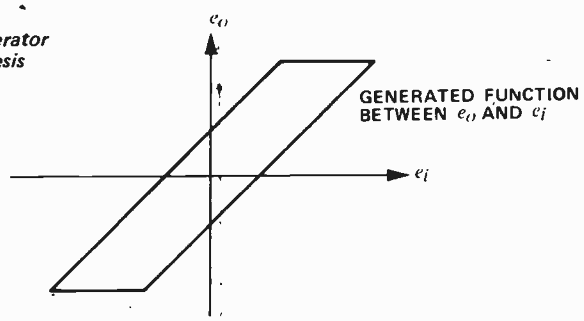


Fig.9. Special diode function generator for simulating backlash or hysteresis characteristics.

that results is that depicted in Fig. 9. This example shows how seemingly difficult-to-produce functions can in fact often be quite easily produced using op-amp techniques. The batteries are included to set the voltage at which the diode conducts. The need for batteries may be eliminated by using Zener diodes in place of the simple diodes used in Fig. 9.

To be continued.

Electronics Tomorrow

by John Miller-Kirkpatrick

Last month we mentioned some digital stopwatch chips and stated that in most cases the main requirements were six digits giving readouts at least to seconds and a reset to zero facility. There are some other chips being made which have the reset to zero facility but are only four digit (Hours & Minutes), as such they are not very useful in most stopwatch applications unless the timing period is very long and seconds accuracy is not required.

One such chip is the GI AY-5-1200 one of a new family of chips from General Instruments. This family is not yet available on the retail market as it is designed for manufacturers only but no doubt the chips will be available to the amateur constructor in the not too distant future.

The main idea behind this family was to produce a chip which would satisfy the requirements for a simple interface to a cheap display, low current drive, four digit output, 12/24 hour and 50/60Hz operation. The display type used is the Phosphor-diode or Fluorescent display typified by the Futaba 5-LT-01 unit, an interface circuit is shown in Fig 1 and as you can see the component count is very low. G.I. have used a double wound transformer giving 12-0-12 at 50mA and 3-0-3 at 200mA but as the latter is only driving a 50mA filament I see no reason why a 3v winding at 50mA could not be used. If you cannot find such a transformer and do not fancy winding one of your own you could always use two miniature transformers, N.B. it is important to remember to have two *separate* windings — a 0-3-12 transformer just will not do.

There are at present only four chips in this family with options that are chip options that could surely just as easily have been pin selected options. The four versions are —

AY-5-1200 7 segment output, leading zero suppression.

AY-5-1201 As above but with a flashing colon output.

AY-5-1204 As 1201 but without leading zero supp. on tens of hours.

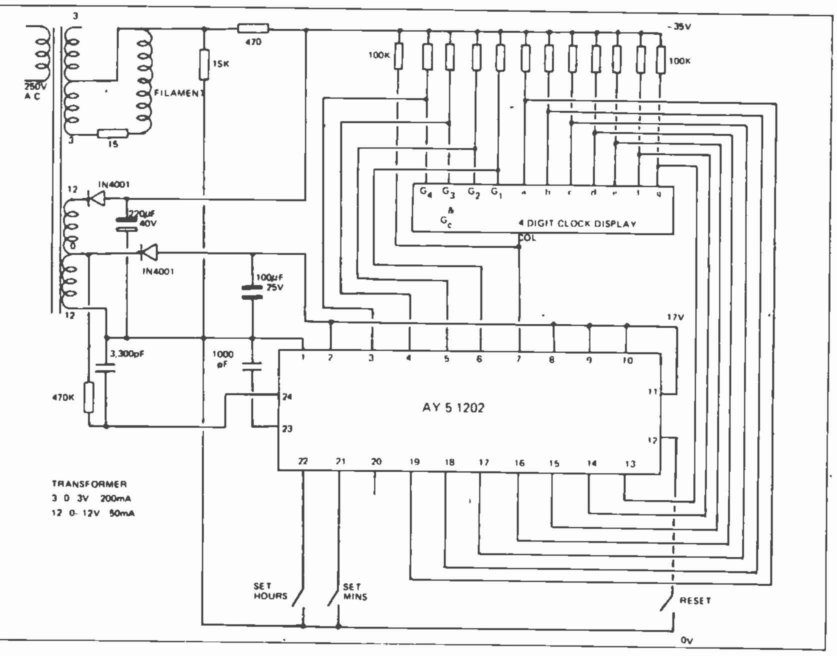


FIG. 1. DIGITAL CLOCK CCT. USING AY 5-1202 WITH FUTABA FLUORESCENT DISPLAY 5 LT 01

AY-5-1203 BCD output only, none of the other features incorporated.

