SEPTEMBER 1973

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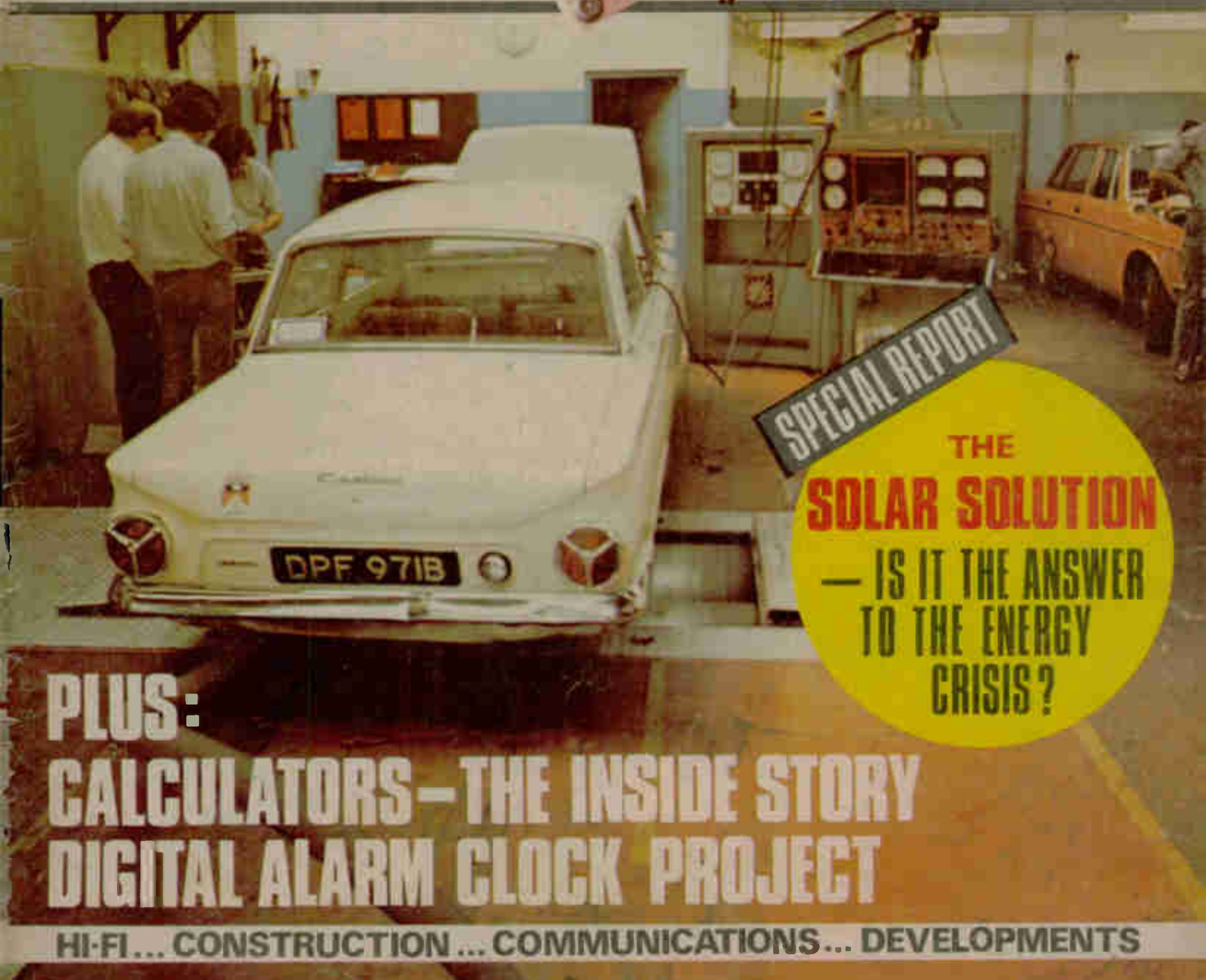

SPECIAL REPORT

THE

SOLAR SOLUTION

— IS IT THE ANSWER TO THE ENERGY CRISIS?

PLUS:

CALCULATORS–THE INSIDE STORY
DIGITAL ALARM CLOCK PROJECT

HI-FI... CONSTRUCTION... COMMUNICATIONS... DEVELOPMENTS

electronics TODAY INTERNATIONAL

SEPTEMBER 1973 Vol 2 No.9

main features

projects

news & information

Cover: The ETI Electronic Ignition System has been fully tested to check out the performance. The photograph shows one of the tests on a rolling-road which was made on the prototype.

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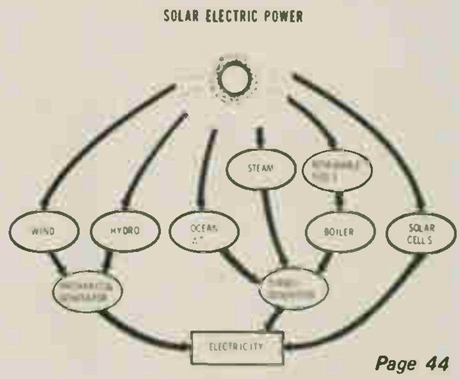

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SOLAR SOLUTION

The feature 'Solar Solution — is it the answer to the energy crisis' — is one that we have been working on for two months. During this time there have been a number of articles and TV programmes covering the same subject but our research has been very extensive and the article includes many unpublicised activities.

To obtain the necessary material we have literally made contacts all over the world: Britain, U.S.A., Australia, France, Japan, India, Israel, Soviet Union, Egypt and South Africa. We have also interviewed a number of researchers in this field.

What has struck us has been the enormous activity that has been going on, most of it initiated within the last two years. However, one point stands out: much of the work has been conducted in isolation. Many of the researchers we spoke to were unaware of the activities of almost identical work being pursued elsewhere in the world.

Interest in harnessing the sun's energy is growing and, to say the least, it seems a pity that co-operation is, as yet, on a limited scale. Our technology has reached the stage when any research into a new field is extremely expensive and this is surely an ideal field for international co-operation. Harnessing the sun's energy must be one of the few fields where there can be no military applications (we can think of none anyway) and it is also one which could help the underdeveloped nations. These nearly all lie in the equatorial regions which are best suited to harnessing solar energy. Similarly, these underdeveloped nations do not have vast plants and capital tied up to produce their electricity from fossil fuels and, starting from scratch, they would seem to be ideal areas to develop.

We have been careful in our presentation of this subject to avoid overstating the case for solar energy—that is our reason for having the question mark in the sub-title. We have drawn attention to the problems as well as to the benefits. Nevertheless, it is certainly a field worth pursuing and one in which international co-operation is needed. Let us hope that this can be achieved before too long. —H.W.M.

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news digest

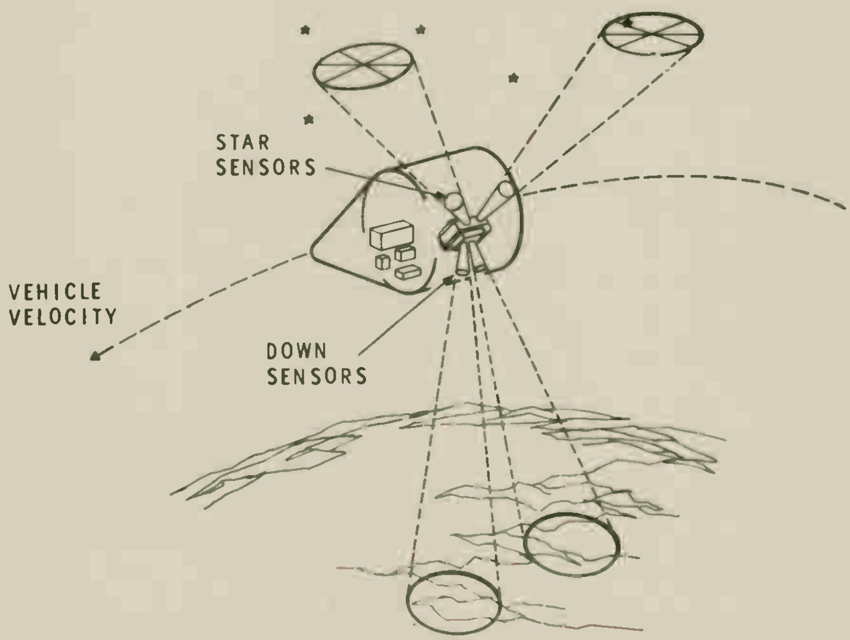
A NEW TRANSISTOR FOR 3W AND 3GHz

The photo shows a UHF broadband power transistor for 3GHz and 3W mounted on a film-type circuit measuring 0.6 x 0.6mm. The two wires are used to connect emitter and base of the component. The transistor design made visible in the photo is typical for microwave technology: close spacing and strip widths in the um range ensure a favourable emitter edge length to collector-base capacitance ratio. The resistors arranged on the left in front of each emitter strip are used to keep the current load uniform and in this way to achieve a good overall HF quality factor. The high frequencies — research has shown that a value of 4GHz is at present possible — and a drive current of up to 0.1A are obtained by extremely shallow surface diffusion of boron and phosphorus ions and by multilayer metallization on a gold base, which also results in high reliability. The silicon planar system is protected against the effects of humidity by nitride passivation.

The new transistor was photographed by the "Autoscan" sampling electron microscope, which has a greater depth of field and a resolution several powers of ten higher than an optical microscope. In this way very favourable methods of assessing new semiconductor components present themselves, in which conventional electric measurements can be supplemented by an electron-optical check of the fine structure.

"INTELLIGENT" SATELLITES

ANT IN ORBIT



A technique for enabling satellites to find their own way around the earth without having to rely on ground tracking stations is being designed at Honeywell's Aerospace Division under contract from the U.S. Air Force Space and Missile Systems Organisation.

The technique — called Autonomous Navigation Technology (ANT) — will enable a satellite to identify its position even before it completes one full orbit of the earth. This particular solution to satellite self-navigation, along with two others being developed by other companies, will be considered by the U.S. Air Force for possible equipment development.

The ANT concept calls for use of a gravitational model of the earth, stored in a satellite's computer memory, which will be continually refined by data provided by optically sensing various earth landmarks.A major part of the Honeywell effort will be to develop a laboratory prototype of the landmark sensing device, called a Down Sensor Assembly (DSA).

The DSA is a telescope that looks vertically at the earth, and receives reflected or radiated energy from features of the earth on its photodetector. For maximum accuracy two such telescopes strapped to the satellite body are required. An image viewed on the first detector will be "seen" by the second detector an instant later. The time lag between the two sightings is the basic measurement used to update the satellite's position and speed.

Horizon sensors and star sensors used to align the satellite after orbit is achieved have already been developed and most of the ANT testing will be accomplished through computer stimulation of these devices.

FASTER REHABILITATION WITH COMPUTER SUPPORTED EDUCATION

Believed to be one of the largest and most complex rehabilitation centres in the whole of Europe, The Heidelberg Centre in the Federal Republic of Germany provides retraining facilities for physically handicapped adult students unable to practise their own

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5" LP	900'	£1·95	£1·08
5" DP	1200'	£2 25	£1·24
5" TP	1800'	£3 26	£1·81
5¾" SP	900'	£1·95	£1·08
5¾" LP	1200'	£2·25	£1·24
5¾" DP	1800'	£3·26	£1·81
5¾" TP	2400'	£4·03	£2·23
7" SP	1200'	£2·25	£1·24
7" LP	1800'	£3·26	£1·81
7" DP	2400'	£4·03	£2·23
7" TP	3600'	£5 04	£2·78
PHILIPS HIGH FIDELITY LOW NOISE TAPES			
5" SP	600'	£1·29	£0·80
5" LP	900'	£1·44	£0·85
5" DP	1,200'	£1·94	£1·15
5¾" SP	900'	£1·70	£1·05
5¾" LP	1,200'	£1·80	£1·10
5¾" DP	1,800'	£2·83	£1·70
7" SP	1,200'	£1·97	£1·19
7" LP	1,800'	£2·57	£1·54
7" DP	2,400'	£3·97	£2·44
10½" LP	3,600'	£5·50	£3·30
PHILIPS LOW NOISE CASSETTES			
C60		£0·71	£0·39
C90		£0·99	£0·59
C120		£1·49	£0·84
SCOTCH DYNARANGE CASSETTES			
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C90		£1 07	£0·50
C120		£1 62	£0·80

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SCOTCH HIGH ENERGY COBALT CASSETTES			
C60		£1·10	£0·79
C90		£1·45	£0·99
SCOTCH HI-FI TAPE			
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5" DP	1,200'	£2·31	£1·41
5" TP	1,800'	£3·32	£2·06
5¾" SP	900'	£1·89	£1·15
5¾" LP	1,200'	£2·20	£1·35
5¾" DP	1,800'	£3·15	£1·95
5¾" TP	2,400'	£3·95	£2·45
7" SP	1,200'	£2·32	£1·44
7" LP	1,800'	£2·95	£1·84
7" DP	2,400'	£4·03	£2·49
7" TP	3,600'	£4·86	£2·99
8¼" LP	2,400'	£3·93	£2·47
10½" LPNA8	3,600'	£6·25	£3·90
SCOTCH LOW NOISE 8 TRACK BLANK CARTRIDGES			
40 min		£1·50	£0·95
80 min		£1·80	£1·10
MEMOREX LOW NOISE HIGH OUTPUT TAPES			
5" SP	600'	£1·34	£0·92
5" LP	900'	£1·89	£1·17
5" DP	1 200'	£2·26	£1·47
7" SP	1 200'	£2·26	£1·45
7" LP	1,800'	£3·21	£1·95
7" DP	2,400'	£4·01	£2·45
10½" SPNA8	2 500'	£5·00	£3·45
10½" LP NA8	3 600'	£6·00	£3·90
MEMOREX LOW NOISE HIGH OUTPUT CASSETTES			
C60		£0·76	£0·39
C90		£1·00	£0·59
C120		£1·50	£0·84
MEMOREX CHROMIUM DIOXIDE CrO_2 CASSETTES			
C60		£1·35	£0·84
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BASF LH HI-FI	Tape length	Rec. Price	Cash Price (not inc. VAT)
5" LP	900'	£2·17	£1·20
5" DP	1200'	£2·49	£1·38
5" TP	1800'	£3·59	£1·99
5¾" LP	1200'	£2·49	£1·38
5¾" DP	1800'	£3·59	£1·99
5¾" TP	2400'	£4·45	£2·46
7" LP	1800'	£3·59	£1·99
7" DP	2400'	£4·45	£2·46
7" TP	3600'	£5·54	£3·06
10½ LP	4200'	£8·95	£4·93
BASF LH HI-FI CASSETTES IN KK8 SWIVEL BOX			
C60		£0·79	£0·48
C90		£1·07	£0·68
C120		£1·57	£0·98
BASF LH HI-FI CASSETTES IN PHILIPS TYPE 'SNAP PACK'			
C60		£0·71	£0·39
C90		£0·99	£0·59
C120		£1·49	£0·84
BASF LH HI-FI SM CASSETTES			
C60		£0·80	£0·49
C90		£1·11	£0·69
C120		£1·51	£0·94
BASF CHROMEDIOXIDE CrO_2 SM CASSETTES			
C60		£1·34	£0·84
C90		£1·74	£1·14
C120		£2·24	£1·44
MALLORY LNF DURATAPE CASSETTES			
C60		£0·71	£0·34
C90		£0·99	£0·49
C120		£1·49	£0·74
MALLORY COBALT ENERGISED CASSETTES			
C30		£1·05	£0·54
C60		£1·25	£0·64
C90		£1·70	£0·84
MEMOREX HIGH FIDELITY 8 TRACK CARTRIDGES			
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INTER-PHONICS

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news digest

profession.

Computer supported education is among a wide variety of teaching techniques employed at this centre. At the heart of the Centre is a computer complex containing two IBM and two Siemens digital computers. One computer, in addition to helping to control a host of administrative functions, stores hundreds of programmed lessons on subjects ranging from electronics engineering to business administration. The computer records, analyses and corrects students answers, assisting and guiding them to the correct solutions. Because students use CRT terminals to communicate with the computer, they can continue their studies even from a hospital bed.

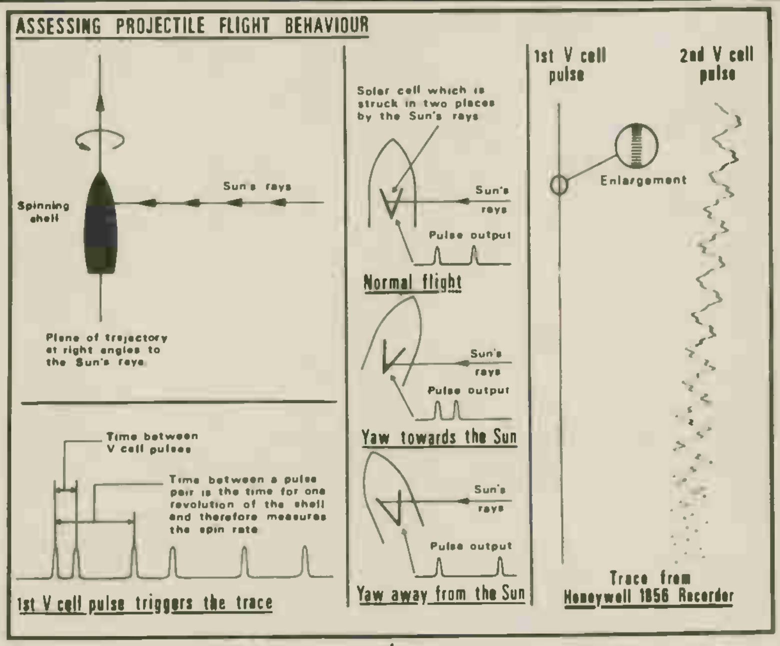
From a maximum of thirty students, each with a CRT terminal, in a building approximately 3Km from the main computer, data is fed along a link to the computer. Normally each terminal would require a telephone link of its own, but using Racal-Milgo multiplexing equipment only one data link is required, thus reducing line rental costs.

EMI-SCANNER, WINS QUEEN'S AWARD

The Central Research Laboratories of EMI Limited have won a 1973 Queen's Award to Industry in "recognition of their outstanding achievement in technological innovation". The award is for the EMI-Scanner — the company's revolutionary computerised X-ray system for the diagnosis of brain disorders which was described in ETI of June 1972.

Fully proven in clinical trials, the machine can build up a highly detailed picture of a patient's brain with much greater sensitivity and clarity than conventional X-ray equipment. The development will enable brain diseases and defects to be diagnosed and located quickly with less discomfort and exposure to X-rays for the patient.

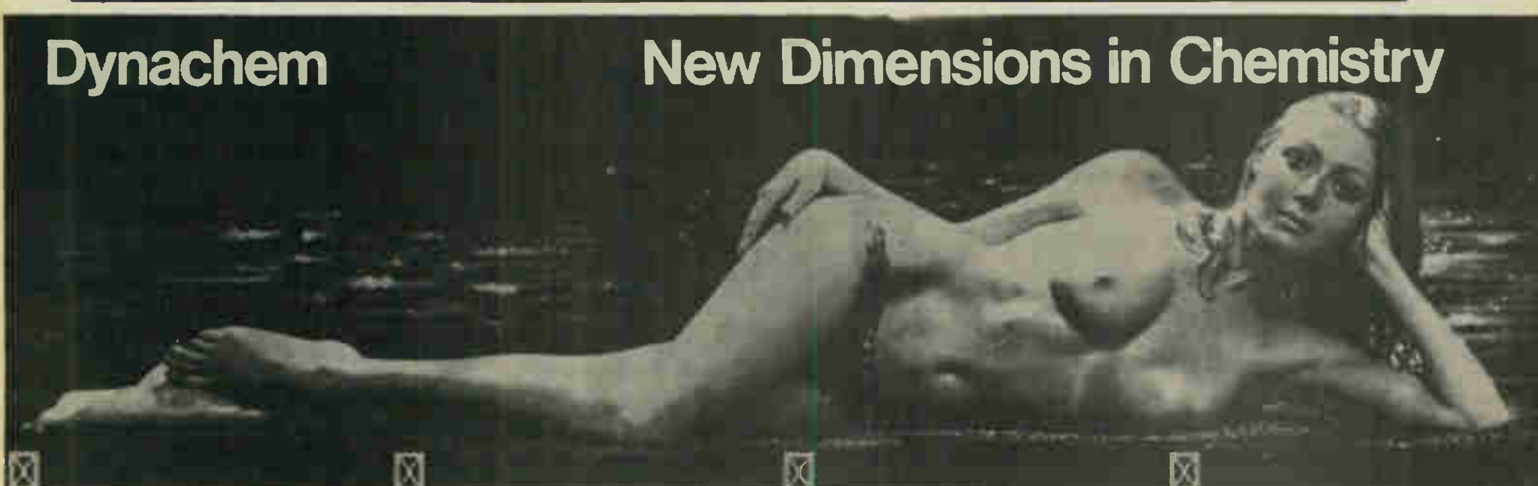
In November last year, the system won Britain's equivalent of the Nobel Prize, the MacRobert Award of £25,000 and a gold medal for Godfrey Hounsfield and EMI.



A method of assessing the flight behaviour of various projectiles is currently being used by the Directorate of Proof and Experimental Establishments, Ministry of Defence. The method uses the sun and a photovoltaic V-shaped attitude sensor carried on board the projectile.

The attitude data is telemetered from the projectile to ground receiving stations. The data consists of pulse pairs generated from the sensor, which when processed result in a record of the projectile's attitude with respect to the sun.

The pulse pairs are transmitted at the projectile's spin frequency of several hundred revolutions per second. These are demodulated from the receiver and displayed on a Honeywell Line Scan FO-CRT Type 1856 in parallel with being recorded on magnetic tape.



GIRL BY INSTALMENTS!

Electronics manufacturers throughout Europe are receiving a series of unusual sales leaflets from a manufacturer of specialist chemicals used in the making of printed circuit boards.

Dynachem are sending out four leaflets spaced at regular intervals. On the front of each will be printed a tantalising part of the company's DYNAGIRL, an exquisite young lady well worth a second look. By keeping the leaflets, the recipient will be able to build up a complete picture.

On the reverse sides will be information about the company's range of photo-resists, plating solutions, brighteners, cleaners and ancillary chemicals.

DRILL CONTROLLER

New 1kW model.
Electronically changes speed from approximately 10 revs. to maximum. Full power at all speeds by finger tip control. Kit includes all parts, case, everything and full instructions £1·65, plus 13p post and insurance. Made up model also available £2·48 plus 13p p. & p.

MIGHTY MIDGET

Probably the finest possible radio, as described in Practical Wireless, January 73. All electronic parts £2·20 post paid.

1 CHIP RADIO

Ferranti's latest device ZN414—gives results better than superhet. Supplied complete with technical notes and circuits £1·38 each. 10 for £11·11.

HI-Q TUNER COMPONENTS

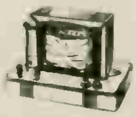
For experimenting with the ZN414

Kit No. 1 Plessey Miniature Tuning Condenser with built-in LW switch and 3in. Ferrit slab and litz wound MW coil 72p.

Kit No. 2 Air spaced tuning condenser 6in. ferrit rod litz wound MW and LW coils. And wave change switch 94p.

Kit No. 3 Air spaced TC with slow motion drive 8in. ferrit rod with litz wound LW and MW coils. And wave change switch £1·10.

KIT No. 4 Permeability tuner with fast and slow motion drive and LW loading coils. And wave change switch 50p.



12 VOLT 1½ AMP POWER PACK

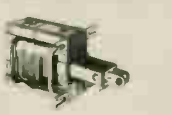
This comprises double-wound 230/240V mains transformer with full wave rectifier and 2000 m/f d smoothing. Price £2·20, plus 20p post & packing.

Heavy Duty Mains Power Pack. Output voltage adjustable from 15-40V in steps—maximum load 250W—that is from 6 amp at 40V to 15 amp at 15V. This really is a high power heavy duty unit with dozens of workshop uses. Output voltage adjustment is very quick—simply interchange push on leads. Silicon rectifiers and smoothing by 3,000mF. Price £6·33 plus 65p post.

MICRO SWITCH

5 amp changeover contacts, 11p each. 10 for 99p. 15 amp. S.P. Model 15p, changeover 17p each.

MAINS OPERATED SOLENOIDS



Model 772—small but powerful 1 in. pull—approx. size 1¼ × 1¼ × 1½in., 66p.
Model 4001/—½in. pull. Size 2¼ × 2 × 1½in. 83p.
Model TT1—1½in. pull. Size 3 × 2¼ × 2in. £1·98 plus 20p post and insurance.

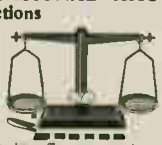
MAINS TRANSISTOR POWER PACK

Designed to operate transistor sets and amplifiers. Adjustable output 6v., 9v., 12 volts for up to 500mA (class B woring). Takes the place of any of the following batteries: PP1, PP3, PP4, PP6, PP7, PP9, and others. Kit comprises: mains transformer rectifier, smoothing and load resistor condensers and instructions. Real snip at only £1·10 plus 20p postage.

TIME SWITCH

Smith's mains driven clock with 15 amp switch, also notes showing how you can wake up with music playing, kettle boiling or come home to a warm house, warn off burglars, keep pets warm, halve your heating bill, etc. £2·25.

EDUCATIONAL KITS—all with pictorial instructions



THIS BALANCE KIT FREE
Eagle educational kits. Japanese made these are excellent value for money. We do not expect to be able to repeat this offer once stocks are sold. Brief description of each kit is given below and with 3 kits or more we give FREE an accurate 11 piece balance kit. Price of kits 44p each post paid. Special price for all 7 kits £3·00 with free balance kit.

KA2 Lens Kit. Eleven parts, including candle, one concave lens, one convex lens, stage and slit frame, etc. Watch light rays bend as they pass through different lenses.

KA3 Water Pump Kit. Thirteen parts. Top of pump is transparent so that operating parts may be observed. Small parts are brightly coloured to be seen easily while working. Three types of pump may be made: Lift pump, Force Pump and Force Pump with reservoir and nozzle.

KA4 Buzzer Kit. Eleven parts. Transparent covers allow the operation of buzzer to be seen. Illustrates and teaches how electromagnetism with an automatic switch results in an operating buzzer.

KA7 Electro Magnet Kit. Fifteen parts, includes compass. Makes two electro magnets, one with one layer of wire and one with several layers of wire. Picks up tacks, nails and any small parts showing how magnetism works.

KA8 Current and Resistance Kit. Twenty nine parts, including bench and light bulb. Conduct interesting and educational projects to learn the application of "OHMS LAW" and see the difference in current and resistance with different types and lengths of wire.

KA9 Bell Kit. Eight parts, including bell and push button switch. Build a complete electric bell and see how the hammer is triggered to make the bell ring.

KA10 Morse Key buzzer and bell kit. 25 part kit easy to construct, simple to operate.

THIS MONTH'S SNIP

GOOD COMPANION I.C. MODEL

We can now offer this fine receiver [illegible] I.C. [illegible] Ferranti ZN414 and Mullard AF Module 1172. Cabinet [illegible] approx. 11in. wide × 8in. high × 3in. deep. Complete with excellent 2 tone cabinet with assembly instructions £5·75.

THYRISTOR LIGHT DIMMER

For any lamp up to 250 watt. Mounted on switch plate to fit in place of standard switch. Virtually no radio interference. Price £3·35. Industrial model 5A £3·30.

10 AMP DIMMER CONTROL

For the control of lighting on stage or in a studio or for control of portable equipment in workshops, etc. This has two 13 amp socket outlets each is controlled by a 5 amp solid state regulator. The overall length is 17in., width 3½in. and depth 1½in. In the end is fitted a master On/Off switch indicator, lamp and fuse. Price £8·25.

STANDARD WAFER SWITCHES

Standard size 1½in. wafer—silver plated 5 amp. contact, standard ¼in. spindle 2in long—with locking washer and nut.

No. of Poles	2 way	3 way	4 way	5 way	6 way	8 way	9 way	10 way	12 way
1 pole	44p	44p	44p	44p	44p	44p	44p	44p	44p
2 poles	44p	44p	44p	44p	44p	44p	44p	77p	77p
3 poles	44p	44p	44p	44p	77p	77p	77p	£1·04	£1·04
4 poles	44p	44p	44p	77p	77p	77p	77p	£1·32	£1·32
5 poles	44p	44p	77p	77p	£1·04	£1·04	£1·04	£1·60	£1·60
6 poles	44p	77p	77p	77p	£1·04	£1·04	£1·04	£1·87	£1·87
7 poles	77p	77p	77p	£1·04	£1·32	£1·32	£1·32	£2·15	£2·15
8 poles	77p	77p	77p	£1·04	£1·32	£1·32	£1·32	£2·42	£2·42
9 poles	77p	77p	£1·04	£1·04	£1·60	£1·60	£1·60	£2·70	£2·70
10 poles	77p	77p	£1·04	£1·32	£1·60	£1·60	£1·60	£3·00	£3·00
11 poles	77p	£1·04	£1·04	£1·32	£1·87	£1·87	£1·87	£3·25	£3·25
12 poles	77p	£1·04	£1·04	£1·32	£1·87	£1·87	£1·87	£3·52	£3·52

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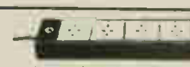


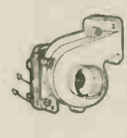
Just what you need for work bench or lab. 4 × 13 amp sockets in metal box to take standard 13 amp fused plugs and on/off switch with neon warning light. Supplied complete with 6 feet of heavy cable. Wired up ready to work, £2·48 plus 25 p. & p.

CAPACITOR DISCHARGE CAR IGNITION

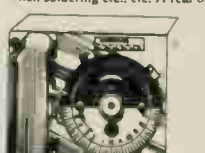
ELECTRONIC IGNITION

This system which has proved to be amazingly efficient and reliable was first described in the *Wireless World* about a year ago. We can supply kit of parts for an improved and even more efficient version (*Practical Wireless* June). Price £5·55 plus 30p post. When ordering please state whether for positive or negative systems. Also available, ready made ignition systems for 6v. vehicle. £5·78 plus 20p.

CENTRIFUGAL BLOWER



Miniature mains driven blower centrifugal type blower unit by Woods, powerful but specially built for quiet running—driven by cushioned induction motor with specially built low noise bearings. Overall size of blower is approx. 4½" × 4½" × 4". When mounted by its flange air is blown into the equipment but to suck air out mount it from the centre using a clamp, ideal for cooling electrical equipment, or fitting into a cooker hood, film drying cabinet or for removing flux smoke when soldering etc., etc. A real bargain at £2·04.



ELECTRIC TIME SWITCH

Made by Smiths these are A.C. mains operated. NOT CLOCKWORK. Ideal for mounting on rack or shelf or can be built into box with 13A socket. 2 completely adjustable time periods per 24 hours. 5 amp changeover contacts will switch circuit on or off during these periods. £2·75 post and ins., 23p. Additional time contacts 55p pair.

SPECIAL SUMMER OFFER

Mullard Unilex at Pre V.A.T. price. You want a good stereo system—well here's an offer you should not miss! The four Mullard modules all in original manufactures cartons and with original makers guarantee. £7 the lot. Control unit with name plate and 4 spun aluminium faced control knobs £3. Total £10 post and VAT paid. 2 Goodmans Speakers £3.00

MULLARD AUDIO AMPLIFIERS

All in module form, each ready built complete with heat sinks and connection tags, data supplied.
Model 1153 500mW power output 72p.
Model 1172 750mW power output 94p.
Model EP9000 4 watt power output £1·60.
EP9001 twin channel or stereo pre amp. £1·99.
10% discount if 10 or more ordered.

WINDSCREEN WIPER CONTROL

Vary speed of your wiper to suit conditions. All parts and instructions to make. £2·48.

HORSTMANN 24-HOUR TIME SWITCH

With 6 position programmer. When fitted to hot water systems this could programme as follows:—

Programme	Hot Water	Central Heating
0	Off	Off
1	Twice Daily	Off
2	All Day	Off
3	Twice Daily	Twice Daily
4	All Day	All Day
5	Continuously	Continuously

Suitable of course, to programme other than central heating and hot water, for instance, programme upstairs and downstairs electric heating or heating and cooling or taped music and radio. In fact there is no limit to the versatility of this Programmer. Mains operated. Size 3in × 3in.× 2in. deep. Price £3·85 as illustrated but less case.

TAPE PLAYBACK UNITS

Mains operated. Made by Rediture the famous "music in background people." These are complete units ready to work and we understand that they are in good going order. We have not tested them but would exchange any that do not work properly. These have a superior motor driven flywheel to control the tape through the capstan and also an even equally useful valve amplifier with EL84 output. In a steel case with carrying handle. Two models offered, good as new £6·50 and some what used at £3·50. 75p carriage up to 200 miles then 50p per 100 miles extra.

NEW ITEMS THIS MONTH

LABORATORY INSTRUMENTS

Used but believed in good order —one only of each—on offer to highest bidder. Emi Paroramic wave analyser.
2× Beckman Universal Eput. Timer Model 7360 c
Furst Electronics Wow Meter 115RA
Manson Proportional Oven and Xtal Osc RD140
Airmec Millivolt Meter type 264
Marconi Magnification Meter TF 329G
Airmec Frequency Meter Type 726
Soarton Laboratory Amplifier 15 c/s—350kcs Aws 51a
GEC Quartz Xtal Activity Test Set 2 —20 mc/s
Muirhead Phasemeter D729 BM
Muirhead Phasemeter D729 BS
Heath Kit—C Bridge C34
RCA Flutter Indicator.
Metrix Standard Sig Generator 50m/cs. 50m/cs to 50 mc.

METAL CHASSIS

14 gauge sheet steel—size approx. 7" × 3½" × ¾" deep. Cadmium plated punched in the centre to take 3 P.O. 3000 type relays. There is also a removeable cover over this section measuring 4½" long × 3½" × 3¼". The chassis also has a few holes and could take a small transformer and/or valve holders also some ⅝" holes for controls, pots etc. This is an ideal chassis for making up a relay unit or similar. These are ex equipment but in excellent condition and may have a few resistors etc. still attached. Price 40p each.

CLOCKWORK TIME SWITCH

For delaying the switching on for up to 12 hours. Being clockwork this is independent of the mains and is therefore useful for remote operation or for battery appliance. The front dial which is calibrated in hours is turned through the required revolution then after pre set time double pole 15A switch operates. Made by Smiths Price £1·65.

MAINS TRANSFORMER

Our Ref. MTJ1. Drop through chassis—open construction 240v Primary—9v 1A Secondary, Price 77p each

MAINS TRANSFORMER

Our Ref MTJ2. Parmeko Neptune series. This is a totally enclosed 'C' core construction, upright mounting and black enamelled. For 230/240v Sec. 25—0—25v at 50 mA Ideal for mounting on metal chassis mentioned above. Ex equipment but unused. 77p each.

3 POST OFFICE TYPE 3000 RELAYS

Ex equipment but guaranteed perfect—any not so would be changed.

1. Ref REL J1. Has 6 sets of change over contacts and 2000 ohm coil. 55p each.
2. Ref REL J2. 2 pairs that close when relay energized and 2000 + 1000 ohm coil. Price 44p.
3. Ref. REL J3. 2 pairs contacts that close and 6.4. K ohm coil. 44p.

1 REV. PER MINUTE MOTOR WITH GEAR-BOX

Made by the famous Chamberlain & Hookman Ltd., These could be made to drive clock or similar. Really robust reliable unit. Price 99p each.

110 REV. PER MINUTE MOTOR WITH GEAR BOX

Good American make. Operates from mains and will drive switch mechanism or other medium device. Size approx 4" × 3" × 2¾" with 4" diameter drive shaft. Price £2·20.

12v CAR BLOWERS

Units made by Delco. 6 Bladed 5" dia. fan inside heavy duty cylinder. These have really powerful series wound motors giving a terrific air suitable for ventilating or heating a car, boat, caravan etc. Price £2·20 plus 40p post and insurance. (note these are intended for 12v D.C. but can be run from A.C. up to 30v. The higher the voltage the more the air flow.)

13 AMP SWITCHED SOCKETS

By G.E.C Standard type for fused plugs. Brown bakelite —17p each or £1·50 for 10.

V.H.E. AMPLIFIERS

With built in mains power pack, these are valve amplifiers, are metal cased and co ax inputs and outputs. Optimum amplification at T.V. frequency—Useful also for re building into another unit which needs a mains power pack. Price £2·75p.

3 CORE MAROON COTTON COVERED FLEX

Very best makers but old coloured code. 6 amp—23/36 × 100 yd coil £2 plus 50p. 15 amp—70/36 × 50 yd coil £3·95 plus 50p post

J. Bull (Electrical) Ltd., 7, Park Street, Croydon CR0 1YD.

Where postage is not stated then orders over £5 are post free Below £5 add 20p S.A.E. with enquiries please.

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news digest

SOLID STATE VALVE

Co-operation in the field of high-voltage direct current was established between ASEA and the two Scandinavian power utilities, ELSAM and NVE, in order to bring about the installation of a new type of thyristor valve in the Danish station of the Konti-Skan DC transmission link between Denmark and Sweden. This new ASEA generation of thyristor valves has been developed to meet future demands on HVDC power and voltage levels. The valve, which is replacing one of the permanent mercury-arc valves, is planned to run commercially for a couple of years in order to gain service experience.

The thyristor valve for HVDC has been developed within a very short period. In 1967 ASEA introduced the thyristor technique to HVDC through the installation of a thyristor valve for a test period in the DC transmission link between Gotland and the mainland of Sweden. The research and development carried on since then have resulted in a new type of thyristor valve with a design principle prepared to meet any voltage and power levels expected for HVDC transmission schemes to come. The new valve has 125MW output (125kV at 1000A).

The thyristor valve is built up from modular units, each comprising six thyristors. Each unit has its separate cooling system, valve damping circuits and control equipment. By means of series connection of the modular units the voltage can be adapted to the optimum voltage level determined by the DC line.

Air is used for both cooling and insulation. The control unit for each thyristor obtains its auxiliary power supply directly from the thyristor voltage.

COMPUTER SYSTEM FOR CRIMINAL INVESTIGATIONS

A major breakthrough in the fight against crime has been achieved in the United States by the introduction of a low-cost computerised investigation system. Developed by the Oakland Police Department's Research and Development Division, the system is based on a Hewlett-Packard mini-computer.

The computerised system performs a number of investigative functions by utilising the often fragmentary descriptions supplied by witnesses to a crime. It helps identify criminals by comparing known physical characteristics and methods of committing crimes with information already contained in police files.

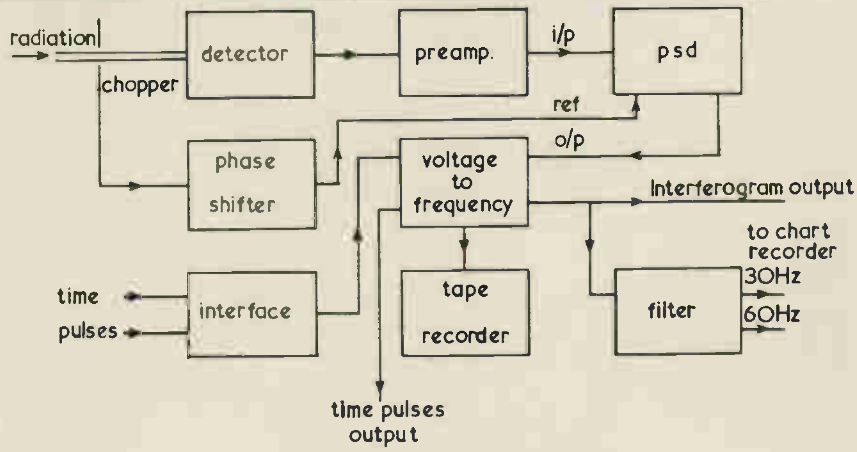
As well as identifying a vehicle (and hence the driver) involved in a crime, it can also match fingerprints found at the scene of a crime with those on file. A fingerprint file search that formerly took four or five hours can now be completed in fifteen to twenty minutes.

The computer is interfaced with two microfiche viewers. One displays photographs so that witnesses can identify offenders, while the other contains classified fingerprints which can be compared with prints taken from the scene of crimes.

In the first few weeks of testing the system, with only a partial data base, eight burglars were identified and arrested as the result of computer-directed fingerprint searches. At least six robbery suspects were identified from photographs and another suspect was identified solely on his nickname.

Data formerly on fingerprint cards, police records and photographs are now stored on files in the computer system or on microfilm. The system is capable of storing information on more than 25,000 people and on 31,000 vehicles.

Criminals' photographs are maintained in a microfilm viewer which is interfaced with the minicomputer. The computer file contains nicknames, first names and up to 25 physical characteristics of each subject (sex, race, height, weight, hair colour, complexion, fingerprint data etc). The police records can be searched on any one, or a combination of these characteristics.



Block diagram of experiment

CONCORDE 001 FOLLOWING THE SUN

On the 30th June 1973 Concorde 001 flew astrophysicists from Queen Mary College, London, to study Pnhomogeneities (electron temperature and density as functions of height and position above the photosphere) on a scale of a thousand Kilometres in the sun's chromosphere during the eclipse by the moon. Concorde flew into the shadow of the eclipse and followed it to obtain about 80 minutes of total eclipse.

The diagram shows the experiment which was conducted. Radiation (infra-red) from the sun was chopped and fed into a Michelson Interferometer which was repeatedly scanning, to take in the wave-lengths of interest. Radiation from the interferometer was then focused onto a Rollin detector – an indium antimonide crystal cooled by liquid helium. The output from the detector was amplified and fed into a phase sensitive detector, the output of which was voltage to frequency converted and stored on a magnetic tape for subsequent analysis.

SKYLAB CREW WELDS WITH AN ELECTRON BEAM

Welding was one of the experiments conducted in the Skylab mission to see how molten metal behaves in a weightless environment. Since welding will

be necessary in future space missions, Skylab's crewmen tested an electron beam welder developed for the space agency's Marshall Space Flight Centre by Westinghouse Electric Corporation's Astronuclear Laboratory.

Electron-beam welding is one of the newest techniques for metal joining and, in many respects, possibly the most desirable. One advantage is that welding is so rapid that the heat in the weld has no chance to spread to the surrounding metal to make it brittle and susceptible to cracking. The process produces exceptionally deep, strong, uniform welds and it can be applied to a variety of metals and alloys including all those likely to be used in space.

A unique feature of the new Westinghouse welder is that it is a completely self-contained unit. It measures 36in long by 13in in diameter. Without the battery it weighs 77 pounds, the battery weighs 43 pounds. Earth-bound counterparts are powered by large external power supplies. The battery produces 100A at 28V for about 10 minutes.

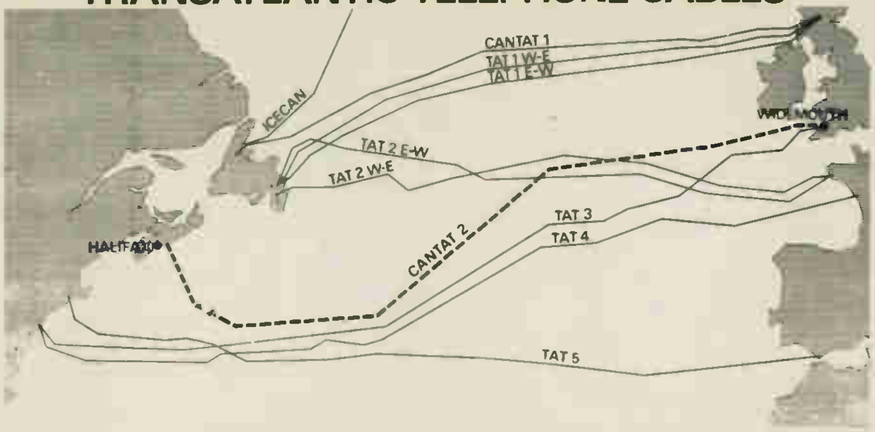
A tungsten filament generates a 20kV, 100mA, tightly focused electron beam that does the welding. The electron gun is attached to a work chamber which during the experiments is vented to space, producing a vacuum. This has two important advantages. One is that the better the vacuum, the better the electron beam welds. The other advantage is that the absence of air and particles means there are no contaminants to affect the quality of the weld.