The 1203 is thus a very simple digital clock chip with BCD outputs, but if you need a decoder to get back to 7 segments why bother to produce a BCD version at all? One answer is to read last month's column again where it was pointed out just how useful a BCD clock can be when connected up to some TTL chips. Another answer is that it interfaces with another new G1 chip called the AY-5-8300 TV channel/time display interface chip. Unfortunately the promised evaluation samples have not yet arrived from GI so I have not yet been able to build this one and report whether it is any better than the similar National chip mentioned a few months ago.

The basic idea behind such a chip is that TV channels in the USA have to be identified by a two digit code and this code must be visible on the front of the set. With the advent of touch tuning and varicap diodes the multi-turn turret knob has started to disappear with the result that television manufacturers have to identify the channel number in some other way. One such way is to display the channel number as a video picture superimposed on the programme picture and this requires a simple lump of logic which is provided by the AY-5-8300.

The information is displayed as coloured characters on a black background, the character colour can be red, green, blue, yellow, magenta, cyan or white. The characters are formed from a 5 x 7 dot matrix which in turn is controlled from a 1.1MHz oscillator and the line sync pulse.

The usual television picture (for 625 line operation) is made up of two frames of 312½ lines each transmitted at 50Hz and thus a complete picture is transmitted 25 times per second. If you assume that the height of the picture on your screen is just over 12 inches then each line is about 0.04in high, each dot in the 8300 is defined as five lines and thus each dot is about 0.2in high. As seven vertical dots define a character the character height is just under 1.5in, i.e., easily visible from the other end of even a very large room. The character width is defined in a similar way based on the 1.1MHz oscillator. The TV lines are about 60μS long and represents about 16in, therefore each 1μS represents about 0.25in, with a 1.1MHz oscillator the pulse widths are 0.9µS or about 0.2in wide, this gives a character width of 5 dots at 0.2in or 1.0in. .Thus we have defined a character five dots wide and seven dots high giving a total of 35 dots, by lighting or darkening various dots we can define the numerals 0-9 (and A-Z, etc, but not in this example).

Now we have one character defined we can easily define another as being a certain distance from the first and a third from the second and so on until we have defined a row of two or four digit spaces. We can define the position of this group on the screen by counting TV lines from the top of the picture (frame sync pulse) and also by counting the 1.1MHz pulses from the left hand side of the picture (line sync pulse).

The AY-5-8300 accepts a four bit BCD line and displays one or two digits 0-15, the AY-5-8310 accepts two four digit multiplexed inputs, the first defining a two digit multiplexed channel number and the second a four digit multiplexed time. It is not clear from the data sheet (and I haven't built one) whether the channel input could take a four digit input, if so it would be possible to display two times, time and date, seconds, or time and an event number, etc.

I think that GI have a great little chip here with a little more potential than they realise! It would seem to interface not only with the 1203 but also with any other clock chip or multiplexed counter with BCD outputs, the National chip would only interface to the MM5318 clock chip. GI have put input latches and re-multiplexers into the front end of the 8310 and made it a lot more versatile, the interface for the basic 8300 is shown as Fig. 2.

On the subject of digital TV channel tuning, for obvious reasons there are no chips available in this country for producing the channel number from the tuning voltage or from the resultant oscillator frequency. Varicap tuning systems have caused great changes in UHF and VHF receivers and similar varicap diodes are now available for tuning MW broadcasts. With a tuning voltage available it is possible to get a digital readout of the tuned frequency by having a digital voltmeter trimmed to give a reading proportional to the tuned voltage. In non-varicap systems this is not possible and the only method of getting a digital readout of the frequency is to use the more correct method of counting that frequency. This is not very easy as you have to remove the IF from the tuned frequency to get a correct figure, this involves a lot of counting and comparator logic and is too expensive for most people to even consider building one.

General Instruments to the rescue once again with the AY-5-8100 frequency counter chip. The AY-5-8100 is a four and a half digit frequency counter for use in radio receivers. Three main frequency ranges are provided, 2999KHz, 29.995MHz and 299.95MHz, the first two having an IF of 460kHz and the latter an IF of 10.7MHz. For use in VHF FM tuners an alternative channel mode is available, this displays a channel number 0-99 with a +/− tuning indicator (IF is 10.7 and channel 0 is 87MHz). The chip will drive either a Phosphor-diode display (eg Futaba 5-LT-03) or a liquid-crystal display, in the L-C mode the digits are multiplexed in such a way as to be suitable for driving L-C digits (presumably Dynamic Scattering). In G.I.'s data sheet the 8100 is shown interfaced to share the display with a 1200 series clock chip — now that really is what I call a digital clock/radio! I assume that the display could also be shared with a digital clock chip capable of controlling an alarm/radio system (CT7001) the only question left is how, why and when do they put the calculator chip in it as well?

A system diagram of the 8100 is shown as Fig 3. As can be seen the system uses prescaler dividers to interface between the local oscillator input and the 8100 itself, these are divided by 8 for MW, by 80 for SW and by 800 for VHF. The prescaler reset pulse (PR) not only resets the prescaler to zero after each count period but can also be used as the 50Hz input for a digital clock chip.

For further information on any of the above chips contact: *General Instrument Microelectronics Ltd, 57/61 Mortimer St, London W1N 7TD.*