£30M TRANSATLANTIC PHONE LINK

The cableship Mercury has started to lay a £30 million telephone cable linking Britain and Canada. Handling more than 1,800 telephone conversations simultaneously the cable, Cantat-2, will be the biggest single telephone cable across the Atlantic, carrying more telephone calls than all the existing transatlantic cables combined. The cable system will be used for communication between the UK and mainland Europe, and Canada and the USA.

Being financed and operated jointly by the British Post Office and the Canadian Overseas Telecommunications Corporation, the 3,000-mile cable is being provided to meet the massive growth in telecommunications between Britain and North America. In ten years 'phone calls between Britain and Canada have risen eightfold from 135,000 calls a year in 1962 to their present level of more than a million a year. This will rise again to nearly 6 million a year by 1980. Growth in calls between the UK and the USA has risen from half-a-million in 1962 to more than 4½ million in a year in 1972, and by 1980 this will have reached 24 million a year.

TRANSATLANTIC TELEPHONE CABLES



Cantat-2 will have 473 repeaters. The task of the repeaters is to amplify telephone signals on their undersea journey. In the deepest parts of the Atlantic repeaters will be under a pressure of three tons to the square inch, and are protected by deep-sea pressure housings.

2,800 transistors will be used in the amplifiers in Cantat-2, each with a design life of at least 25 years.

Cantat-2 will also have 31 equalisers, spaced at approximately 90-mile intervals in the cable and placed in pressure housings similar to a repeater. Equalisers are electrical circuits designed to compensate for variations in the match between repeater gain and cable loss. The electrical characteristics of the cable are altered when it is placed in the sea, and equalisation compensates for the difference between the predicted and actual change.

Equalising these differences ensures that the performance of telephone circuit over the whole of Cantat-2's frequency range will be virtually identical. The equaliser is initially assembled at the cable works and finally completed at sea during the course of laying operations.

Cantat-2's 1,840 circuits are arranged as 23 supergroups, transmitting in the frequency band 312-6, 012kHz in the UK-Canada direction and 8,000-13, 700kHz in the Canada-UK direction. In addition four speaker circuits of nominally 3kHz bandwidth each, use the frequency bands 6,024-6, 036kHz in the UK-Canada direction and 7,976-7, 798kHz in the Canada-UK direction, for system and circuit maintenance.

The cable itself is predominantly of lightweight design and will weigh no more than five tons a mile. Less than two inches in diameter for most of its length the cable has an outer conductor of aluminium. Its strength is centred in a steel rope inside an inner copper conductor. External armour will be used to protect the cable at the UK shore end.

LASER FOR CLOUD HEIGHT MEASUREMENT

ASEA, Sweden, have developed a new low-power cloud ceilometer, QL 1210, as complementary equipment to the high-power type introduced some years ago. This smaller unit is intended for use at airfields, meteorological stations etc., for the continuous recording of cloudbase height up to 1000m (3300ft).

An injection laser transmitter is employed, using a gallium arsenide diode. The light intensity is well below the limit for non-injurious radiation, so it is not necessary to take any special precautions in use or during servicing. A 2-core telephone line connects the transceiver to a pen recorder, set up indoors.

The control unit sets the recorder pen off on its sweep at the same time as a light pulse is transmitted. When an echo pulse is received the pen begins to write, having reached a position on the scale corresponding to the height of the cloud. ●

VAT INVOICES ON REQUEST

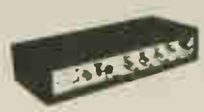
UNLESS SHOWN OTHERWISE P&P ON UK ORDERS IS 8p OVERSEAS ORDERS AT COST

Mullard LP1186

£4 15

LP1185

£4.85



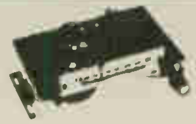
THE TEXAN

£31.35 + p & p 49p

SGS EA1000

FREE HEATSINK

Our Price £2.49



A1005S

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A1018

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A1005MS

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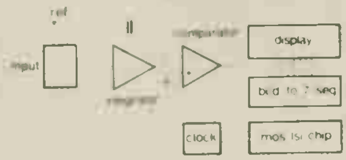
[illegible]	[illegible]	£1.79
[illegible]	[illegible]	£1 59
[illegible]	[illegible]	£1 65
[illegible]	[illegible]	£1 59
[illegible]	[illegible]	£3.95
[illegible]	[illegible]	£1.32

3½ decade DVM



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[illegible]	—	—	92p
[illegible]	42p	45p	43p

[illegible]	95p	[illegible]	£1 65
[illegible]	£1 65	[illegible]	£1 65
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[illegible]	77p	[illegible]	£3 49
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[illegible]	83p	[illegible]	£2 29
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[illegible]	20p	[illegible]	14p	[illegible]	17p	[illegible]	13p	[illegible]	19p
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[illegible]	13p	[illegible]	18p	[illegible]	8p	[illegible]	16p		

ELECTROLYTICS

µF	4V	6.3V	10V	16V	25V	40V	63V	100V
[illegible]							6½p	8p
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[illegible]						6½p	6½p	
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[illegible]	29p			44p	68p	79p	149p	252p
[illegible]				75p	93p			
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[illegible]	14½p			[illegible]	16½p
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[illegible]			11p	[illegible]	29p
[illegible]			11p	[illegible]	29p

Other types obtainable upon application.

TIMTRONIC

A digital alarm calendar clock

BY JOHN MILLER-KIRKPATRICK

The basic circuits for a TTL digital clock are well known and usually require from 20-25 i.c.s. These designs however, apart from their complexity, are subject to spurious mains pulses which frequently mean that the clock will gain a few seconds each day. In addition, the power requirements are not insignificant and a current drain of 0.5A is typical. These problems have resulted in true electronic digital clocks being very expensive and no company has produced these in quantity.

Commerical digital clocks usually use flip-over digits or 'Nixie' tubes switched by rotary switches. Both these types use a synchronous electric motor. A true electronic clock has no moving parts (except for the setting switches) and will not wear out. In fact, a true electronic clock could still be running when electricity goes out of fashion!

For this reason an electronic clock could be regarded as a pretty good investment but how about one that makes full use of the accuracy of a electronic technique and operates as an alarm or displays time and date alternately?

Using TTL techniques the complexity would present serious problems — thirty or more i.c.s would be required and the current drain would be about 1A. The associated switching would also be highly complex.

Wouldn't it be wonderful if the technology which produces calculator chips could be applied to clocks... well, it has! Mostek, who produce a calculator chip found in many machines have recently introduced a range of clock chips. The range is known as the MK5017 and there are three variations: the AA which has an alarm circuit, the AN with alarm and sleep circuitry and the BB which has a calendar facility. The AA and BB are very similar and with a few modifications a clock built with the MK5017AA will accept the BB chip.

In this feature we shall describe the AA, digital alarm clock version but the modifications to incorporate the BB will also be given.

MOSTEK 5017AA ALARM CLOCK CHIP

The MK5017AA is designed to drive 7-segment luminescent-anode display tubes directly without interface circuitry. Either four or six digits can be accommodated and the clock will work from 50 or 60Hz mains frequency. The clock always works in the 24 hour mode for alarm setting reasons but

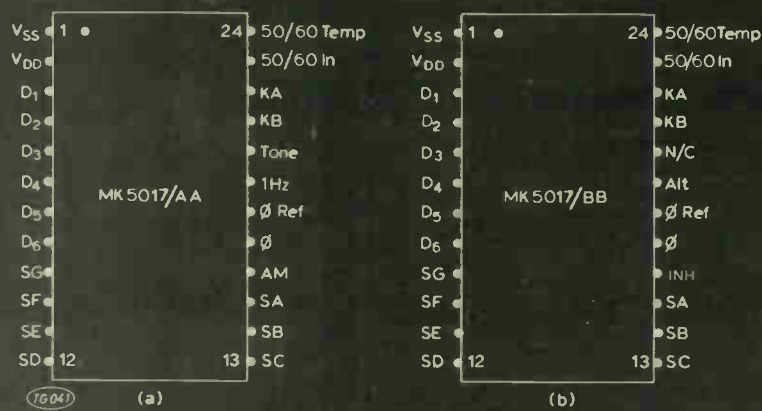


Fig. 1. The pins connections for the a) MK 5017/AA (alarm clock) and b) MK5017/BB (calendar clock).

either 12 or 24 hour display can be selected, if the 12 hour display is selected, the AM/PM output can be used to show which part of the day the time refers to. Time setting is simplified since separate controls of the hours, tens of minutes and minutes is provided The alarm time is set in a similar way to the time of day, and then stored in a RAM (Random Access Memory) and continuously compared to the current time; when co-incidence is detected, the alarm circuit is switched on. The alarm is a 700Hz signal modulated at 1Hz which may be fed via a simple transistor amplifier to a loudspeaker. The display output is a multiplexed 7-segment output on 6 digit drives, the multiplex frequency is decided by a CR network external to the chip. Supply voltage is 11-18V D.C.(unregulated) at 16mA. The pin configuration is shown in Fig. 1a.

tional and has two separate secondary windings. One of these goes to the heaters of the display tubes via a dropping resistor. This is only necessary to enable a widely available transformer to be used. The heaters of course operate from a.c.
The 50/60 TEMP point is for a useful feature; if there is a *short* interruption of the mains frequency and a DEAC rechargeable cell is incorporated, the chip will continue to work, the 50Hz being provided artificially by the network R1, C1.

On the right hand side of the circuit it will be seen that the decimal of the second display can be arranged in three ways. It can either be on permanent, flashing at 1Hz or only be shining during a.m. if the clock operates on a 12 hour display.

The ϕ REF and ϕ points connect to a preset pot which controls the flicker rate of the displays.

The tone output is the alarm signal which gives 700Hz switched on and off at 1Hz. The switching associated with outputs D1-D6 is rather more complex than shown in the circuit but is amplified in Fig. 3. There are optional links for 60Hz operation and for 12 hour operation.

CONSTRUCTION

The basis of the Timtronic is an extremely complex I.C. which, although physically very small, contains thousands of transistors. It is far from cheap and should be handled with care. It is supplied protected by a piece of black plastic material which prevents static building up with possibly disastrous results. Do not remove this material until the last minute. It is essential that the I.C. is mounted in a socket so that

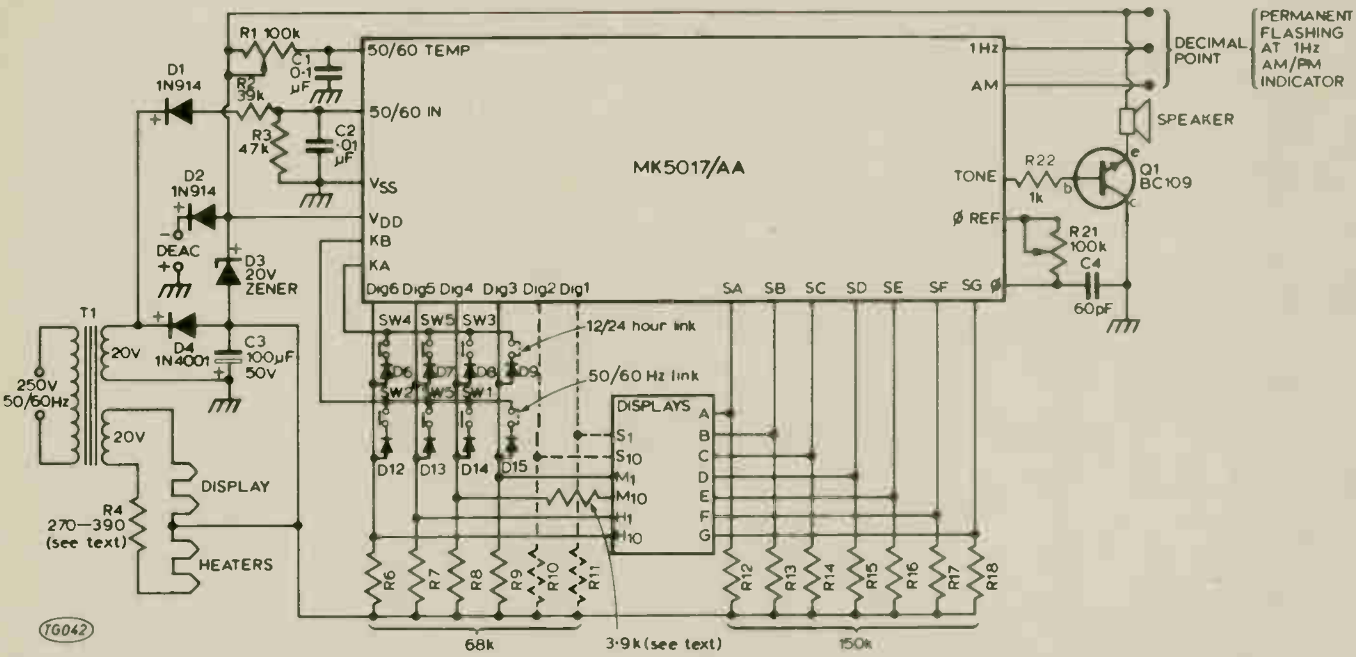


Fig. 2. The complete circuit of the alarm clock. See the text for the differences for the calendar clock. D6-D9 and D12-D15 are all 1N914 diodes.

MOSTEK MK5017BB CALENOAR CIRCUIT

The features of the BB chip are similar to the AA. The time is displayed for eight seconds and then the date for two seconds; either may be latched on for longer periods (as when setting), by use of the time set or calendar set switches. The BB also includes an *Inhibit* pin which when connected to Vss causes the display outputs not to switch and thus means that the clock can share a display with an existing calculator or similar device. The pin configuration is shown in Fig. 1b.

CIRCUIT OPERATION

The circuit, as far as the constructor is concerned, is extremely simple and is shown in Fig. 2. As you will see, there are a mere handful of components in addition to the chip itself.

The power supply is fairly conven-

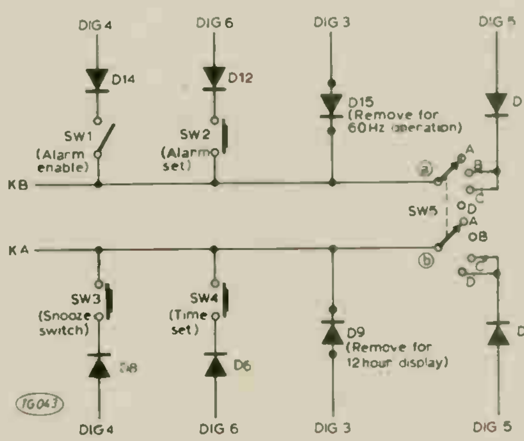


Fig. 3. The controlling switch circuitry.

handling, etc., can be kept to a minimum.

The printed circuit board pattern is shown in Fig. 4. As can be seen, this is far from a simple pattern with very close tracks. For those readers who want to purchase a p.c. board, ready etched, drilled and with the component siting printed on top, these are available — see the components list.

The p.c. board has been designed as small as possible and this means that the tracks are very close together. For this reason care must be taken to avoid 'bridging' with solder.

The instructions which follow describe the method of construction of the Timtronic 5017AA Digital Alarm Clock. Construction for the Timtronic 5017BB Digital Clock-Calendar is identical in nearly all respects. Where differences occur, they are clearly noted in the text.

CONSTRUCTION OF DISPLAY SECTION

The recommended display tubes for the clock are either DG-10A or DG-12C The latter have a slightly larger digit size. Wire lead-out diagrams for each are shown in Fig. 5.

The two heater leads are easily identified by the red sleeving which is on them. It will be seen that there are either 6 leads to the front of the tube between the heater wires (DG-10A), or 5 leads to the front between the heater wires (DG-12C). You should now identify the grid wire on each of the tubes you are using. It is one of the leads to the front, and location is a simple matter using Fig. 5. When you have located each grid wire, mark it in the same way as the heater by slipping a short peice of insulation on to it.

Now locate the decimal point (DP) lead on each tube, and remove it on all but one of the tubes by snipping it off as close to the tube as possible. The tube on which you leave the decimal point lead will become the hours units' indicator, or DIG 2. Finally, if you are using DG-10A tubes, remove the two leads marked 'N/C' (not connected).

Start building up the display section by inserting DIG 2. This is the tube on which you left the decimal point wire. Sôlder it into position between one-eighth and one-quarter of an inch above the printed circuit board. This will give the tube a certain amount of flexibillty for final positioning, when you come to align all four tubes.

Do not solder in either the heater wires, or the grid lead on DIG 2 for the moment. Work on these will follow after the other tubes have been soldered into position.

After you have soldered DIG 2 into position, insert DIG 1, and then DIG 3 and DIG 4 in exactly the same way. Try for as good alignment as possible as you insert each tube, paying especial attention to the relative heights of the actual digits in the tubes. You may find that the outer glass body of the tubes varies slightly in height, and it is therefore wise to check that the digits themselves are in line horizontally with each other.

The printed circuit board has been basically designed for DG-10A tubes. If you are using DG-12C tubes, you will find their slight extra width makes fitting a little more difficult, but they will fit satisfactorily if care is taken.

When all four tubes are in position, twist together and solder the heater leads between DIG 1 and DIG 2. Make the twist as close in to the tubes as possible, removing the red sleeving to assist in this, then snip off the surplus wire. Repeat this on the two heater leads between DIG 2 and DIG 3, and between DIG 3 and DIG 4.

This process will effectively have connected the heater leads in series. Now the heater lead on the left-hand side (looking at the tubes from the front) of DIG 1 should be extended with a short piece of wire, and soldered into the point marked HTR 2 on the printed circuit board. Now connect the heater lead from the right-hand side of DIG 4 to HTR 1 on the PCB.

Finally solder a wire, which should be insulated, to the twisted join in the heater wires between DIG 2 and DIG 3. Solder the other end of this wire to the point marked HTR 3 on the PCB.

TESTING THE DISPLAY

All connections in this section are temporary. First, connect between 2 and 3V across the points HTR 1 and HTR 2. The polarity is not important. When this is done, you will probably be able to see the heater filaments glowing very faintly. Do not worry at this stage if you cannot, however, and certainly *do not increase the voltage!*

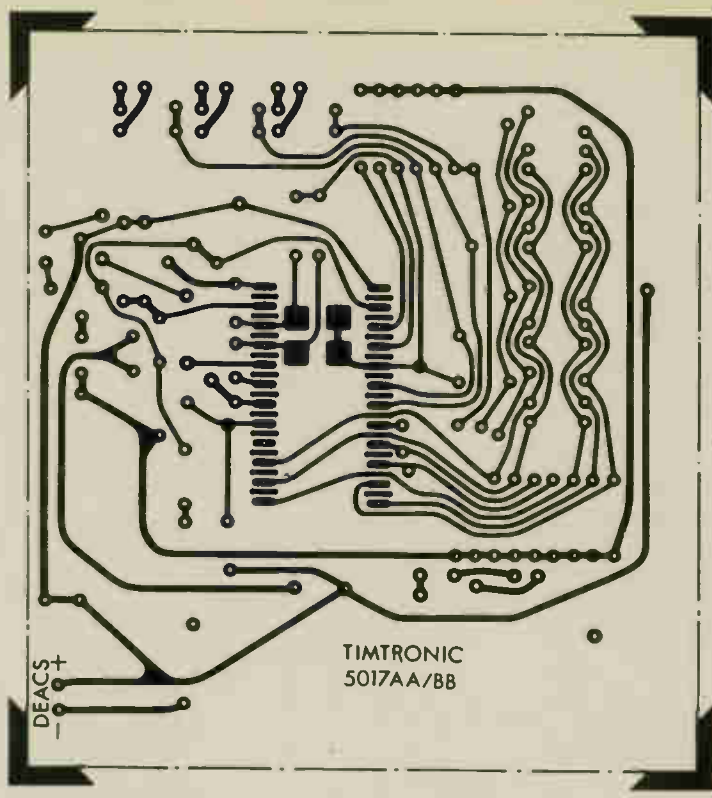


Fig. 4. The PCB pattern shown full size.

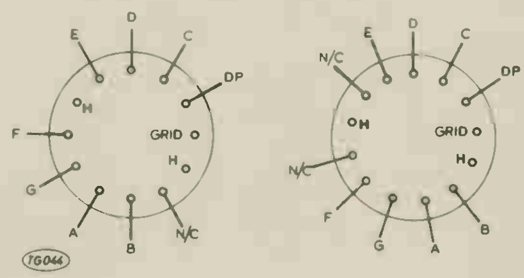


Fig. 5. The pin connections for the alternative tubes. The DG-12C is shown on the left, the DG-10A on the right.

PARTS LIST

R1	Preset Resistor	100k miniature skeleton type
R2	Resistor	39k 5% ⅛W or ¼W
R3	"	47k " "
R4	"	270-390ohms 1W – see text
R6	"	68k 5% ⅛W or ¼W
R7	"	68k " "
R8	"	68k " "
R9	"	68k " "
R10	"	68k " "
R11	"	68k " "
R12	"	150k" "
R13	"	150k" "
R14	"	150k" "
R15	"	150k" "
R16	"	150k" "
R17	"	150k" "
R18	"	150k" "
R21	Preset Resistor	100k miniature skeleton type
R22	Resistor	1k 5% ⅛W or ¼W
C1	Capacitor	0.1uF Mylar, polyester, ceramic etc.
C2	"	0.1uF
C3	"	100uF 50V electrolytic
C4	"	60pF ceramic, polystyrene etc.
Integrated Circuit		MK 5017-AA or MK5017-BB
D1	Diode	1N914
D2	"	1N914
D3	Zener Diode	20V 250mW min.
D4	Diode	1N4001
D6	"	1N914
D7	"	1N914
D8	"	1N914
D9	"	1N914
D12	"	1N914
D13	"	1N914
D14	"	1N914
D15	"	1N914
Q1	Transistor	BC109

DISPLAY TUBES
Four DG-10A or four DG-12C luminescent anode seven segment display tubes.

TRANSFORMER
240 volt primary, 0-20, 0-20 volt secondary (R.S. Components Miniature 20V type)

LOUDSPEAKER
75-80 ohm miniature type, or GPO telephone earpiece

SWITCHES
SW1....................single-pole on-off miniature switch
SW2....................single-pole push-to-make push button
SW3....................single-pole push-to-make push button
SW4....................single-pole push-to-make push button
SW5....................two-pole four-way rotary wafer

MISCELLANEOUS
Case, solder, fine gauge insulated wire in several colours, 24-pin socket for integrated circuit, transistor socket if desired, transformer mounting screws, 3 volt and 9 volt batteries for initial testing of displays, etc.

SYMBOLS NOT USED–R5, R19, R20, D5, D10 and D11.

A kit of the PCB, socket, four display tubes and IC is available from: BYWOOD ELECTRONICS, 181 Ebberns Road, Hemel Hempstead, Herts for £24 plus VAT (inc. postage)

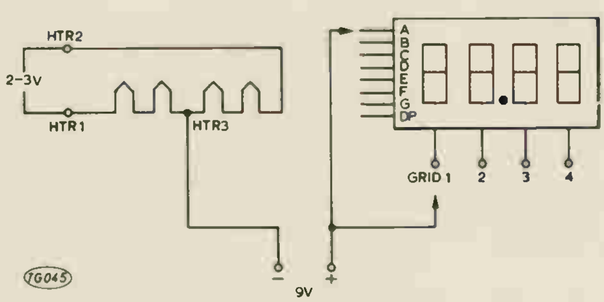


Fig. 6. Test circuit for testing the displays.

Now connect the negative side of a 9V source to HTR 3, and the positive side of the same source to the grid lead of DIG 1, and also to any one of the segment wires of DIG 1.

When the 9V positive is applied to one of the segment wires of DIG 1, one and only one, of the DIG 1 segments should light. If no segment lights, measure the voltage across each heater. It should be approximately 0.75V. If this figure is obtained, then check all connections. If more than one segment lights, check for solder bridges across the 'runs' on the underside of the PCB, or for short-circuits between the leads of the tubes.

When one segment lights successfully in DIG 1, repeat the test for the remainder of the segments in DIG 1, and then carry out an identical check on DIG 2, DIG 3 and DIG 4. This is a total of 29 checks, including the decimal point in DIG 2.

Do not proceed further with construction until these checks have been successfully carried out. When they have, disconnect the voltage sources and leads used for the testing.

FINISHING THE DISPLAY SECTION CONSTRUCTION

Solder the grid lead of DIG 1 to the point on the printed circuit board marked SC1. The grid lead will probably be sticking out to the front of the tube, and so you will have to carefully bend it down and feed it to the rear of the tube, passing it under the two soldered heater wires. Make sure the insulation of the grid lead prevents it shorting against any other wires.

Repeat this process for DIG 2, soldering the grid lead to the point marked SC2. In the same way, solder the grid leads for DIG 3 and DIG 4 to the points marked SC3 and SC4 on the PCB. Finally insert and solder into position the plain wire links L1, L2 and L3. These may be uninsulated wire, since there is little likelihood of any shorts occurring.

This concludes the construction of the display section.

CONSTRUCTION OF THE MAIN CLOCK CIRCUIT

First, insert the 24 pin i.c. socket into the holes on the p.c.b. The socket may be either way round. Insertion must be done with great care and may require some patience! You may find that a small screwdriver will help to align the pins of the socket to the holes in the board, and it will certainly be worthwhile taking a few moments before you begin insertion to straighten any pins which may have become slightly misaligned.

After the socket is firmly in position, solder all 24 pins on the underside of the PCB. Again, take your time over this as this is one point at which the space between the pins is very small, and it will be easy to accidentally bridge the gaps with solder. When you have finished, examine the soldering carefully to make sure no bridges have occurred.

Under no circumstances insert the clock integrated circuit at this stage.

Most of the rest of the components can now be inserted and soldered into position.

The first of the differences between the Alarm Clock and the Clock Calendar must now be mentioned. Diode D9 is *not* inserted for the Clock Calendar. This will provide a conventional 12-hour clock display, but the clock chip will nevertheless operate in 24-hour mode. It is necessary to operate the Clock Calendar with a 12-hour display to ensure that the months indication is correct when the clock switches to calendar display. If diode D9 is inserted then the clock display will be 24-hour, but the calendar months will only run up to '11' for November, 'O' for December, and then revert to '1' for January. This is because of the integrated circuit design.

Constructors of the Alarm Clock may also omit diode D9 if they prefer a 12-hour, rather than 24-hour display, There will be no side-effects from doing this.

Should either clock be intended for operation on 60Hz mains frequency, diode D15 should also be omitted.

The penultimate items to be added are the two links L4 and L5, and the transistor. The short link L5 poses no problems and need not be insulated, but link L4 should both be of insulated wire and also somewhat slack. The slackness is required to allow the link to fit round one side of the transformer which is, as you will see, mounted quite close to L4.

The resistor R4 should be left until last and the value should lie between 330 ohms and 390 ohms if DG-10A tubes are being used, or 220 ohms and 270 ohms if DG-12C tubes are being used. We suggest you use the larger value initially, as it is very easy to apply too much voltage to the heaters, which will over-run them and immediately destroy the displays!

The aim is to secure the optimum heater voltage without actually getting the heater wire glowing visibly. You may therefore find that you will have to experiment with slightly different values of resistor for R4 to achieve this state.

There is a second reason for making R4 the last component to go into

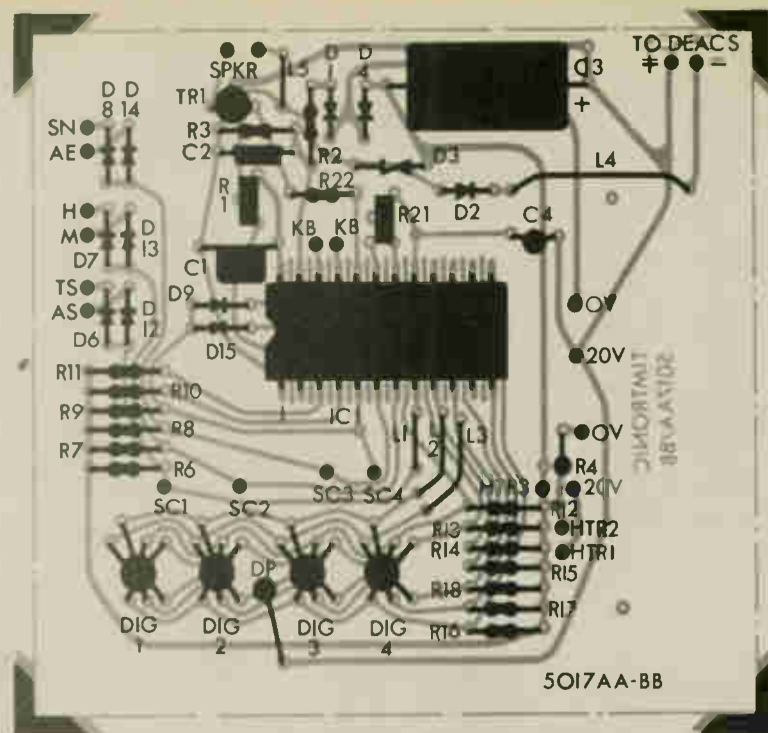


Fig. 7. The component layout on the PCB.

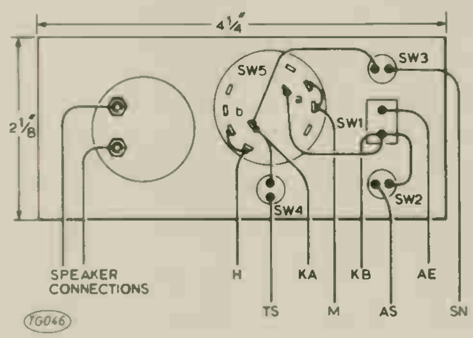


Fig. 8. The back panel wiring.

position — it must be fitted in such a way as not to touch any other component. Since it is dropping most of the 20V output from one of the transformer secondaries, it gets very hot.

The best position is lying across links L1, L2 and L3 but not in contact with them. You should also note that part of R4 will lie under part of the transformer windings.

WIRING THE CONTROL BUTTONS AND SWITCHES

The basic wiring for the control buttons and switches is as shown in Fig. 3, but the purpose of some of them differs, according to whether the Alarm Clock or the Clock Calendar is being constructed.

SWITCH SW1: 'ALARM ENABLE' ONLY

Alarm Clock: To enable the alarm, the switch is closed: to disable the alarm, it is opened. After the alarm is disabled it may be re-enabled immediately without causing the alarm to continue sounding. The alarm will now sound again 24 hours later. In this way, the 24-hour alarm capability of the clock is fully utilised.

Clock Calendar: Switch SW1 is not used in the Clock Calendar.

SWITCH SW2: 'ALARM SET' OR 'CALENDAR SET'

Alarm Clock: This is the alarm set switch. When the switch is closed, the display will show the content of the alarm counter — in other words, the time for which the alarm is set. This will not disturb the clock timing operation, and when the switch is released the display will revert to showing time. The switch is also used when actually setting the alarm time, in a way which will be described under 'Switch SW5' later.

Clock Calendar: This is the Calendar Set switch. The normal operation of the Clock Calendar is to display the time for 8 seconds and then to display the date for 2 seconds, switching from one to the other occurring automatically. When the Calendar Set switch is closed, the display will show the calendar only. This switch is used when the calendar is set initially, and when it is reset at the end of months containing less than 31 days. This process will be described under 'Switch SW5' later.

SWITCH SW3: 'SNOOZE' ONLY

Alarm Clock: This switch temporarily resets the alarm when it begins sounding to allow a short period for an extra snooze! Hence the name 'Snooze Switch' The reset period is a timed 7 minutes before the alarm sounds again. At this point the switch can be reactivated for a further 7 minutes. The maximum number of reactivations is 8, as the alarm automatically disables after 60 minutes, if it is not disabled with Switch SW1 before that time.

Clock Calendar: Switch SW3 is not used in the Clock Calendar.

SWITCH SW4: 'TIME SET' ON BOTH CLOCKS WITH SMALL DIFFERENCES

Alarm Clock: Setting the time is accomplished with the clock circuit counting or temporarily stopped, and is done via SW5 (described next). However it is desirable for accuracy to set the time with the clock stopped, subsequently releasing the clock against a known time reference source (the telephone time clock, for example). Switch SW4 allows this to be done. When the switch is closed, the internal seconds counter resets to '00' and the clock operation stops until the switch is released.

Clock Calendar: As noted, the clock calendar alternates between a time display for 8 seconds, and a calendar display for 2 seconds. If Switch SW4 is closed, time will be displayed continuously. It has already been seen that SW2 causes the calendar to be displayed as long as the switch is closed, but it should be further noted that both switches should not be closed together; if they are, incorrect display conditions will result. Switch SW4 is thus used when time is being set initially via SW5 (described next). However, the clock circuit will continue counting, even though SW4 is closed — counting will actually occur on digits less significant than the digit being set.

SWITCH SW5: HOURS, TENS OF MINUTES AND MINUTES TIME SET

Alarm Clock: Assuming your wiring is as shown in Fig. 3, and you are therefore using a 2-pole, 4-way switch, the first position allows normal clock operation. The second position will cause the minutes to count from '0' to '9' at two counts per second. No other digit will be affected. The third position will cause the tens of minutes to count from '0' to '5' again without affecting any other digit. The fourth position will cause the hours and tens of hours to count from '00' to '23' if you have constructed a 24-hour clock, or from '1' to '12' if you have constructed a 12-hour clock. In the latter case, the tens of hours digit will not at any time show a '0' but will remain off until '10' is reached, when it will then show the '1'. All of the foregoing is equally true when the 'Alarm Set' switch SW2 is closed, and the display is showing the contents of the alarm counter; incrementing of the alarm counter is done in an identical way to incrementing of the main time display.

Clock Calendar: The preceding details regarding setting the time display on the Alarm Clock are equally true for the time display on the Clock Calendar. When the Calendar Set switch SW2 is closed, the date will be displayed and may be set. Special note: the first two figures of the display are the month, and the second two are the day. This is in accord with common practice in many Continental countries and in the USA. When the setting is done, DIG 4 will run from '0' to '9'; DIG 3 from '0' to '3'; and DIG 1 with DIG 2 from '01' to '12'. As before, the setting of any one digit will not affect the setting of the others, with the obvious exception of DIG 1 and DIG 2 which set in conjunction with each other. When the calendar is set, the clock time display will reset to the AM portion of the day automatically. This means that calendar setting should always be done before setting the time, or considerable frustration is likely to ensue!

FINAL WIRING OF THE SWITCHES

The final wiring of the switches may now be done, following the wiring diagram given in Fig. 8.

We suggest you wire the switches 'loose' first of all, rather than mounting them into the case. This will allow reasonably long lengths of wire to be used for the wiring: any circuit 'bugs' which might occur to be traced easily; and the final wiring into the case to be done with much shorter lengths of wire for neatness and appearance.

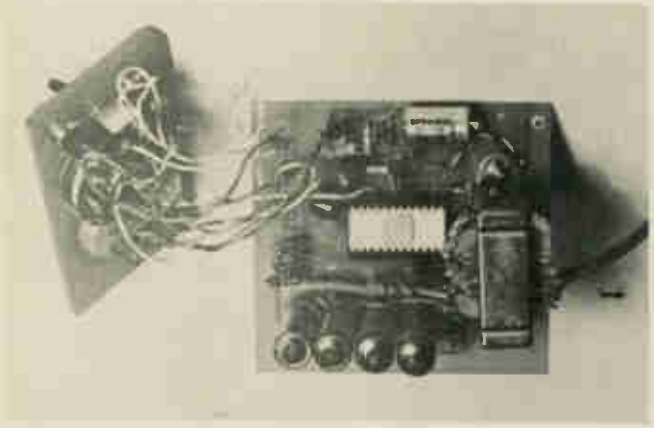
TESTING THE CIRCUIT

Before commencing testing, the transformer must be connected to the mains and to the p.c.b. Do not mount the transformer on the board at this stage.

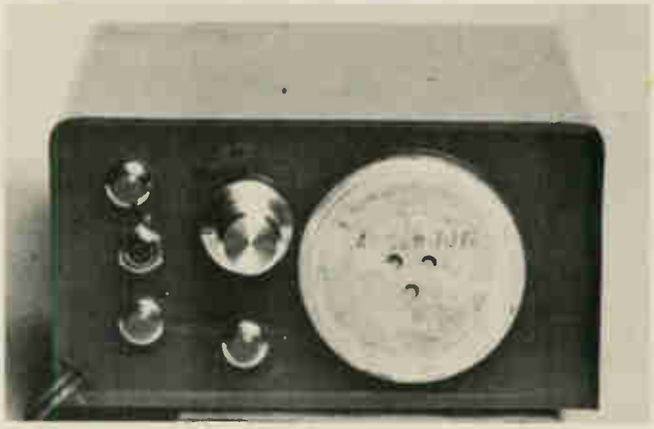
After you have connected the mains lead to the transformer, and before you do anything further, we strongly urge you to cover the mains tags of the transformer with two short lengths of insulating tape, both at the top and, if your transformer also has tags on the mains side at the bottom, over those also. As testing proceeds, it is all too easy to become deeply interested and unwittingly lay one's hand, wrist or arm on the mains point.

Connect one of the 20V outputs from the transformer to the points near R4 marked '0' and '20'. Switch the mains on and check the heater filaments in the display. If you have followed the instructions carefully, and chosen the value of R4 correctly, you may just be able to see the faintest possible glow from the heaters in a totally darkened room! If you can see nothing, do not worry — this is highly desirable, and you know from your early testing of the heaters and segments that all is probably well.

Transformers do, however, vary in their output voltages, and you may have a perceptible glow from the heaters. Should this occur, you will need to switch the mains off and change R4 for a slightly higher value. Don't forget that R4 will be very hot by this time.



Inside view of the prototype.



Rear view showing the switches and speaker.

TIMTRONIC

When you are happy with the heaters switch off again, and connect the other 20V output from the transformer to the two remaining points marked '0' and '20'. Switch on again, and check the voltage across C3, and the voltage between the positive end of C3 and pin 2 of the socket. The voltage across C3 should lie between 30V and 40V while the voltage between C3 and pin 2 should be between 15V and 20V.

If your voltages do not correspond with these, check the power supply components. Look particularly at the polarity of capacitor C3, and the polarity of the diodes D1, D3 and D4. If the polarities are right, check the functioning of these components, their positioning on the PCB, the adequacy of the soldering, and so on.

When the correct voltage ranges are obtained, switch off the mains again. Now check on the two preset potentiometers. The wiper of each one should be set to approximately mid-position.

The integrated circuit can now be inserted into the socket. Take the greatest care at all stages of this operation, because this is an expensive component deserving respect!

Handle it by the ends, keeping your fingers away from the pins. Take care not to short the pins out, even with your fingers, and do not short the pins to any component on the board. Make especially sure that, when you start to insert the component into the socket, it is the right way round. Pin 1 on the component is identified with an arrow, while Pin 1 for the socket is clearly marked on the board and in Fig. 7. Seat the component firmly into the socket before proceeding further.

The mains can now be switched on again. The display should then light up and show '88.88'. This particular display of four '8's is the standard indication that power has failed and then been restored. If the display appears to be flickering or pulsing, make a small adjustment in either direction to the preset R21 until the flicker disappears.

Now close the 'Time Set' control SW4 and then open it again. The display should immediately change to '00.00' in the case of 24-hour clocks, or '12.00' in the case of 12-hour clocks. Counting will also begin, but this will only become obvious quickly on the Clock-Calendar, when the display will switch from time to calendar after 8 seconds; hold the calendar display for 2 seconds; and then switch back to time. It will become clear that the Alarm Clock is counting satisfactorily after 1 minute, when DIG 4 will change to '1'.

CONCLUDING THE CONSTRUCTION

All that remains now is to mount the transformer permanently and to place the clock in whatever case you have decided to use, setting the switches into their final positions.

The transformer will need to be mounted on the p.c.b. if you are planning to use the plastic case designed for the clock.

It is highly likely that the tags on the secondary winding of the transformer not only protrude above the top of the secondary, but also below. If this is the case, you will have to bend those below either backwards or forwards, to clear resistor R4.

Before you finally mount the transformer, there is one more point to note. We suggest you place a small piece of insulating material — black vinyl insulating tape, for example — between the base of the transformer and the PCB. Make the insulation a little larger than the transformer base and, if you use insulating tape, bend it up slightly on each side of the transformer, so that it runs along the windings. This will avoid any last possibility of shorts occurring between the transformer and any other item on the PCB.

Actually mounting the transformer and reconnecting the secondaries to the board is straightforward, and requires no comment beyond a suggestion that the connecting wires should be as short as possible, and neatly twisted together.

ALARM CLOCKS: SETTING THE TIME

1. For ease of explanation, let's assume the time, when you come to set the clock is 10.13 p.m.
   With one hand, close the 'Time Set' switch SW4. With the other hand, move Switch SW5 to its 4th position
2. The hours will now start to count forward at the rate of 2 digits per second. This isn't nearly as fast as it sounds, as you'll see. If you have built a 24-hour clock, you should be ready to move SW5 to its 3rd position when the hours figure reaches '22'. If you have built a 12-hour clock, be ready to move SW5 when the hours reach '10'.
3. When you move SW5 to its third position, the hours will stop counting and remain set on either '22' or '10' while the tens of minutes begin counting. Again, be ready to change SW5 to its 2nd position when the tens of minutes reaches '1'.
4. When SW5 is changed to its second position, tens of minutes will stop counting and remain on '1', while the minutes units will begin counting. Again, you should be ready to change SW5 back to its 1st position when the units figure — and this is important, if you want accuracy — reaches either '4' or '5'.
5. When SW5 is turned back to its 1st position, the time showing on the display will either be '10.14' or '10.15'. Throughout this process you will have kept the 'Time Set' switch SW4 closed, and you should continue to keep it closed to prevent the clock starting to count before you are ready.
6. On the assumption you have a phone and it's close at hand, you can now dial the 'speaking clock'. As it announces that the time is precisely 10.14 or 10.15 release the 'Time Set' switch.
7. The telephone clock will continue to announce the time for about 90 seconds and we suggest you stay on the line until the next precise minute arrives. Your morale will be enormously boosted to see your clock change in precise synchronism with the speaking clock!

CLOCK CALENDARS: SETTING THE TIME

1. The basic instructions for setting the time for the Clock Calendar are exactly as given for the Alarm Clock.
2. Remember, however, that less significant digits than those actually being set continue to count, even though the 'Time Set' switch is held closed. This means that minutes and seconds are counting while the hours are being set, and seconds are counting while the minutes are being set.
3. If near-perfect accuracy is wanted, it is therefore necessary to slightly change the setting order. We then use the fact that less significant figures to those being set continue to count in the Clock Calendar, while more significant figures are disconnected from the counting chain. The only constraint is that the setting must be done at any time before 12 noon, because we shall be setting the calendar after the clock, and when the calendar is set, the clock reverts to the AM part of the day.
4. First, switch the mains off completely, and then on again. This will produce the standard 'power failure' indication of '88.88'. Now move SW5 to its 4th position. and then obtain a standard reference time source, such as the speaking clock. Stand by with your finger on 'Time Set' switch SW4 and, when an exact minute is reached by the time source close 'Time Set' and hold it closed.
5. The display will now switch to '00.00', seconds will start to count internally, and the hours display will start to count visibly.
6. When the correct hours indication appears, move SW5 to its 3rd position to begin incrementing the tens of

minutes. Again, when the right digit appears, move SW5 to its 2nd position.