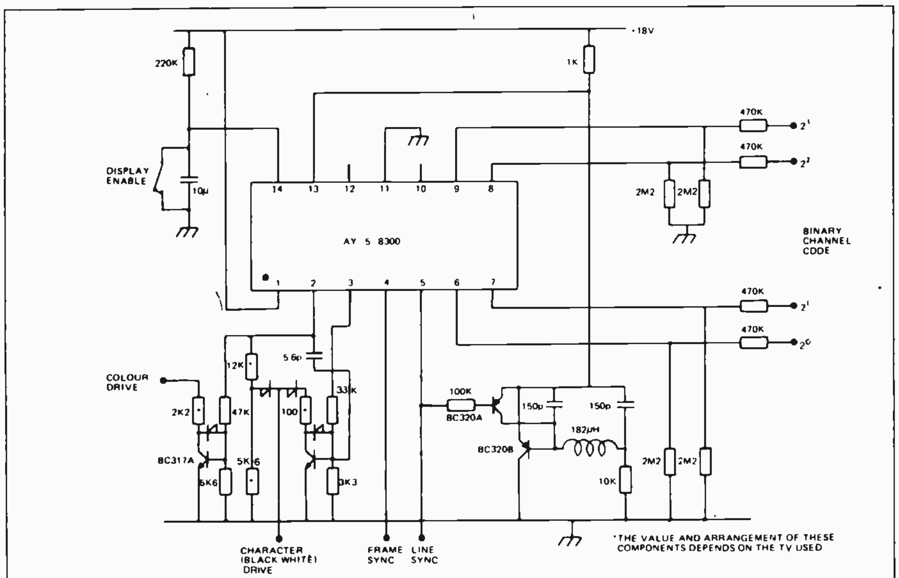


FIG. 2

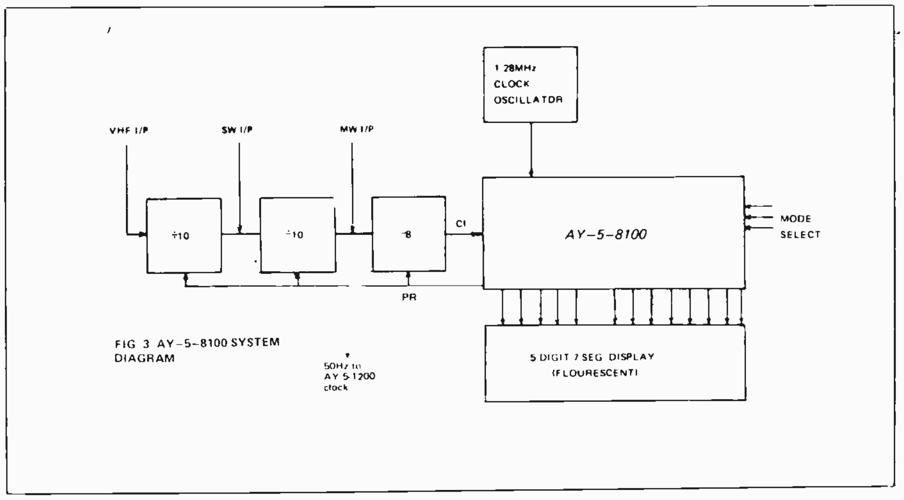


FIG 3 AY-5-8100 SYSTEM DIAGRAM

tech-tips

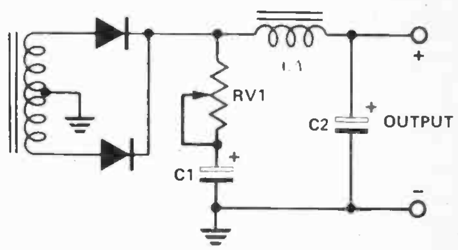
ADJUSTING POWER SUPPLIES

When the output voltage of a power supply comes out a little higher than expected it can be adjusted by making the simple addition illustrated above.

R1 is a 500 ohm or 1000 ohm potentiometer (10 watt rating) inserted in series with the input filter capacitor. Adjust it to give the correct voltage under load.

For low voltage supplies (i.e. up to 50 V or so) a 50 ohm or 100 ohm pot might be more suitable.

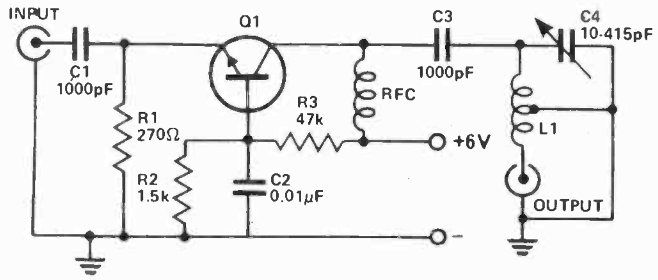
The pot could be connected between the negative lead of C1 and ground and would not then need to be insulated.



SIMPLE RF PREAMP

Many shortwave receivers of the cheaper variety and old surplus general coverage receivers (i.e. RBZ, AR8 etc) don't have a great deal of sensitivity, and are prone to image problems due to poor front-end selectivity.

This circuit considerably improves matters, providing a worthwhile increase in sensitivity and considerable improvement in front-end selectivity.



The transistor, Q1, can be any of BFY90, 2N3653, BF115, SE3001, TT3001, BC108 or any good RF amplifier transistor.

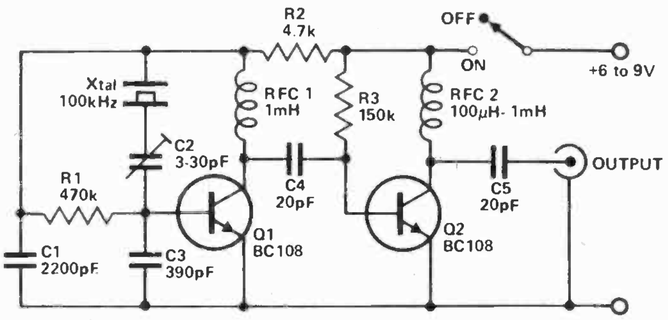
The tuning capacitor can be any standard broadcast-type (i.e. Roblan RMG-1). The RFC can be either 1 mH or 2.5 mH (i.e. Aegis C13 or C4 or C2).

The coil, L1, can be 20 turns on a suitable toroid tapped at 4 turns (try also tapped at 7 turns). Alternatively it could be any suitable coil tapped at about one fifth of the total turns.

100 KHZ MARKER GENERATOR

The above marker generator will produce strong signals every 100 kHz from 100 kHz to over 200 MHz. It is very useful for calibrating receivers and for use as a signal generator.

Cheap transistors type BC108 give good results but almost any PNP or NPN transistor having a gain-bandwidth product greater than the desired frequency range will give good results.



The oscillator should be calibrated by adjusting it to zero-beat with WWV at 10 MHz, or 15 MHz, on a communications receiver, or with a digital-frequency meter.

The choke, RFC1, can be any suitable small RFC (i.e. Aegis C13), the same for RFC 2 (i.e. Aegis C13 or UPC 100 to UPC 560).

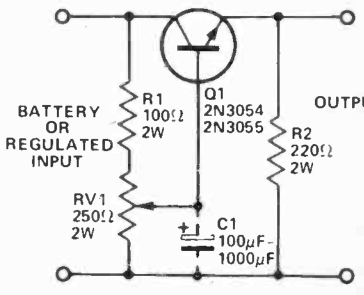
REGULATED VOLTAGE DIVIDER

IC's requiring 3.6 or 6 volts can be run from a battery or fixed-regulated supply of a higher voltage by using the circuit shown.

The transistor should be mounted on a heatsink as considerable power will be dissipated by its collector.

Additional filtering can be obtained by fitting a capacitor (C1) as shown. The capacitance is effectively multiplied by the gain of the transistor. A ripple of 200 mV (peak to peak) at the input can be reduced to 2 mV in this fashion.

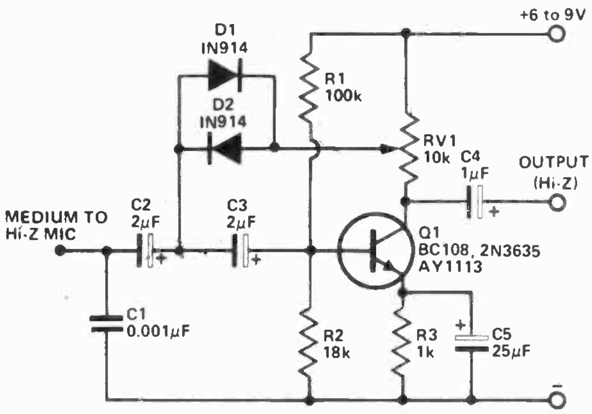
Maximum output current depends on the supply rating and transistor type (with heatsink) used.



Tech-Tips is an ideas forum and is not aimed at the beginner. We regret we cannot answer queries on these items.

ETI is prepared to consider circuits or ideas submitted by readers for this page. All items used will be paid for. Drawings should be as clear as possible and the text should preferably be typed. Circuits must not be subject to copyright. Items for consideration should be sent to the Editor, Electronics Today International, 36 Ebury Street, London SW1W OLW.

CLIPPER PREAMP



Maintaining a high average modulation level for mobile communications transmitters considerably improves the effectiveness of a transmitter, especially under difficult conditions. This circuit provides a small amount of preamplification as well as variable clipping level (preset).

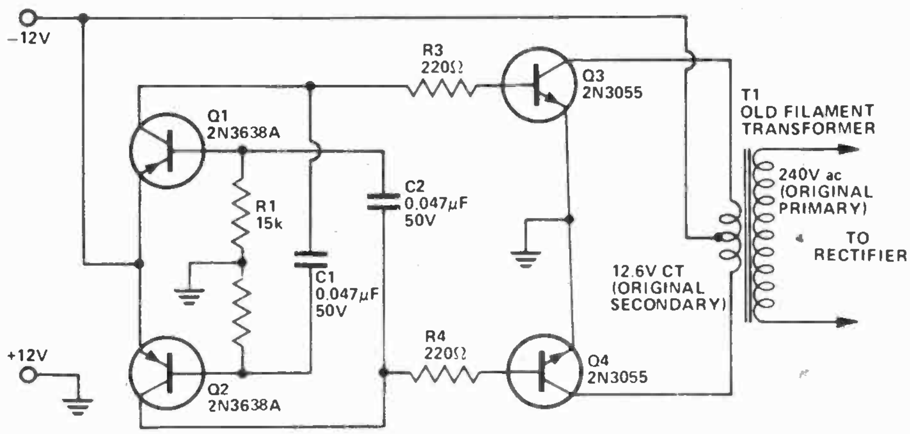
The two diodes should be a matched pair or clipping will not be symmetrical.