7. This will increment the units of minutes, and SW5 should be moved back to its original 1st position when the correct minutes unit appears. Providing you have completed the process within one minute from obtaining the reference time, this will be the minutes unit figure of the reference time.
8. Only after you have the correct time indication, and switch SW5 is back in its first position, should you release 'Time Set' switch SW4.

ALARM CLOCKS: SETTING THE ALARM

1. Setting the alarm is a very simple matter, and is done exactly the same way that the time was set, excepting that the 'Alarm Set' switch SW2 should be held closed throughout the process, and not 'Time Set' switch SW4. The time will remain undisturbed throughout the process but remember not to open the 'Alarm Set' switch until switch SW5 is back in its 1st position.
2. To test the alarm operation, set an alarm time one or two minutes ahead of the time display on the main clock, and close the 'Alarm Enable' switch SW1. When the main clock reaches the time set on the alarm, a quiet but insistent 'beep... beep... beep'sound will be heard from the loudspeaker.
3. If the 'Snooze' switch SW3 is momentarily closed, the alarm note will cease immediately, and resume after 7 minutes have elapsed.
4. If 'Alarm Enable' switch SW1 is opened, the alarm note will also cease immediately. The 'Alarm Enable' switch may then be closed again, as the alarm will have automatically reset and will not come on again for another 24 hours.
5. If you have constructed a 12-hour version of the Alarm Clock, there is one further point which you will need to note. The display is 12-hour but the clock operation remains 24-hour, as does the alarm operation also. It is therefore possible to set the alarm to a certain time, and for that time to be reached on the main clock display without the alarm sounding. This is because the alarm will have been set into the other 12-hour segment of the 24-hour clock. You should therefore check, if you are operating a 12-hour clock function, that this is not likely to occur, by testing the alarm function. We would not like you to hold us responsible if you arrive at work 12 hours late!
6. When you first test the alarm function after construction, it may be that the alarm will only produce one quick 'beep', or not sound at all. Should this happen, place a 3.9K resistor in series with the grid of DIG 3. This should cure the problem. If the brightness of DIG 3 is slightly affected by the resistor, place a similar resistor in series with the other three grids to restore even brilliance.

CLOCK CALENDARS: SETTING THE CALENDAR

1. Calendar setting is achieved very simply by pressing 'Calendar Set' switch SW2 and then moving SW5 to its 4th position.
2. This will cause the months to increment but remember that the calendar display shows the months *first* and the day-date *second.*
3. When the right month figure is shown move SW5 to its 2nd position to increment days.
4. When the calendar setting is correct, move back to its 1st position and release 'Calendar Set' switch SW2.

EXTRA DATA ON THE CLOCK INTEGRATED CIRCUITS

Experienced constructors may be interested in some extra information. We suggest, however, that great care is exercised if any circuit modifications or additions are attempted.

THE ALARM CLOCK AM OUTPUT

Pin 16 of the chip carries an AM output which is near Vss for an AM indication and is open-circuit for a PM indication. It can be used to convert a seven-segment 'P' to an 'A' for example, or to advance an external calendar. The transition occurs at 12 hour intervals.

1Hz OUTPUT

Pin 19 of the chip carries a 1 Hertz square-wave. Blinking of an external a.m./p.m. or seconds indicator is possible. The 1Hz output is modulated to maintain the relative intensity at the same level as the time display.

TEMPORARY AC POWER FAILURE

Temporary power failure can be tolerated if a battery back-up is provided. Pin 24 oscillates at a frequency determined by R1 and C1, and continues to provide an approximate line frequency provided that a Vdd is maintained within the chip's operating range. With the display tubes used, power is not required to operate them, since the filaments are a.c. driven. A small rechargeable battery is required, however to power the chip, and this must supply at least 18V. However, the cost of rechargeable cells for this facility is so high that many readers will think this facility something of an extravagance.

THE CLOCK CALENDAR ALT OUTPUT

Pin 19 of the chip carries at ALT output, which indicates whether the time or the date is being displayed. During the time display, the output will be near Vss. The indication occurs when neither 'Time Set' nor 'Calendar Set' are closed. The output can be used to select either a colon or a dash, as required, or used to select the 24-hour display during the time display period, if 24-hour display conditions are preferred.

FULL SIX-DIGIT DISPLAY

A full six-digit display is possible, basing the necessary wiring on that demonstrated by the printed circuit board supplied. A modification to the value of R4 will be needed, and this should be calculated with great care, using data and voltage indications provided elsewhere in these instructions. It will probably be possible to contain the extra two digits on the PCB, if the transformer can be mounted elsewhere. Alternatively, a new display section can be constructed, using Veroboard or a similar material, and running leads from the main PCB to appropriate points on it. Pins 3 to 8 on the chips provide the digit drives for the display, while pins 9 to 15 are the seven-segment decoded segment drives. Pin 1 is Vss and pin 2 is Vdd, which should be 0V and between 11V and 18V respectively.

Expensive Equipment

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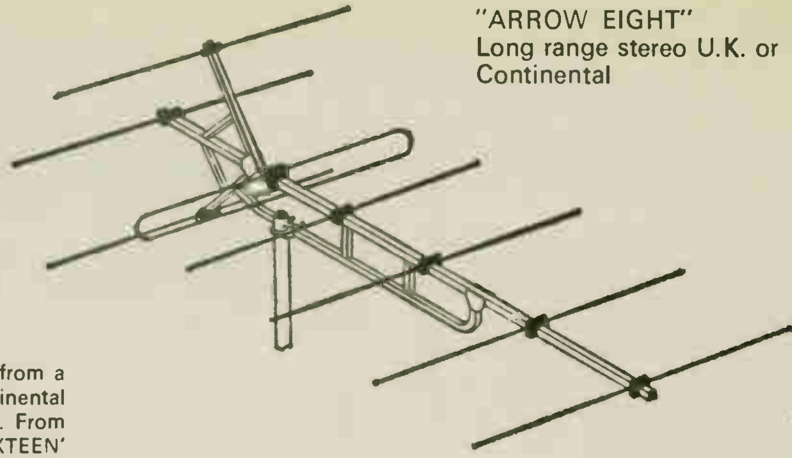

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A. Ang. Degrees	78	68	67	66	63	59	58	56	45	38
Length–inches	32	42	72	42	72	102	84	114	162	222
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THE WATERGATE BUGGING

— how it was done, Collyn Rivers reports.

SOMETIME during the second week in June 1972, two men, James McCord and Howard Hunt, entered the Watergate headquarters of the US Democratic Party and installed a number of bugging devices in selected areas.

The two conspirators were subsequently spotted by an alert security guard — and their subsequent trial and indictment triggered off a scandal that has made the late and unlovely President Harding's escapades of the 1920's seem by comparison to be mere peccadilloes.

The main bugs consisted of so-called 'infinity transmitters' and were installed inside each of four telephones inside the Democratic Party's headquarters.

The Watergate infinity bugs were adaptations of the 'conventional' infinity transmitters described in our article on bugging in June, 1972.

These bugs enabled all sound within the bugged rooms to be picked up and transmitted to the conspirators' listening station in the Howard Johnson Hotel — just across the road from the Watergate building.

HOW THEY WORKED

A block schematic drawing of these bugs is shown (in simplified form) in Fig. 1. The section that was installed inside each telephone is shown in dotted lines. This section consists of a frequency sensitive decoder that actuates a miniature multi-pole relay. The conspirators used a resonant reed encoder that was switched onto the telephone line *immediately* after the bugged telephone's number had been dialled. This encoder generated a tone (probably 500 Hz) that was detected by the decoder concealed within the bugged telephone. This caused the relay to be actuated which in turn open-circuited the bell ringing circuit and connected the handset's microphone to an inbuilt audio amplifier the output of which was connected to the telephone line.

Thus the bugs, once actuated by the conspirators, picked up all sound within the room and transmitted it to the bugging headquarters — even though the handsets were still on the rests: if a third party tried to ring the number whilst the bug was in use he would receive a normal 'busy' tone.

The conspirators also installed a small microphone and low-power FM transmitter inside a fire alarm smoke detector that was conveniently fitted to the ceiling of the Democratic headquarters. The low-power signals from this unit were received just outside the Watergate building and then relayed by a more powerful transmitter to the bugging headquarters across the road.

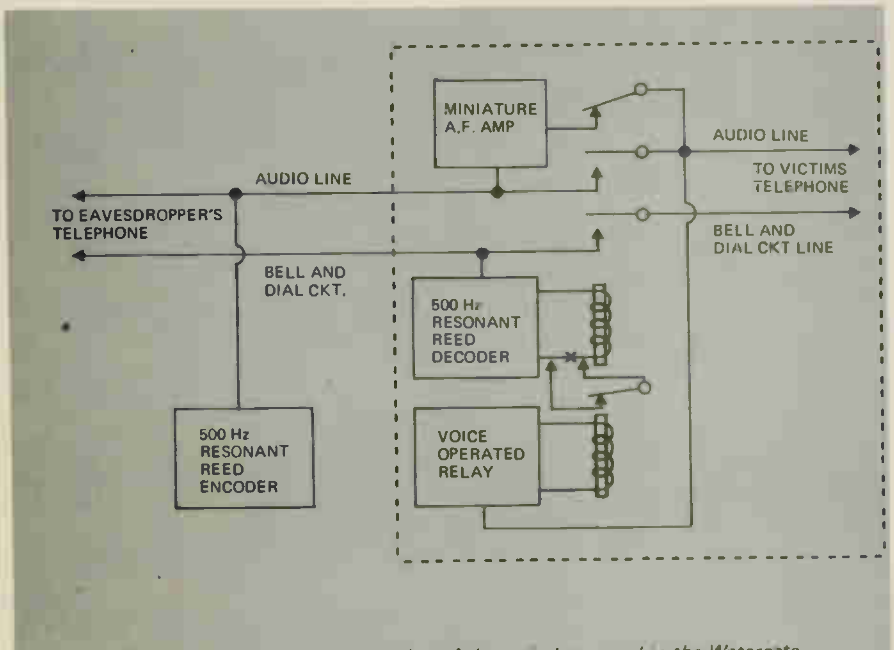

Fig. 1. This is a block schematic drawing of the main bugs used in the Watergate affair. The section shown inside dotted lines was installed in the bugged telephones.

The relatively sophisticated bugs described above appeared to be mass-produced. They carried no manufacturer's name — but this lack of identification is normal practice. Certainly, even outside the USA, it is not too difficult to purchase this type of equipment if one is sufficiently determined and can pay the high prices involved. But surprisingly — at least to those who are not aware of the extraordinary amount of surveillance equipment commercially available — most of the electronic bugging equipment used by McCord and Hunt was purchased on the open market. For example the conspirators bought a considerable quantity of communications equipment — transmitters, receivers, microphones, etc. from the Kelcom Division of Bell & Howell. Invoices and shipping documents from that firm show that the equipment was shipped to McCord and his associates on May 26 — about three weeks before the bugs were installed.

Bell & Howell state that the equipment sold to McCord was normal off-the-shelf communications gear. The company does in fact make surveillance equipment but this they stress is sold only to 'bona-fide law enforcement agencies'. They emphasize that they did not make any of the actual bugging units used in the Watergate conspiracy.

Another firm that supplied equipment to McCord was the CEI Division of Watkins-Johnson.

This division specializes in the manufacture of military electronic countermeasure receivers — it is believed that the sale to McCord and his associates was for a type RS 11 wideband receiver. This receiver is a standard commercial item — produced as an offshoot of the company's military equipment — and is available to anyone who wishes to buy one.

The Watergate inquiry is not yet over and it is quite probable that evidence may yet be given which will highlight the ever increasing use of surveillance equipment — not only by industrial saboteurs — but by the FBI, the CIA, the Secret Service, and now it seems at the highest levels of government itself. ●

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AC107	0·20	AD162	0·33	BC148	0·10	BD137	0·45	BF188	0·40	OC19	0·35	[illegible]	0·16
AC113	0·20	AD161 &		BC149	0·12	BD138	0·50	BF194	0·12	OC20	0·65	[illegible]71B	0·18
AC115	0·23	AD162 (MP)		BC150	0·18	BD139	0·55	BF195	0·12	OC22	0·30	[illegible]	0·17
AC117K	0·20		0·55	BC151	0·20	BD140	0·60	BF196	0·14	OC23	0·42	[illegible]	0·17
AC122	0·12	ADT140	0·50	BC152	0·17	BD155	0·80	BF197	0·14	OC24	0·56	[illegible]	0·30
AC125	0·17	AF114	0·24	BC153	0·28	BD175	0·60	BF200	0·45	OC2[illegible]	0·38	[illegible]	0·16
AC126	0·17	AF115	0·24	BC154	0·30	BD176	0·60	BF222	0·95	OC[illegible]	0·25	[illegible]	0·16
AC127	0·17	AF116	0·24	BC157	0·18	BD177	0·65	BF257	0·45	OC[illegible]	0·50	[illegible]	[illegible]
AC128	0·17	AF117	0·24	BC158	0·12	BD178	0·65	BF258	0·60	OC29	0·50	[illegible]	0·30
AC132	0·14	AF118	0·35	BC159	0·12	BD179	0·70	BF259	0·65	OC35	0·42	[illegible]	0·30
AC134	0·14	AF124	0·30	BC160	0·45	BD180	0·70	BF262	0·55	OC36	0·50	[illegible]	0·25
AC137	0·14	AF125	0·25	BC161	0·50	BD185	0·65	BF263	0·55	OC41	0·20	[illegible]	0·35
AC141	0·14	AF126	0·28	BC167	0·12	BD186	0·65	BF270	0·35	OC42	0·24	[illegible]A	0·35
AC141K	0·17	AF127	0·28	BC168	0·12	BD187	0·70	BF271	0·35	OC44	0·15	[illegible]	0·20
AC142	0·14	AF139	0·30	BC169	0·12	BD188	0·70	BF272	0·80	OC45	0·12	[illegible]A	0·28
AC142K	0·17	AF178	0·50	BC170	0·12	BD189	0·75	BF273	0·35	OC70	0·10	[illegible]	0·42
AC151	0·15	AF179	0·50	BC171	0·14	BD190	0·75	BF274	0·35	OC71	0·10	[illegible]	0·42
AC154	0·20	AF180	0·50	BC172	0·14	BD195	0·85	BFW10	0·60	OC72	0·14	[illegible]	0·35
AC155	0·20	AF181	0·45	BC173	0·14	BD196	0·85	BFX29	0·27	OC74	0·14	[illegible]	0·42
AC156	0·20	AF186	0·45	BC174	0·14	BD197	0·90	BFX84	0·22	OC75	0·15	[illegible]	0·45
AC157	0·24	AF239	0·37	BC175	0·22	BD198	0·90	BFX85	0·30	OC76	0·15	[illegible]	0·12
AC165	0·20	AL102	0·65	BC177	0·19	BD199	0·95	BFX86	0·22	OC77	0·25	[illegible]	0·12
AC166	0·20	AL103	0·65	BC178	0·19	BD200	0·95	BFX87	0·24	OC81	0·15	[illegible]	0·24
AC167	0·20	ASY26	0·25	BC179	0·19	BD205	0·80	BFX88	0·22	OC81D	0·15	[illegible]	0·35
AC168	0·24	ASY27	0·30	BC180	0·24	BD206	0·80	BFY50	0·20	OC82	0·15	[illegible]A	0·09
AC169	0·14	ASY28	0·25	BC181	0·24	BD207	0·95	BFY51	0·20	OC82D	0·15	[illegible]	0·12
AC176	0·20	ASY29	0·25	BC182	0·10	BD208	0·95	BFY52	0·20	OC83	0·20	2N711	0·30
AC177	0·24	ASY50	0·25	BC182L	0·10	BDY20	1·00	BFY53	0·15	OC84	0·20	2N717	0·35
AC178	0·28	ASY51	0·25	BC183	0·10	BF115	0·24	BPX25	0·85	OC139	0·20	2N71[illegible]	0·24
AC179	0·28	ASY52	0·25	BC183L	0·10	BF117	0·45	BSX19	0·15	OC140	0·20	2N71[illegible]A	0·50
AC180	0·17	ASY54	0·25	BC184	0·12	BF118	0·70	BSX20	0·15	OC169	0·25	2N726	0·20
AC180K	0·20	ASY55	0·25	BC184L	0·12	BF119	0·70	BSY25	0·15	OC170	0·25	2N727	0·20
AC181	0·17	ASY56	0·25	BC186	0·28	BF121	0·45	BSY26	0·15	OC171	0·25	2N743	0·20
AC181K	0·20	ASY57	0·25	BC187	0·28	BF123	0·50	BSY27	0·15	OC200	0·25	2N744	0·20
AC187	0·23	ASY58	0·25	BC207	0·11	BF125	0·45	BSY28	0·15	OC201	0·28	2N914	0·14
AC187K	0·20	ASZ21	0·40	BC208	0·11	BF127	0·50	BSY29	0·15	OC202	0·28	2N918	0·30
AC188	0·22	BC107	0·09	BC209	0·12	BF152	0·55	BSY38	0·18	OC203	0·25	2N929	0·21
AC188K	0·20	BC108	0·09	BC212L	0·11	BF153	0·45	BSY39	0·18	OC204	0·25	2N11[illegible]1	0·20
ACY17	0·25	BC109	0·10	BC213L	0·11	BF154	0·45	BSY40	0·28	OC205	0·35	2N11[illegible]2	0·22
ACY18	0·20	BC113	0·10	BC214L	0·14	BF155	0·70	BSY41	0·28	OC309	0·40	2N1[illegible]02	0·14
ACY19	0·20	BC114	0·15	BC225	0·25	BF156	0·48	BSY95	0·12	P346A	0·20	2N1[illegible]	0·14
ACY20	0·20	BC115	0·15	BC226	0·35	BF157	0·55	BSY95A	0·12	P397	0·42	[illegible]	0·17
ACY21	0·20	BC116	0·15	BCY30	0·24	BF158	0·55	Bu105	2·00	OCP71	0·43	[illegible]	0·17
ACY22	0·16	BC117	0·15	BCY31	0·28	BF159	0·60	C111E	0·50	ORP12	0·43	[illegible]	0·21
ACY27	0·18	BC118	0·10	BCY32	0·32	BF160	0·40	C400	0·30	ORP60	0·40	[illegible]	0·21
ACY28	0·19	BC119	0·30	BCY33	0·22	BF162	0·40	C407	0·25	ORP61	0·40	[illegible]	0·21
ACY29	0·35	BC120	0·80	BCY34	0·25	BF163	0·40	C424	0·20	ST140	0·12	[illegible]	0·23
ACY30	0·28	BC125	0·12	BCY70	0·14	BF164	0·40	C425	0·50	ST141	0·17	2N13[illegible]	0·23
ACY31	0·28	BC126	0·18	BCY71	0·18	BF165	0·40	C426	0·35	T1843	0·30	[illegible]	0·20
ACY34	0·21	BC132	0·12	BCY72	0·14	BF167	0·22	C428	0·20	UT46	0·27	[illegible]171	0·20
ACY35	0·21	BC134	0·18	BCZ10	0·20	BF173	0·22	C441	0·30	[illegible]	0·09	[illegible]	0·02
ACY36	0·28	BC135	0·12	BCZ11	0·25	BF176	0·35	C442	0·30	[illegible]	0·19	[illegible]	0·45
ACY40	0·17	BC136	0·15	BCZ12	0·25	BF177	0·35	C444	0·35	[illegible]	0·19	[illegible]	0·37
ACY41	0·18	BC137	0·15	BD121	0·60	BF178	0·30	C450	0·22	[illegible]	0·24	2N2147	0·72
ACY44	0·35	BC139	0·40	BD123	0·65	BF179	0·30	MAT100	0·19	[illegible]	0·40	2N214[illegible]	0·57
AD130	0·38	BC140	0·30	BD124	0·60	BF180	0·30	MAT101	0·20	2G[illegible]	0·35	2N21[illegible]	0·60
AD140	0·48	BC141	0·30	BD131	0·50	BF181	0·30	MAT120	0·19	[illegible]	0·35	[illegible]2	0·35
AD142	0·48	BC142	0·30	BD132	0·60	BF182	0·40	MAT121	0·20	[illegible]	0·20	2N219[illegible]	0·35
AD143	0·38	BC143	0·30	BD133	0·65	BF183	0·40	MPF102	0·42	[illegible]A	0·16	2N2194	0·35
AD149	0·50	BC145	0·45	BD135	0·40	BF184	0·25	MPF104	0·37	2G344	0·18	2N[illegible]217	0·22
AD161	0·33	BC147	0·10	BD136	0·40	BF185	0·30	MPF105	0·37	[illegible]	0·16	2N221[illegible]	0·20

2N2219	0·20	[illegible]	0·46	2N4059	0·10
2N[illegible]	0·22	[illegible]	0·50	2N4060	0·12
2N2221	0·20	[illegible]	0·14	2N4061	0·12
2N2222	0·20	[illegible]A	0·16	2N4062	0·12
2N2[illegible]	0·17	[illegible]	0·14	2N4284	0·17
2N[illegible]	0·14	[illegible]	0·14	2N42[illegible]	0·17
2N[illegible]A	0·14	[illegible]	0·14	[illegible]	0·17
2N2411	0·24	[illegible]	0·17	[illegible]	0·17
2N2412	0·24	[illegible]	0·21	[illegible]	0·17
2N2646	0·47	[illegible]	0·28	[illegible]	0·17
2N2711	0·21	[illegible]	0·28	[illegible]	0·17
2N2712	0·21	[illegible]	0·42	[illegible]	0·17
2N2714	0·21	[illegible]	0·15	[illegible]	0·17
2N2904	0·17	[illegible]	0·15	[illegible]	0·17
[illegible]A	0·21	[illegible]	0·28	2N5172	0·12
[illegible]	0·21	[illegible]417	0·28	[illegible]	0·32
[illegible]A	0·21	[illegible]	0·75	[illegible]	0·32
[illegible]	0·15	2N3646	0·09	[illegible]	0·40
[illegible]A	0·18	2N3702	0·10	[illegible]	0·50
2N2907	0·20	2N3703	0·10	[illegible]A	0·42
2N2907A	0·22	2N3704	0·11	[illegible]	0·42
[illegible]	0·14	2N3705	0·10	[illegible]	0·55
[illegible]	0·14	[illegible]	0·09	[illegible]	0·70
[illegible]	0·14	[illegible]707	0·11	[illegible]	0·84
2N2926 (G)		2N370[illegible]	0·07	[illegible]	0·84
	0·12	2N3709	0·09	[illegible]	0·84
2N2926 (Y)		2N3710	0·09	[illegible]	0·56
	0·11	[illegible]711	0·09	[illegible]	0·42
2N2926 (O)		[illegible]	0·35	[illegible]A	0·42
	0·10	[illegible]	0·35	[illegible]	0·56
2N2926 (R)		[illegible]	0·35	[illegible]24	0·70
	0·10	[illegible]	0·28	[illegible]	0·70
2N2926 (B)		[illegible]	0·28	[illegible]	0·70
	0·10	[illegible]	0·30	[illegible]	0·70
[illegible]010	0·70	[illegible]	0·28	[illegible]	0·42
2N3011	0·14	[illegible]	0·27	[illegible]	0·40
[illegible]	0·17	[illegible]	0·12	[illegible]	0·45

DIODES AND RECTIFIERS

AA119	0·03	BY1[illegible]	0·21	OA10	0·35
AA1[illegible]	0·03	BY164	0·50	OA47	0·07
AA1[illegible]	0·08	BYX[illegible]		OA70	0·07
AAY30	0·09		0·42	OA79	0·07
AAZ13	0·10	BYZ1[illegible]	0·[illegible]	OA81	0·07
BA100	0·10	BYZ11	0·30	OA[illegible]	0·09
BA116	0·21	BYZ1[illegible]	0·30	OA[illegible]	0·06
BA126	0·22	BYZ1[illegible]	0·25	OA91	0·06
BA148	0·14	BYZ1[illegible]	0·40	OA[illegible]	0·07
BA154	0·12	BYZ17	0·35	OA200	0·06
BA155	0·14	BYZ1[illegible]	0·35	OA202	0·07
BA156	0·13	BYZ1[illegible]	0·25	SD10	0·05
BY100	0·15	CG[illegible]		SD19	0·05
BY101	0·12	([illegible]) OA91		IN34	0·07
BY105	0·17		0·5	IN34A	0·07
BY114	0·12	C[illegible]		IN914	0·06
BY126	0·14	(Eq) OA70-		IN916	0·06
BY127	0·15	OA7[illegible]	0·06	IN414B	0·06
BY128	0·15	OA[illegible]	0·35	IS[illegible]1	0·10
BY130	0·16	OA[illegible]L	0·21	IS951	0·06

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on heat sink.
100PIV. 90p each

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400v RMS	46p ..

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ORP60, ORP61 40p each

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50	For	1·00
100	For	1·75
500	For	7·50
1000	For	13·00

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300mW	30	0·50
40PIV(Min.)	100	1·50
Sub-Min.	500	5·00
Full Tested	1,000	9·00

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100	30	50	76
200	50	60	90
400	70	75	1·10

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FOR USE WITH TRIACS
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T3	8	D1216	OC81D
T4	8	2G381T	OC81
T5	8	2G382T	OC82
T6	8	2G344B	OC44
T7	8	2G345B	OC45
T8	8	2G378	OC78
T9	8	2G399A	2N1302
T10	8	2G417	AF117

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Sil. trans. suitable for P.E. Organ. Metal TO-18 Eqvt. ZTX300 5p each. Any Qty.

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U 9	20	Mixed Voltages, 1 Watt Zener Diodes	0·50
U10	20	BAY50 charge storage Diodes DO-7 Glass	0·50
U11	25	PNP Sil. Planar Trans. TO-5 like 2N1132, 2N2904	0·50
U12	12	Silicon Rectifiers Epoxy 500mA up to 800 PIV	0·50
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Code No's. mentioned above are given as a guide to the type of device in the pak. The devices themselves are normally unmarked.

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Q6	5	OC 72 transistors	0·50
Q7	4	AC 128 transistors PNP high gain	0·50
Q8	4	AC 126 transistors PNP	0·50
Q9	7	OC 81 type transistors	0·50
Q10	7	OC 71 type transistors	0·50
Q11	2	AC 127/128 Complementary pairs PNP/NPN	0·50
Q12	3	AF 116 type transistors	0·50
Q13	3	AF 117 type transistors	0·50
Q14	3	OC 171 H.F. type transistors	0·50
Q15	7	2N2926 Sil. Epoxy transistors mixed colours	0·50
Q16	2	GET880 low noise Germanium transistors	0·50
Q17	5	NPN 2 × ST.141 & 3 × ST.140	0·50
Q18	4	MADT'S 2 × MAT 100 & 2 × MAT 120	0·50
Q19	3	MADT'S 2 × MAT 101 & 1 × MAT 121	0·50
Q20	4	OC 44 Germanium transistors A.F.	0·50
Q21	4	AC 127 NPN Germanium transistors	0·50
Q22	20	NKT transistors A.F. R.F. coded	0·50
Q23	10	OA 202 Silicon diodes sub-min.	0·50
Q24	8	OA 81 diodes	0·50
Q25	15	1N914 Silicon diodes 75 PIV 75mA	0·50
Q26	8	OA95 Germanium diodes sub-min. 1N69	0·50
Q27	2	10A PIV Silicon rectifiers 1S425R	0·50
Q28	2	Silicon power rectifiers BYZ 13	0·50
Q29	4	Silicon transistors 2 × 2N[illegible], 1 × 2N[illegible]7, 1 × 2N698	0·50
Q30	7	Silicon switch transistors 2N706 NPN	0·50
Q31	6	Silicon switch transistors 2N708 NPN	0·50
Q32	3	PNP Silicon transistors 2 × 2N1131, 1 × 2N 1132	0·50
Q33	3	Silicon NPN transistors 2N1711	0·50
Q34	7	Silicon NPN transistors 2N2369, 500MHz (code P397)	0·50
Q35	3	Silicon PNP TO-5, [illegible] × 2N[illegible]04 & 1 × 2N[illegible]	0·50
Q36	7	2N[illegible] TO-18 plastic 300 MHz NPN	0·50
Q37	3	2N3053 NPN Silicon transistors	0·50
Q38	7	NPN transistors 4 × 2N3703, 3 × 2N[illegible]	0·50

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NEW LOW PRICE TESTED S.C.R.'s

PIV	1A TO5	[illegible]A TO[illegible]6	5A TO[illegible]	5A TO64	7A TO48	10A TO48	[illegible]A TO48	[illegible]A TO48
50	0·23	0·25	0·35	0·35	0·47	0·50	0·53	1·15
100	0·25	0·33	0·47	0·47	0·50	0·58	0·63	1·40
200	0·35	0·37	0·49	0·49	0·57	0·61	0·75	1·60
400	0·4[illegible]	0·47	0·56	0·56	0·67	0·75	0·93	1·75
[illegible]	0·53	0·57	0·68	0·68	0·77	0·97	1·25	—
[illegible]	0·63	0·70	0·80	0·80	0·90	1·20	1·50	4·00

SIL. SECTS. TESTED

PIV	[illegible]mA	750mA	1A	1·5A	3A	10A	[illegible]A
[illegible]	0·04	0·05	0·05	0·07	0·14	0·21	0·60
10[illegible]	0·04	0·06	0·06	0·13	0·16	0·22	0·75
[illegible]	0·05	0·09	0·06	0·14	0·20	0·24	1·00
400	0·06	0·13	0·07	0·20	0·27	0·37	1·25
[illegible]	0·07	0·16	0·10	0·[illegible]	0·34	0·45	1·86
[illegible]	0·10	0·17	0·11	0·25	0·37	0·55	2·00
1000	0·11	0·25	0·14	0·30	0·46	0·63	2·50
1200	—	0·[illegible]	—	0·38	0·57	0·75	—

POWER TRANS BONANZA!

GENERAL PURPOSE GERM. PNP

[illegible] BRAND NEW TO-[illegible] CASE POSSIBLE REPLACE[illegible] NKT [illegible] 404– [illegible] 2N[illegible]0A 2N456A– [illegible]7A [illegible]A, [illegible]11 A & B, [illegible] ETC. VCBO 80V VCEO 50V IC 10A PT. [illegible] WATTS Hfe [illegible]-170.

PRICE	1-24	[illegible]-99	100 up
	[illegible] each	40p each	36p each

SILICON High Voltage 250V NPN
TO-[illegible] case. G.P. Switching & Amplifier Applications. Brand new Coded R 2400 VCBO 250 VCEO 100 IC 6A [illegible] Watts. HFE type 20 fT 5MHZ.
OUR PRICE EACH

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115 WATT SIL POWER NPN 50p EACH.

SILICON 50 WATTS MATCHED NPN PNP
BIP 19 NPN TO-[illegible] Plastic. BIP 20 PNP. Brand new. VCBO 100 VCEO 50 IC 10A. HFE type 100 ft 3mHZ.
OUR PRICE PER PAIR
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AD161/162 *PNP*

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TO-18 Lens end NPN Sim. to BP × [illegible] and P21 BRAND NEW. Full data available. Fully guaranteed

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[illegible]	50p	[illegible]	40p
[illegible]	35p	BFW10	40p
2N[illegible]	30p	MPF10[illegible]	40p

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SN7404	0·15	0·14	0·12	SN7460	0·15	0·14	0·12	SN74151	£1·00	0·95	0·90
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SN7438	0·64	0·62	0·60	SN74100	£1·65	£1·60	£1·55	SN74191	£1·90	£1·85	£1·80
SN7440	0·15	0·14	0·12	SN74104	0·97	0·94	0·88	SN74192	£1·95	£1·90	£1·85
SN7441	0·67	0·64	0·58	SN74105	0·97	0·94	0·88	SN74193	£2·00	£1·80	£1·75
SN7442	0·67	0·64	0·58	SN74107	0·40	0·38	0·36	SN74194	£2·70	£2·60	£2·50
SN7443	£1·30	£1·25	£1·20	SN74110	0·55	0·53	0·50	SN74195	£2·00	£1·90	£1·80
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SN7445	£1·80	£1·77	£1·75	SN74118	£1·00	0·95	0·90	SN74197	£1·80	£1·70	£1·60
SN7446	0·97	0·94	0·88	SN74119	£1·35	£1·25	£1·10	SN74198	£5·50	£5·00	£4·50
SN7447	£1·00	0·97	0·95	SN74121	0·40	0·37	0·34	SN74199	£5·50	£5·00	£4·50
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NUMERICAL INDICATOR TUBES

MODEL	CD66	GR116	3015F Minitron
Anode voltage (Vdc)	170min	175min	5
Cathode Current (mA)	2·3	14	8
Numerical Height (mm)	16	13	9
Tube Height (mm)	47	32	22
Tube Diameter (mm)	19	13	12 wide
I.C. Driver Rec.	BP41/14 141	BP41 or 141	BP47
PRICE EACH	£1 70	£1 55	£2·00

All indicators 0-9 + Decimal point. All side viewing. Full data for all types available on request.

STEREO PRE-AMPLIFIER TYPE PA100

Built to a specification and NOT a price, and yet still the greatest value on the market, the PA1000 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.

SPECIFICATION:

Frequency response	20Hz—20kHz ± 1dB	Bass control	± 15dB at 20Hz
Harmonic distortion	better than 0·1%	Treble control	± 15dB at 20kHz
Inputs: 1. Tape head	1·25mV into 50KΩ	Filters: Rumble (high pass)	100 Hz
2. Radio, Tuner	35mV into 50KΩ	Scratch (low pass)	8kHz
3. Magnetic P.U.	1·5mV into 50KΩ	Signal/noise ratio	better than + 65dB
		Input overload	+ 26dB
		Supply	+35 volts at 20mA
		Dimensions	292 × 82 × 35 mm

All input voltages are for an output of 250mV.
Tape and P.U. inputs equalised to RIAA curve within ± 1dB from 20Hz to 20kHz.

SPECIAL COMPLETE KIT COMPRISING 2 AL50's, 1 SPM80, 1 BMT80 & 1 PA100 ONLY £23.00 FREE p.&p only £13·15

INTEGRATED CIRCUIT PAKS

Manufacturers "Fall Outs" which inclue Functional and Part-Functional Units. These are classed as 'out-of-spec' from the maker's very rigid specifications, but are ideal for learning about I.C's and experimental work.

Pak No.	Contents	Price	Pak No.	Contents	Price	Pak No.	Contents	Price
UIC00	12 ± 7400	0·50	UIC46	5 × 7446	0·50	UIC86	5 × 7486	0·50
UIC01	12 × 7401	0·50	UIC47	5 × 7447	0·50	UIC90	5 × 7490	0·50
UIC02	12 × 7402	0·50	UIC48	5 × 7448	0·50	UIC91	5 × 7491	0·50
UIC03	12 × 7403	0·50	UIC50	12 × 7450	0·50	UIC92	5 × 7492	0·50
UIC04	12 × 7404	0·50	U1351	12 × 7451	0·50	UIC93	5 × 7493	0·50
UIC05	12 × 7405	0·50	UIC53	12 × 7453	0·50	UIC94	5 × 7494	0·50
UIC06	8 × 7406	0·50	UIC54	12 × 7454	0·50	UIC95	5 × 7495	0·50
UIC07	8 × 7407	0·50	UIC60	12 × 7460	0·50	UIC96	5 × 7496	0·50
UIC10	12 × 7410	0·50	UIC70	8 × 7470	0·50	UIC100	5 × 74100	0·50
UIC13	8 × 7413	0·50	UIC72	8 × 7472	0·50	UIC121	5 × 74121	0·50
UIC20	12 × 7420	0·50	UIC73	8 × 7473	0·50	UIC141	5 × 74141	0·50
UIC30	12 × 7430	0·50	UIC74	8 × 7474	0·50	UIC151	5 × 74151	0·50
UIC40	12 × 7440	0·50	UIC75	8 × 7475	0·50	UIC154	5 × 74154	0·50
UIC41	5 × 7441	0·50	UIC76	8 × 7476	0·50	UIC193	5 × 74193	0·50
UIC42	5 × 7442	0·50	UIC80	5 × 7480	0·50	UIC199	5 × 74199	0·50
UIC43	5 × 7443	0·50	UIC81	5 × 7481	0·50			
UIC44	5 × 7444	0·50	UIC82	5 × 7482	0·50	UICX1	25 Assorted 74's	1 50
UIC45	5 × 7445	0·50	UIC83	5 × 7483	0·50			

Packs cannot be split, but 25 assorted pieces (our mix) is available as PAK UIC X1.

The STEREO 20

The 'Stereo 20' amplifier is mounted, ready wired and tested on a one-piece chassis measuring 20 cm × 14 cm × 5 5 cm This compact unit comes complete with on/off switch, volume control, balance, bass and treble controls. Attractively printed front panel and matching control knobs. The 'Stereo 20' has been designed to fit into most turntable plinths without interfering with the mechanism or, alternatively, into a separate cabinet.

Output power 20w peak	Input 1 (Cer.) 300mV into 1M
Freq. res. 25Hz-25kHz	Input 2 (Aux.) 4mV into 30K
Harmonic distortion	Bass control ± 12dB at 60Hz
typically 0 25% at 1 watt	Treble con. ± 14dB at 14kHz

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C 3	50	Precision Resistors 1%, mixed values	0·50
C 4	75	⅛th W Resistors mixed preferred values	0·50
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C 9	3	Micro Switches	0·50
C10	15	Assorted Pots & Pre-Sets	0·50
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C12	40	Paper Condensers preferred types mixed values	0·50
C13	20	Electrolytics Trans. types	0·50
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C16	20	Assorted Tag Strips & Panels	0·50
C17	10	Assorted Control Knobs	0·50
C18	4	Rotary Wave Change Switches	0·50
C19	3	Relays 6—24V Operating	0·50
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Data and Circuits Booklet for IC's Price 7p.

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PROF. TYPE No.	1-24	25-99	100 up.
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TSO 16 " "	35p	32p	30p
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BP 701C—SL701C	63p	50p	45p
BP 702C—SL702C	63p	50p	45p
BP 702—72702	53p	45p	40p
BP 709—72709	36p	34p	30p
BP 709P—µA709C	36p	34p	30p
BP 710—72710	44p	42p	40p
BP 711—µA711	45p	43p	40p
BP 741—72741	75p	60p	50p
µA703C—µA703C	28p	26p	24p
TAA 263—	70p	60p	55p
TAA 293—	90p	75p	70p
TAA 350	170p	158p	150p
S.G.S. EA1000 £2·63			

ROCK BOTTOM PRICES LOGIC DTL 930 Series I.C's

Type No.	Price 1-24	25-99	100 up
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BP935	13p	12p	11p
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BP945	25p	24p	22p
BP946	12p	11p	10p
BP948	25p	24p	22p
BP951	65p	60p	55p
BP962	12p	11p	10p
BP9093	40p	38p	35p
BP9094	40p	38p	35p
BP9097	40p	38p	35p
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Devices may be mixed to qualify for quantity price. Larger quantity prices on application (DTL 930 Series only).

SYSTEM 12 STEREO

Each Kit contains two Amplifier Modules, 3 watts RMS, two loudspeakers, 15 ohms, the pre-amplifier, transformer, power supply module, front panel and other accessories, as well as an illustrated stage-by-stage instruction booklet designed for the beginner. Further details available on request.

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SETTING UP P.A. SPEAKER SYSTEMS

by Bogen Division of Lear Siegler Inc., Paramus, New Jersey.

THERE are four primary considerations when using cone or horn speakers as a part of a PA system. These are the power available to the speakers, the number of speakers, the type of speakers, and the placement and connection of speakers.

The first step is to survey the proposed installation and carefully determine how many and what type of speakers are needed. The following table may be of aid in this respect.

AMPLIFIER POWER	SPEAKERS NEEDED FOR INDOOR INSTALLATION	SPEAKERS NEEDED FOR OUTDOOR INSTALLATION
6 to 8 W	Two 8-in. speakers	One 12-in. speaker
15 to 18 W	Two 12-in. speakers	One trumpet
25 to 30 W	Four 12-in. speakers	Two trumpets
45 to 50 W	Six 12-in. speakers	Three trumpets
60 to 70 W	Eight 12-in. speakers	Four trumpets

There are several types of speakers available, and the choice of speakers depends upon five main factors:

1. Geometry and acoustical characteristics of the area to be covered.
2. Ambient sound level in which the speakers must operate.
3. Fundamental use of the system (i.e. — speech or music reproduction.)
4. Fidelity and intelligibility requirements.
5. Economic factors.

SPEAKER PLACEMENT

The most complex step in speaker installation is their placement and hookup. Conditions under which each system must operate vary so widely with each installation, that only the primary steps are given when considering speaker placement. For indoor systems, two kinds of placements can be used. The speakers may be positioned flat against the walls, and the axis of the speakers rotated so that they radiate energy at an angle from the wall. The speakers may also be positioned in the corners of a room. Variations from these two arrangements must be considered where there are alcoves, balconies, booths, dividing walls, and side rooms. In such cases, extra speakers must be set up to prevent dead spots resulting from unusual reverberations or blanking by obstacles.

For outdoor systems, the main considerations are direction of sound and the area to be covered. Here brute-force is generally used by employing highly-directive trumpets. Bear in mind that subjective loudness drops approximately 45% to 55% below the previous level each time the distance from the speaker is doubled. Also, directivity (amount of power concentrated along the speaker axis) increases with the size of the speaker horn.

SPEAKER CONNECTIONS

When connecting the speakers together, impedance matching and phase relation must be considered.

Efficient transfer of power from the amplifier to the speakers is the prime consideration in a sound system. The two methods of transfer of power are connection from the amplifier directly to the speaker voice coils, and connection from the amplifier to the speaker voice coils through a transformer. The first method is used when short runs of wire not over 200 feet in length and simple speaker arrangements involving low impedances are used.

The second method is used when the wire runs are over 200 feet, when there are complex speaker arrangements, and when it is desired to have less than 15% power loss in the transmission lines. The use of transformers also simplifies impedance calculations and facilitates changes in complex speaker arrangements.

IMPEDANCE MATCHING WITHOUT TRANSFORMERS

For the most efficient transfer of power, it is important that the total speaker impedances match the output impedance of the amplifier. Single speakers should be matched as shown in Fig. 1.

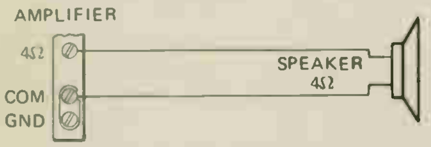

FIG. 1—SINGLE PA SPEAKER is connected like this. Just match the two impedances.

When there is more than one speaker in a sound system, calculations of total speaker impedance are based upon two formulas:

(a) For series connection of speakers, add the individual speaker impedances together to obtain the total matching impedance (see Fig. 2).

$$Z_T = Z_1 + Z_2 \ldots\ldots + Z_n$$

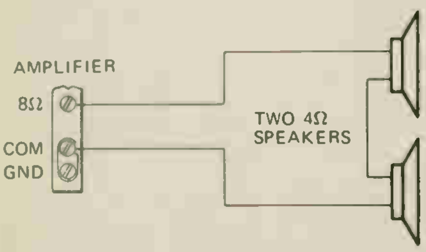

FIG. 2—SERIES SPEAKERS are selected so the sum of impedances matches amplifier.

(b) For parallel connection, add the reciprocal of the individual speaker impedances together to obtain the reciprocal of the total matching impedance (see Fig. 3).

$$\frac{1}{Z_T} = \frac{1}{Z_1} + \frac{1}{Z_2} \ldots\ldots\ldots\ldots \frac{1}{Z_n}$$

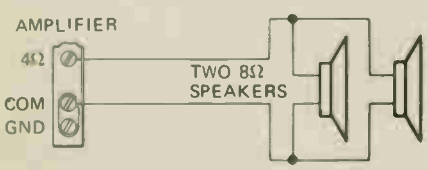

FIG. 3—PARALLEL SPEAKER connections tend to cause excessive line losses.