It is possible to mount the complete unit in many styles of hand-held microphone cases.

DC TO DC/AC INVERTER

This inverter uses no special components such as the torodial transformer used in many inverters. Cost is kept low with the use of cheap, readily available components.

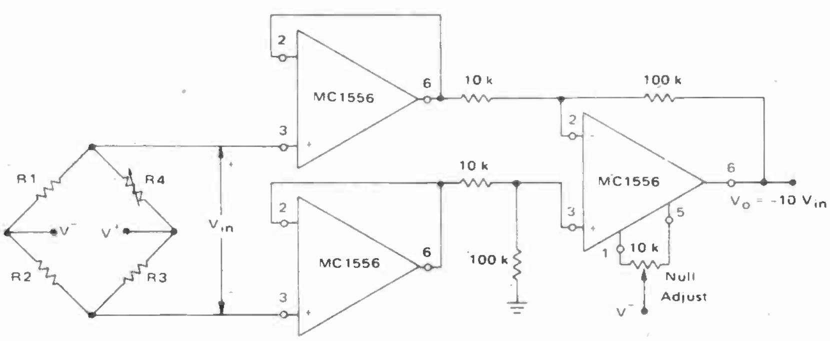
Essentially, it is a power amplifier driven by an astable multivibrator. The frequency is around 1200 Hz which most 50 Hz power transformers handle well without too much loss. Increasing the value of capacitors C1 and C2 will lower the frequency if any trouble is experienced. However, rectifier filtering capacitors required are considerably smaller at the higher operating frequency.



The two 2N3055 transistors should be mounted on an adequately sized heatsink.

The transformer should be rated according to the amount of output power required allowing for conversion efficiency of approx. 60%.

HIGH IMPEDANCE BRIDGE AMPLIFIER

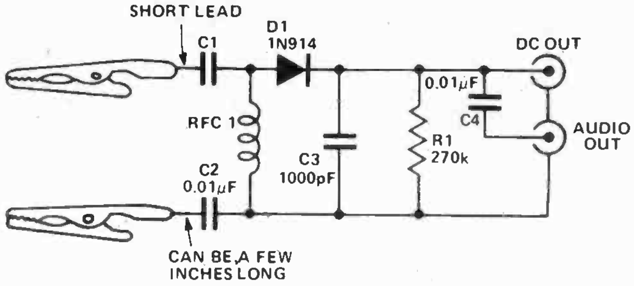


The MC1556 operational amplifier may be used as a voltage follower in a bridge amplifier application. The high input impedance avoids loading effects on the bridge and transforms the impedance down to a level where a third amplifier used in a differential mode can provide voltage gain, 10 in this case. The third amplifier employs the standard offset adjust circuit to provide nulling capability for the configuration.

Although the circuit is shown for complementary supply voltages, it lends itself well to operation from a single supply since the bridge can be operated just as well from the single supply. One must, however, provide for biasing the now-grounded 100 kΩ resistor to half the supply voltage using a simple resistive divider. Also, of course, the output is no longer referenced to ground, but to half the supply voltage. MOTOROLA-AN531.

tech-tips

GENERAL PURPOSE RF DETECTOR



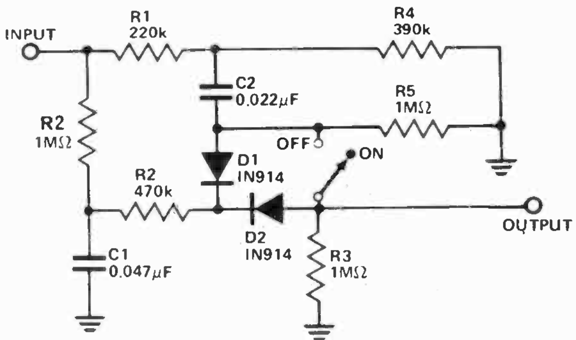
When constructing or developing communications equipment, such as transmitters, receivers etc, a very handy gadget is this general purpose RF detector. It provides dc output to a meter and audio output (if necessary) for checking transmitters or modulated signals.

It can be used also as a field strength meter or transmitter monitor.

The values of C1 and RFC vary depending on the frequency range in use. Below 1 MHz, C1 can be .001 μF and RFC at 2.5 mH or 5 mH RFC (i.e. Aegis C2, C4 or C9). In the HF region to 30 MHz, C1 can be 20 pF or a 5-40 pF trimmer while RFC1 can be a 2.5 mH choke (i.e. Aegis C2 or C4) or any choke down to 470 μH (i.e. Aegis C13, UPC560 or VPC470). In the VHF range C1 can be a 2 to 10 pF capacitor or 0.8 to 7 pF trimmer. RFC1 can be between 47 μH and 150 μH (i.e. Aegis VPC 150, UPC120, VPC100, VPC82, VPC68, VPC56 or VPC47).

Diode D1 can be almost any germanium diode or a hot-carrier diode. Mixer diodes such as the IN21 and IN23 series are also excellent. Use a diode with a high reverse-voltage rating if working with valve transmitters.

NOISE LIMITER



Noise pulse interference from motor vehicle ignition systems (another form of pollution – cars just can't win) can render a communications or shortwave receiver unuseable, completely blanketing reception of all signals except the very strong ones.

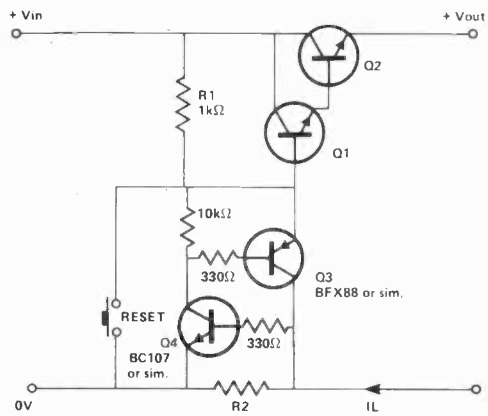
The limiter shown will very effectively improve the signal-to-noise ratio so that even quite weak signals can be copied.

It is connected between the detector output and the audio input (if high impedance) or at some relatively high-impedance section between two audio stages – preferably the low level stages.

The diodes, D1 and D2 can be any diode having relatively low forward resistance and very high back resistance. Types OA202, IN457, IN458 or IN459 are suitable. Resistors of ¼ watt or 1/8 watt rating can be used if miniaturization is desired.

The circuit is excellent for receivers having bandwidths down to 2 or 3 kHz. Increase the value of C1 for receivers having narrower bandwidths.

BETTER ELECTRONIC FUSE



The electronic fuse published in the April 75 "Tech-Tips" implies that load current is disconnected in the event of an overload. In fact it merely limits the load current to a value given by $\frac{0.7}{R2}$ amps. The following circuit will actually cause the load current to fall to zero.

If it increases so that $I_L R_2 > 0.7V$, Q4 will turn on, supplying base current to Q3. Q4 thus turns on, supplying further base current for Q4. Regenerative action continues until Q4 and Q3 are saturated. Q3 will then remove all base current from Q1, thus switching Q2 off making the load safe.

If the reset button is depressed, all current drive will be removed from Q3 and Q4, bringing them out of saturation. On releasing the reset button, the circuit will either revert to normal if the overload cause has been removed, or will snap off again if it is still present.

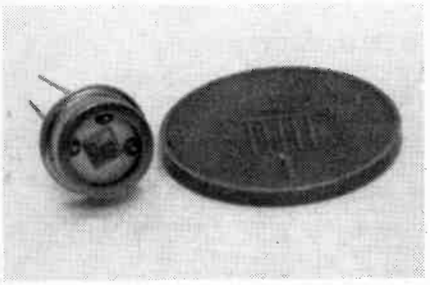
Care should be taken with earthing to avoid shorting R2.

Continued from page 9

PHOTOCELL PLUS

Photocells and phototransistors are available by the score but a new type available from Photain looks extremely interesting.

The IS-006 is spectrally matched to both Gallium Arsenide and Tungsten Lamp light sources making it suitable



for most types of photocell application. An I.C. and power output stage are incorporated. Current capacity is 80mA making it possible to energise a relay directly. A pot can be incorporated to determine the switch on intensity. Price is £3.50 plus VAT downwards depending on quantity.