It is generally not advisable to use more than two speakers in parallel. Operation with less than 4 ohms impedance will result in excessive line losses.

(c) For series/parallel connections, combine the two formulae as the speaker connections indicate. For example, in Fig. 4. apply the series formula for A and B, then for C and D. Take the results of this and apply the parallel formula to obtain the final matching impedance:

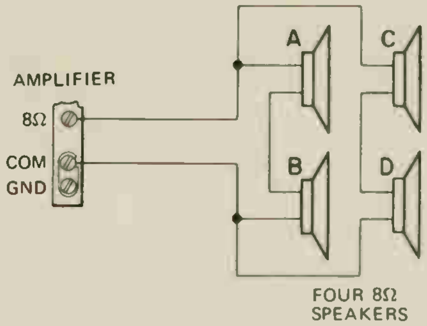

FIG. 4—SERIES-PARALLEL connections may be used to gain desired power distribution.

$$A + B = X \qquad (1)$$
$$C + D = Y \qquad (2)$$
$$\frac{1}{Z_T} = \frac{1}{X} + \frac{1}{Y} \qquad (3)$$
$$Z_T = \frac{XY}{X+Y} \qquad (4)$$

POWER DISTRIBUTION WITH TRANSFORMERS

In a series system of speakers, all with the same voice coil impedances, equal power distribution will occur. However, if one speaker has 4 ohms impedance and another 8 ohms, the power consumed by the 4 ohm speaker will be twice that of the 8 ohm speaker.

In parallel systems of speakers, all with the same voice coil impedances, equal power consumption will result. When speakers of different impedances are connected in parallel, the smaller impedance speaker will receive the greater power. If one speaker is 8 ohms and one is 16 ohms, the 8-ohm speaker will consume twice as much power as the 16-ohm speaker.

When operating speakers on voice coil impedance (without transformer), use as heavy a wire as possible. Speaker cable runs of 100 feet or over should be at least 16 s.w.g. wire. Runs from 50-100 feet should be 18 s.w.g. wire or larger.

IMPEDANCE MATCHING WITH TRANSFORMERS

The proper use of transformers with speakers far from the amplifier prevents comparatively large power losses in the transmission lines. In complex installations having large numbers of speakers, the use of transformers simplifies power distribution.

Constant-voltage transformers are most commonly used for this purpose, though impedance-matching transformers may be used in some sound installations. The constant-voltage transformer has its secondary tapped for different values of power (watts) for the speaker. The primary matches the constant voltage line, which is either 25 volts or 70 volts.

CONSTANT VOLTAGE SYSTEM

The constant-voltage system was developed particularly for use in large multi-speaker installations, but that does not prevent smaller installations from enjoying its advantages.

The constant-voltage method greatly reduces the amount of computation necessary to determine the proper transformer taps when varying sound levels are required. It also permits the addition to, or changing of, an existing system without recalculation of the total impedances and the power required.

A favourable load condition exists if the total power consumed by the loudspeakers is always less than or equal to the amplifier rating.

When the constant voltage transformer taps are marked in watts:

1. Choose the transformer with a matching secondary (8-ohm secondary for an 8-ohm speaker).
2. Select the power tap desired, and connect to speaker.
3. Connect the constant-voltage line to the primary.

If the transformer is marked in impedances, the required power can be determined by applying the formula:

$$Z = E^2/P$$

Where Z = Required transformer impedance in ohms, E = Amplifier output voltage (25 or 70 volts) and P = desired power at the speaker in watts.

MISMATCHING SPEAKER TO AMPLIFIER

Mismatching upward (connecting an 8-ohm speaker to the 4-ohm output of an amplifier) will decrease the power delivered to the speaker. Power loss will be about proportional to the upward impedance mismatch (50% when connecting an 8-ohm speaker to a 4-ohm amplifier tap). Mismatching cannot ordinarily damage a well-designed amplifier.

As a general rule, no serious frequency response deficiency will be noted if upward mismatches up to about five-to-one ratio are used.

Downward mismatching (connecting a 4-ohm speaker to an 8-ohm amplifier tap) should be avoided. It will reduce the amplifier power output and overload the output tubes or transistors, seriously affecting their life and performance.

PHASING SPEAKERS

When more than one speaker is used in a sound system installation, it is advisable to phase the speakers to reduce the cancellation effect. Speakers out of phase lose up to

SETTING UP P.A. SPEAKER SYSTEMS

one-half of their normal volume and operate with degraded tone quality and increased distortion.

For speakers facing in the same general direction, the speakers are in phase when their respective diaphragms move outward and inward at the same time. With two speakers facing each other, proper phasing is achieved when the diaphragm of one speaker moves outward as the diaphragm of the other speaker moves inward.

Phasing is done by checking the polarity of the speaker terminals with respect to the movement of the speaker diaphragm, and connecting the speakers to produce the diaphragm movement or phasing desired. With loudspeakers of the same make and model, the respective diaphragms should move in the same direction when the terminals are connected in the same manner, but it is safer to check the polarity.

Where different speakers are used, carry out the following procedure to determine the diaphragm movement with respect to the speaker terminals for speakers connected in parallel:

1. Connect one lead from a 1.5-volt dry-cell to one voice coil terminal of the speaker.
2. Momentarily touch the other lead from the dry cell to the other speaker terminal.
3. Observe direction of cone or diaphragm movement (either inward or outward) when the circuit is closed.
4. Note this direction of the movement on a slip of paper.
5. Mark the terminal connected to the positive pole of the dry cell if the movement is outward, mark the terminal connected to the negative pole if the movement is inward.
6. Repeat steps 1 through 5 for other speaker or speakers to be checked.
7. Connect the marked and unmarked terminals according to the manner of electrical arrangement shown in Fig. 5 if the speakers are facing in the same direction. If the speakers face each other, make connections as shown in Fig. 6.

In simple sound systems, it may be easier to check phasing by listening to a low audio frequency while alternating the speaker leads. The human ear can usually detect when the low frequency sound is at the higher volume, indicating that the speakers are properly phased.

BALANCED LINE CONNECTIONS

In most sound installations, unbalanced speaker lines will provide satisfactory performance. A typical unbalanced line installation for a 25-volt system is shown in Fig. 7. Two-conductor unshielded cable is normally employed in such installations. One conductor is connected to the 25-volt terminal on the amplifier output strip. The other wire goes to the common terminal, which is then connected to ground.

However, in more elaborate systems where input lines are run in close proximity to the speaker lines for extended distances, currents in the speaker lines may be picked up by the input lines. When these stray currents are fed back to the amplifier, hum and crosstalk will be introduced into the system, or the amplifier may oscillate.

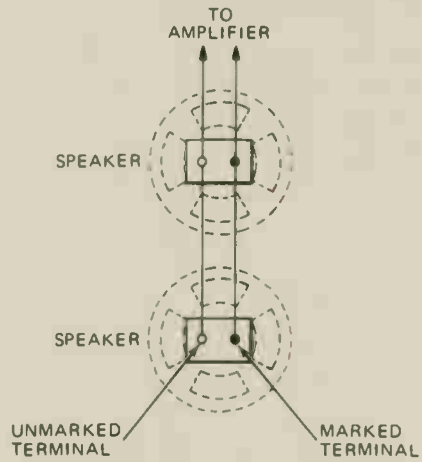

FIG. 5—PA SPEAKERS facing same way are phased with like terminals wired together.

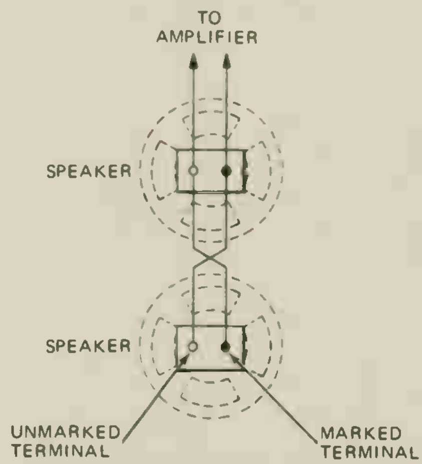

FIG. 6—SPEAKERS FACING EACH OTHER have line transposed for in-phase operation.

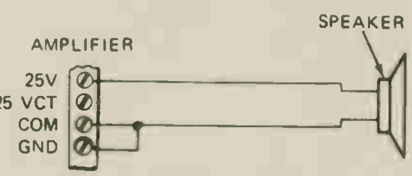

FIG. 7—A 25-VOLT UNBALANCED line is typical. Balanced lines are for special cases.

For this reason, balanced line connections are recommended for installations in which long input and speaker lines are run close together. A balanced line is obtained by under-grounding the common terminal, leaving the outputs floating. In a balanced line, any current which is developed in one side of the line is offset by an equal and opposite current in the other side. This greatly reduces the possibility of inducing stray currents in nearby input lines.

In some balanced line installations, it may also be necessary to connect the appropriate centre-tap terminal to ground, and to ground the amplifier chassis.

If hum or other pickup is encountered with a balanced line as described above, it may be necessary to run a shielded two-conductor cable to the speakers and to ground the shielded two-conductor cable to the speakers and to ground the shield at the amplifier end.

SOUND COLUMN SPEAKERS

Sound columns are designed for sound reinforcement in theatres, auditoriums and arenas where it is necessary to cover a large area with a minimum number of speakers. A sound column consists of six or more cone loudspeakers enclosed in a rectangular cabinet lined with acoustic material. Depending on the size and type of cone speakers employed, the output rating of a sound column may range from 25 to 200 watts. The terminal strip and sometimes a plate for mounting a line-matching transformer are located on the rear panel.

The arrangement of the speakers in the column is such that their acoustic output adds up in the forward direction, so that the effective throw of the sound column far exceeds that of the individual cone speakers. The effective throw or maximum distance at which sound from the column is distinctly audible is usually between 100 and 200 feet.

Because of its configuration, the sound column produces a highly directional beam pattern, which permits the sound to be aimed over a well-defined area of the installation site. Since about 90% of the acoustic output of the column is confined to this pattern, there is virtually no random sound available to cause reverberation or reflection. Consequently, a sound column can be properly directed to cover a hall or section of a hall most effectively and to keep harmful reflections away from the floor and ceiling.

In addition, the geometrical configuration of the speakers in the column produces a sound dispersion pattern which is quite broad in the horizontal plane but much narrower in the vertical plane. In a typical sound column, the horizontal dispersion pattern is 120°, which is a great deal more than that of the individual

SETTING UP P.A. SPEAKER SYSTEMS

speakers. However, the cumulative effect of the in-line speakers produces a vertical dispersion pattern of approximately 25° as shown in Fig. 8.

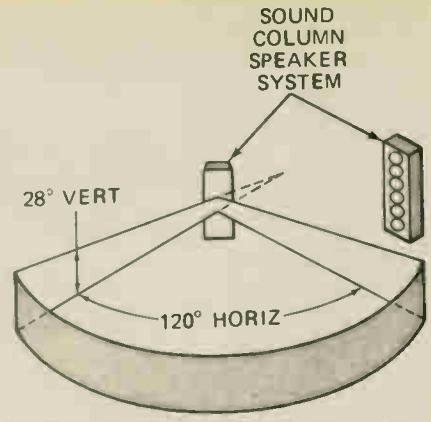

FIG. 8—RADIATION PATTERN from a vertically oriented sound column is horizontal.

PLACING SOUND COLUMNS

A typical sound column installation is shown in Fig. 9. The sound column is placed in the general vicinity of the original sound source (singer, speaker), as close as practicable to the source. Having the loudspeaker sound originate near the original source provides a more natural effect for the audience, and avoids confusing the performer.

The column is placed so that the microphone is below and slightly behind the sound column, to minimize feedback. The sound column is oriented so that its vertical distribution will deliver nearly equal minimized feedback. The sound column is oriented so that its vertical distribution will deliver nearly equal loudness to all listeners, from front to back, except those who are within the effective range of the speaker's voice.

A sound column can be aimed quite accurately at this point by the light reflection method. Attach a small mirror to the face of the column centre. Standing at the aiming point with a light directed at the sound column, have the column adjusted for maximum light reflection from the mirror.

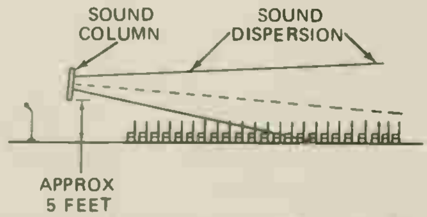

FIG. 9—HOW SOUND COLUMN IS PLACED for most effective coverage of an audience.

CONNECTING SOUND COLUMNS

One or more sound columns may be connected to an amplifier in a sound system. The columns are normally connected in parallel as shown in Fig. 10.

Sound columns normally have an impedance rating of 16 ohms. If only one sound column is used, connect the amplifier leads to the 16-ohm output terminal. For two sound columns in parallel, connect the leads to the 8-ohm terminal.

There you have it, a quick guide to PA speaker installation — use it to simplify your next PA job. ●

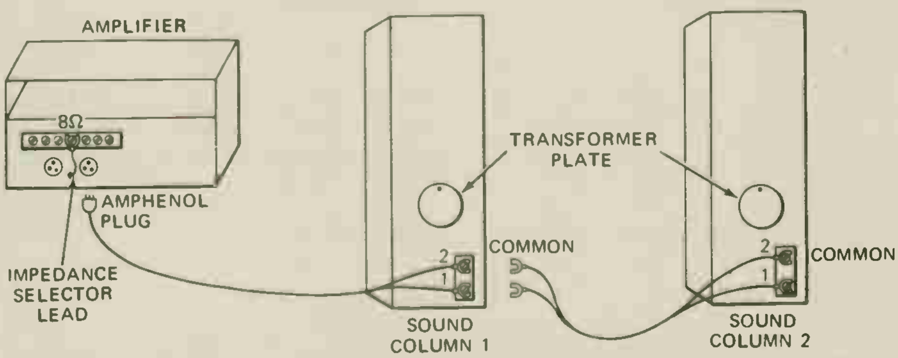

FIG. 10—ONE WAY to connect sound columns to PA amplifier system. Here two 16-ohm columns are in parallel across the amplifier output adjusted for an 8-ohm load impedance.

INPUT GATE

LETTERS FROM OUR READERS

ELECTRONIC TENNIS

I was recently invited to play "tennis" in a West End pub by some friends of mine who had discovered an electronic game there. The game looked like a big, old fashioned, TV set. On the screen a white dot bounced diagonally up and down, backwards and forwards. Beneath the screen there were two knobs—one for each player.

The game was quickly explained to me—the rules were like those of tennis, but the "ball" (represented by the moving dot) was allowed to bounce off the "side walls" (the top and bottom of the screen as the players see it). A dotted line indicated the position of the "net".

On insertion of a coin, two "men" (represented by vertical 15mm lines) appeared on the screen. By use of the control a player can move his "man" across the court (seen by the viewer as a vertical movement).

A skillful player will move his "man" into the path of the "ball", which will bounce the ball back to his opponent. If a player fails to return the ball, his opponent scores a point and this is registered on the score display projected onto the screen.

Variation is introduced when the "ball" doesn't bounce cleanly off the "man". Sometimes it will reverse along its incident path, sometimes bounce back at a different angle. Clever features of the game include the "serve" facility—where the "ball" appears to come out of the "net" on service, cutting down the time available to prepare the return shot—and the realistic "ping" sound which accompanies the successful return.

I was absolutely fascinated by the game and soon got the hang of the play (although I seemed to deteriorate after I had won my first pint!) Trying to work out the electronics has kept me occupied for days—it must be something simple.

It is good to see electronics coming into the amusements field and I hope to see more such games around (I have quite a few ideas myself).

—R.P. London, W.1.

We managed to contact the owners of this particular game and they say it is the only one of its kind in the country. It was brought over specially from the United States where games like this have been in use since the late 60's.

Production is soon to start in England too, but only on this one model. In the US there are already 5-a-side football games, squash and doubles games, based on the TV screen idea. The electronics are pretty intricate and a special I.C. board, with over fifty circuits, will be imported from the States for use in the British model. The rest of the circuitry is as in a standard TV set.

COMPONENT PROBLEMS

Through your columns I would like to draw attention to the bad service that everyone I know seems to be getting from mail-order component suppliers lately.

They seem to be getting worse and worse with part-orders being delivered more often than not. Isn't it time that these companies pulled their socks up?

I am sure many of your readers have had the same experience and I wonder if you, as a magazine, can draw attention to this situation in the hope that these companies will not like the adverse publicity.

—K.T.Eye, Suffolk.

We have had a number of comments similar to the above. If we knew of any company dragging its heels, we would be the first to criticise.

However, the current situation is almost certainly not the fault of the component suppliers as there is a serious world wide shortage of almost all electronic components. This is made worse in the U.K. because of our current boom which has added to the problems.

We are in touch with several component suppliers and to a man they are in serious trouble with obtaining supplies. Even mundane components such as resistors are becoming harder and harder to obtain. You could answer that the distributors should keep higher stocks but even those who had massive stocks have had these exhausted.

One small electronic company we know wanted several thousand each of 8 resistor values. His usual suppliers could only help him with one or two values and it took 30 'phone calls and five different suppliers to fulfil his requirements. These resistors were not unusual either, being standard ¼W types in the E12 series.

The delivery times being quoted by the makers normally now run into six months or more. If a manufacturer can't get hold of stock, you can imagine what it is like for the retailer.

We can only suggest to readers that they show a little patience until this chronic shortage is overcome and take it easy on your retailer—his problems are much worse than yours.

BRITISH AMATEUR TREASURE HUNTING CLUB

May I offer the following background information on amateur treasure hunting which may be of interest to readers who construct the "COIN COLLECTOR" metal detector featured in your July issue.

There are 30,000 amateur treasure hunters in Britain and our activities are governed by a strict CODE OF CONDUCT which was written with the help of the Department of the Environment at a time when our hobby was under severe attack from professional archaeologists. It is absolutely essential that anyone who uses a detector should abide by this code; any reader who wishes to obtain a copy may do so by sending a stamped addressed envelope to me.

The British Amateur Treasure Hunting Club welcomes the publication of do-it-yourself metal detector circuits. The Club is currently campaigning in its magazine, "TRUE TREASURE MONTHLY", for a reduction in the retail prices of many detectors now on the market which are far too costly and which do not do what their manufacturers claim. You would do us a great service if you made do-it-yourself detector circuits a regular feature of your magazine.

Edward Fletcher, Editor, TRUE TREASURE MONTHLY. 24-9 Trellick Tower, 5 Goldborne Road, London W10.


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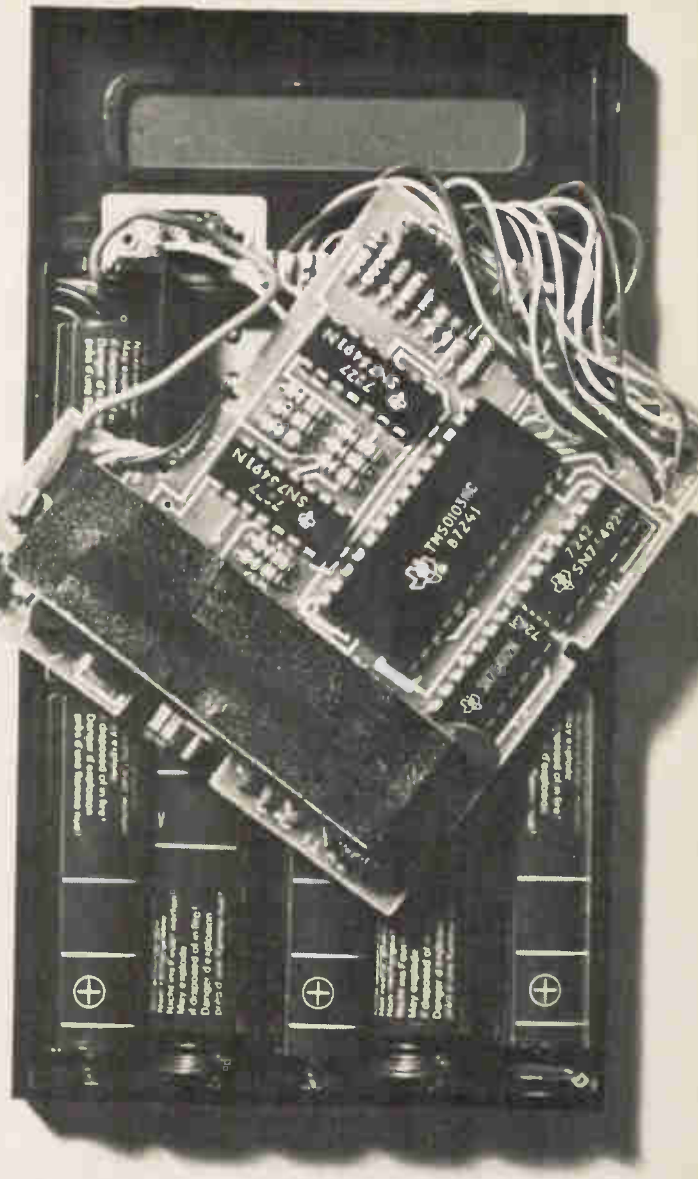


THE ETI Electronic Transistorised Ignition

By Caleb Bradley B.Sc.

TRANSISTOR IGNITION will be standard equipment on tomorrow's cars but today you can easily fit the ETI Electronic Transistor Ignition to your present car, old or new. It will give the proved advantages of smoother engine running, greatly extended life from spark plugs and contact breaker, freedom from plug fouling, plus worthwhile improvements in miles-per-gallon, performance and pollution . . . all this plus a burglar foiling facility!

STANDARD IGNITION

The simple ignition circuit which is still used in virtually all mass-produced cars is shown in Fig.1. Incredibly it was designed 60 years ago by Charles Kettering as an improvement on early magneto ignition. The way it works and the reasons why it is no longer adequate for today's highly developed petrol engine are as follows.

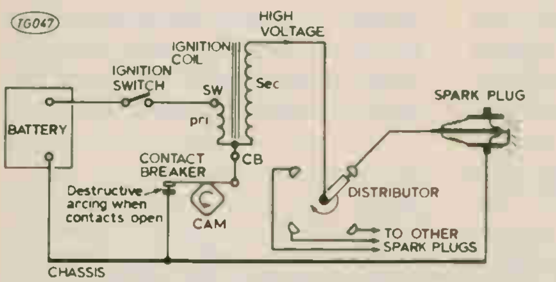
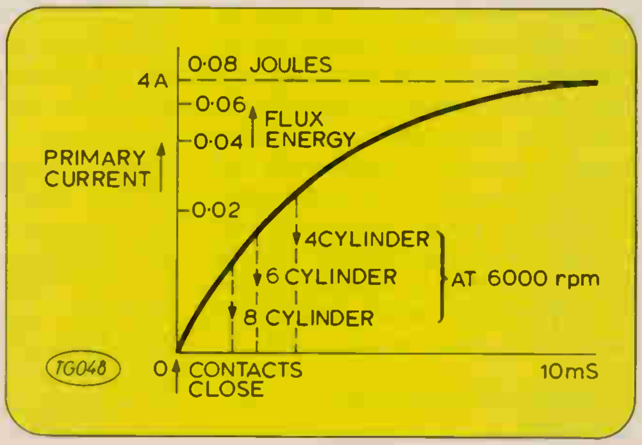


Fig. 1 (Above) The standard (Kettering) ignition circuit as fitted to virtually all mass produced cars for 60 years.

Fig. 2 (Right) After the contact breaker closes, current in the coil primary builds up at an exponential rate. Dotted lines show the times when the contact breaker opens for different sizes of engine at high speed. This graph assumes the contact breaker is in good condition and is driven with 50/50 mark/space ratio.



The contact breaker (or 'points') in Fig. 1 is driven by a cam to break the current in the ignition coil primary every time a spark is required to ignite the petrol vapour in a cylinder. Consider when the contact breaker has just closed. The battery is then connected across the primary, via the ignition switch and, since the primary has inductance, the current increases at a slow exponential rate as shown in Fig. 2. With typical primary inductance and resistance values of 10 millihenries and 3 ohms the circuit's time constant (the time for the current to reach 63% of its final value) is about 3.3 millisecond, though there is considerable variation between coils. If the engine is not running (so the cam is not turning) the primary current will settle at its maximum value of 4A or more which is set only by the battery voltage and the primary resistance. This high current tends to overheat the coil and run down the battery if a car's ignition switch is left on with the engine stationary.

Primary current causes magnetic flux in the coil, representing stored energy of value $\frac{1}{2}LI^2$ joules. When a spark is required, the contact breaker opens and the primary current is broken. As the previously created flux collapses it induces voltages in the coil windings, proportional to their numbers of turns. The peak voltage induced in the primary is about 300V but, since the secondary has about a hundred times as many turns, the secondary voltage is about 30,000V. This is sufficient to ionise the air gaps in the distributor (between the rotor arm tip and whichever terminal connected to a spark plug is nearest) and at the selected spark plug, so a spark occurs. Actually the spark plug is not firing in air but in a gas compressed to 200 lbs per square inch or more which requires a higher voltage to ionise it.

The weak link in the Kettering circuit is the contact breaker. This is a simple mechanical device which must be driven relatively slowly compared with rise of voltage in the primary; this is dictated by practical factors such as the return spring strength, the weight of the moving contact and the allowable force on the distributor cam. The unavoidable result is that the primary voltage transient rises faster than the breakdown potential of the newly opening air gap in the contact breaker and therefore arcing occurs in the early stages of contact breaking. Besides wasting some of the energy stored in the coil, this arcing detaches metal from one contact face and deposits it on the other and after only a few miles driving the first signs of pitting become visible — see the photograph. Pitting creates sharp edges on the contact faces which worsen arcing; the available spark voltage is reduced since arcing limits the voltage achieved in the primary. Also pitted contacts have significant resistance when closed so that optimum current (energy) is no longer built up in the primary. Eventually the loss of engine performance becomes so serious that the contacts have to be replaced.

THE 'CONDENSER'

This is a small capacitor which is connected across the contact breaker to reduce pitting and improve the spark slightly. When the contacts open, this capacitor is in effect connected across the coil primary and slows down the voltage transient so the contacts have a better chance of breaking the primary current cleanly. It is only a partial improvement, sufficient to make the Kettering circuit barely useable, and the capacitor must not be too large or the spark voltage will suffer.

DESIGN LIMITATIONS

Two situations stretch conventional ignition to its limit. These are:

a) Starting on a wintry morning when the starter motor loading reduces the battery voltage and hence the primary flux so only a feeble spark is available to ignite a cold mixture, and

b) High speed running when the time between sparks does not allow adequate flux to build up.

Most drivers are well aware of shortcoming a) but it is not well known that most cars with conventional ignition suffer from misfiring at high speeds, though there is a definite loss in m.p.g. and smoothness. The reason for spark deterioration at high speeds

Electronic Transistorised Ignition

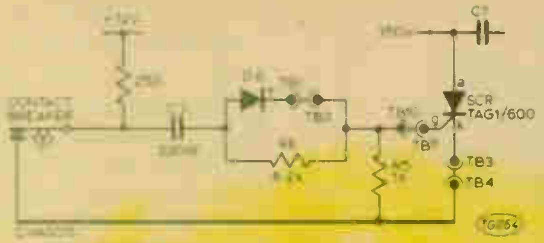


Fig. 8. Trigger circuit for negative chassis vehicles.

A surprising feature of the inverter circuit is that it continues to function weakly if one of the transistors is removed or goes open circuit. This might suffice to get you home at 30 m.p.h.!

In most previously published designs the inverter is allowed to 'see' a short circuit (via the bridge rectifier), for example at switch-on when C1 is not charged, and every time the S.C.R. fires. Although this does no damage it causes the inverter to run briefly in a high-frequency low-efficiency mode since the only inductance loading the transistors is the leakage inductance of the transformer. An alternative is to design the inverter to stop oscillating when shorted but this presents starting delay problems. For this design it was thought preferable to keep the inverter running continuously in the proper audio-frequency high-efficiency mode. A simple way of achieving this is by having a resistor in series with the secondary winding. The inverter now continues to run audibly even if the bridge output is shorted. If a milli-ammeter is used to do this a short-circuit current of 30 - 40mA can be measured indicating the circuit has excellent 'pick up' after each spark. Note that T1 and the secondary resistor normally run warm but get quite hot if the bridge output is shorted continuously. No difficulty has been found in relying on the backswing from the ignition coil to turn off the S.C.R. specified in this circuit, in spite of the high charge current.

OVERSHOOTS

The inverter provides adequate output voltage to start the engine at reduced battery voltage of 8V or less yet will not exceed 400V with a fresh battery, so no attempt has been made to use the inverter waveform overshoots for output regulation. As can be seen on the waveforms in Fig. 7 the overshoots are small, partly because the primary of T1 is bifilar wound for low leakage inductance and partly because most of the overshoot power is taken by the neon indicator.

NEON LAMP

A neon lamp with series resistor is connected across C1 so that illumination indicates that the inverter is working, C1 (a highly stressed component) is not short circuit and that the ignition coil primary connections are intact. To avoid taking excessive power from the circuit, the neon is not driven very brightly but should be clearly visible in the shade of the engine compartment.

S.C.R. TRIGGERING

The S.C.R. must be triggered by means of a positive pulse at its gate relative to its cathode every time a spark is required, i.e. every time the contact breaker opens. Different means of triggering are used for negative- and positive-chassis vehicles as shown in Fig. 8 and Fig. 9. Viewing Fig. 8, 0.5A is passed through the contact breaker when closed by the 25 ohm resistor. The purpose of this current is to keep the contacts clean by burning off any minute deposits; contact breakers switching smaller currents can be very troublesome due to a fine film of oil and dirt building up on the contact faces. Since the contact breaker has approximately 50/50 open shut period, the mean current drain of this arrangement is negligible at 250mA.

When the contact breaker opens, the 25 ohm resistor pulls one side of C3 from 0V to 12V, D6 conducts and a positive pulse, differentiated by C3 and R5, is fed to the S.C.R. gate causing it to fire and discharge the 350V on C1. It is not possible for another trigger pulse to be produced until C1 discharges. D6 blocks the discharge current which cannot flow until the contact breaker closes and must then flow through the comparatively high value resistor R6 and R5. Thus a new trigger pulse cannot be produced until the contact breaker has been closed long enough to discharge C3. This arrangement effectively makes the system immune to false triggering caused by contact breaker bounce. The component values are chosen to suit the trigger characteristics of the S.C.R. specified and may not suit other types.

The trigger circuit for positive chassis in Fig. 9 works similarly with the difference that the trigger is a *negative* pulse which is passed by D5 to the S.C.R. *cathode*. Since the gate is connected to chassis this gives the correct trigger conditions. When the S.C.R. fires the discharge current flows through D7.

FULL CIRCUIT

The full circuit is shown in Fig. 10 and has the features of easy switch-over from transistor to conventional ignition by means of toggle switches S1, S2, and convertibility for positive or negative chassis by mounting a link strip in alternate positions on a miniature terminal block. The main elements of the circuit have been described; the connections to the terminal block are rather complex but can be understood by reference to Figs. 8 and 9. When S1 and S2 are both switched to conventional the transistor circuit is isolated (though

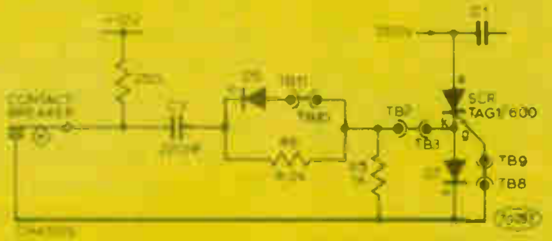


Fig. 9. Trigger circuit for positive chassis vehicles.

the inverter still receives power) and the normal connections for Kettering ignition are remade i.e: coil primary connected to ignition switch and contact breaker. This switchover facility can be used while the engine is running for comparison purposes.

COMPONENTS AND CONSTRUCTION

For obvious reasons the unit must be dependable while driving. To this end all the components specified are of high quality and in many cases of higher than necessary ratings. Construction must be equally sound. Component substitutions are not recommended e.g. slide switches should *not* be used in place of the toggle switches because of the inductive circuit switched, nor is it a good idea to remote these switches to the dashboard.

The components are mounted on the lid of a standard Norman AB10 aluminium box for easy access. The layout is shown in Fig. 11 and in the photograph. Drilling details are given for the box in Fig. 13 together with

PARTS LIST

R1	Resistor	220ohm 5W wirewound
R2	"	220ohm "
R3	"	7·5k "
R4	"	25-39ohm 10W "
R5	"	1k ½W 5%
R6	"	8·2k " "
R7	"	330k " "
C1	Capacitor	0·47uF or 0·5uF 440V a.c. tubular (MFD type TSAC)
C2	"	3500uF 25V electrolytic
C3	"	220nF (0·22uF)
D1-D4	Diodes	1N4006 or 1N4007
D5-D9	"	1N4001 (or -2, -3 etc.)
SCR	Thyristor	TAG 1/600
Q1-Q2	Transistor	NPN silicon plastic power type with min Vce of 50V and min gain at 500mA of 40.
T1		Inverter Transformer (Bi-Pre-Pak)
S1,S2	Switches	Heavy duty DPDT toggle switches
FS		5A 1¼in fuse with holder
TB		11 way miniature terminal block with screws and solder tags (Carr)

Miscellaneous

Norman AB10 chassis with lid; Heatsink; Neon bulb; 2 x 10 way tag strips; Transistor mounting hardware; Grommets; Coloured wire; Nuts and bolts etc.

A complete kit including predrilled chassis is available to readers at the special price of £5.92. A built, tested and guaranteed unit is also available at reduced cost. These offers are limited to ETI readers using the coupons on page 77. Offers end September 30th 1973.

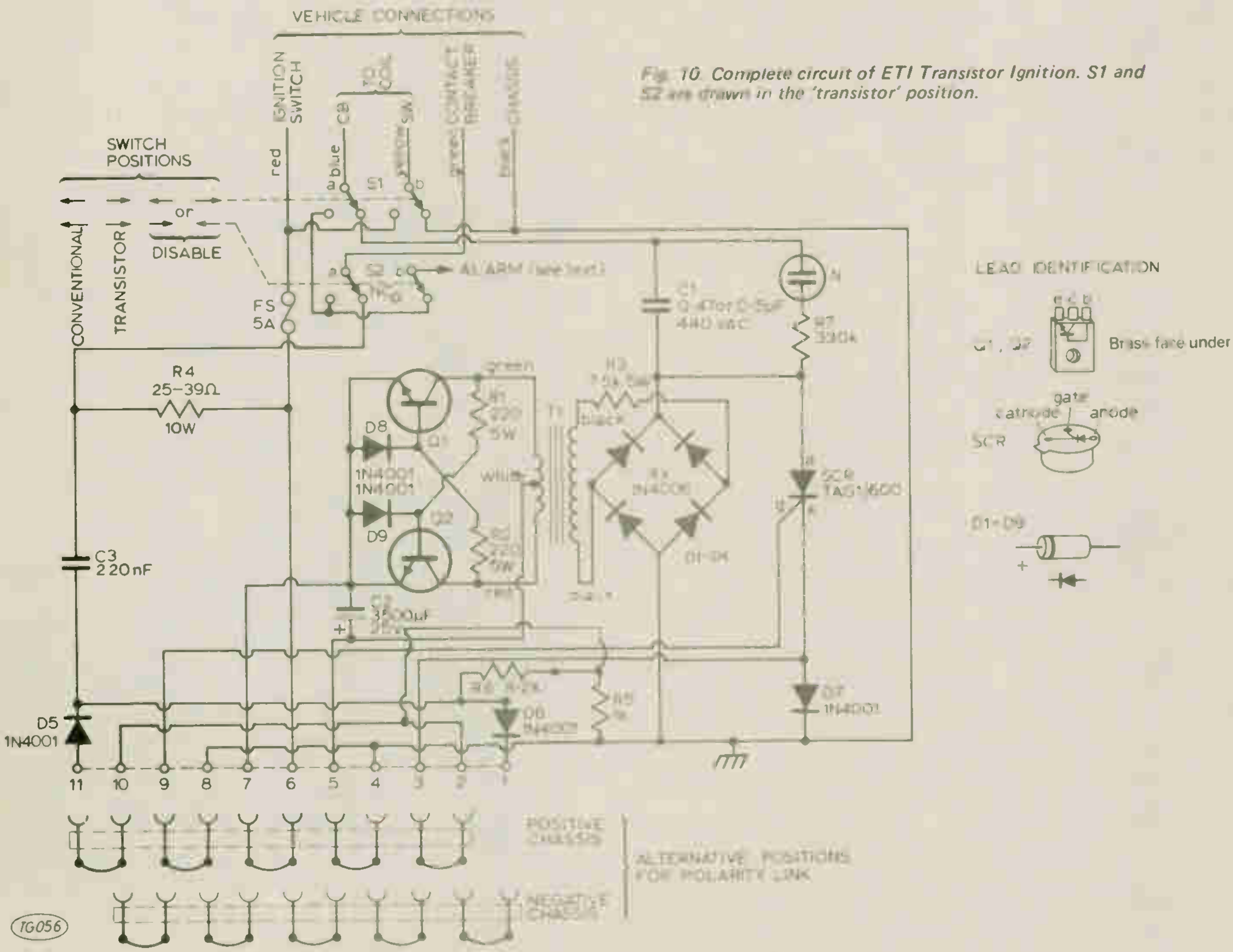


Fig. 10. Complete circuit of ETI Transistor Ignition. S1 and S2 are drawn in the 'transistor' position.

Electronic Transistorised Ignition

an aluminium heatsink for the transistors and inverter transformer but the kit is supplied with a predrilled chassis and will not in this case be necessary.

It is convenient to mount as many components as possible on the tagstrips before mounting the tagstrips in the box. Pass the tagstrip mounting bolts through both the lid and the heatsink. Then mount the plastic power transistors using the mica washers and insulating bushes supplied to isolate the metal part of the transistor (collector) from the box — see Fig. 12. The transistor mounting bolts are live to the collectors.

Mount the toggle switches, transformer, fuseholder and terminal block. The wiring can now be completed. Take special care to make robust connections to the transistor leads, using sleeving to prevent shorts. Wrap component wires round tags before soldering to give strength to the joint. Be careful with connections to the small tags on the terminal block, this is mounted with pin 1 on the right when viewing the unit from the out-

An excellent example of pitting on a contact breaker. Due to the very much lower current switched for an electronic ignition system such problems are eliminated.

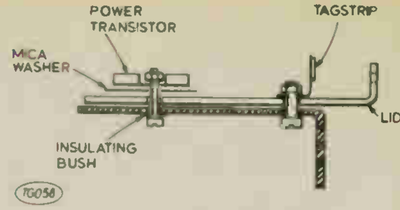


Fig. 12. Method of mounting power transistors. The shaded part is the heatsink.

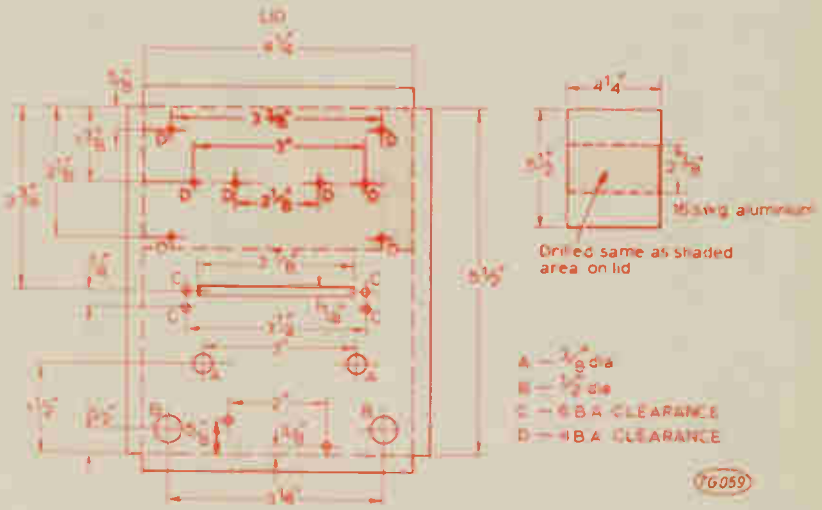


Fig. 13. The chassis drilling details. The three-eighth inch holes may have to be larger with some toggle switches.

Continued on Page 76

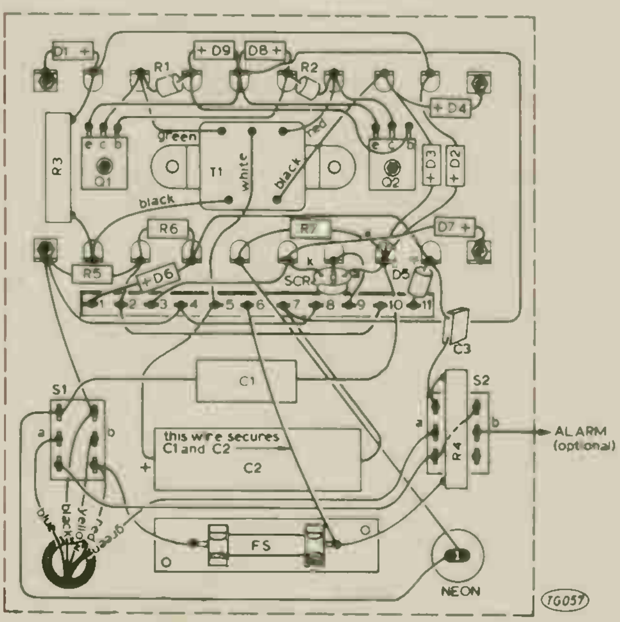
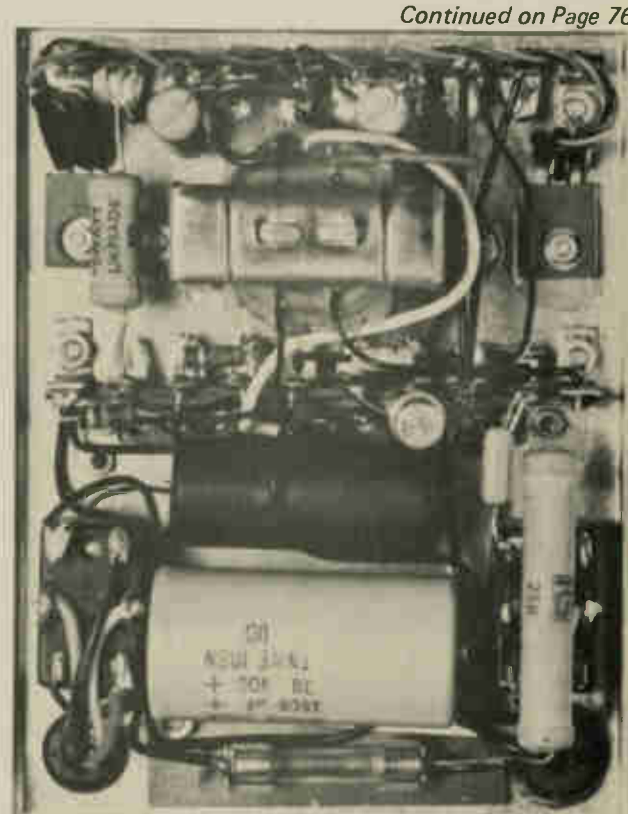


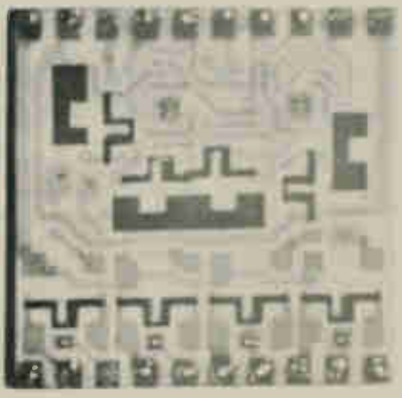
Fig. 11. ETI Transistor Ignition Component layout. (Prototype has Q1, Q2 in slightly different positions, also has an unused position 12 on the tag block).