Photain Controls Ltd., Unit 18, Hangar 3, The Aerodrome, Ford, Sussex.

SYNTHI Q.U.E.G.

Latest product from E.M.S. is the Synthi Q.U.E.G (Quadraphonic Effects Generator) an electronic device for processing quadraphonic audio signals. It has the ability to place 4 mono signals anywhere, and independently, inside a square domain. The position of the four signals may be moved manually, with a joystick control or automatically using the internal Quadrature Voltage Controlled Oscillator. Combinations of the automatic and/or manual control may be selected.

Each of the four audio channels has a level control. The audio signal passes via this control to a bank of four Voltage Controlled Amplifiers. The four outputs are controlled such that the total power is maintained constant (assuming a constant input) no matter where the signal is placed. Each channel has a display of 4 LED's which indicate the position of the signal of that particular channel. There are 4 channels and each channel has 4 outputs. Thus there is a total of sixteen outputs, which is available at the facilities socket. However, to make life easier, these 16 have been mixed down into four (also available at the facilities socket).

LITHIUM/METAL SULPHIDE BATTERIES

Commercial development of lithium/metal sulphide batteries gets under way as Argonne National Laboratory (USA) awards contracts to three firms for making cells and electrodes. The high-performance batteries have about five times the energy density of lead-acid batteries. First test cells are due by October; full-sized prototypes for electric vehicle tests may be available by 1981, Argonne says.

MINI BLOW TORCH

A new blow-torch which has a pencil point slim flame and is claimed to have wide use for electronic engineers has

been announced by Longs Limited.

The small butane cyclinder has a life of 4–5 hours give an operating temperature up to 2,200°C; refills are readily available.

The gas burner has a brass nozzle fitted with special cooling fins. A detachable solder pencil and standing base are included. Cost is £6.25 including VAT and postage.

Longs Limited, Hanworth Lane Trading Estate, Chertsey, Surrey KT16 9LZ.

BIPOLAR TRANSIENT SPIKE SUPPRESSORS

The first two in a range of voltage spike suppressors for protecting semiconductor circuit boards from random analogue and digital input transients and noise have been introduced by Coutant Electronics Ltd. Called *'transtectors'* these tiny devices, which have the appearance and size of a resistor, eliminate entirely both incoming spikes (particularly critical with TTL circuitry) as well as any reflected spikes that may emanate from the load.

Their principal advantage is that they can be used in parallel with a standard delayed SCR overvoltage 'crowbar' unit to provide a satisfactory method of meeting two prime requirements for semiconductor circuits: very fast acting protection when it is needed (their response time is only 5 nanoseconds), and the avoidance of unnecessary circuit shutdown (the so-called 'nuisance shutdown that is so common with conventional high-speed overvoltage protectors).

The transtectors operate by clamping the input and output lines of the device being protected to a specified voltage. *Coutant Electronics Ltd., 3 Trafford Road, Reading, RG1 8JR.*

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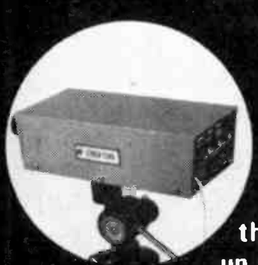

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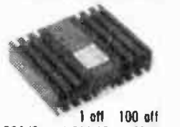

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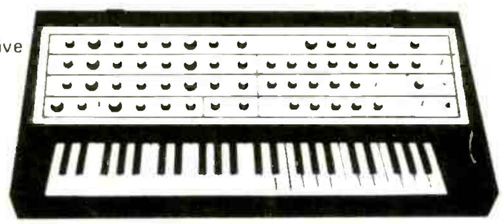

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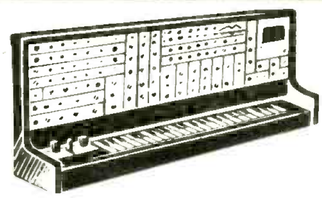

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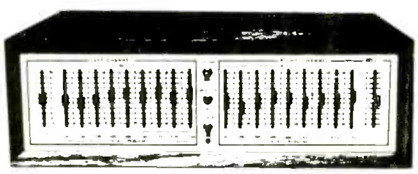

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