An internal view of the unit. This is one of several prototypes and uses the components supplied in the special kit.

WHAT TO LOOK FOR IN OCTOBER..

THICK FILM



Thick film technology facilitates the mass production of resistors which cannot be incorporated on the silicon chip of an integrated circuit. Thick film circuitry is being adopted by many manufacturers—for various reasons. Decreased size and enhanced reliability attract the professional and military market. For consumer and automotive users mass production of uniform packages decreases assembly costs.

The technology is based on the screen printing of glazes on to a ceramic substrate. Next month we tell you about the design of thick film substrates, their production and their uses in "hybrid circuits" for many applications.

eti AUDIO WATTMETER

Our direct reading Audio Wattmeter gives instant power readings in r.m.s. watts and level differences in decibels. It operates at any frequency within the audio range and is specifically designed for Hi-Fi amplifiers with output impedances of 4, 8 or 15 ohms. Three ranges are provided—up to 500mW, to 5W and to 50W.

Next month full details of circuit boards, calibration and metal work will be provided for this project, enabling you to make yourself an instrument invaluable in the checking of amplifier performance.

MAGNETIC LEVITATION

Repulsive or attractive? This is just one of the debates going on amongst researchers into magnetic levitation/ suspension. The latest interest of researchers is in using principles of magnetism in the support of high speed trains. A recent contender in the field of train levitation is the principle used by Bachelet in 1912 but discarded as impractical. This utilises eddy currents, induced in a thick aluminium plate by a fluctuating magnetic field, to provide the repulsive force to lift the vehicle. Recent developments in cryogenics and superconductivity now make this form of transport a practical possibility.

ON SALE MID-SEPTEMBER—20p

ETI TAKES A PRIDE IN BEING REALLY UP-TO-DATE, SO WE OURSELVES DO NOT ALWAYS KNOW WHAT WILL BE IN THE NEXT ISSUE SO THE FEATURES MENTIONED ON THIS PAGE ARE ONLY SOME OF THOSE THAT WILL BE INCLUDED.

electronics today INTERNATIONAL

THE SOLAR SOLUTION

IS IT THE ANSWER TO THE ENERGY C

". . . We are facing a vitally important energy challenge. If recent trends continue unchecked, we could face a genuine energy crisis. But that crisis can and should be averted, for we have the capacity and resources to meet our energy needs if only we take the proper steps and take them now."

President Nixon, 18th April, 1973.

SIX MONTHS AGO, if someone had used the term 'Energy Crisis', the chances are that it would have required a lengthy explanation. Today it is such a common talking point that it is running the danger of being overstated. What are the facts?

In the United States, which consumes a third of the world's energy, a number of independent filling stations have had their supplies stopped by the oil giants because they no longer have a surplus. That is all that has happened; why then are we getting concerned? The answer is that although this is only a beginning it has focused attention on a potentially very serious situation. Every TV station, every newspaper, every centre of higher learning has taken out the crystal ball and is gazing into the future. . . most of the time the forecasts are gloomy.

We, *Homo sapiens,* have increased our standard of living so enormously in the last 100 years that we are beginning to effect our environment; in addition to increasing our standard of living we are also multiplying our numbers very rapidly, adding to the problems.

In the developed countries we are surrounded by machines: motor cars, combine harvesters, air conditioners, central heating plants and so on. The definition of man used to be the *toolmaker* (though this is now falling from favour) and as we have progressed we have harnessed a variety of energy forms to operate these tools to make our lives more comfortable.

For thousands of years we harnessed the energy of the ox and later the horse. Then we harnessed the wind for sailing ships and windmills, then the waterwheel.

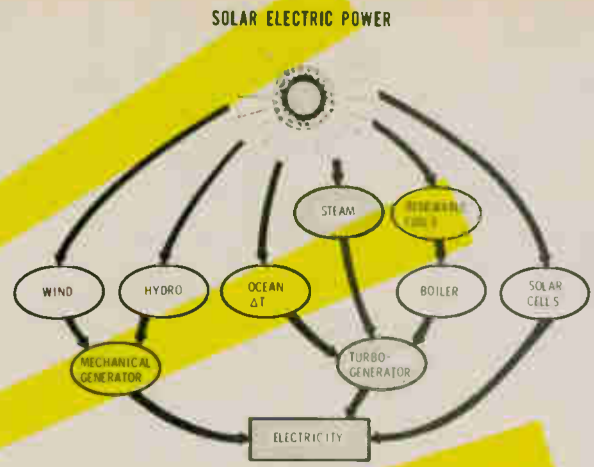
The industrial revolution required large resources of energy and coal was the answer. It is no coincidence that the industrial revolution started in Britain, on an island that has been called a 'floating coal mine'.

As we progressed we found that oil was more convenient, especially for transport, and if we call the last century the 'age of coal' we must refer to the last 30 years as the 'age of oil'.

Oil is a marvellous resource. It is cheap (at the moment), easily transported and stored, it is stable and, until now, has been abundant. We have continued to use a large variety of other energy forms but oil is dominant. The trouble is that oil is a limited resource and is being used up at a staggering rate.

Production of oil in the United

Methods of harnessing the sun's power. This diagram illustrates that there are a variety of approaches that can be taken.



RISIS ?

SPECIAL REPORT BY HALVOR MOORSHEAD

States has reached its peak and will start to decline before the decade is out. To fill the gap between supply and demand the Americans are now beginning to buy on the world market in a big way and the pressure is on.

What of the Alaskan and North Sea oil fields, surely these are going to save the day and what of the continual discoveries still being made? The predictions have taken account of future discoveries: we are without doubt now consuming oil faster than new fields are being discovered. There are still substantial reserves but our appetite is so great that nearly all the experts agree that *if we continue to use oil at the same rate* we will not have a drop left in twenty years time. Many of the cars being turned off the production lines today will still be around then and it will be within the lifetimes of most of us.

In fact things will not happen this way. As the reserves are exhausted, the price will soar upwards and other energy forms will be found, leaving oil for specialised uses.

One danger we run into in an article of this type is that we cannot predict the future with any certainty, for technology is moving at a remarkable rate. We could fall into the 'Malthusian Trap'* of predicting too far ahead, while assuming that conditions will not alter. However, we are looking into the forseeable future and we can safely say that alternative energy sources must be found and found pretty quickly. The alternatives must be operative and on a vast scale within twenty years. What are the alternatives?

*Thomas Malthus (1766-1834) in his gloomy essay 'The Principle of Population' foresaw the maximum world population as a fraction of what it is now and a declining standard of living. He calculated what the population would be but did not forsee the huge improvement in agriculture or technology. He said that technology could not increase as there was not enough grazing land for the horses necessary to provide the motive power!

COAL

There is still plenty of coal, even bearing in mind our appetites. The known reserves of coal, in energy terms, are at least 15 times greater than for oil and this is despite the fact that modern technology has not been applied (to any great extent) to finding new reserves.

Coal has its disadvantages. The unworked seams are deeper and deeper and more costly to mine; there is the problem of subsidence and there are social problems. In addition, most coal produces SO_2 when burnt and it is not easy to transport.

Even so, coal may well gain in importance and help to fill the gap before another energy source is found but, like oil, it is a diminishing, non-replaceable source and it is not the long term answer.

NATURAL GAS

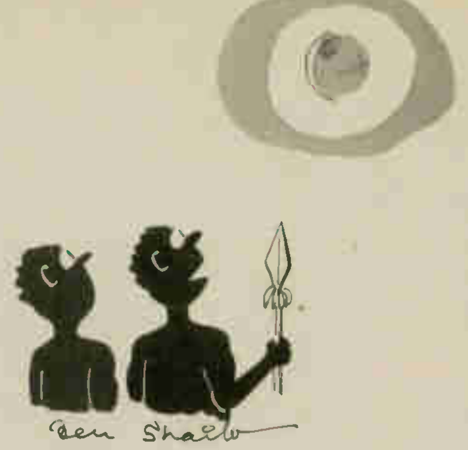
Natural gas and oil are closely allied; if anything the gas will run out before the oil. Gas is very important in certain parts of the world, notably North America and Britain, where in the last few years it has become a major energy source.

Despite there being substantial remaining reserves, gas, like coal, is certainly not a long term answer.

NUCLEAR ENERGY

If we are forced to look into the future it seems likely that our needs will be met by nuclear energy, but this is some way off. The conversion of matter into energy makes a very attractive formula. A few pounds of matter, when converted into energy, is enough to satisfy a person's energy requirements for life. We are a long way from this, however, and at present we are confined to using a limited number of elements, such as uranium, for this.

THE SOLAR SOLUTION



"I think the gods are warning us about an impending energy crisis" (from the Daily Telegraph at the time of the recent Solar Eclipse).

Despite the fact that, in terms of weight, we need very small quantities of uranium, there are not vast reserves and the processing requires a substantial back-up industry.

There is also the political question: are we prepared for nuclear power stations, as used in the developed world, to be installed in less stable countries? Once you have a nuclear power station and access to uranium it is not too difficult to make your own nuclear bombs!

There are also the problems of radioactive waste which are very serious. A variety of methods are used to dispose of this but none are truly safe. These problems will no doubt be overcome but an answer has been sought for the last 20 years and still the problem remains.

Nuclear fusion uses deuterium which is abundant (enough to last us 10^9 years!) but, despite intensive research, this is more theory than practice at the moment. We know it works but we have a long way to go and this still poses the problem of waste disposal.

GEOTHERMAL

We all know that the inside of the earth is very hot. In certain parts of the globe, where ground water comes into contact with hot rock, high pressure steam is produced which can be harnessed. Italy, France, New Zealand, USA, Japan and the USSR already harness this energy but the natural occurance of this phenomenon is rare.

It has been suggested that we could create these conditions artificially but this has yet to be tried and there are not suitable conditions in many parts of the world.

OTHER ENERGY SOURCES

We have been very ingenious at harnessing various energy sources. Hydroelectric stations are in use all over the world and produce cheap electricity but there are few remaining sites which can be used. The great dam building days of the 1930's and the 1950's are over and every available site in Western Europe and the USA has been used.

Tidal power is used in France. By damming suitable estuaries, the rise and fall of the tide can be harnessed to drive turbines. The French scheme has had severe problems but is now operative. But once again the potential and the number of sites make this a curiosity rather than an answer.

For centuries the wind was the sole motive power for ships and the major energy source for grinding corn; even today in remote locations it is used to generate electricity. However, the capital investment and inconsistency of wind does not make it anything more than a curiosity.

The temperature gradients in the ocean could provide staggering quantities of energy but, as yet, no commercial plant has been built. This, however, holds out great promise. The difference between the temperature at the surface and at the depths of the oceans can be as much as 20°C, and energy can be harnessed from any potential heat difference. This is, of course, one aspect of harnessing the sun's energy. This suggestion is not new, having been proposed by J. D'Arsonval in 1881. The chief advocate now is C. Zener of the Carnegie-Mellon University, U.S.A. In 1966 a cost analysis of this project indicated that it would compare with a conventional power station.

The disadvantages are the physical size of such a plant. Water would have to be pumped 1000 metres through a 12 metre diameter tube. Various methods could be used to convert a 20°C heat difference into a higher potential difference.

This scheme appears fairly attractive but very little work has been done on it and the scheme remains on the drawing board with a number of problems remaining.

THERMAL POLLUTION

We do not wish to 'write-off' any of the above but vast research remains to be done on those which appear promising. All may be used as our demands increase but we have to take an overall view of our world and the effect we are having on it. The American astronauts, returning from the moon, could only make out one unnatural feature on the surface of the earth—the massive smoke plume from the Four Corners power station in the south western U.S.A.—one of the largest power plants in the world.

We have become acutely conscious of pollution even to the extent of overstatement, as with most good causes, but we normally think in terms of industrial waste and effluent. If we think in terms of pollution we must also think in terms of heat pollution.

A speeded up radar view of south-east England in the winter shows vast flocks of birds leaving London every morning to feed on the surrounding countryside. At dusk the process is reversed. Why? Because the temperature at the centre of London is about 2°C higher than that of the surrounding countryside and this in turn is due to the quantity of energy consumed in the city and suburbs.

At present this effect is localised and of little importance but it can be calculated that in 50 years the world temperature will rise by 1°C and in 100 years by 5°C. There are two schools of thought as to the consequences of this. The good news is that plant life will take up the excess and become more prolific. . . the bad news is that it will start the melting of the polar icecaps with the low lying parts of the world being flooded. Even if we accept the optimistic view, there is obviously a limit to the ability of plant life to absorb the extra heat.

This warming up of the environment will happen with most of the energy sources mentioned in our survey of possibilities but it does not apply to one which we shall now investigate—Solar Power.

THE SUN

The sun has been worshipped by most races at one time or another as a god. When one realises the potential and power of it, a cynic could well suggest that perhaps we should never have stopped.

The statistics are easy to come by but the scale is almost outside our imagination. The sun is 865,000 miles across and is a vast nuclear fusion bomb, gobbling up matter at a phenomenal rate and releasing it as energy. At the centre the temperature is calculated to be 13 million degrees centigrade (a coal fire is under 1000°C).

At this temperature atoms are split into separate nuclei and electrons —in such a state this is called plasma. The atomic nuclei frequently collide with each other at great speeds and reactions occur between them. This process converts hydrogen, of which the sun is chiefly composed, into helium and releases enormous quantities of energy in the form of electromagnetic radiation.

Although the sun is on average 93 million miles away, the energy falling onto the surface of the earth is sufficient to sustain life for thousands of millions of years to come.

This energy has been stored on the earth by natural phenomena in a number of ways. The organic life of more than 100 million years ago has become coal and oil and this is due to the sun. The temperature gradients in the ocean, wind and hydroelectric power are also a result of the sun's power. (Geothermal and nuclear power are not a direct result of the sun's energy, however).

We are rapidly using up this stored energy in the form of fossil fuels while the other forms do not at present seem easy to harness with present technology.

On a normal day the energy falling on the surface of the earth is equivalent to over 1kW per square metre— and taken over the whole earth this is about the nearest we can get to an unlimited reserve.

AVAILABLE POWER

Enough energy falls on the earth in a 15 minute period to supply our requirements for a whole year. Looking at it practically, worldwide energy requirements until the year 2000 could be derived from the energy falling onto 250 miles square.

This energy is virtually limitless, pollution free, available anywhere in the world and it would not upset the temperature balance of the earth. The surface temperature would fall where collection takes place and this would be channeled to population centres where it is released; these would cancel exactly.

One query may arise. As the sun has been feeding this energy onto the surface of the earth for about 4,000 million years, why is the earth not heating up naturally? The reply is that the earth itself is in balance and almost exactly the same quantity of heat is reradiated as we receive, maintaining an equilibrium. We can channel this to new areas and concentrate that energy without upsetting the overall balance.

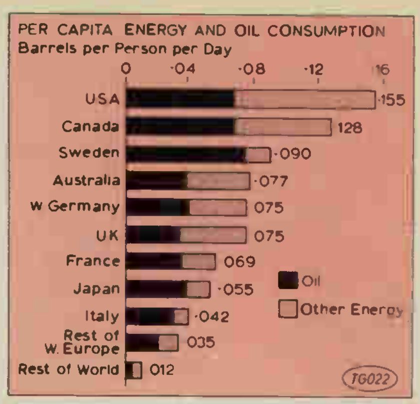
LIMITATIONS

It is tempting to propose the sun as the obvious answer and to take the 'why-didn't-we-think-of-it-before' attitude. It is also tempting to regard the sun's energy as free. . . it is not.

A lot of rubbish has been talked about new energy forms, for instance, that atomic power would reduce the cost of electricity to virtually nothing. Electricity is cheap but even if the fuel was free the price would drop by only 20 per cent. In most of the world 80 per cent of the cost of electricity is accounted for by the capital equipment, the power lines, the personnel, etc., and only one fifth by the fuel cost. This has been the problem with nuclear power stations. The electricity from these costs about twice as much as from coal or oil despite the fact that they use only a few pounds weight of fuel each year because the capital cost is so very much greater than for conventional power stations.

This formula applies to solar energy. Whatever methods are used to harness it, it will have a massive capital cost and this has to be paid for by the user. Most of the realistic protagonists of solar power estimate that the cost will be at least twice that of conventional methods but this still makes it competitive with nuclear energy. Cost, however, must take a back seat; new energy sources must be found. On the other hand, these estimates do not take account of major technical breakthroughs, though this is an unwise argument. We have no right to assume, or even guess, that there will be technical breakthroughs in this field while assuming there will not be breakthroughs in completely new sources of energy.

Another temptation is to advocate the sun's energy because the technology is easily understood. A 15-year-old schoolboy can understand the technology necessary for many of the sun power schemes while very few understand the processes and problems of nuclear fusion for instance. We have mentioned these qualifications before explaining the various methods



proposed in order that we keep the whole thing in perspective.

Not everyone is enthusiastic about the idea: a Committee of the U.S. National Academy of Sciences only last year reported that sun power was unlikely to be of much importance for future energy needs and we cannot dismiss such an august body of gentlemen. However, research is not only continuing but is expanding in all parts of the world. The U.S. Government has increased the budget for research in this field ten-fold, from $1.2 million in 1972 to $12 million for the coming year. Considerable research is also going on in France, Australia, India and Israel. It has been suggested that a number of the Arab states are prepared to back research from their oil revenues as their countries will be ideal collection areas; this could give them something to fall back on when the oil wells dry up.

Research in Britain appears to be on a very minute scale at present. This is probably due to the fact that, as far as the energy crisis is concerned, Britain is one of the best placed countries in the world. The Table of Per Capita Energy and Oil Consumption for the world (1970 Data) shows that Britain is rather less dependent on oil than most countries due to the considerable use of coal and nuclear energy (Britain easily leads the world in this). The natural gas and oil deposits in the North Sea will shortly be brought into production. On the other side the climate in the United Kingdom does not exactly encourage research into sun power!

HARNESSING THE ENERGY

Harnessing the sun's power is not a new idea and from 1860-1920 a large number of solar engines were built. Some of these were remarkably ingenious but the technology of the time was not able to provide the precision necessary for viable mass production. In the 1920's oil started to grow in importance and the in-

THE SOLAR SOLUTION

A solar collector built in 1913 and used beside the Nile River.

centive for continuing the research disappeared. One photograph shows a solar collector in use beside the Nile River in 1913.

The main disadvantage with harnessing the sun's energy is the low density. Although the energy is equivalent to over 1kW per square metre, the conversion efficiency is likely to be considerably less than 100 per cent: most researchers will be happy with 25 per cent efficiency. From the table of energy consumption it will be seen that Australia, West Germany and the U.K. have very similar figures, each person using a little less than 0.08 barrels of oil per day equivalent; converted to electricity equivalent this is 12kWh per day per head. If we assume a 25 per cent conversion rate, this will necessitate about 4 sq. metres of collection area each (the 1kW applies only in daylight of course) or 20 sq. metres per household—and this does not allow for the rapid growth which is taking place. Even if individual solar collectors were cheap, this area is rather large for many houses and would be impractical in a city.

There are two main methods of collecting this energy—high concentration and low concentration.

HIGH CONCENTRATION METHODS —THE ODEILLO FURNACE

Five thousand feet up in the French Pyrenees, near the village of Odeillo, is the world's largest solar furnace which is the inspiration of Professor Felix Trombe, Director of the Solar Energy Research Laboratory. This is a massive concave mirror which concentrates the energy from other mirrors feeding into it. This enables the sun's energy to be concentrated 16,000 times and is equivalent to 1000kW and a temperature of 3,800°C.

This furnace has been designed primarily for research but is already in limited industrial use where super-high, super-pure heating is required, such as in the fusion of silicas.

The furnace sounds a simple conception but is considerably more complex than it appears. The 'feeder mirrors' have to track the sun across the sky very accurately and these feeder mirrors total 325 sq. yards.

This research project is by far the most advanced in the world and is at least working but it is very unlikely to be the model for a major power plant. The siting of the Odeillo project was carefully chosen; in the high Pyrenees there are few overcast days and at this height the water vapour, which cuts off much of the energy at lower altitudes, is very low. The size of the furnace is considerable and though 1000kW sounds a lot, it is only sufficient for about 500 homes.

The Odeillo solar furnace high in the French Pyrenees.

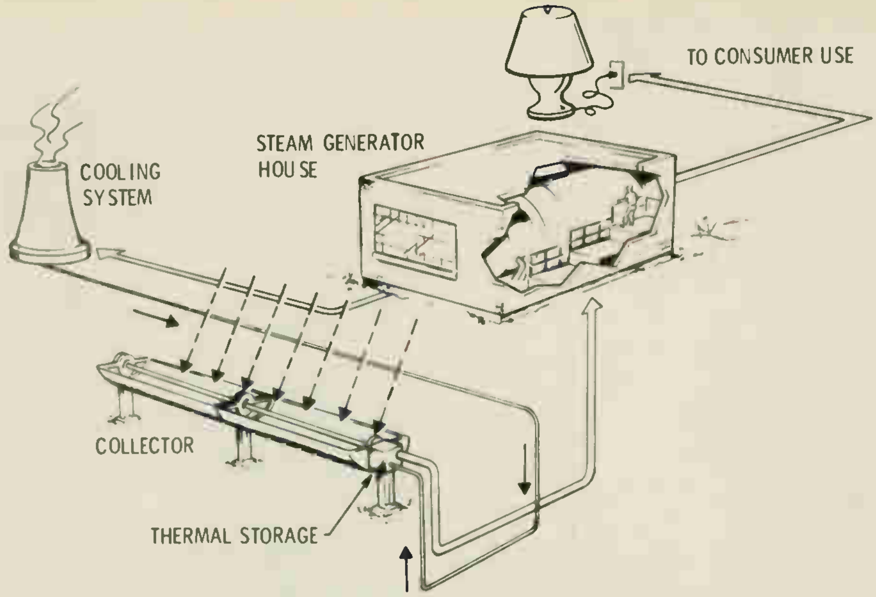
TROUGH COLLECTORS

The University of Minnesota and Honeywell Inc. are co-operating in the research of trough collectors and have been given a substantial grant by the U.S. National Science Foundation to pursue this.

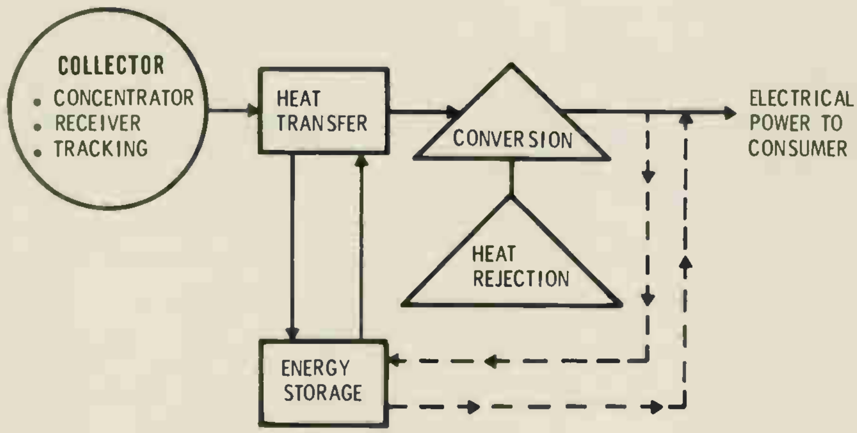
Unlike many of the research projects being undertaken, this one is aimed at finding a solution for large scale energy needs and to the mass production of collectors. Most of the work so far has been theoretical and at the time of writing a prototype has not been built. Nevertheless a considerable amount of research has already been devoted to this by Roger Schmidt of Honeywell and, since the design is based on current technology, it looks promising.

The basis of this method is the trough-shaped collector which would concentrate the energy onto a 'heat-pipe'. This, in effect, would raise the temperature to about 1000°F and feed it to one end of the pipe where a heat exchanger would produce high pressure steam to be fed to a conventional generator. The heat exchanger would also incorporate an eutectic material, that is, one that will store heat and act as a reservoir during the night. The problem of storage has not yet been dealt with but it is of course vital. We shall not be able to use the sun as an energy source unless we have a reasonably constant energy supply. Electricity is not easily stored, batteries can be used but show only a tiny capacity and are prohibitively expensive. In Britain the Central Electricity Generating Board has a scheme where at night, when there is an excess of electricity, water is pumped to a high reservoir and during the day this is fed down again to provide hydroelectric power, but this is not very efficient and the number of suitable sites is limited.

On the other hand, heat can be

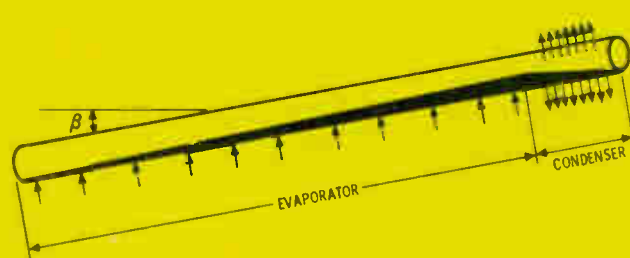


The University of Minnesota/Honeywell suggested method for producing electricity from the sun's rays.



Basic elements of the parabolic solar collection system.

HEAT PIPE/REFLUXER



The principle of the heat pipe/refluxer.

stored fairly easily. The University of Minnesota/Honeywell method is to melt salt in periods of excess heat and rely on the latent heat released during the cooling process to keep the cycle fairly constant.

The size of the trough is somewhat arbitrary but for efficiency, ease of transport and repair, etc., the best size would seem to be 40ft. x 10ft., but larger or smaller units may prove to be better once the research has been done. The cross-section of the trough is a parabola but surprisingly the design of this proved to be rather complex and a massive computer program had to be drawn up to design it. This parabola concentrates the sun's energy by a factor of 20 onto the heatpipe. Various reflective surfaces are being tried. The heat pipe itself has to be coated to provide high acceptance for the wavelengths received from the sun but low emittance at infra-red. This is necessary to prevent the heat being reradiated. A suitable coating has been developed and tested at the necessary high temperatures; this consists of alternating layers of alumina and molybdenum. The heat pipe is surrounded by a glass tube and the space evacuated to reduce convective losses.

HEAT PIPE

The heat pipe is a sealed hollow-bored tube containing a fluid which changes phase—from liquid to vapour and vice versa. The pipe operates by absorbing energy along its whole length, which causes the fluid to vaporise and release energy at one end by condensing the vapour back to liquid. This then runs back down the tube to repeat the cycle.

Heat pipes act like a diode—heat can only travel one way and the process is not reversible. They are also amazingly efficient, being a thousand times better conductors of heat than a solid copper rod.

A variety of liquids show promise, especially water, but this has the disadvantage that at high temperatures steam is rather corrosive and has a maximum operating temperature of 325°C. Other materials are being investigated, such as potassium and Dowtherm, but water seems the most promising.

The heat pipe feeds into a heat exchanger where it will convert steam for feeding the generators. The heat can either be stored at each collector, or centrally at the generating station. A material that stores heat in melting and releases it in freezing has the advantage that the temperature stays nearly constant. Some eutectic salt mixtures have been developed for this purpose. The Philips Research Laboratory at Aachen in West Germany has demonstrated the suitability of a mixture NaF_2–CaF_2. This stores 350kWh per cubic metre but at a rather high temperature of 745°C, rather too high for use with water. The search is on for a suitable material which stores heat around 300°C. As little research has yet been conducted in this field it is not regarded as a serious problem.

Another method of storage would be to bubble the high pressure steam into a pressurised water tank. The temperature inside would rise but, due to the pressure, the water would not be converted to steam. When the steam is required the pressure is reduced and flash vaporisation occurs. This method of energy storage is already to use and allows about 100kWh per cubic metre to be stored.

Each of the associated solar collectors would provide 2kW averaged over a 24 hour period but the range would be enormous, from a 25kW peak to

THE SOLAR SOLUTION

Sunshine catchers like these may be the answer to the power shortage. This artist's impression shows a solar farm in the desert, with sun collectors providing shade for grass to grow.

nil for periods of darkness.

The parabola would have to track the sun across the sky to achieve maximum efficiency.

Costs have already been worked out and such a collector produced in reasonable quantities would work out at £600. A complete generating station would need 500,000 of these units to produce 1,000 Megawatts. With the connecting pipes, storage and generating plant the cost would work out at £400 investment per kilowatt as opposed to present conventional systems which cost about £80 perkilowatt. As we have mentioned before, on a purely cost basis solar power does not stand up well.

The solar farms, the name already coined for these collecting areas, could serve a dual purpose. They would almost certainly be sited in desert areas and would provide a considerable amount of shade which would encourage fertility in the soil.

The collectors would have to be washed regularly to retain the efficiency and this waste water could be used for irrigation of these dry areas . . . a minor point but an additional benefit.

Anyone who doubts the benefit of this shading should consider one of the rare benefits of pollution. The smoke haze surrounding Salt Lake City in Utah, U.S.A., has cut down the sunlight to such an extent that the desert is becoming fertile again!

The Honeywell/University of Minnesota scheme is not the only one based on the trough type collector and other people are working along the same lines, notably Aden and Marjorie Meinel of the University of Arizona who have a prototype collector in operation.

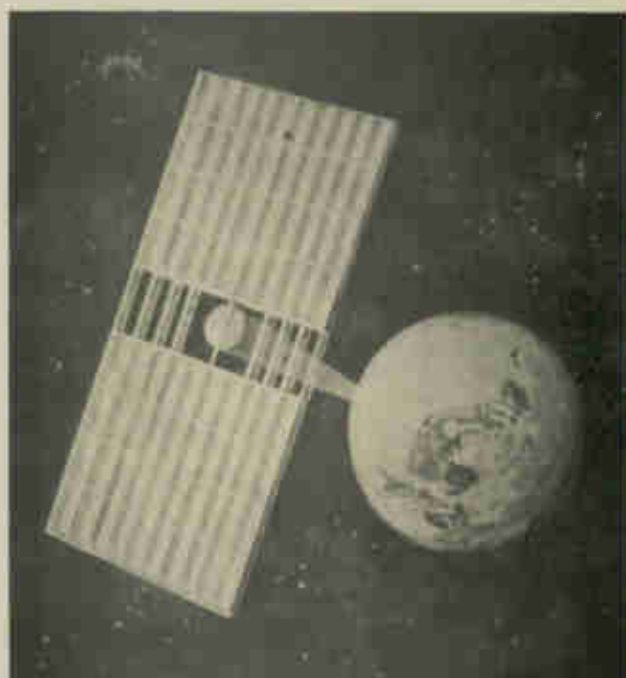
Individual collectors could be used, siting these on the roof of a house but this would require individual generators. Simpler versions without storage and with no generators could find a market. In the areas of the world where these collectors could be used, one of the main uses of electricity is for the powering of air conditioning plants - which are only required during daylight when the sun is strong. More than one expert has forecast that sun-powered air conditioning plants will be available before the end of the decade.

Surprisingly a solar collector will have a slightly higher efficiency during the winter than in the summer. The shorter daylight hours and lower air temperature are more than compensated for by the lower concentration of water vapour in the atmosphere which allows more sunlight to reach the collector.

SATELLITE SOLAR POWER STATION

The most ambitious plan for harnessing the sun's energy must be the idea of Peter E. Glaser of the U.S. company Arthur D. Little. This has attracted the support of some major companies and N.A.S.A.

This scheme would utilise a massive artificial satellite in synchronous orbit around the earth. This would comprise a massive bank of solar cells about 18 sq. miles in area. The current generated would be fed to a microwave transmitter (a frequency of 3.3GHz has been proposed) and beamed down to an earth receiving station, 3 miles in diameter. This would comprise a vast array of half-wave dipoles



Peter Glaser's satellite scheme could provide enough energy for the largest of the world's cities using a satellite with a collector area of about 18 sq. miles.

which would connect to solid state rectifiers. Schottky barrier diodes at present have an 80 per cent microwave rectification efficiency at 5 watts and a figure of 90 per cent is envisaged.

This scheme would generate 5,000MW, enough to keep the world's largest cities going. Being in space there would be far more energy collected by the cells as the attenuation of the atmosphere would not be present and the satellite would always be operating providing a source of energy 24 hours a day. It is thought that there would be no harmful effects if a bird or plane flew into the microwave path though this requires investigation.

Precise alignment of the beam would be necessary and this could achieved by transmitting a beacon from the ground station back along the same path.

There are disadvantages and they are major ones. This scheme assumes a technological breakthrough in several areas—especially in the price reduction of solar cells which would have to cost about one thousand times less than at present. It would also require several hundred space shuttle flights and this is not yet in operation.

This scheme is certainly imaginative and should not be condemned for that reason, but it is certainly a very long way off. Even the protagonists of this scheme do not expect a prototype before 1990 even if the go-ahead was given now. Optimistic cost forecasts give a figure of £400 per kilowatt, similar to the solar farms and, incidentally, both are again similar to the capital costs for a nuclear power station. However, the satellite solar power station costs assume cost reductions on a massive scale; solar farms and nuclear power do not.

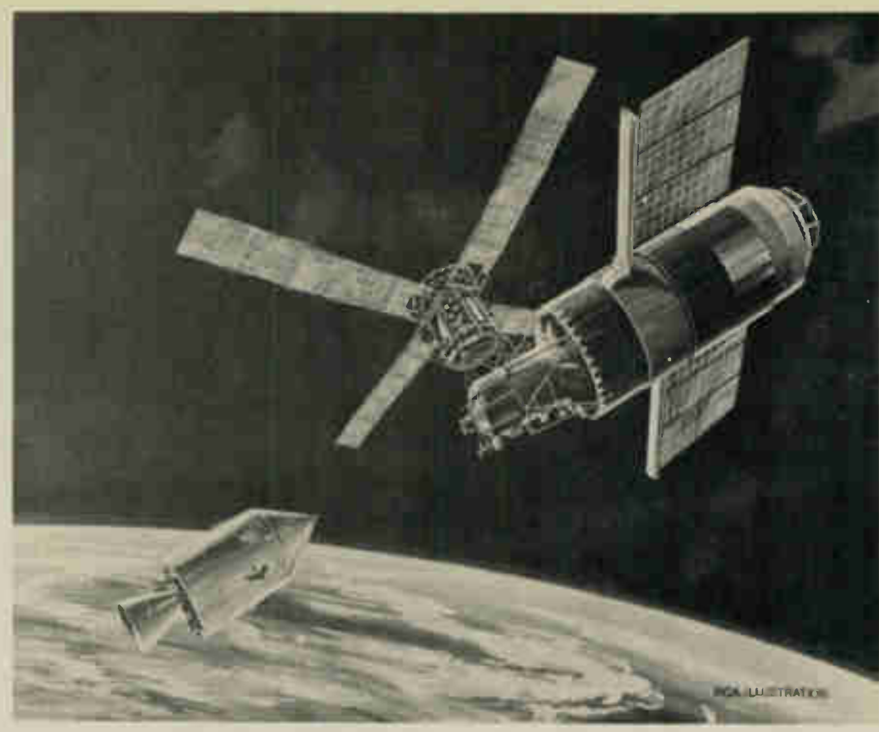
SOLAR CELLS ON EARTH?

If the solar cell is a possibility for a satellite, why not on earth? Despite truly extensive research we have not come across anyone seriously proposing this. It would assume an even greater cost reduction than the SSPS and would give no power at night and considerably reduced power in cloudy conditions. Storage would involve conversion from electricity to some other medium, probably heat, and this would reduce efficiency.

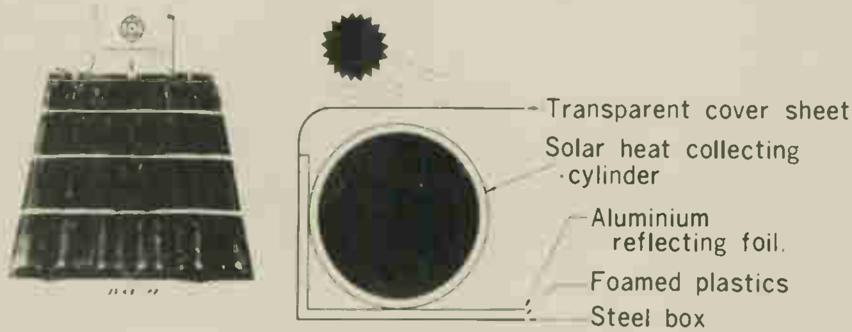
It is tempting to suggest that house roofs could be made from a bank of solar cells but although it is simple in its conception, it lies a long way behind the other schemes for cost and practicality.

FLAT PLATE COLLECTORS

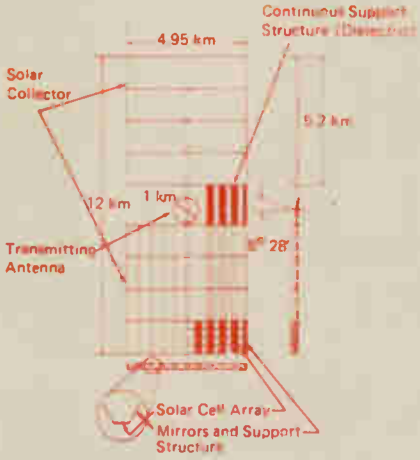
Solar farms require reliable weather conditions and are unlikely to be of use in latitudes of 40° or more but diffused light can be harnessed anywhere for low temperature uses.



Solar power is already harnessed for many space projects including Skylab. Unfortunately, one of the solar collector plates failed to open and is causing some of the current problems of this project.



Photograph and cut-away drawing of a Japanese water heater operating as a solar flat-plate collector.



Dimensions of the SSPS.

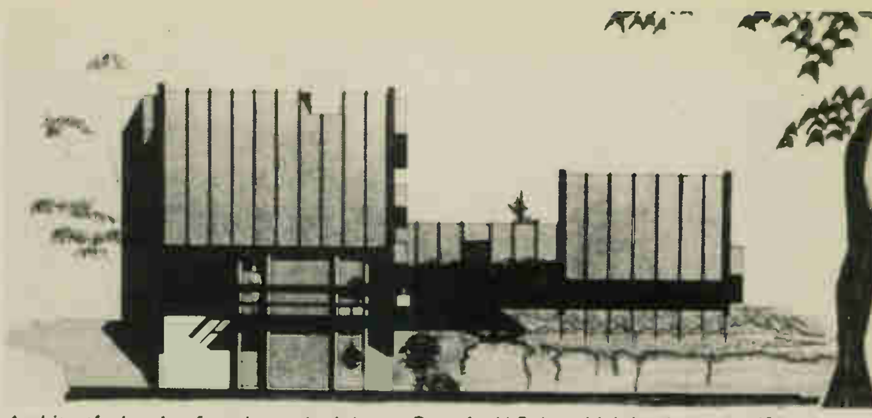
We suggest you try a simple experiment. Get hold of a glass bottle, paint it matt black, fill it with water and put it outside. After an hour or two, measure the air and water temperatures with a thermometer. We set up this experiment which demonstrates perfectly the principle of the flat plate collector.

With an air temperature of 72°F, after an hour the water temperature was over 100°F. We also put water in an unpainted bottle and this had risen only to 85°F.

With a properly designed system, it is quite possible to achieve temperatures of 140°F, rather warmer than is comfortable to the touch. About 12-15 per cent of the energy consumption in the industrialised nations is used for heating water up to this sort of temperature.

Water heaters of this type, which usually look like a modern central heating radiator, were popular in Australia and the U.S.A. in the 1930's and over a million homes in Japan today use roof mounted flat plate collectors as the source of warm and hot water. Surprisingly, these are becoming less common, especially in Japan where they are associated with

THE SOLAR SOLUTION



Architect's drawing for a house in Atlanta, Georgia, U.S.A., which has been specifically designed to incorporate flat-plate solar collectors.

a low standard of living.

Flat plate collectors are best built into the original structure of the house and this need not make the building unattractive as the architects' drawings for a house in Atlanta, U.S.A. show.

Atlanta is in a sunny area of the world but plans are well advanced for the construction of such a house in the North of England. This is being designed by a team led by S.V. Szokolay of the Central London Polytechnic.

Flat plate collectors are only considered to be a very basic system which must be used with a conventional heating system, but the saving in fuel bills can be quite dramatic.

A number of swimming pools in Britain are heated by solar power: the photograph shows one such installation for a 50,000 gallon pool at East Grinstead. You can buy one of these flat plate collectors and the cost is less than £60 for a 25 sq. foot unit and a few houses have these fitted already. Including installation, the cost should be less than £100 and this can show a dramatic saving in fuel costs with the cost being recovered in a few years. Sun Trap units, the proprietary name, are made by Solar Heat Ltd., 99 Middleton Hall Road, Kings Norton, Birmingham 20.

USING THE ELECTRICITY

All the methods of harnessing the sun's power have been designed to produce electricity or direct heat. Electricity can be fed easily to remote locations. Already power lines cross international boundaries. The peak current periods in Britain and France are different and a power line laid under the English Channel feeds current to France during their peak and the process is reversed during the British peak. The huge Cabora Bassa dam on the Zambesi in Mozambique will provide electricity for several countries in southern Africa, so there are already precedents for transmitting electricity large distances. Northern Europe could take electricity from the Sahara for instance, either using conventional power lines or via superconductors.

Electricity, however, is not the most convenient energy source for all uses—especially in the field of transport.

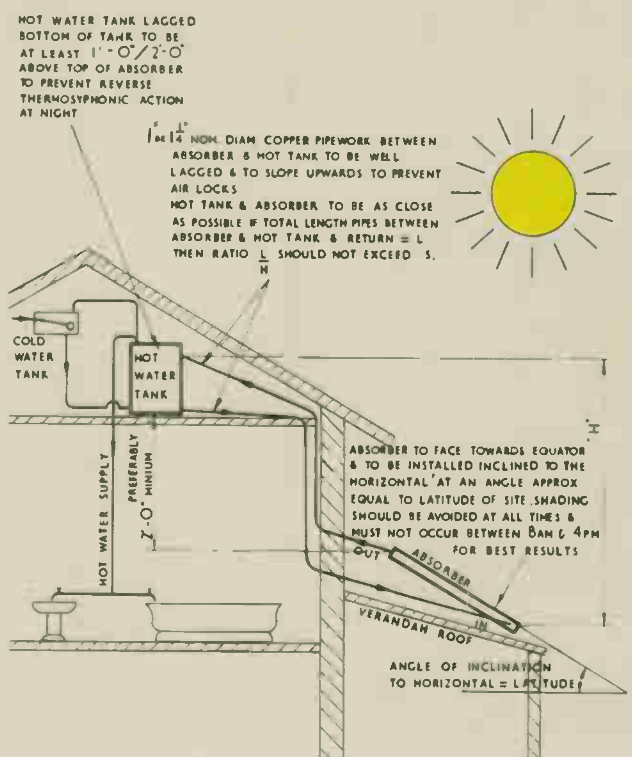
The electric car has been dreamed about for a long while and we are continually hearing that it is 'just around the corner'! The facts are that electric cars have been produced and Enfield Automotive, Isle of Wight, expect to make 500 before the end of the year. Even so, mass production is some way off. Most of the prototypes use lead-acid batteries but there is probably not enough lead available for true mass production of cars based on this. Energy cells are lighter but much more research is required to improve the efficiency.

Petrol is such an ideal material with regard to the power in each gallon that artificial production may be the answer. Towards the end of the last war, after the Germans lost the Rumanian oil wells, they were able to continue the war by distilling petrol from Lignite which is low grade brown coal. Production was on a substantial scale but the cost was such that it was discontinued after the war.

A whole range of hydrocarbons, including petrol, are produced in South Africa by Sasol. These are produced by the gasification of coal and catalytic synthesis of hydrocarbons using the Fischer-Tropsch process. Over 10 per cent of South Africa's petrol is produced in this way and is sold under the 'Blue Pump' brand name. The South Africans are the world leaders in this field. As a temporary measure coal could well be converted to hydrocarbons but, as we have mentioned, it is a limited resource.

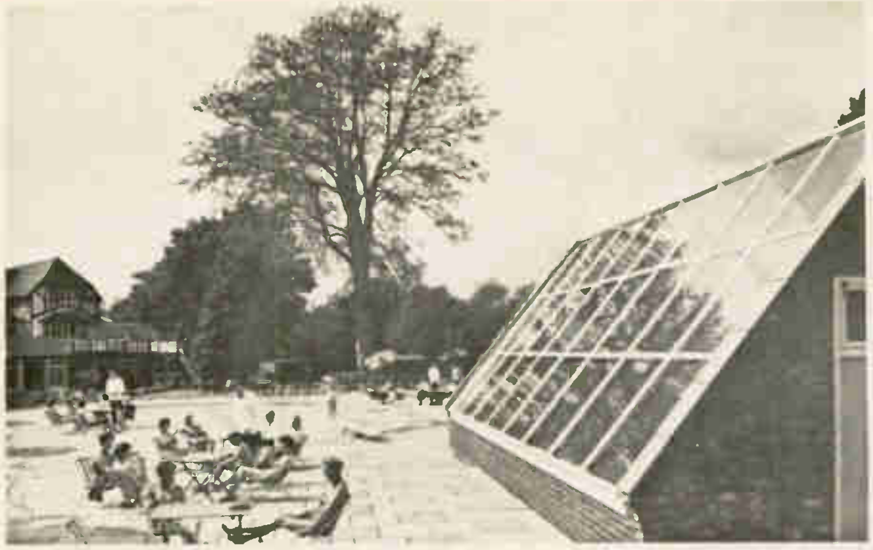
The artificial production of petrol

Arrangement for connecting a flat-plate collector to an existing water system.



is possible; after all, the elements are carbon and hydrogen, both of which are very plentiful. Hydrogen can be derived from water while carbon can be obtained from CO_2 in the air or from limestone and chalk—both of which are plentiful. Enormous quantities of energy however are needed for this production.

There are a number of advocates for Hydrogen Power, especially in the United States. Rather than combining the hydrogen with carbon to form petrol, it can be used directly. There is plenty of water and using electricity it can readily be broken up into hydrogen and oxygen. A hydrogen car is actually running, it has been developed by the University of California, and only the simplest modifications are necessary to a standard motor car to enable it to run off hydrogen. It is of course pollution free and it is claimed you can drink the exhaust! The hydrogen is carried at high pressure and the storage space is comparable to a conventional petrol tank.



Solar collector used for heating a 50,000 gallon swimming pool in East Grinstead.

Apart from the technical problems, the use of solar power could well necessitate some changes in the law: what will be your rights with regard to shadows cast by other people's property for instance.

WHAT IS THE ANSWER?

In this article we have described various research work going on all over the world, but the subject is so vast that we have only been able to give a very general outline of the subject. We have not even mentioned some schemes and have concentrated only on the most interesting or those which we consider most practical. We have commented but have avoided judgment.

Let us look into the future and guess at the developments in the next few decades.

1975-1980

Oil goes up considerably in price due to an anticipated shortage, but production continues at a high level due to intensified searching for new fields and the working of previously uneconomic sources (e.g. the Tar Sands and oil-shale in North America). New power stations are either coal burning or nuclear, but environmental arguments oppose these.

1980-1990

Intensive investigation to replace oil takes place and also a massive investment in solving the nuclear power problems, but also in solar research. Oil continues to rise in price and hydrogen becomes an important source of energy, especially in transport and towards the end of the decade surpasses oil in importance. Hydrocarbons are produced from coal on a very large scale.

1990-2000

Solar power used on a large scale, either using solar farms or by harnessing ocean temperature gradients. Hydrogen power supreme for transport but petrol and oil still important. Nuclear power gaining in importance as the problems are solved.

2000-2010

Nuclear power dominant in the industrialised world, solar power elsewhere. Hydrogen universal for personal transport.

2010-2020

Nuclear power and hydrogen are dominant though existing solar power stations continue.

Predictions in the past have almost invariably been wrong and so this time scale may be wildly out. What we can say with certainty is that a new energy source must be found, and found fast, to take over from oil. Various problems beset nuclear power at present and until solutions are found we are going to have to find an alternative. Solar power has its own problems, especially with regard to cost, and it may not be the answer, but it is certainly worthwhile investigating. . . and time is running out.

ETI would like to thank the following for their help in compiling this article and for their permission to use drawings and photographs:

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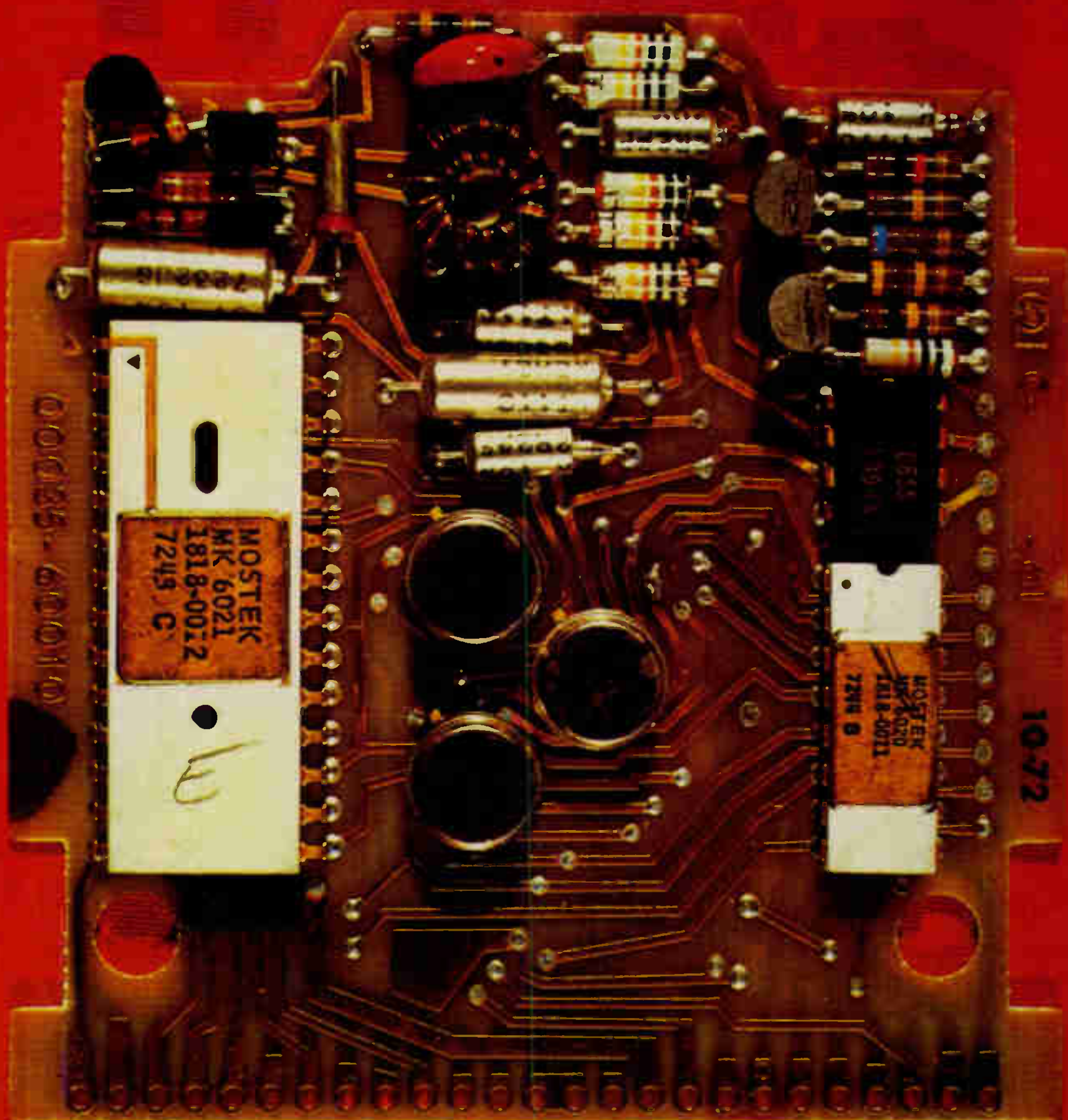
PERSONAL



Logic board of Hewlett Packard HP35 calculator.

CALCULUS

Had you been late for an appointment with Julius Caeser, you would no doubt have hailed a passing hire chariot and galloped hastily on your way through the cobblestoned streets of ancient Rome.

As you progressed you would have heard a periodic clunk coming from a device mounted on one of the wheels. This device was called a "hodometer" – or road measurer. Every time the wheel rotated one turn, a pebble would pass from one container to another via a small hole. At the destination the driver would simply count the number of pebbles to calculate the charge.

The Latin word for pebble is "calculus" – and so we see how our english world "calculate" had its beginning.

JUST what does make a calculator tick? It is not possible to answer this question fully in a short article such as this because even the simplest of four-function calculators is based on one or more integrated circuits containing at least 5000 transistors. These are arranged in a logic array which would have astounded the computer engineer of 20 years ago – in fact it's still amazing! So we will not get involved too much in the 'innards' of the integrated circuits themselves but will describe the way they are used in currently available machines.

The small electronic calculator can add, subtract, multiply and divide.

CALCULATORS -the inside story

How they work, and how to choose one.

Most models can handle the decimal point, either by presetting it or by using floating point arithmetic. The number of displayed digits varies between six and 16, depending on the model, with negative results (so called credit balances in the business world) clearly indicated as such.

Operations are done nearly instantaneously, and the machines are silent, small, light, and in most cases service-free. Some personal calculators are capable of remembering a constant for repeated multiplication or division, and some have a completely separate memory which may totalise numbers for recall whenever required. Still others, to be described later, can solve functions such as logarithms, trigonometric identities and such like. One recent model is even capable of solving accounting equations (such as compound interest) at a single keystroke — and all this for a selling price of around £200.

With such features as these, and with the virtual assurance that prices will continue to fall dramatically, (we hazard a guess at £20 per 8 digit, four-function calculator by the end of the year) it seems most likely mum will be checking the grocery bill on her pocket four-function calculator, and the kids in a few years time will all have their personal, electronic slide-rule to remove the unnecessary drudgery from mathematics.

The electronic calculator, although it looks simple enough, is really the most complicated machine available to the consumer today. In a way it may be said to be a scaled down version of a digital computer with some important differences. The computer is designed for flexibility and hence it needs to be continually reprogrammed for each problem of a different kind. It must also be capable of performing many different functions with the computed data — It may drive a teletype, control a process automatically, or print out the data at high speed. It may also produce a range of answers to a problem from a string of input variables. Thus we say that the computer is not dedicated to any one job. But it suffers for this by having complicated input and output structures. Thus to add two and two by computer you must first program the machine to perform arithmetic and instruct it what to do with the results — a time consuming process for one calculation to say the least!

The personal calculator on the other hand, is a dedicated machine. It solves mathematical problems in accordance with a program that is built into the integrated circuits. It accepts data from a manual keyboard only, and presents its output almost invariably direct to a display. Some other types of calculator approach the computer more closely by having external program capability, but they are *still* calculators *not* computers because they are dedicated to solving individual mathematical problems. The computer on the other hand may solve thousands of such problems in less than a second in order to perform its programmed function. Nowadays the two machine capabilities overlap to some extent and it is sometimes difficult to differentiate between a programmable calculator and a mini-computer, but that is another story.

The calculator revolution moved into full swing when Texas Instruments (the inventors of integrated circuits in the late 50's) began mass producing a single-chip, MOS/LSI calculator-logic device in late 1971. Bowmar and Eldorado Electrodata were the first to use these devices to manufacture small calculators which retailed in the US for around $200.

30 000 TRANSISTORS IN YOUR POCKET

It is interesting at this point to compare these LSI (Large Scale Integration) calculators with the first electronic computer ENIAC. This machine, built in 1946, used 18 000 vacuum tubes and occupied 1800 feet of floor space. The LSI calculator contains up to 30 000 transistors, in integrated form, and can be carried in your pocket.

Typical of the latest four-function and memory calculators is the ELS1·811A from Sharp.

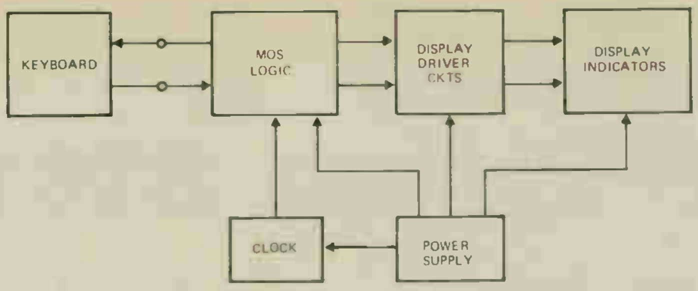


Fig. 1. Simplified block diagram of a calculator showing interconnection of the major component blocks.

This degree of miniaturization was made possible by the progress in MOS (Metal Oxide Semiconductor) technology. Where, for example, an RTL (Resistor Transistor Logic) or TTL (Transistor Transistor Logic) integrated circuit contains on average 10 transistors per silicon chip the integrated circuits fabricated with the MOS technology can typically accommodate 1000 to 5000 transistors per chip.

This increase by a factor of at least 100 in the number of transistors per chip opened the way for using integrated circuits as memory elements, where 1000 or more bits of information can be stored in one integrated circuit. In fact, single chip devices capable of storing 8192 bits of information are now available.

Another advantage of MOS integrated circuits, in addition to miniaturization, is their small power consumption. Typically the power consumed by an MOS integrated circuit is 10 microwatts per transistor, compared to 10 milliwatts per transistor in an RTL circuit. Nothing being perfect in this world, MOS integrated circuits have also certain drawbacks. One of them is their relative slowness (microseconds switching times rather than the nanoseconds required by modern computers). Another drawback has been the relatively high cost, in particular when compared to a large magnetic core memory. But MOS prices have fallen such that they are now challenging even core as a storage medium. A third drawback is that early MOS circuits could easily be damaged during handling through static electricity discharges. Therefore special precautions, like grounding of all tools, have to be taken during production, assembly, and testing of such circuits. Most modern MOS devices incorporate protection circuitry against this eventuality, and some later families such as CMOS may be handled without fear of such damage.

Considering the advantages and drawbacks of the MOS technology, it can be seen that it is ideally suited for personal calculators where speed is not too important and a division lasting 100 milliseconds is still considered pretty fast.

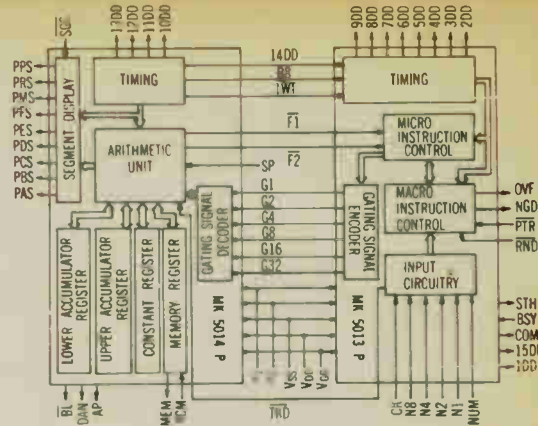
A typical personal calculator contains from one to six MOS LSI integrated circuits with a total of 5000 to 30 000 transistors and perhaps a dozen or more discrete transistors and a few non-MOS integrated circuits to interface with displays. Chips are now coming on the market which include all circuits except power supply, display and keyboard. Typical of these newer systems is the Philips EDC200/210 set (see Fig. 1).

In a typical calculator, MOS integrated circuits perform the arithmetic and memory functions, direct the flow of logic, and store the instructions and results. The discrete transistors provide the interface between low power, low voltage MOS integrated circuits and high power, high voltage displays (e.g. Nixie tubes). Discrete transistors are also used for clock signal generation and for voltage regulation. Standard TTL or RTL ICs are used for interface between MOS ICs and medium-power, low-voltage displays like LEDs (Light Emitting Diodes). Standard ICs are also used for translation of numbers from the form in which they are handled by the calculator into appropriate display form (either numbers 0-9 in Nixie tubes or the proper segments in multiple segment displays).

The main blocks of an electronic calculator are the power supply, keyboard, display circuitry, clock generator, input scanner, registers, arithmetic control unit, the ROM (Read Only Memory) for instruction storage, and the output control. We will not describe the power supply or the keyboard as these are entirely conventional.

CLOCK GENERATOR

The clock generator provides a series of pulses at a rate between 20 kilohertz and 500 kilohertz, depending on the calculator model. These pulses synchronize the flow of information between various calculator blocks and step the logic through the program steps contained in its ROM (Read Only Memory).



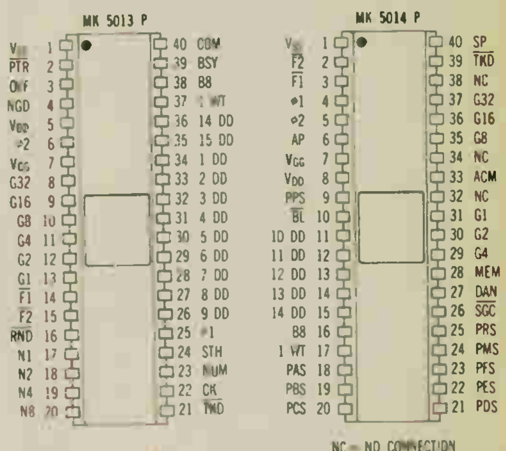


Fig. 2(a)

INPUT SCANNER

The input scanner continuously scans the keyboard so that it can detect which key has been depressed. The numbers from the keyboard are entered into the input register and the selection function (−,+,x,÷) is translated into an initial address to the ROM. The input scanner is then disabled until that key is released and the control ROM has completed its function. This prevents erroneous entries.

REGISTERS

Every calculator has at least two or three shift registers. Firstly there is an input register which stores the number entered by the keyboard one digit at a time in BCD (Binary Coded Decimal), each digit requiring four bits of storage. Thus the number 1973 would be stored as:—

1	9	7	3
0001	1001	0111	0011

(8421 weighting)

A 12 digit calculator would therefore require 48 bits of storage capacity in each shift register.

Each number as it is stored in the input register is decoded and appears on the output display.

When an add, subtract, multiply, or divide command is entered, the command is stored and the contents of the input register are transferred into a register known as the 'Accumulator', freeing the input register to accept a

Fig. 2(a) Block diagram and (b) circuit diagram of Mostek, two chip, 12 digit calculator with constant and memory. The display is multiplexed, and transistors are used to interface the output of the chips to the high voltage requirements of a Panaplex display.

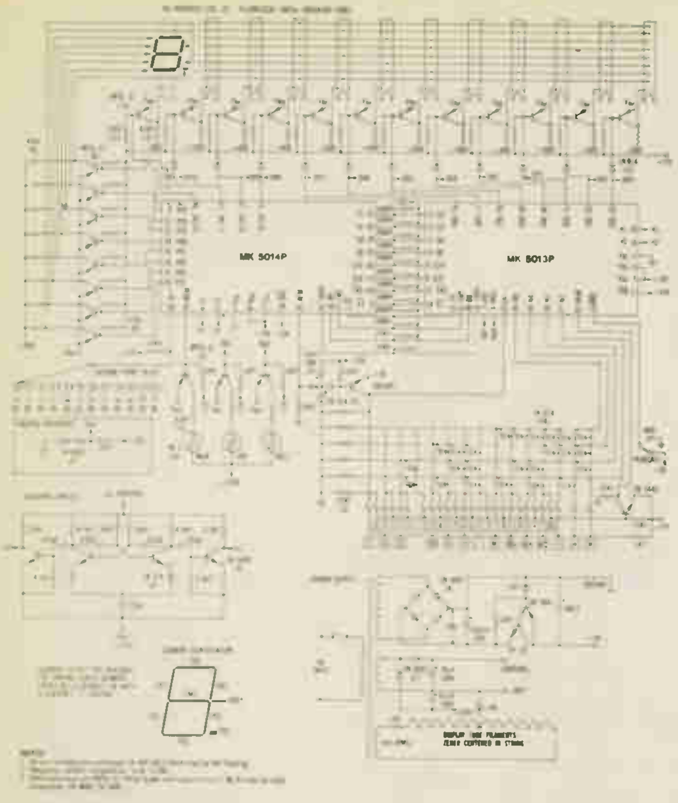


Fig. 2(b)

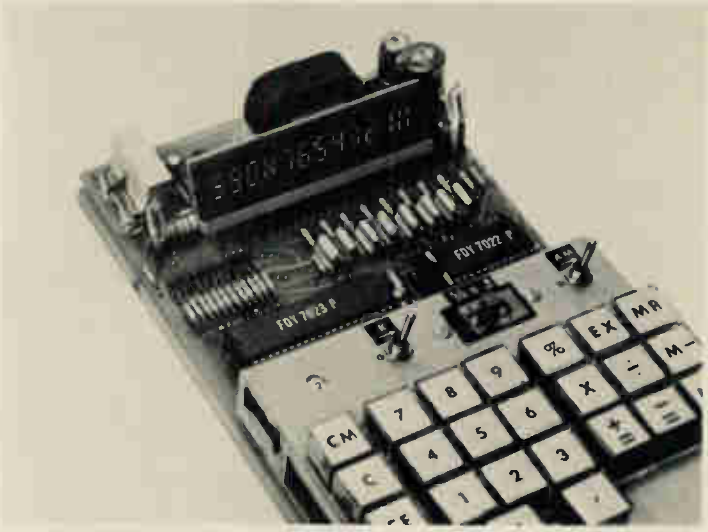


Fig. 3(a) Prototype calculator using the Philips EDC200, two chip set and the Philips Pandicon display type ZM1500/12. It has 12 digit capability, full memory, percentage floating or fixed point operation, and round-up or round down.

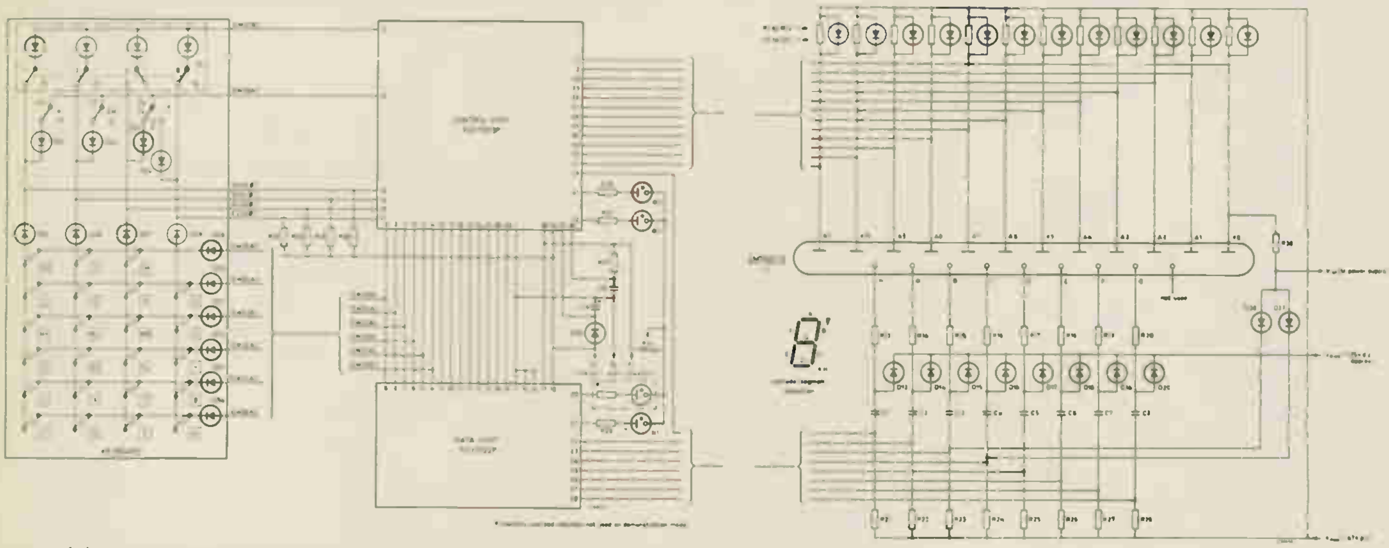


Fig. 3(b) Circuit diagram of Philips EDC200 shown in Fig. 3(a)

new number. When the first key is selected for the new number the input register is cleared, and the new digits are stored and displayed as the keys are pressed. The calculator now awaits a new command. If the 'equals' key is pressed, the command is carried out (for the two stored numbers) by the arithmetic and control logic, and the result displayed.

For multiplication or division a third register is used to shift the digits left or right and store intermediate results. This register is therefore sometimes known as a multi-quotient register.

Those calculators which have a 'Constant' facility have a switch that prevents the number initially transferred onto the accumulator from being cleared. Successive operations may therefore be performed without continually re-entering the constant.

A further register may be used as a 'memory' in which totals can be accumulated. The contents of this register can ideally be separately cleared or recalled to the input register for further processing as required without destroying the contents of the memory. This facility adds considerable power to the calculator.

ARITHMETIC CONTROL UNIT

The arithmetic control unit provides logic for performing additions and subtractions. Multiplication is performed by repetitive addition and shifting of digits in the multi-quotient register in association with the ROM. In the same register, division is performed by subtraction and shifting. Most calculators, depending on the circuitry, will either truncate (cut short) the results, or round them to the next digit. For example, a simple calculator will show 2 ÷ 3 = 0.6666, a more elaborate one would show the result as 0.6667. Because all numbers are stored and operated upon one digit at a time, the calculators are true decimal machines. Therefore, the results are exact as long as they can be represented with the number of digits available for display.

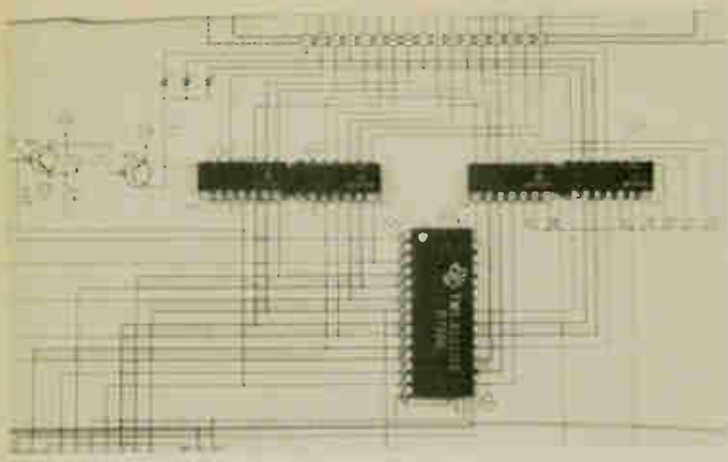


Fig. 4. This Texas Instruments' chip set is for an eight digit floating-point calculator with constant facility. The 28 pin pack, TMS0 03, is MOS/LSI and performs the calculator logic. The other four chips decode the outputs to drive a seven segment LED display.

READ ONLY MEMORY

The Read Only Memory provides instructions to the arithmetic unit and to the registers in order to perform the required arithmetic operations. Part of each instruction is the address of the next instruction in the ROM. Both multiplication and division require approximately 50 instructions each. The keyboard operation entry leads to the address of the first instruction corresponding to a particular arithmetic operation. The control is then transferred to the second instruction using its address attached to the first instruction and so on until the complete operation is performed.

OUTPUT CONTROL

Output control transfers the number stored in the output register to the display indicators. To save on BCD-to-decimal translators, the display indicators are generally operated in time-shared mode. Digits are scanned and transferred one at a time and the display is repeated every few milliseconds. At this fast rate, it appears to the eye that the display is continuous.

Other functions of the calculator are imbedded within previously described major blocks. These are control of the decimal point, storing of constants for multiplication or division, checking for negative results and activation of the negative sign, checking for overflow etc.

DISPLAYS

In personal calculators, particularly those designed for battery powered operation, the display poses a problem in terms of both power dissipation and cost. Older calculators almost invariably used single neon-indicator tubes for each digit. But with this type of display a high voltage power supply is required as well as drivers capable of high voltage operation. Neon indicator prices cannot be reduced much below about £1.00 per digit, and this coupled with extra mounting and driver costs has ruled them out for new designs. In fact one of the pioneers of neon indicator tubes is phasing them out of production completely except for replacement quantities.

Those displays which are at present enjoying the most favour are multi-digit units constructed using gas discharge, light-emitting-diode or liquid-crystal technologies.

Gas discharge displays such as the Panaplex or Pandicon are favoured where large digit size (¼" or more) is required. Up until recently LEDS (light emitting diodes) have enjoyed almost exclusive use in calculators employing digit heights of around 1/8". However they are still too expensive to be used for the larger digit sizes. More recently liquid crystal displays (LCDs) are being used as 'life' problems and ac drive requirements of these displays have been largely overcome.

The tendency now in the 'pocket' calculator field is to integrate all the display drive circuitry into the one chip together with the rest of the logic. Thus true one-chip calculators are beginning to become available.

THE SCIENTIFIC CALCULATOR

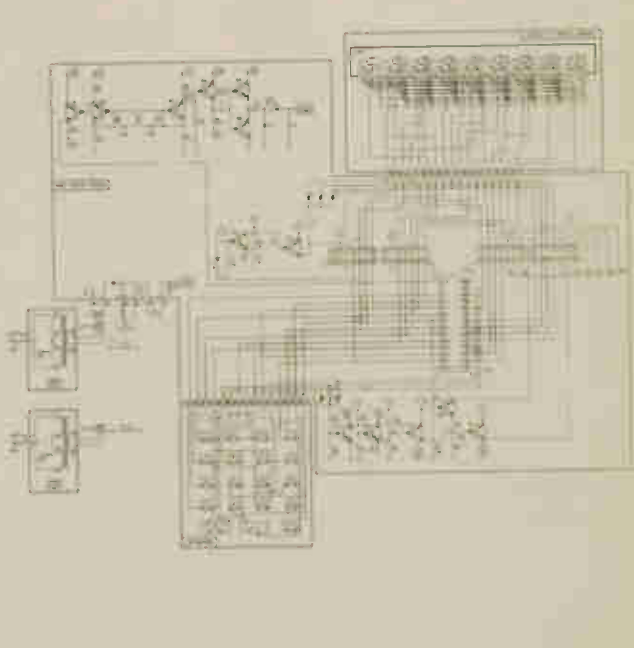
The four-function calculator, although extremely useful, has limited mathematical capability. It cannot handle very large or very small numbers, nor can it handle transcendental functions (that is, trigonometric, logarithmic, exponential etc) or in most cases even square root. Thus they are a long way from replacing the ubiquitous slide-rule.

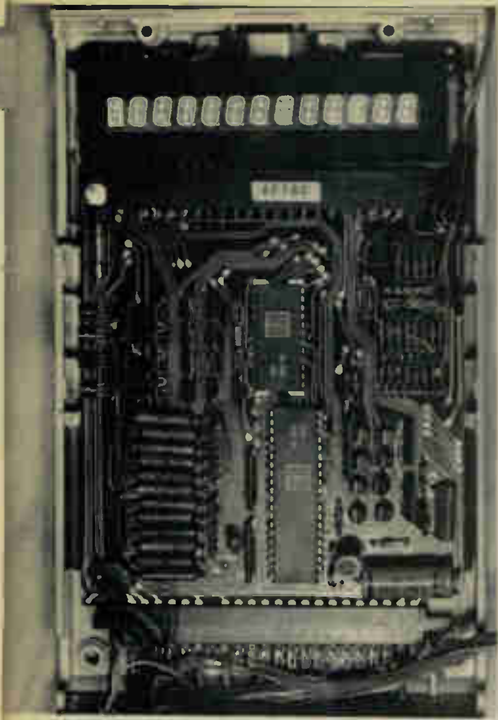
A new class of personal calculator is now appearing, members of this family being known as scientific calculators. Typical examples are the Hewlett Packard HP35 and HP80, the MITS 7400 and the shortly to be released Texas Instruments SR10.

The block diagram of an HP35 can be seen in Fig. 7. The essential differences between this and the four-function system is the inclusion of more registers, four of which are arranged in an operational stack, much more extensive ROM to perform the transcendental function calculation, and a re-orientation of the display so that numbers may be represented in scientific notation. The 15 digit display is capable of registering *and operating on,* numbers between 10^{-99} and $9.999999999 \times 10^{+99}$, the last two digits of the display being used to represent the exponent.

Calculators of this class can be said to truly replace the slide rule. They provide an accuracy which had previously been unattainable even with seven place logarithm and trigonometric tables.

Fig. 5. Circuit diagram of the Heathkit IC-2009 calculator kit which uses Texas Instruments MOS/LSI chips.





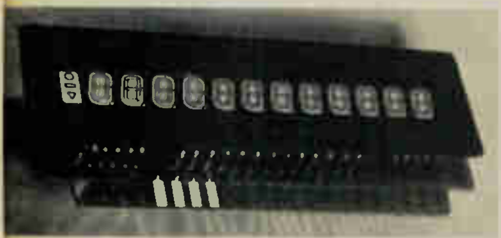


Fig. 6. Typical 12 digit calculator, the Sanyo ICC3101 uses two chip logic and a seven-segment, fluorescent display panel.

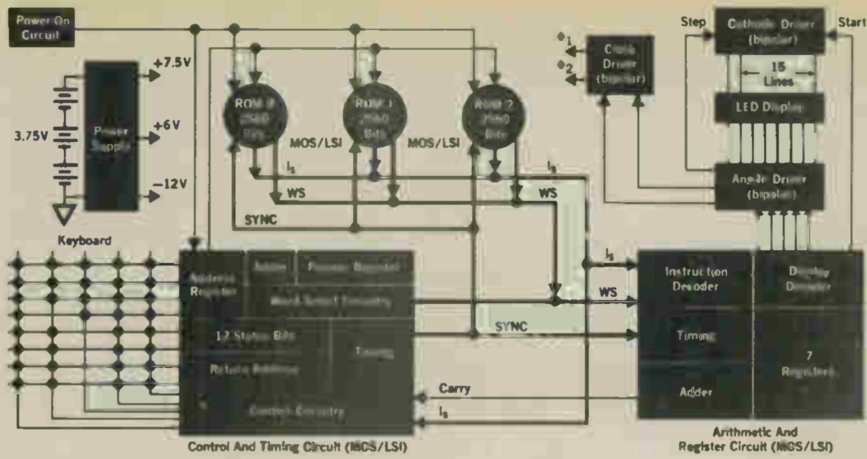


Fig. 7. Block diagram of the HP35 calculator.

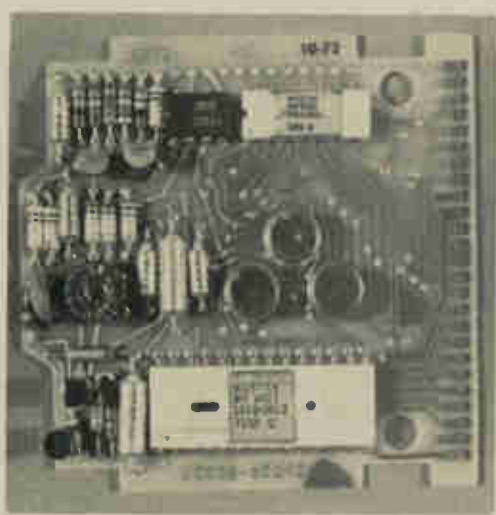


Fig. 8. Logic card of the HP35 calculator is deceptively uncomplicated in the light of the calculator's capabilities.

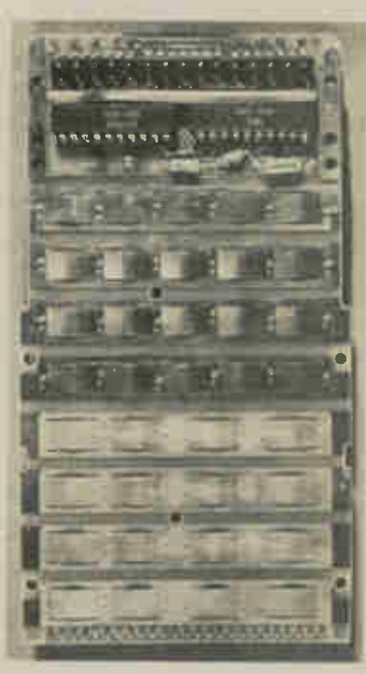


Fig. 9. Gold-plated keyboard contacts, display decoders and the three display chips (each with five characters) of the HP35.

WHAT OF THE FUTURE?

In the future, we see the four function calculator remaining as a very cheap (£15 and non repairable) unit for the consumer market, and a memory will probably become a standard feature.

The pocket scientific calculator will have more models dedicated to specific branches of engineering. For example – as the HP80 is dedicated to accounting problems, we will see others dedicated to surveying, navigation, electronics etc.

No doubt for the desk range we will also see the incorporation of a cheaper printer, and plug-in programmers will also become available, at reasonable prices, which will give the calculator a capability approaching the mini-computer. Already one company has plans to introduce such a programmer for its under £250 scientific calculator. The question now arises – Now that we have all this calculating power what are we going to do with it? ●

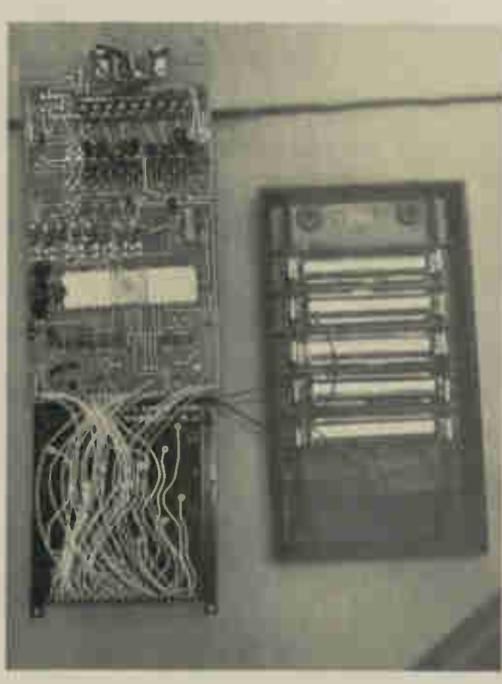


Fig. 10. (left) The Mini- Executive 8-digit calculator from Advance uses one-chip logic for fixed or floating point operation with constant facility.

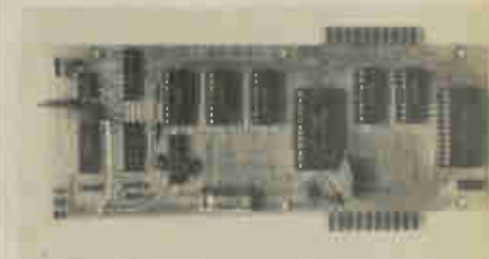


Fig. 11. An alternative for those who wish to build a calculator into other equipment is this MAPS 14 digit system from National Semiconductor which has two memories, percentage and constant as well as floating or selectable fixed point operation. A version using scientific notation will shortly be available.

Transducers in measurement and control

Dr Sydenham discusses the measurement of force and related topics in this, the final part of this series.

Physical objects have a property of mass as well as size. This is a fixed value for an object (provided time has no influence). It is the magnitude of the gravitational attractions upon it that decides its weight (weight = mass gravity). An object exerts a force upon its support due to the gravitational attractions. When zero gravity exists there is no such force — articles float in outer space because the gravitational pull of the heavenly bodies is negligible. A force can also be exerted by an accelerating mass (as Newton realised with his force = mass x acceleration equation) in the absence of gravity. Gravity is but one form of acceleration. A force can also be created by devices such as springs or magnetic attractions which do not rely on acceleration or gravity.

Basically then, the weight of an object is decided by our knowledge of the gravitational pull acting on it. Fortunately, variations in gravity with time and place (on the Earth at least) are small compared with the precision needed in most commercial applications and a fixed value, or even a total disregard for it, suffices. (For example the roughly 12 hr period gravity variations due to the effect of the changing orbit of the Moon are roughly one part in 10^7.) The standard value of gravitational acceleration is 9.80665 m/s^2.

Units of mass, weight and force in existence are varied. The Imperial systems' pound and slug (an engineering term used for mass as opposed to weight) have been confusing to the uninitiated. The distinction between mass and weight is often not made.

Metrication now dictates the use of the kilogram kg as the mass unit and the Newton N as the force unit. As force and weight are often synonomous it has been usual practice to qualify force by the use of the letter f as in lbf but now only Newtons N and kilonewtons KN are to be used for force with the gram g, kilogram kg and tonne t being reserved for mass.

Not always is it the total force of a system that is of interest. Instead it may be a derived quantity. Pressure is the force exerted by a distributed force on a unit area of surface. Torque is variable acting about a pivot joint that is created by a force effectively acting at the end of a lever arm.

Common Imperial pressure units are pounds per square inch, psi, or inches of mercury Hg or water H_2O. (A column of liquid exerts an absolute pressure at the bottom depending on its density and the height of the column). In the new metric system the unit of pressure is the pascal Pa (Pa = $N.m^{-2}$). Older units were kilograms per square centimetre or metre and centimetre height of water or mercury. In meterological measurements of atmospheric pressure the millibar mb is commonly used — weather charts express pressures of highs and lows in hundreds of millibars mb. A standard atmosphere is now exactly defined as 101.325 kPa, but millibar units will still be used in weather records. A pound per square inch equals 6.89kPa.

To further confuse the issue, vacuum pressures (those less than atmospheric in general) often use a unit 'torr' that is the pressure exerted by 1 mm of Hg at 0°C. In this range it is also acceptable to use mm Hg and uHg units. Specific mention is made of vacuum gauges for they measure low pressures by quite different methods to the above atmospheric pressure devices.

To conclude this brief resume of units there are three forms of pressure definition. Firstly it can be expressed in an absolute sense, pure vacuum being zero pressure. In absolute terms atmospheric pressure is the familiar 14.7 psia or the 101 KPa mentioned above. (Note the use of 'a' to denote absolute). Secondly, a gauge pressure can be used, psig for instance, where atmospheric pressure is used as a reference datum of zero pressure. Thirdly, pressure might be the difference between the unknown and a convenient datum pressure other than atmosphere. This is the differential pressure — psid is how it is denoted. If the pressure is stated in the column height form it could be designated as in.wg (water gauge) or inH_2O

measuring inches of water.

Torque is now correctly expressed as newton metres N-m but the many older units such as pounds force-inches, ounce-inches, dyne-centimetres, kilogram-metres and others will be in use for a considerable time to come. They should not, however, be used in newly-prepared documents describing new products.

THE STANDARD OF MASS AND CALIBRATION OF FORCE

As force, weight, pressure and torque depend on mass it is appropriate to discuss the means by which the unit of mass is standardised.

Like all standards, that of mass is man-made — there is nothing about our everyday experience of nature that is regular enough to suggest its use as a standard. The aim, therefore, has been to provide commerce and science with a certain piece of substance that is the sole mass standard. The earliest mass standard seems to be the beqa used by the Egyptians around 3 800 BC. it was a cylindrical object with rounded ends (perhaps to ensure no corners could be knocked off?) that weighed around 0.2 kg. It is said our Troy weight system developed from this. As civilisations flourished independently in those times there were also other standards. Today the standard is universal and is a lump of platinium-iridium that is held by the International Bureau of Weights and Measures (BIPM) in Paris. This object defines the prototype kilogram — all others are substandards and are calibrated by comparison with this.

Many modern standards are now based on atomic phenomena (a verbal definition of an apparatus enables any group to construct its own standard to the same precision without need to actually inter-compare the two — atomic phenomena give excellent results) but to date it is not possible to relate the prototype kilo with the fundamental mass unit ($1.66\ 10^{-27}$kg) to a precision equal to the current arrangements of merely weighing the unknown and the standard. Even a comparatively simple beam-balance can be used to compare similar masses to within parts in 10^9 when used with adequate precautions. If the masses are of different material the task is not so simple. Firstly, the bouyancy of each in a fluid will be different due to their different volumes, and secondly they each will have a different quantity of absorbed gas. The use of vacuum weighing to avoid the bouyancy problem only introduces a problem by removing the absorbed gas that is regained when the vacuum is released. The practical solution (standards must be a practically useful arrangement) is to compare different masses in a standard air pressure.

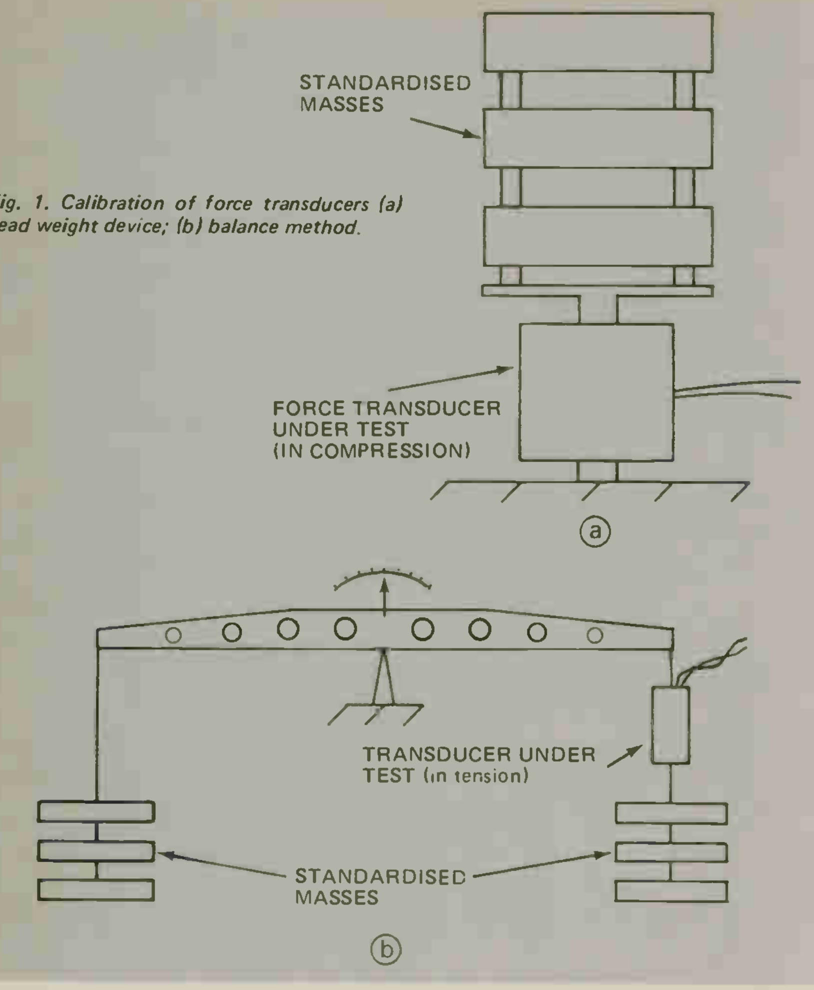


Fig. 1. Calibration of force transducers (a) dead weight device; (b) balance method.

In use, a standardised mass will exert a defined force due to gravity. Force transducers are therefore calibrated by putting them in series in a force loop. The two ways of doing this are shown in Fig. 1. Deadweight testing rigs go as high in capability as 100 000 000 N. Balances usually are used to calibrate to 10 000 N.

FORCE TRANSDUCERS

The need to determine the force acting in a mechanical loop arises in the calibration of pressure transducers, in the testing of civil structures where stress levels must be known, for weighing both static and moving loads, in the testing of automatic machine-tool structures, as the basis of accurate electric current determination and in force-balance devices mentioned earlier.

Unlike other variables there are comparatively few forms of force measuring transducer. The main principle employed makes use of an elastic mechanical member that deforms proportionately with loading. A secondary output transducer monitors the resultant displacement.

The design-aims for the elastic member are to achieve a linear movement of adequate magnitude that suits the available microdisplacement sensors. It must also have low mechanical hysteresis, a long fatigue life and be minimally influenced by environmental factors such as temperature. A few of the force sensing elements in common use are shown in Fig. 2. In each arrangement the sensor is usually placed at the position of maximum stress. Resistive strain gauges, inductive and capacitive sensors are generally used. The complete device is termed a load-cell. In some designs a solid-block is machined out to produce areas of considerably high stress to enhance the sensitivity. In the measurement of dynamic force systems a compromise must be made between the load cell spring rate (a more elastic cell gives a larger strain signal) and the sensitivity obtained (a less elastic cell results in higher resonant frequencies but gives a smaller output signal).

Piezo-electric ceramics provide an electrical output directly from the application of force across the device. During the initial period of force variation, charge will flow to balance the energy but as there is only a fixed amount of energy available for a given force distance product the

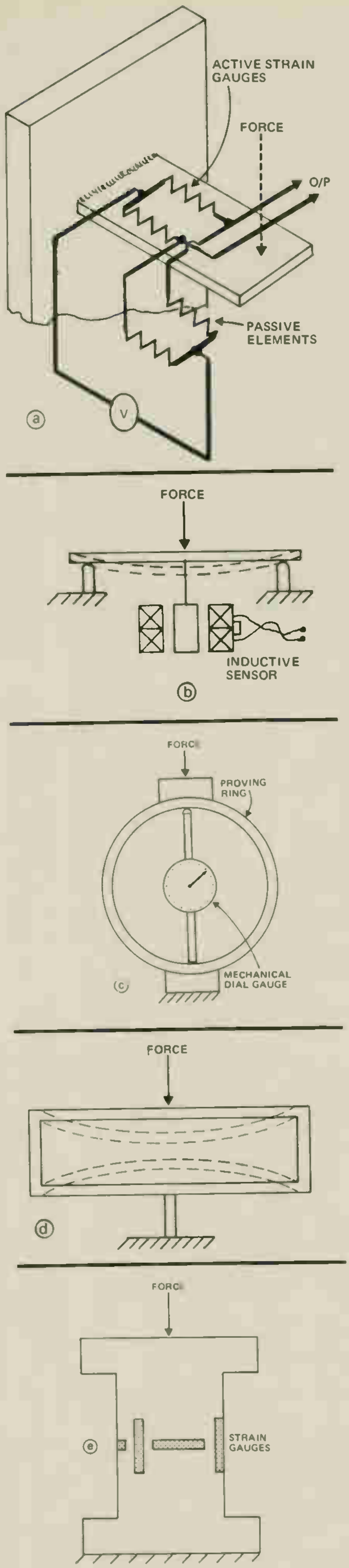


Fig. 2. Elastic elements used in force transducers. (a) cantilever; (b) simply supported beam; (c) proving ring; (d) disk cell; (e) solid or tube column.

signal eventually drops to zero. To extend the duration of the signals (to give the piezo device quasi-static performance) an extremely low-leakage amplifier is used to read the charge flow. When measuring rapidly varying forces, as for instance in machine-tool vibration analysis, there is a continual energy supply and the high input impedance amplifier is not as vital. The force transducers are extremely stiff so little deflection occurs across them.

Many instruments rely on springs to provide a calibrated balancing force that can be used to measure an unknown force. There is a basic difference between such dynametric devices and force assessment by the use of weights.

The weight of an object determined by the absolute method using a beam-balance will be the same regardless of the value of gravity for both masses are equally attracted. A spring devised determination, however, will vary with gravitational changes, for the spring provides a constant force distance relationship. (This is the basis of many sensitive gravity-meters).

CHEMICAL BALANCES

Beam balances have been in use since the earliest times and even a crude arrangement can be used to compare weights to high precision. In the 18th century the rise of research interest in chemistry created a continual need for better balances. Joseph Black reported results of a chemical weighing to the nearest grain (0.065 gm). By the 19th century Handolt was weighing 500 gm loads to several micrograms.

The simple beam balance has been continually developed to reduce the errors in knowledge of the length of the arms, to increase the sensitivity by reducing frictional errors and to simplify the balance adjustment and reading arrangement. Modern balances often make allowance for bouyancy effects and are quite different in appearance from the traditional beam balance. Counterbalancing loads are sometimes applied by front mounted knobs and this provides for simple use and direct readout of value.

Microbalances measure small loads to micrograms resolution, (they are, however, not often small in size). Most make use of a fine torsion-fibre or ribbon suspension that is twisted by the load. To determine the exact load, a counter-torque is applied to rezero the beam. Figure 3 is schematic of a commercial electro-balance. The sample is placed in one pan and a roughly equal weight in the other. To achieve balance the current in the coil is varied until the photocell displacement detector receives a standard illumination level. The process is easily automated to follow changing weights. A recently developed microbalance makes use of a magnetic field suspension system to support the load without mechanical restraint. The field-coil current needed to establish position balance is a measure of load. Modern microbalances can resolve weights of less than a microgram.

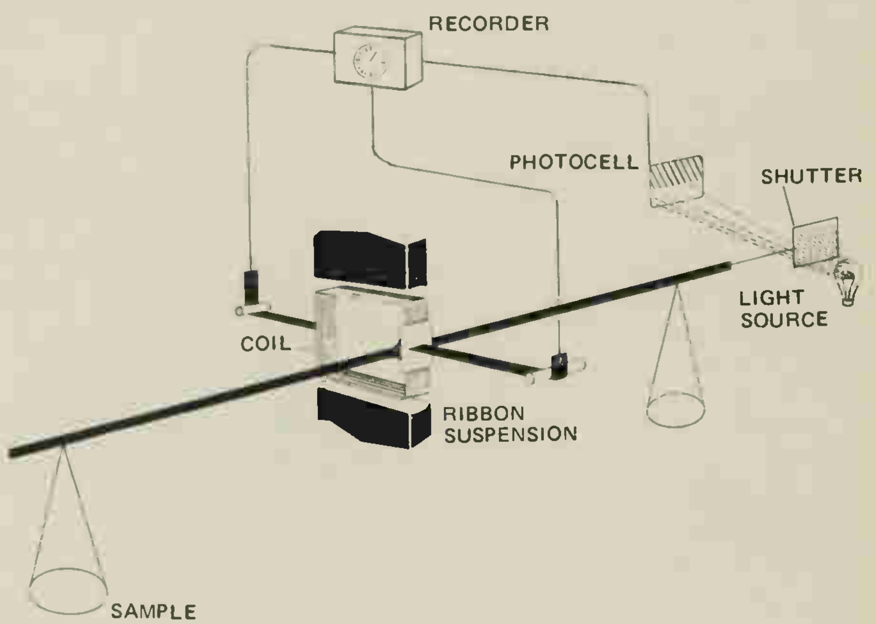


Fig. 3. Schematic of the Cahn electro- balance.

Transducers in measurement and control

DYNAMIC WEIGHING

An automatic readout weighing machine consists of a platform operating on effectively frictionless pivots that bears down upon a load-cell. Details of a commercial unit are shown in Fig. 4. If the load is stationary, the reading is reliable, but a moving load, such as an animal or a travelling string of goods wagons on a railway or material on a conveyor belt, will produce a more complex signal such as that shown in Fig. 5. Averaging the value eliminates the fluctuations about the true mean but to obtain a fast response more sophisticated adaptable filtering is used. The power of such methods is shown by stating that a simple R-C low pass filter gives 200 times greater error than a weighted averaging method (patented by Avery) when used in an equal, short-time period.

PRESSURE SENSORS

The range of pressures that exist is vast and ranges from tens of megabars (10^8 atmospheres) down to inter-stellar space pressure (10^{-19} atmospheres). Consequently many techniques are used to suit the range.

As with force transducers the commonest procedure uses a mechanical elastic element coupled to a microdisplacement transducer. The main difference is that pressure transducers usually do not need the stiffness essential in force sensors.

Commonly used sensing elements are shown in Fig. 6. The limiting factor is usually the magnitude of mechanical hysteresis and perhaps bearing friction in the simpler devices.

The most general need for accurate pressure measurement around an atmosphere is for weather mapping and for elevation determination (barometric levelling). The aneroid barometer uses a stack of bellows to drive a pen or transducer. The best resolution instruments are termed microbarometers. The schematic of an advanced instrument is given in Fig. 7. Note the quartz helical bourdon tube that is used because of the excellence of its stability and spring-rate. Microbarometers have been used to detect the pressure surges caused by nuclear test explosions on the opposite side of the globe.

Pressure sensors using an elastic element are not absolute and must be calibrated against those using a head of liquid as a reference, or by the use of dead weights driving a piston filled with liquid.

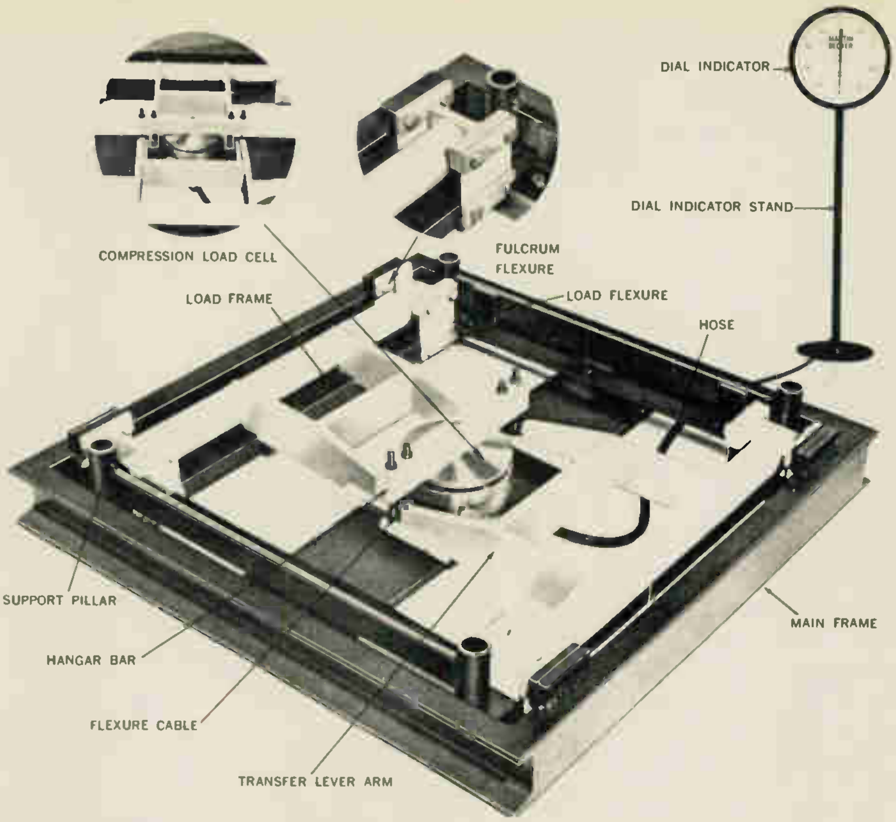


Fig. 4. Inside details of a Martin Decker deck scale.

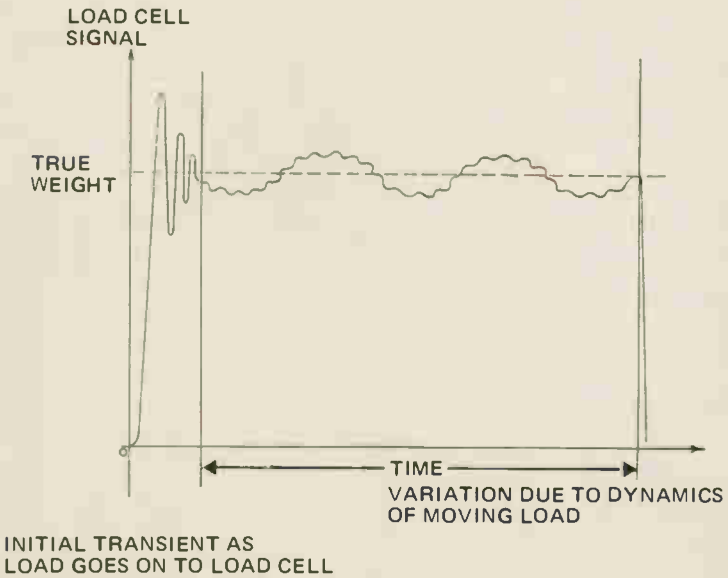
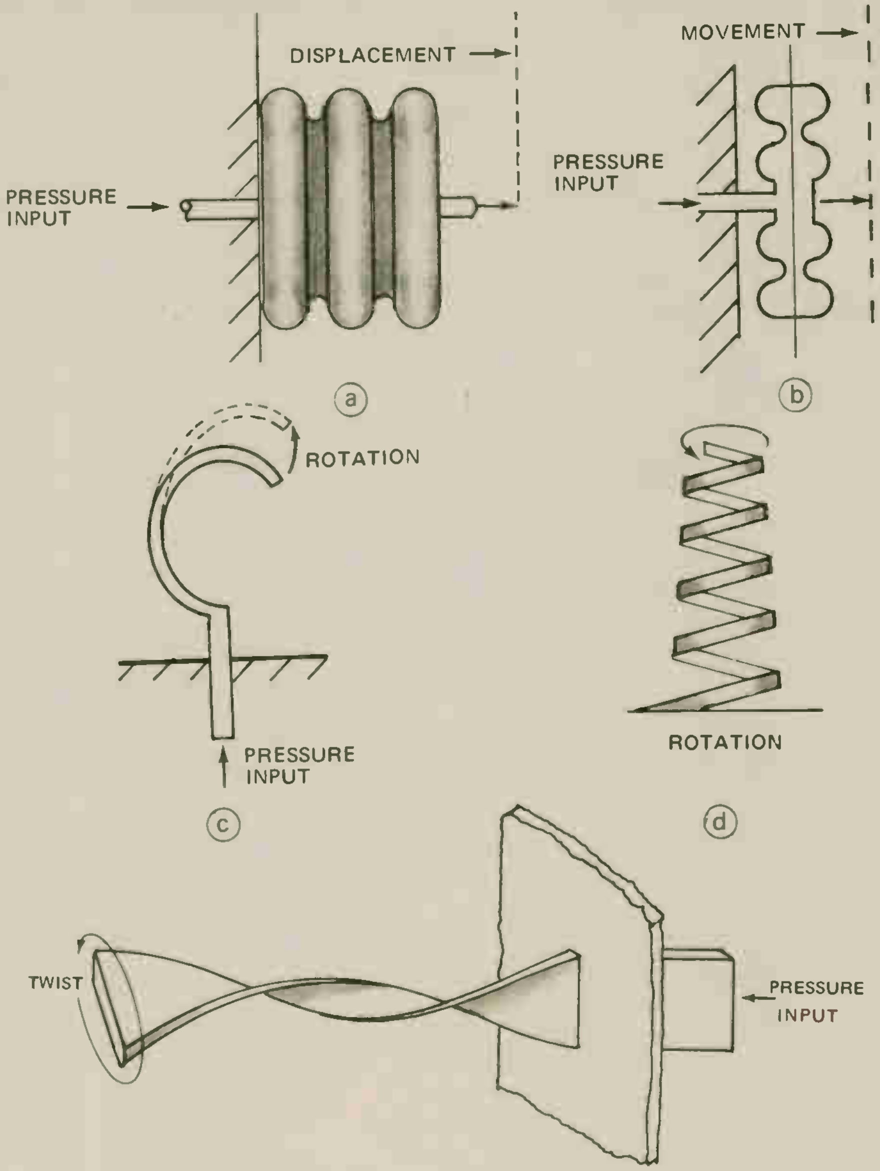


Fig. 5. Typical weighing signal produced by rolling stock passing over a battery of load cells.

The standard mercurial barometers, of the Kew or Fortin pattern, are devices in which the height of a mercury column is measured against a mounted scale. If the column is coupled to the pressure within a closed system via a pipe it is termed a manometer. These are used in abundance in hydraulic research as readouts for pressure difference flow meters and in aerofoil section investigation. Chemical reactions often must be monitored under precisely known pressure conditions. Manometers used in this work are often made more precise by electrically sensing the position of the top surface of the column. Auto tracking inductive sensors, such as that given in Fig. 8, and capacitive or optical sensing have been employed to resolve to micrometers. One micromanometer measures the surface height with an optical interferometer that looks at the mercury surface from above.

An analog output signal may be undesirable from a pressure sensor. A

Transducers in measurement and control



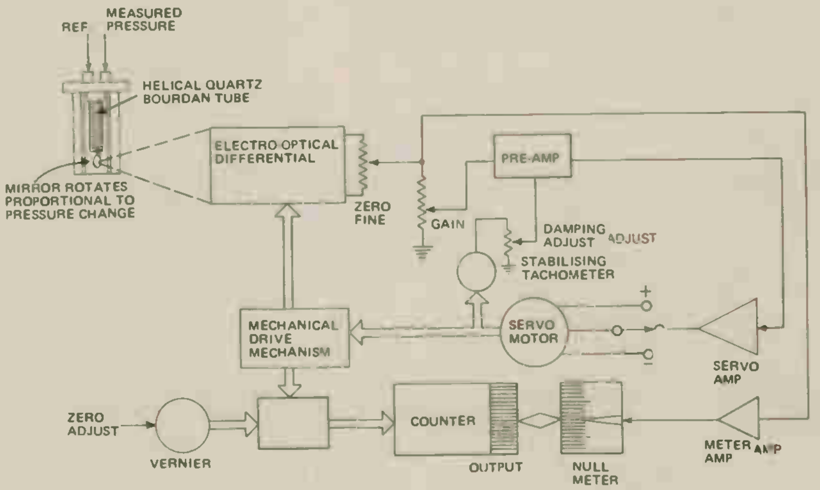


Fig. 7. Block diagram of the Mensor helical quartz pressure sensor having digital readout to 0.0005% of full scale.

sensor developed at the Royal Aircraft Establishment uses the force-balance technique in an oscillatory mode. From the schematic of Fig. 9 it can be seen that the driving coil forces the diaphragm against the pressure, opening the contact. This in turn de-energises the electrodrive, setting the system into vibration. The average duration of the contact dwell is the measure of pressure. This form of transducer can provide a time-duration modulated signal that is easy to transmit due to its binary nature.

Another transducer derives a frequency modulated output by monitoring the natural resonance of the sensing diaphragm. An electromagnetic excites the diaphragm. A capacitive sensor monitoring the displacement is coupled to the excitation driver and the two oscillate at the resonant frequency. As pressure changes so does the frequency.

VACUUM PRESSURES

From 1 mm Hg (1 torr) to an atmosphere is low vacuum, from 10^{-3} mm to 1 mm is medium vacuum. High vacuum extends from here down to

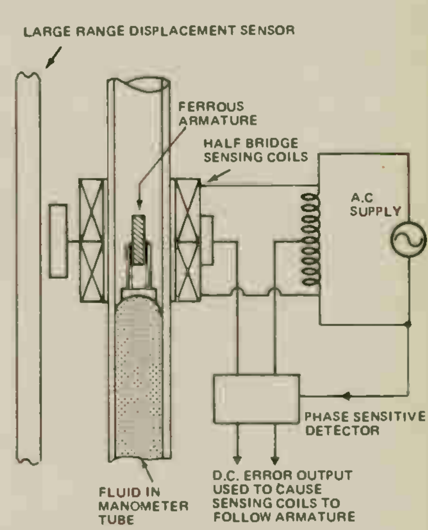


Fig. 8. The height of the liquid column is measured by slaving the detecting coils to follow the armature in this servo-manometer.

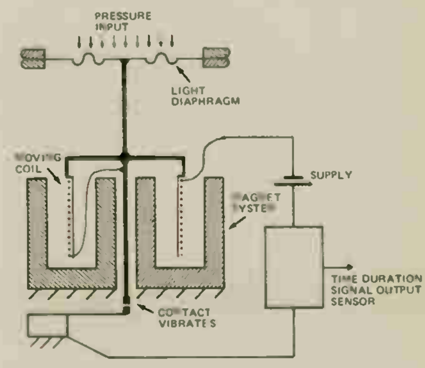


Fig. 9. Schematic of the RAE vibrating-contact, pressure transducer.

10^{-6} mm, very high from 10^{-9} to 10^{-6} mm. Ultra-high vacuum is a pressure less than 10^{-9} mm of Hg. Mechanical pressure gauges are often capable of measuring to 10^{-3} mm Hg but for better than low vacuum it has been necessary to employ quite different methods.

For the pressures of 10^{-4} mm Hg upward, the simplest vacuum gauge is the thermo-conductivity unit. The heat transfer from a heated sensor depends upon the mass of gas thermally coupling it to the container heat sink. The lower the vacuum the less the transfer. Earlier designs used a purely resistive sensor connected to a Wheatstone bridge to monitor its temperature via its resistance change — see Fig. 10, and this is commonly called the Pirani gauge. Another variation uses a thermocouple to measure the temperature. The most recently introduced models make use of a thermistor sensor instead. In this range the McLeod gauge — a type of manometer, provides an absolute method.

Below 10^{-3} torr, ionization gauges are used that rely on the ionization of the gas molecules to determine pressure. In the hot filament kind a heated cathode provides electrons that are accelerated by a grid to make impact on an anode, providing ions in the process. (The design is similar to a triode valve.) Positive ions are collected by an electrode and the ratio of ion to electron current is a measure of gas pressure. The Bayard-Alpert configuration, shown in Fig. 11a, has a small collector to reduce errors from unwanted soft X-ray generation. The anode collector can be replaced by an electron multiplier and versions using this can detect 10^{-18} torr pressure changes.

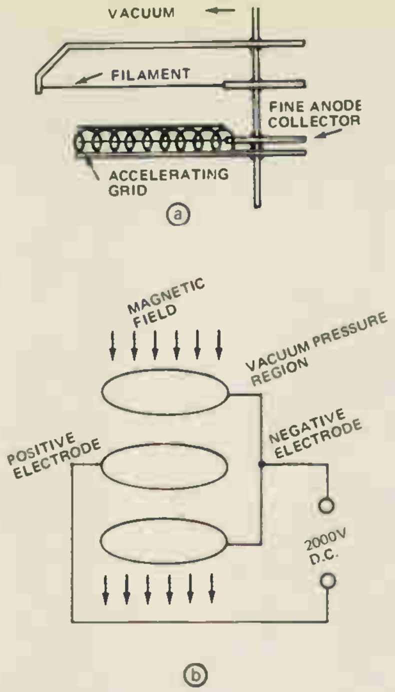


Fig. 11. Ionization gauges used to determine vacuum pressures. (a) This Bayard-Alpert sensor uses a hot filament; (b) In the Penning gauge a cold cathode is used.

The Penning, or Philips gauge, shown in Fig. 11b, is a cold-cathode, magnetic field, ionization pressure sensor. A discharge current is established by the application of 2000 Vdc between the anode and cathodes. The purpose of the magnetic field is considerably to lengthen the electron path (it makes them travel in a helical locus) enhancing the chance to form ions. The current drawn is the sum of electron and ion currents and is, therefore, not a linear measure of pressure. These are useful in the range 10^{-7} to 10^{-3} torr. The cold cathode is often preferred, for an unintentional vacuum loss will not destroy the cathode as would the heated version.

For pressures below 10^{-7} torr there are other methods. The Redhead gauge is also a cold cathode, magnetic, instrument but the internal layout is different being based upon the Magnetron. It has the advantage of giving a linear ion-current to pressure relationship down to at least 10^{-10} torr.

The Knudsen radiometer gauge is occasionally used and is the only absolute method for the range 10^{-8} to 10^{-2} torr. A small mirror is suspended in the vacuum by a torsional filament that also supports a moving paddle-vane. Fixed close to the moving vane ends are two others that are heated. The momentum of the gas molecules passing near the heated plates causes them to bombard the unheated vane deflecting it in proportion to the gas mass present. The mirror forms part of an optical level readout.

SOUND MEASUREMENTS

Acoustic propagation involves pressure wave travel. The above mentioned pressure gauges are of little value for sound pressure measurement due to the high frequency low pressure characteristics of sound waves. The detector, therefore, (the microphone) is designed to have a bandpass response including the frequencies of interest. Generally microphones have to couple an air medium so a comparatively compliant diaphragm is used to obtain an efficient acoustic match. Motion is transduced with a displacement sensor. Microphones in use use piezo-electric crystal, capacitance and moving-coil principles.

When making sound-level measurements it is necessary to use specially designed meters, Fig. 12. In these a stable characteristic microphone produces a basic pressure

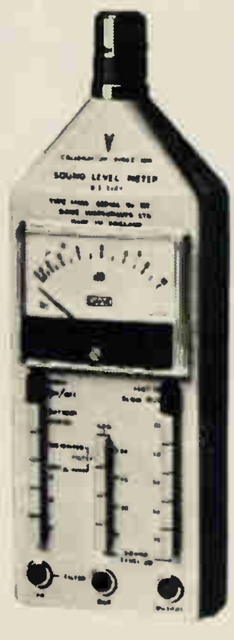


Fig. 12. The Dawe Sound level meter.

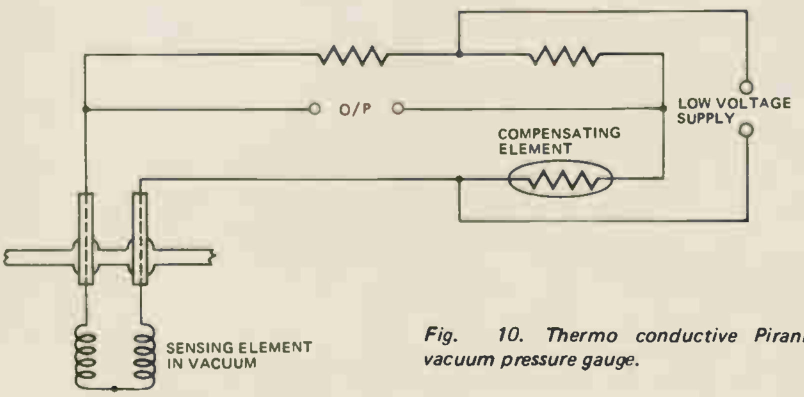


Fig. 10. Thermo conductive Pirani vacuum pressure gauge.

Transducers in measurement and control

signal. This is processed to allow for the random-like nature of sounds and for the frequency characteristics of the human ear.

By definition a sound level pressure (SPL) of OdB is 0.0002 ubar this being the lowest discernible level for the ear (the pressure is 10^{-9} psi!). The compensated noise-level (that makes allowance for the frequency response of the ear) is expressed as the effective perceived noise level EPNL. The threshold of pain occurs at 144dB. At 4 km. Concorde 002 produced 120 EPNdB. The loudest noise produced is probably that generated by the NASA 50ft steel and concrete horn – 210dB which is 400 000 acoustic watts! (Don't tell any pop groups! – Ed).

TRANSDUCING TORQUE

Torque is the product of a force acting at a distance, so for static shaft measurements a torque transducer is little more than a load cell driven via an arm (as shown in Fig. 13a). As the shaft is constrained it is not of any value for measuring rotating shaft torques.

A simple way to monitor the rotating shaft is to fix a strain rosette at 45 degrees to the axis (for this is the maximum stress direction) and connect the gauge to the bridge via slip rings as shown in Fig. 13b. Mercury-wetted rings have been used for extreme rotational rates; monitoring at 30,000 r.p.m. is quite feasible. A more sophisticated arrangement is shown in Fig. 14. Power to excite the bridge is induced by magnetic means, thus avoiding the problems associated with sliprings. A similar approach is to mount the power supply on the shaft along with the circuits and radio-telemeter the output. This has the advantage that the sending receiver and transducer needs no rigid position tolerance. It has been used in the measurement of tail-shaft torque in automobile research.

When the rotation is constrained, as with bearings at each end, a phase difference method can be employed. Detectable 'marks' (for inductive, capacitive or optical sensing) are mounted around the shaft at two points as shown in Fig. 15. Fixed proximity sensors generate two alternating waveforms which will have the same frequency but a varying phase-difference depending upon the amount of twist in the shaft. (This method is similar to a shaft encoder principle described in the earlier discussion on angle transducers). The major disadvantages are that there is no output when the shaft is stationary and that the frequency at which the phase comparison must be made varies with speed.

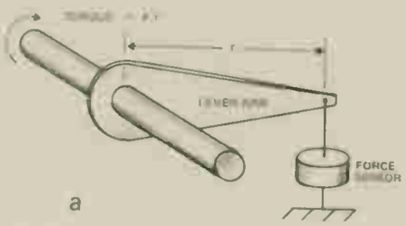
FURTHER READING

"Handbook of Transducers for Electronic Measuring Systems" H.N. Norton, Prentice Hall, 1969.

"Measurement Systems: Application and Design" E.O. Doebelin, McGraw Hill, 1966.

"Weighing Vehicles in Motion" A.C. Fergusen, Trans Inst. M.C. 1969, 2, 12, 214-222.

"Development of the Chemical Balance" J. T. Stock, Her Majesty's Stationery Office, 1969. ●



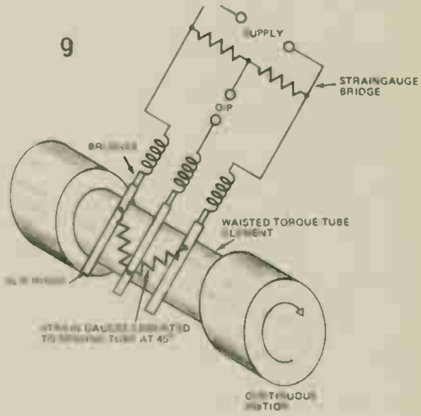
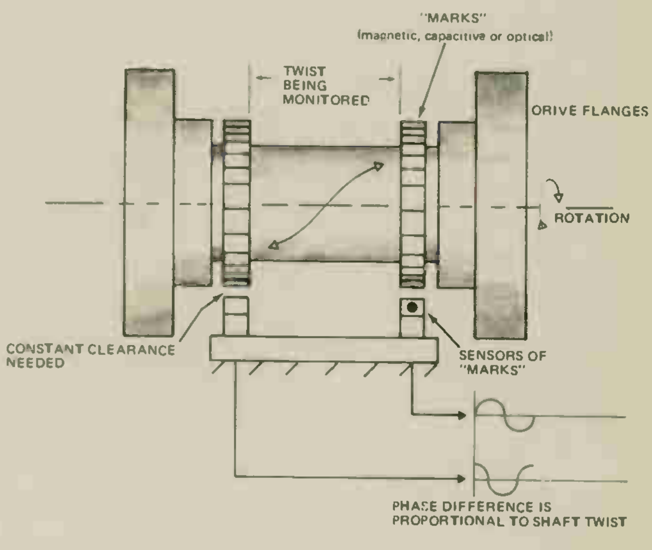


Fig. 13. Torque measurement. (a) Load cell and lever suffices if rotation is not needed; (b) Slip-rings enable the shaft to turn whilst monitoring torque.

Fig. 14. This Philips torque transducer supplies power and monitors the output of a strain gauge bridge via a new contact inductive coupling head.

Fig. 15. Measuring the torque of a rotating shaft by the phase difference method.



electronics tomorrow

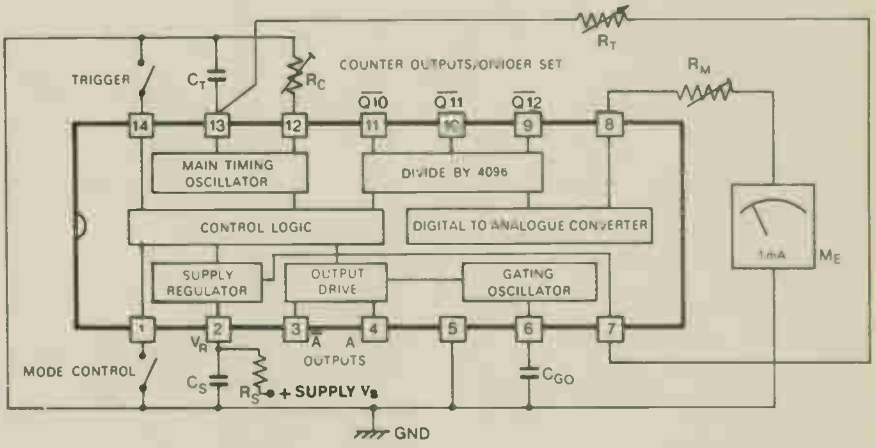
Are you reading this magazine whilst you are lazing in a deckchair with the sun blazing down on you? Perhaps you are reading it in a hot crowded train or bus on your way to or from work, or even at work? In any case it is a bit difficult to imagine the darker evenings to come in only a couple of months, those beautiful evenings spent over a hot soldering iron and birds-nest wiring. Perhaps we can help you plan those evenings with some of the products we have this month. As the first Electronics Tomorrow article has not been published whilst this is being written, we are a little short of response from manufacturers, etc. on new products but we have enough for this month so lets get on with it.

LSI TIMER CIRCUIT

Many of you may have seen this on *Tomorrow's World* in May, set up to demonstrate its ability to run the house whilst you are away by switching on lights, air-conditioning, etc, to deter burglars. It was also mentioned in the July ETI but we have chased up a bit more data for this column. It is the LR171E made by Ferranti for Elremco for long or short term accurate timing pulses. Elremco are in the timer business already and have made their name with mechanical timers, the introduction of a solid state timer is an obvious move from which the amateur might benefit.

An integral operational amplifier is used to form a relaxation oscillator with an externally adjustable timing period. These pulses are passed to a counter chain capable of dividing by 4096, this means that a pulse width of, say, one second produced by 1µF can be converted to a pulse width of just over one hour, the alternative method of using 5000µF in the original CR network would be bulky and also unreliable in temperature and humidity changes. A digital-to-analogue converter on the chip may be used with a meter to show how much of the timing period has elapsed... just think of the applications for that alone. A total of five driving outputs are supplied A and $\overline{A}$ at 4096, $\overline{Q12}$ at 2048, $\overline{Q11}$ at 1024 and $\overline{Q10}$ at 512 input pulses, these can be combined to give eight switching periods each one eighth of the main period.

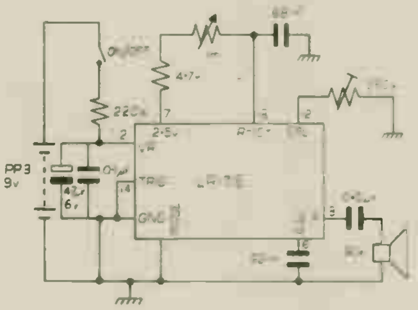
One of the most interesting parts of the data sheet on this device is the supply current at typically 5mA for battery operation or, if you want to run it off the mains, do so: the supply voltage reads min.6V, typical 12V, max (this is not a printing error) 450V d.c.! Just think of the hours spent getting 5V d.c. ripple-free and stabilised a'5V for other ICs, one of my pet moans is transformer sizes but perhaps they won't be needed in future? Data and devices (1).



Internal arrangemnt of the LR171E made by Ferranti for Elremco

555 + 555 = 556

Or to put it another way two 555's are now a 556. The Signetics 556 is a fourteen-pin IC containing two 555 timers, no data or prices were available from Signetics at the time of writing as the device is not scheduled for release until October. Similarly no prices have been set at present but it seems unlikely that the 556 is going to be twice the price of the 555. If you haven't yet become familiar with the 555 type of timer it would be a good idea to do so, these devices are going to be as popular as BC109s in circuits in a few months.



Battery-operated general purpose timer, 2 seconds - 5 minutes. The gating oscillator is used as a drive for a speaker which sounds at the end of the timing.

The 555 timer can function as the heart of an automatic battery charger. The circuit is intended to maintain full charge on a standby battery supply for an instrument that is not always connected to mains supply. These kinds of instruments usually use NiCD batteries or similar, the battery charger is typically for calculators, DMMs, etc. The zener diode provides a reference voltage for the two on-chip comparators through the timers internal resistive divider network. Calibration is done with known voltages across the battery terminals and OFF adjusted to the high (ie stop charging) voltage and the ON to the low voltage, with NiCD cells these are typically 1.2V and 1.4V per cell. The timer output in this circuit switches between 0 and 10V d.c. R1 is used to limit the current and D2 blocks the batteries discharging through the 555.

In the second circuit two 555's or one 556 are used to produce an inexpensive burglar alarm for the car or home. The first 555 produces a time delay of, say, five to ten seconds to allow entering and leaving; turning off the ignition causes 12V to be connected to the timer, opening the driver's door (or similar microswitch) connects the timer trigger to ground and thus starts the delay timing. The second timer is able to trigger as soon as the delay is complete, the trigger of the second 555 is held high until one of the sensing microswitches is closed, these could be under the driving seat or connected to one of the car functions. The output from timer two could be fed via a relay to the car horn or lights. Two alarm enable switches are shown although only one is required, the one on the ignition is for the lazy owner who forgets that his car is "alarmed" and works on the principle that if the car alarm goes off the last thing a thief is likely to do is switch on the ignition. Anyway they are two new circuit ideas to play with, if you have any more let us at ETI know, they might be worth publishing.

555, 556 Data: 2, 555 chips: 3.

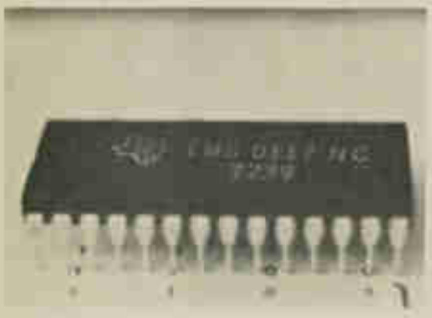
WILLIAM TELLS ALL!

Having mentioned our William we could either go on to apples or arrows, it happens to be Arrow's catalogue. Arrow Electronics Ltd is a mail order firm working from Brentwood, Essex, their catalogue arrived recently and it proved to be quite interesting as catalogues go. The first few pages list

semiconductors and prices; all popular transistors and ICs are stocked. Similarly, several pages are devoted to capacitors, knobs, other hardware, rectifiers, resistors, diodes, and switches. Some of the more interesting products stocked are RCA COS-MOS logic circuits, IC mounting pins (DIY sockets), Motorola ICs (MC1303, 1310), some thick film circuits, opto devices and ultrasonic transducers. One of the thick film devices, the NMC457, is a 75db gain amplifier requiring only a 9V supply, microphone and 300ohms headphones. It is stated as being suitable for hearing aids, null detection process amplifiers and sensing applications. The price is £3 (plus VAT), quite reasonable.
Catalogue: 4.

NUMBER CRUNCHER

This is the name given to the Texas TMS0117 LSI chip announced recently. Basically it can be imagined as a ten-digit calculator chip but, instead of keyboard inputs and seven-segment outputs, data are entered and extracted in BCD format allowing interface with other ICs and thus enabling the TMS0117 to become the heart of a complex device. In addition to the formal calculator operations this will add 1, add 1 until overflow, subtract 1 to zero, shift left, shift right and exchange operands. The rather vague data received so far states that the chip can be used so that "special purpose, dedicated, processing systems can be constructed at ridiculously low cost." Unfortunately the low cost would need to start with the £26.50 required for the one-off price of the chip. It would seem reasonable that manufacturers of these kind of chips would make a limited number available to schools, clubs, etc, one day it might pay off with genius designs/designers in the future. In the meantime: **Data from : 5,6, Chips from 5.**



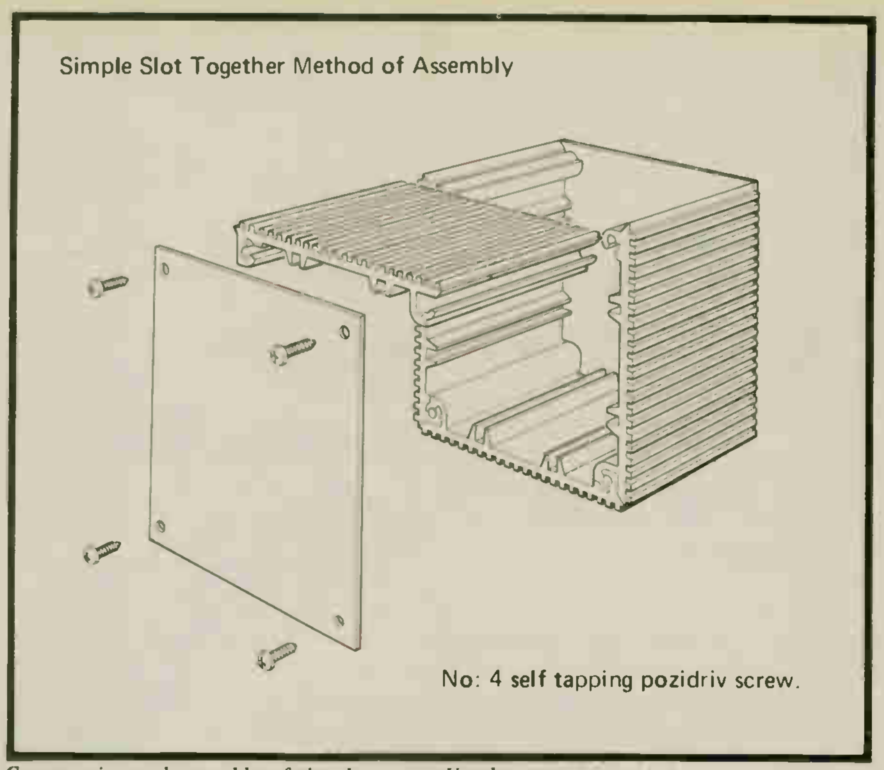
The Texas TMS 0117; it feeds on numbers but at which end?

Whilst on the subject of Texas Instruments and data on their devices some readers may be interested to know that they run a subscription service enabling you to receive data sheets, books, etc, as they become available. The author joined this service about a year ago for £6 and has received about 9 data books, 20 booklets and numerous data sheets but is, however, still waiting for the TMS0117 data booklet. For details of the service write to: **'Subscription Service'** at 6.

MORE TIMERS

In addition to second sourcing the Signetics timer with the LM555, National Semiconductors have another timer the LM322. This is a precision timer that offers great versatility with high accuracy, operating voltages are 4.5V to 40V unregulated. The output of the timer is a floating transistor with built in current limiting. It can drive ground referred or supply referred loads up to 40V and 50mA. The floating nature of this output makes it suitable for interfacing, lamp or relay driving, and signal conditioning where an open collector or emitter is required. The trigger input has a threshold of 1.6V independent of supply voltage but is fully protected against inputs as high as plus or minus 40V, even when using a 5V supply. An internal 3.15V regulator is included in the timer to reject supply voltage changes and to provide the user with a convenient reference for applications other than a basic timer. External loads up to 5mA can be driven by the regulator. An internal 2V divider between the reference and ground sets the timing period of 1 R/C. The timing period can be voltage controlled by driving this divider with an external source through the Vadj pin, timing ratios of 50:1 can be achieved.

The data sheet received on this device is beautiful, for a start it contains full data, electrical characteristics, performance graphs (12 of them), schematic diagram, definition of terms and 14 application examples. Price of the LM322 is £2.50.
Data: 7, Devices: 3, 8.



Construction and assembly of the clever new Veroboxes

BUILD IT YOURSELF BOXES

As mentioned earlier, one of my pet moans is transformer sizes, another is casing. The aluminium boxes, plastic boxes and die-cast boxes available are all very well as long as they are not to be seen. So far no manufacturer has taken a production case for a clock or calculator or even anything non-electronic and made it available to the public and thus if you need to house something attractively there is no alternative but to make your own metal, plastic or wooden case which, if your handiwork is anything like mine, finishes as a mess if it finishes at all. Now Vero have introduced a range of plastic cases and a range of extruded aluminium cases, the latter are called Veroboxes. These Veroboxes are based on a finned aluminium unit 50mm wide and in units of 25mm deep from 25mm to 200mm. The units slot together and screw to an end plate to give an attractive range of boxes that can be left in the raw or sprayed with paint (matt black is very effective) or anodised, etc. Two types of extrusion are used, a corner joint and an extension joint, thus a 50mm cube would use four 50mm deep corner jointed extrusions and two 50mm high, 100mm wide and 75mm deep would use 75mm deep extrusions, four corner joined and two extension jointed plus two 50mm by 100mm end plates. The boxes come in a plastic wallet with extrusions, end plates and screws, they are ordered by quoting the end plate dimensions and then the depth, thus our two examples are a 50-50/50 and a 50-100/75.

Out of eighty standard Verobox kits available to industry, Vero have released only six kits for retail, a telephone call to Vero confirmed that they are quite willing to deal with direct orders for any of the other 74 kits at industrial prices. They also said that they might extend the retail range if the demand is large anough, so here's your chance to affect future product availability. The kits available and their prices (exclusive VAT) are listed below, the first six are the retail kits and the rest are examples of the industrial kits.

50-50/50	49p	50-50/25	40p
50-100/50	73p	100-100/50	98p
100-100/75	117p	100-150/50	125p
50-100/100	91p	100-100/125	140p
50-150/200	187p	200-200/200	401p

If ordering direct from Vero don't forget to add VAT and about 5% for carriage and packing charges. Data and cases: 9. It is also worth asking about the range of plastic cases.

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1 Electrical Remote Control Co. Ltd. P.O. Box 10, Bush Fair, Harlow, Essex CM186LZ
2 Signetics International, Yeoman House, Croydon Rd, London SE20
3 Bywood Electronics, 181 Ebberns Rd, Hemel Hempstead, Herts.
4 Arrow Electronics Ltd. 7 Coptfold Rd, Brentwood, Essex.
5 SDS Components Ltd. Hilsea Trading Estate, Portsmouth, Hants PO3 5JW
6 Texas Instruments Ltd. Manton Lane, Bedford, Beds.
7 National Semiconductors (UK) Ltd. The Precinct, Broxbourne, Herts.
8 Atlantic Components Ltd. 143 Loughborough Rd, Leicester LE4 5LR
9 Vero Electronics Ltd. Industrial Estate, Chandler Ford, Hants SO5 3ZR
NB. Please note that all prices exclude VAT and carriage.

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We also stock the new broadband J-Beam F.M.4S, 1, 2, 3, element F.M. arrays high performance A.M. vertical rod aerials, all U.H.F. T.V. aerials, Stolle Memomatic and Automatic aerial rotators, balanced twin feeder, coaxial cables, masts, fixings, amplifiers, baluns, and a host of other accessories. Please send large S.A.E. for catalogue to:

APOLLO AERIALS, STATION FORECOURT, GUILDFORD STREET, CHERTSEY, SURREY

TEL CHERTSEY 60320 and BYFLEET 43151

eti component news

FASTEST IC FET OP AMP

National Semiconductor now claim to make the industry's first really fast - and really easy to use - IC FET-input operational amplifier. The new LH0062/LH00620 is an order of magnitude faster than conventional IC FET amplifiers, yet it plugs directly into standard monolithic amplifier sockets to solve system performance problems immediately.

The circuit contains a monolithic dual JFET chip and a specially designed bipolar op amp similar to the LM118. National's interdigited dual JFET design assures tight input matching. Typical offsets are 2mV and 1pA.

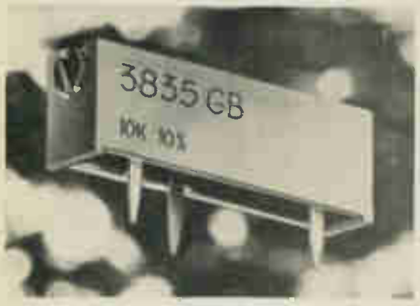
No external components are required for operation, since the amplifier is internally compensated, compensation and balancing can be added, if desired. Speed ratings with normal compensation are 15MHz bandwidth 70V/μs slew rate, and 1μs settling time to 0.1%. Feedforward compensation almost doubles the speed, while an extra capacitor lowers settling time.

Gain is 100V/mV and noise currents less than 0.1pA rms. Other characteristics are similar to those of quality monolithic amplifiers. The supply range is ±5V to ±20V The LH0062 is specified over the full military temperature range.

Both are available in 8-pin TO-5 and 14-pin dual in-line packages. The TO-5 version is pin-compatible with most monolithic op amps.

National Semiconductor (UK) Ltd. The Precinct, Broxbourne, Herts.

ULTRA-LOW PROFILE TRIMMERS



High performance low profile cermet trimmers designated 3835 GB Series are now available from Amphenol. In a standard length of 19.2mm and measuring only 5.8 mm high and 4.3mm wide, these devices are very well suited to applications requiring high packing density or with limited space available for discrete components. Resistance values range from 100Ω to 2MΩ.

Amphenol Limited, Thanet Way, Whitstable, Kent CT5 3JF.

NEW QUICK-HEAT TUBE

A new 12in monochrome picture tube that warms up so rapidly it can present a clear picture within five seconds of being connected to a heater supply has been introduced by Mullards. Type A31-410W, it has a deflection angle of 110° and operates with an anode voltage of 12kW. It requires a heater supply of 11V at 140mA.

Mullard Ltd, Mullard House, Torrington Place, London W.C.1.

FERRANTI CUT LED DICE COSTS

The Special Components Department of Ferranti Limited at Gem Mill have announced reductions in the price of red and green LED dice of up to 50%.

Ferranti, who were the world's first manufacturers of LEDs, are now opening up an entirely new area of this rapidly expanding market. The availability of these dice, which can be mounted and bonded by techniques identical to those used in silicon technology, will enable traditional device manufacturers to enter the LED field without committing effort to the development of growth and processing techniques for the complex III-V compounds. In addition, it will enable hybrid houses and existing LED manufacturers to produce green emitting lamps and displays at highly competitive prices, as semi-conductor dice are now being offered at 6p each in medium quantities, falling to 4p for larger orders.

The devices, which are manufactured from gallium phosphide for green emission and gallium arsenide phosphide for red emission, are available as dice for producing individual lamps or matrices, bars for bybrid seven segment arrays or full monolithic seven segment devices 1.25mm and 2.5mm high.

Ferranti Limited, Special Components Dept. Gem Mill, Chadderton, Oldham, Lancashire OL9 8NP.

PRECISION POTENTIOMETERS

High precision 10-turn potentiometers specially developed to satisfy the design requirements in industrial electronic equipment are now available from Sasco.

The 47130 Series of Micropots with wire-wound elements offers a wide range of standard resistance values from 10Ω to 200 kΩ ± 5% with linearity tolerances ± 0.25% (100Ω – 100kΩ) not exceeding ± 0.5% at the highest and lowest resistance values.

The components have a power dissipation of 2W (+40°C), an insulation resistance of 1,000MΩ minimum and a noise figure of 1000 E.N.R. max. Rotational life is 2 x 10^6 revolutions.

Two versions of gold-plated Beryllium Copper terminals give the option of solder connection to wired circuits or plug-in to printed circuit assemblies.

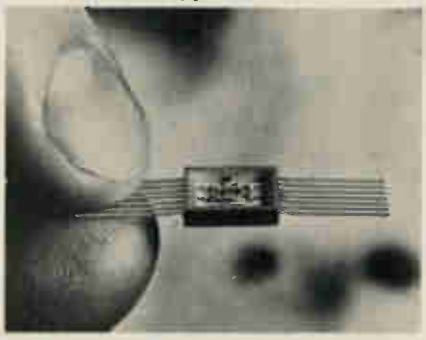
The tough polyamid housing is resistant to most solvent and cleansing agents and there is high resistance to shock, vibration, humidity and other environmental characteristics.

These compact 10-turn potentiometers have an overall length of less than 3cm.

Sasco Ltd, PO Box 2000, Gatwick Road, Crawley, Sussex, RH10 2RU.

V-F ANNOUNCE SMALLEST PANEL LAMPDRIVER

What is claimed to be the smallest hybrid display panel lampdriver currently available has been introduced by V-F Instruments Limited of Gloucester. The new LD401 Series Hybrid Lampdriver announced by the Company consists of six 60mA drivers in one flatpack measuring 0.375in x 0.375in x 0.075in thickness, or approximately one-half the volume required for the next smallest available unit. Unlike the larger DIP packaged lampdrivers which provide only four drivers, the new hybrid package is a hermetically-sealed, all-metal type.



Capable of driving a wide variety of lamps from different lamp voltages up to 20V d.c. the LD401 Series offers complete flexibility for a broad range of special driver requirements. Principal applications, in addition to its use in lampdrivers, are as relay drivers, power drivers and hex inverters. Input is DTL and TTL compatible.

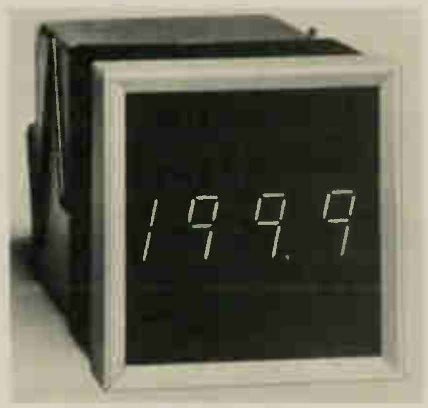
Another important feature of the hybrid lampdriver is extremely low power consumption, typically 50mW from the 5V power supply. "On" voltage is typically less than 0.2V, and remains so over the unit's operating temperature ranges from –55°C to +125°C.

V-F Instruments Ltd, Northgate Mansions, 110 Northgate Street, Gloucester GL1 1SL.

component news

DIGITAL PANEL METER

48 x 48mm . . . less than 4 square inches, is all the panel space required by Schlumberger's new miniature 3½ digit DPM, the 6520.

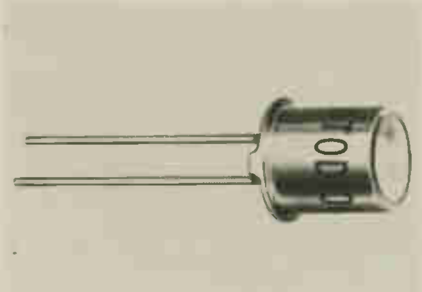


The 6520 features a floating input, auto polarity, 0.1% precision, a ± 1999 display using 7 segment tubes with a polarised green filter and a range from 2 to 200V. The decimal point can be preset by the user.

Easy to install, the 6520 requires only 5V d.c. ± 10% (1.5W) and allows direct replacement of existing analog meters at low cost.

Schlumberger Instruments et Systemes, 12 place des Etats-Unis, Montrouge, France.

PLANAR DIFFUSED PHOTO DIODE



A planar diffused photo-diode which, when reversed biased has a leakage current proportional to the incident light, has been introduced by RS Components. With the fast linear response it is ideal for photometer circuits and many applications, for instance, batch counting, punch card reading, intruder alarms etc. The diode is housed in a two lead TO18 case with end window. It costs 85p and is available from *RS Components Ltd, PO Box 427, 13/17 Epworth Street, London EC2P 2HA.*

CMOS IN PLASTIC PACKAGES

Motorola Semiconductors have just announced that 39 devices from their standard CMOS logic family are now available in plastic packages. In the past, ceramic packages have been used for all CMOS devices manufactured by this company.

The new devices, all in 14 or 16 pin dual-in-line plastic packages, have the same electrical specifications as the standard ceramic packaged components with type numbers suffixed CL. They will operate over the extended commercial temperature range of -40 to +80°C and are roughly 10% cheaper than their ceramic packaged counterparts.

Motorola Semiconductors Ltd, York House Empire Way, Wembley, Middx.

NARROW ANGLE HIGH INTENSITY LED LAMP

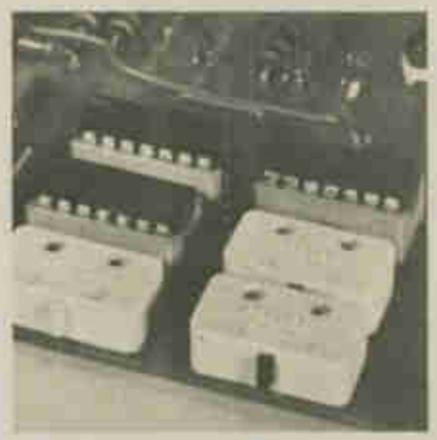
A new GaAsp solid state high intensity LED lamp - the NSL5027 - has been introduced by National Semiconductor.

The new lamp has a very high intensity at 10mA and is intended for front panel pilot lights, optical coupling and back panel lighting.

It has a forward current of 70mA, a reverse voltage of 3V and a power dissipation of 140mW.

NEW PC MOUNTING MICROSWITCH

Feltec Components Ltd have announced the availability of a new microswitch, Type 9201, for printed circuit mounting. The switch has a SPDT action and a 14 lead DIL package area — using pin positions 1, 6, 7 and 14.



The switch has a minimum life expectancy of 10^6 operations, and has contact ratings of 3A at 24V a.c. or 1A at 250V a.c. Insulation resistance of the standard type is better than 100MΩ. Alternative case and contact materials are available for applications requiring lower contact resistance or higher insulation resistance.

Feltec Components Ltd, Weydown Road, Haslemere, Surrey.

SAMPLE/HOLD CIRCUITS

Guest International Ltd have available the S/H725 and S/H725WB sample/hold circuits which are suitable for insertion into 16-pin DIL sockets.

Both units are packaged in a small, compact, completely self-contained module measuring just 1.4 x 0.6 x 0.48in and offer a linearity of better than 0.01%. Sample-to-

hold offset error is under 2mV and the devices will operate with signals in the ± 10V range. They have an aperture time of under 100nS and aperture uncertainty time of 10nS.

Both units are powered by ± 15V at 10mA and operate over the 0 to 70°C temperature range. They use high reliability components and should find applications in such areas as the holding of a signal for an A/D converter and as cascading sample/holds.

Guest International Ltd, Redlands, Coulsdon, Surrey, CR3 2HT.

NEW TRANSISTORS

New transistors from Mullards for use in high-power, high-quality audio amplifiers are families of complementary pairs that can give outputs of up to 100W. For example, in applications where an output of 6 to 15W is required, pairs from the transistor family BD433 to BD438 are suitable. (Odd numbers are NPN types, and even PNP.) These have a maximum V_{CEO} rating of 22 to 45V and a total dissipation of 36W.

Silicon power transistors type BD266 and BD267 form a complementary pair that can give a high-quality, audio output of 25W; they are also suitable for use in general purpose amplifiers and switching applications. Both are monolithic epitaxial-base Darlington transistors. Consequently, with a collector current of 3.0A and a collector-to-emitter voltage of 3.0V, each has a typical h_{FE} of 1500, a high value that enables a simple drive circuit to be used with them.

The BD266 is a PNP device with a maximum V_{CBO} rating of 60V, and the BD267 an NPN type with a maximum V_{CBO} of 80. The maximum I_{CM} rating is 12A, and with a mounting base temperature not greater than 25°C a total dissipation of 55W is permissible.

Other new Darlington devices to be shown are types BDX62 to BDX67, which are power transistors with TO-3 encapsulations. Complementary pairs selected from these for use in audio amplifiers will give outputs of 25 to 100W. Typical h_{FE} values are 1500, and peak collector current ratings are 12, 16 or 20A. Total power dissipations vary from 90 to 150W, and the devices have a transition frequency ranging from 2.5 to 7MHz which makes them particularly suitable for use in high-quality amplifiers.

Mullard Ltd, Mullard House, Torrington Place, London W.C.1.

EQUIPMENT NEWS

DIGITAL MULTIMETER

Fluke International claims that its new systems oriented instrument offers unusual capability in a 5½ digit multimeter. The standard configuration combines high accuracy measurement of d.c. volts, true r.m.s. a.c. volts and a broad resistance range plus a unique self-test feature for rapid checkout of all measurement functions. Many systems options, available for both factory and field installation, are also offered.

Basically, the instrument offers 5½ digits, autoranging and autopolarity, functional self-test, 5 ranges of d.c. volts to measure from 1μV to 1100V, 4 ranges of true r.m.s. a.c. volts measuring from 10μV to 1100V and 7 ranges of resistance to measure from 100uΩ to 12MΩ.

Other features include switched four-pole filter with true broadband noise rejection, variable sample-rate control, push-button selection of range and function with complete interlocks, 100V guarding and 1500V overload protection.

Options include data output, remote control and real time ratio for four terminal d.c./d.c. ratio measurement.

Fluke International Corporation, Garnett Close, Watford WD2 4TT.

LOW COST POWER UNIT

A new, low cost, regulated d.c. power supply – made by Zauie Industries Ltd – is available from PBRA Ltd.

Designated Type 2005, the unit has an output range of 0 – 20V d.c. at 0 to 0.5A. Both line and load regulation is within 0.01% + 1mV. Ripple and noise at full load is less than 1mV peak-to-peak and resolution is within 50mV. The unit has a 20uS transient recovery time and a total drift figure of less than 0.1% + 4mV over an eight hour period.

Measuring only 3in x 6in x 8in, the 2005 has its own voltmeter and separate ammeter built in, and is priced at £25.00.

PBRA Ltd, 33 Holmethorpe Avenue, Holmethorpe Trading Estate, Redhill, Surrey.

NEW STROBES

We have information from two companies manufacturing stroboscopic equipment. Electroplan Ltd have a new *Strobe Automation* range of instruments and accessories on the market. There is a low cost torch, covering the speed range 3 to 100 flashes per second, and the 15K stroboscope, with a speed range of 4 to 250 flashes per second.

The 15K stroboscope from Electroplan

The 5K model is an intermediary instrument, suitable for demonstrating the principles of the stroboscope by analysing the movement of rotating parts. The prices range from £30 to £110.

S.E. Labs Limited have developed an instrument *(Type EM6)* with an extended range, from 5 to 1,000 flashes per second. By illuminating once every revolution, machinery moving between 300 and 60,000 r.p.m., can be observed. (Up to 120,000 r.p.m. if every second cycle is observed).

The S.E. Labs EM6

See over

EQUIPMENT NEWS

A 6in scale meter indicates the rate in flashes per second and the corresponding shaft speed in r.p.m. The flashing can be controlled in one of five ways - (1) using the internal continuously variable oscillator, (2) by an external mechanically operated switch (3) applying external sine or squarewave pulses, (4) introducing the supplied photo-electric transducer, or (5) locking to multiples or sub-multiples of the mains supply frequency.

The lamp reflector can be operated, by using the extension lead, separately from the control unit. An output pulse is supplied at half the flash rate, facilitating the driving of ancillary equipment or digital counting.

Electroplan Ltd., P.O. Box 19, Orchard Road, Royston, Herts.

5 DIGIT, 32MHz COUNTER

We have news of a portable (225.8mm x 177.8mm x 92mm, 3½lbs), easy to operate piece of equipment from RCS Electronics.

The RCS 301 Counter is a straight frequency counter based on a new deisgn with leading zero suppression, automatic level control and decimal point. The instrument will measure from 0-32MHz in two ranges with 1Hz resolution. A low voltage 5 digit 7 segment display is employed so a d.c. supply of 10 to 15V may be used, instead of mains operation using the internal fully stabilized P.S.U.

RCS Electronics, National Works, Bath Road, Hounslow, Middlesex.

ELECTRONIC THERMOMETERS

Electroplan have been appointed as the distributors for a range of new Comark electronic thermometers. There are five in the range covering -120°C to +1100°C. The instruments are easy to use and are calibrated for direct reading in $^{\circ}$C. Cold junction errors and problems from the resistance of thermocouple and lead length are eliminated. Four of the thermometers are calibrated for Chromel/Alumel thermocouples, the fifth is calibrated for Copper/Constantan.

The 1601 and 1621 models are 2% RSD units for general purpose use with varying resolution depending on the range. The 1602 has a 1°C resolution with suppressed zero. For measurement in 10°C steps the 1604 and 1605 types have a resolution of 0.1°C at an accuracy of ± 0.5°C. These thermometers are claimed to be ideal for a wide range of research and practical laboratory applications in agricultural, process industries and academic environments.

Electroplan Limited, PO Box 19, Orchard Road, Royston, Herts. SG8 5HH.

A TORCH THAT TESTS FUSES

Every electrician carries two basic tools - a torch and a fuse tester. Now Fluvent Electric have combined them in one simple instrument that slips into the pocket. The Fluvent FuseTester looks like an ordinary hand torch, taking two U2 batteries. It comes in two models - the standard in metal, the heavy duty encased in rubber.

The instrument functions as a conventional torch and, without change, as a tester for circuits and fuses. It must never be used, of course, on live circuits, sockets or switches. Each model is fitted with a pair of leads which, when applied to each end of a fuse or section of a circuit, make the torch bulb light if the circuit is complete. One lead is arm length, making it particularly useful for reaching inaccessible corners. Sockets on the body neatly show and protect the leads when the instrument is not in use. Recommended prices (without batteries) are - standard £1.20, heavy duty £1.80, from electrical wholesalers or direct from the manufacturers.

Fluvent Electric Ltd., Newton Avenue, Longsight, Manchester.

ALUMINIUM SOLDER

Multicore Solders Ltd., have announced that their 'Alu-Sol' - believed to be the first cored solder that readily joins aluminium and many of its alloys - is now available to the amateur constructor. This does not mean, however, that one can now solder aluminium using a standard soldering iron.

The specific heat of aluminium is high (about 2½ times that of copper) and its thermal conductivity is good. To bring the job to the required temperature range (280-370°C) a larger capacity of heat is needed compared to that necessary in most soldering jobs. These thermal characteristics, however, mean it is easier to heat the assembly evenly.

Unless the amateur is prepared to buy a large capacity soldering iron (with the recommended tip temperature) another method will have to be devised, using a hot plate for instance. Care must be taken to keep the finished joint dry, possibly by painting with a protective coating, because aluminium is subject to a greater degree of oxidation and electrochemical corrosion than most metals.

DIGITAL SIGNAL GENERATOR

Radiometer A/S of Copenhagen, have announced a new digital signal generator, the MS30. This is an AM-FM instrument which covers the frequency range 50kHz to 520 MHz, indicated on an 8 digit display with a 10Hz resolution. A coarse frequency setting employs electronic tuning in steps of 10MHz and 100MHz and a fine tuning control covers the entire range continuously. In combination with a 3 digit selector and a frequency lock capability this provides very precise and very easy frequency selection. Both accuracy and stability are ± 10Hz

Output level is also digitally displayed on a 3 digit indicator in μV, mV or dBm and the output can be adjusted within the range +10dBm to -126dBm by means of an electronically controlled 1 and 10 step attenuator and a verier. The r.f. output includes an on/off facility and is protected against unwanted signals up to 20W.

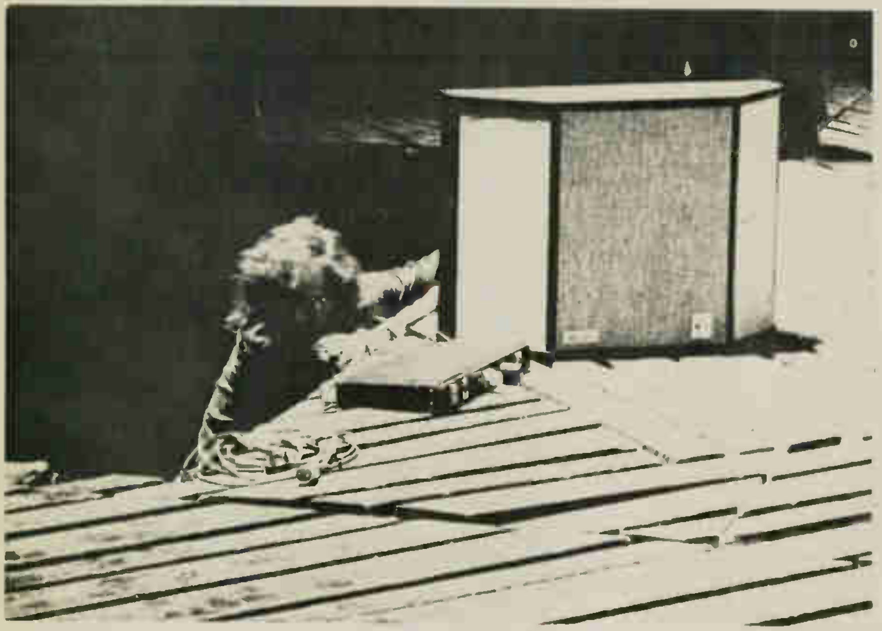
A third 3 digit display indicates the mode frequency and AM% or FM deviation of either of two modulation generators. One generator has 6 fixed frequencies of 150, 300, 400, 1000, 3000 and 6000Hz with an accuracy of ± 1% and the other has continuously variable frequency from 300Hz to 3kHz with an accuracy of ± 1 digit.

Another feature includes facilities for phase locking the internal 10MHz reference signal to an external reference so that when required the MS30 can be frequency locked with another MS30.

The RF frequency and the output level of the MS30 can be programmed via an interface unit and several versions of this unit are available to cover the requirements of most OEM and automatic test systems.

Marketed through International Instruments Ltd, Cross Lances Road, Hounslow, Middlesex. ●

eti AUDIO NEWS



In the recent production of Don Giovanni, at Covent Garden, the voice of the Commendatore's statue reached the audience through an AR-LST speaker system concealed beneath the stage grillwork. The real singer was singing into a microphone off-stage. Many people have been listening to a loudspeaker and thinking it to be 'live' music.

The photo shows a Covent Garden technician removing the AR-LST from its concealed position after a dress rehearsal of Don Giovanni.

The Royal Opera House owns 5 AR-LST's, which have been used a number of times this season. The offstage brass band in Aida was actually a pair of these speakers, painted black and placed near the end of the proscenium.

The AR-LST is the professional version of Acoustic Research's basic acoustic suspension speaker system.

Acoustic Research International, High Street, Houghton Regis, Dunstable, Bedfordshire LL15 5QJ

VACUUM RECORD CLEANER

The manufacturers, R.I. Audio, claim that their new "Groovac" record cleaner is the only unit available which removes dust from records by vacuum cleaning. It has long been recognised that vacuum cleaning is the best way to remove dust, especially fine dust. Now the suction method is available for the effective removal of the fine dust particles which collect inside record grooves and which are responsible for record and stylus wear.

A tracking force of only 0.7 gram has been achieved by using a lightweight design with lubricated-for-life bearings throughout. This is considerably below the 3 to 6 grams force of simple brush cleaners. Low tracking force allows fine hairs to be incorporated in the Groovac cleaning nozzle which ensure efficient removal of dust from the bottom of record grooves – most brush cleaners have hairs with a diameter which is larger than the width of the record grooves. Low tracking force also means an almost immeasurable reduction in turntable speed, a reduction which is at least three times less than that caused by brush cleaners.

The Groovac consists of a precision lightweight arm, and a suction unit which is acoustically isolated in a special enclosure. The suction unit has been designed to be inaudible at a distance of 2 metres; it has a mains switch and indicator, and is attractively finished in teak. The arm takes less space than brush cleaners – the counterweight projects less and the arm occupies less height. It mounts by means of a convenient magnetic base, and its height is adjustable to suit different turntables. When not in use it is simply rotated outwards and lowered onto its integral rest. The price is £6.90 plus VAT and is available from hi-fi retailers or direct from the makers.

R.I. Audio, Kernick Road, Penryn, Cornwall.

MINIATURE CASSETTE RECORDER

Here is a pocket-sized, (6½in x 4in x 17/8in, 1.6lbs without batteries) Cassette Recorder with all the features you would normally find only on larger machines.

JVC's model CP-1646 has an unusual built-in Condenser Microphone which operates in two ways. Retracted into the record casing it behaves as an omni-directional microphone recording all the surrounding sounds. When pulled out from the casing it becomes a uni-directional microphone picking up only those sounds at which it is aimed. Furthermore JVC have fitted an Automatic Level Control circuit.

Control of the CP-1646 cassette-drive mechanism is simple: the one-touch recording button is interlocked to the playback button so that recordings can be made with just one finger. Autostop, automatically disengages the mechanism thus switching off the whole electrical circuit, and the power is switched off to conserve the batteries. A pause button is also fitted, and the normal Fast/Forward/Rewind switch and Eject button are provided.

Other features are a combined recording and battery level meter. An earphone can be fitted for monitoring purposes, and an external microphone can be plugged in if required. In addition, a remote control socket is fitted which allows all the recorder's functions in either the record or playback mode to be controlled externally. Power is normally obtained from 4 built-in cells, but it can be run off the a.c. mains or a car battery if necessary.

CASSETTES AND AMSTRAD AMPLIFIERS

A.M.S. Trading (Amstrad) Ltd. have now set up facilities in their new enlarged Service Department to give advice on the use of Cassette/Tape Decks with Amstrad Amplifiers. Should the Cassette/Tape Decks owned by any Amstrad customer prove non compatible, the Service Department can modify the Amplifier as necessary at a cost of £3.00. All arrangements should be made through Simon Angel – Service Manager.

A.M.S. Trading (Amstrad) Ltd., 89 Ridley Road, Dalston. London E8.

Electronic Transistorised Ignition

Continued from Page 42

side with the heatsink uppermost. Check these tags cannot foul the edges of their rectangular cutout. Use insulating sleeving on all exposed wires. The neon is held in a black rubber grommet to improve visibility and give physical protection. All connections to the vehicle are by means of heavy gauge colour-coded cables which pass out of the unit through a grommet. Note that C1 and C2 are held secure by the wire from the fuseholder to TB6 being passed over them. R4 is mounted flat against the bottom of S2. Check that there are no shorts to the box when the two halves are screwed together. Solder the five links on the link strip and screw it to the terminal block in the correct position:

LEFT (heatsink uppermost) for positive chassis;
RIGHT for negative chassis.

The completed unit. The heatsink should be sprayed matt-black.

INSTALLATION AND USE

With the ignition switched off, disconnect the existing leads to your car's ignition coil. Mount the unit by means of two screws passed through the base of the box in a convenient part of the engine compartment, less than 30in from the ignition coil and in a position well away from the hot exhaust manifold and reasonably well ventilated. DO NOT mount unit on engine. A good position is on a flat surface such as the main bulkhead since this helps heatsinking. Recheck the polarity setting, then connect the colour coded leads as follows:

RED: To ignition switch. Normally the lead just disconnected from the ignition coil SW terminal can be used but there must be no ballast resistor in series with the supply to the unit. Beware of ballast resistors incorporated in the SW lead.

BLACK: To chassis. This lead can be anchored under a nearby bolt to ensure a low resistance connection. It may seem anomalous that on positive chassis vehicles, red goes to battery negative and black goes to positive!

GREEN: To the contact breaker in the distributor. It can be connected to the free end of the lead previously disconnected from the CB terminal of the ignition coil.

BLUE and **YELLOW:** To the CB and SW terminals of the ignition coil. Remove any suppressor capacitor on the coil.

Check that all connections are secure (especially those to the coil) and taped to prevent shorts. Dress all wiring neatly and clear of hot or moving engine parts.

Put both toggle switches towards the heatsink and switch on the ignition. The neon should light and a whistle come from the unit showing the inverter is working. Start the car and observe the neon while revving up; it should not dim greatly. Treat your car to a new contact breaker, a plug gap check and a garage tune-up since these will not have to be repeated for a long time. If the garage is suspicious of transistor ignition, switch back to conventional. Resistive (suppressor) plug leads in poor condition should be replaced as they deteriorate faster with transistor ignition.

BURGLAR FOILING

If the toggle switches are put in alternate positions (one up, one down) neither transistor nor conventional ignition circuits are complete and the engine will not start. This feature can be used to immobilise the car when parked. Most car thieves will give up at this but a stronger deterrent can be arranged for more persistent thieves. A wire can be taken from the unused pole (b) of S2 (see circuit and layout) to the coil of the horn relay (if fitted) or to an extra hidden relay which when energised operates the horn or other alarm. Then if the ignition is disabled by putting S1 down and S2 up, any unauthorised use of the ignition switch will energise the relay and sound the alarm. Since the alarm supply at S2b comes via the ignition coil primary it may not be able to operate the horn directly although this may be possible with some horns if they are sufficiently sensitive. Horns that are switched in their chassis returns cannot be used without a relay.

SPARK POLARITY

At speed the tip of a spark plug runs at high temperature and some cathode emission, as in a radio valve, occurs. This means that the breakdown voltage is slightly lower for a negative spark pulse (with respect to chassis) than a positive one. The effect is usually ignored and is fairly academic with transistor ignition where adequate spark voltage is always available. However some claims are made that reversing the leads from

Electronic Transistorised Ignition

the unit to the ignition coil (blue and yellow) improves performance and there is no harm in experimenting.

To increase the spark energy another 0.47uF or 0.5uF capacitor can be added across C1 but the unit is then suitable only for fairly low-revving engines with 4 cylinders or less.

Please note that this project is only suitable for 12V cars and we are unable to provide modifications details for 6V models. ●

SPECIAL OFFER FOR ETI READERS

Use the coupons below to order either the kit or a built, tested and guaranteed version of the ETI Electronic Transistorised Ignition, in both cases at £2 less than the normal price.

USE THIS COUPON FOR THE BUILT VERSION

To: DOLPHIN DESIGNS, New Farm House, North Shoebury Rd., Shoeburyness, Essex.

Please find enclosed a cheque/PO for a built version of the ETI Electronic Transistorised Ignition at the special price of £8.91 which includes postage, packing and VAT.

Name . . . .

Address . . . .

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This offer applies only to orders postmarked before September 30th 1973 after which the normal resale price of £11.00 applies. Please allow 28 days for delivery. Orders at the special price will not be accepted unless accompanied by this coupon.

USE THIS COUPON FOR THE KIT

To: BI-PRE-PAK LTD., 222 West Road, Westcliff-on-Sea, Essex SSO 9DF

Please find enclosed a cheque/P.O. for a complete kit of the Electronic Transistorised Ignition at the special price of £5.92 which includes postage, packing and VAT.

Name . . . .

Address . . . .

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This offer applies only to orders postmarked before September 30th 1973 after which the normal resale price of £7.92 applies. Please allow 28 days for delivery. Orders at the special price will not be accepted unless accompanied by this coupon.

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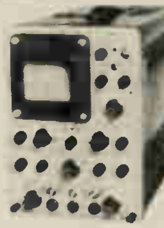

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Frequency range	from 20 Hz to 50KHz
Accuracy	Within 0.5 dB
Load input resistances	40 Values
Resistances accuracy	better than 5%
Instrument Calibration	R.M.S.

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The Ampertest 690 is supplied complete with voltage measuring leads and probes and combined twin wire adaptor/current transformer in a solid leather carrying case. A belt fitting pouch is available as an extra.

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DX MONITOR

Compiled by Alan Thompson

GEAR - that's the subject of this month's compilation: a subject of which DXers never tire! Numerous letters indicate that many of you are intrigued by some of the gear which appeared in the picture at the head of the first DX MONITOR so let me take you on a conducted tour of my shack adding, as we go, some notes that I hope will be of interest and use to fellow DXers.

AERIAL

There are two basics in any receiving installation - the receivers and the aerials. Currently, I'm using five separate aerials in the search for those elusive DX signals. The first is the easiest to describe - it is the "Aerialite" Mastatic vertical aerial, all 18ft. of which rises slimly from a rear chimney. This aerial may not have any terrific 'gain' - the manufacturers make no claims in that regard - but if you live in a noisy location it can certainly be recommended for the way in which an ingenious feeder set-up eliminates a lot of the noise-blanket of electrical interference which exists around any house in an urban location. The second one is also a vertical which was erected experimentally about 3 years back and has never been taken down because - despite all theoretical considerations - it does give an astonishing amount of pick-up, even though it has a feeder of about 80ft. between aerial base and receiver terminals.

Third comes the aerial which brings in most of the low-powered African stations that form my real favourite hunting ground. Erected so that it runs in an east-west direction it is an inverted-L, about 50ft. long including the vertical portion, and is only 20ft. high at best, falling to about 15ft. at the receiver end. Aerials 4 and 5 really go together - basically, they are derived from a long-wire about 130ft. long, mounted some 45ft. high. This is centre-tapped to form a 'T' and is also tapped at one-third of its length, which you will recognise as forming a 'Windom'. In practice, the two feeders off the same aerial cause no problems at all, and the aerial switching is so arranged that both feeders can be fed to a receiver at the same time, if required, which gives an improvement of an S-point or more on some signals. Comparison with separate aerials of 'T' and 'Windom' construction show no appreciable difference between them and the 'composite' system I am using. Each aerial is fed to a DPDT switch so that when it is not in use it is connected direct to earth- useful in thundery conditions and a good way of avoiding interaction between aerials. DPDT switches are used in preference to SPDT types since some of the aerials are fed by coaxial cable and others by single wire feeder: the use of DPDT swtiches means that it is easy to accommodate changes in the system (something that is always going on). The selected aerial is fed to a home-brew pi-network coupler, concealed in the space behind the control panel under the receivers, and from there can be easily switched to either of the two main receivers, or to any other receiver that may be on test.

RECEIVER

That brings us to the receiver department and the main receiver is the "Racal" RA1 7K (right centre of picture), a professional Communication Receiver covering from about 500kHz to 30MHz without any break at all. This 23-valve job is for me the ultimate in receivers for DXing for two reasons — firstly, its stability is such that one can tune to a frequency and be sure that the receiver will still be 'spot-on' however long the DX session lasts, and, secondly, the degree of bandspread is astonishing, spreading each MHz band over 5ft. so that the total medium- and short-wave spectrum occupies something like 150ft. with each kilohertz clearly marked on the superb dial. As you might guess, RA17's don't come cheap! New you wouldn't have a lot of change from £1,000 and a second-hand one in good condition is likely to separate one from about £300: I'm sure, though, that anyone who has used one will agree that it is money very well spent as the mechanical and electrical construction is superb.

The other receiver (the one under my left hand in the 'photo) is not at all well-known and my example has been somewhat modified as it needed some pretty extensive re-furbishing when I acquired it. It is an ex-Royal Navy receiver, the "Rees-Mace Marine" model CAT, sometimes known as the A.P.100339, and it is another general coverage receiver spanning about 50kHz to 31MHz in 8 calibrated wavebands, and using 12 valves as well as requiring a separate power-pack (not visible in the picture). This is not the world's best receiver above about 10MHz but its performance on the lower frequencies is excellent and I find it ideal for medium-wave DXing.

PRESELECTOR

Sitting atop the "CAT", we find a "Hamgear" P.M. IIBX pre-selector and this is a mains-powered solid state device covering frequencies above about 1.5MHz. The pre-selector is claimed to give between 20 and 25db gain in that frequency range and has proved to be really excellent when used with the "Racal". A switching arrangement allows it to be taken in or out of circuit as needed. For years, there has been much speculation as to whether a good Communication Receiver requires a pre-selector, and it has even been suggested that there is something amiss with the receiver if one is needed! To me, this seems to be one of those hoary chest-nuts which remains in circulation for ever and a day — if not, perhaps, someone can explain why "Racal" do (or did?) make a pre-selector of their own for use with the RA17-series, which are generally acknowledged as being the best receiver ever made using valves. DXers are concerned with achieving the best possible signal-to-noise ratio they can, so one starts with getting as much signal as possible to the aerial terminal of the receiver, reducing, in the process, the noise pick-up as much as possible. Now, the early stages of a receiver add their own noise to the signal and, thereafter, both signal and noise get amplified in the various stages of the receiver. If one can insert, between the aerial and the receiver, a device which has a low noise level of its own then it is axiomatic that the signal-to-noise ratio at the receiver's aerial terminal will be better than would be the case without the use of such a device. This pre-selector, using an F.E.T. front-end, certainly does improve the signal-to-noise ratio and makes otherwise useless signals into fair DX-copy.

DX MONITOR

AUDIO PROCESSING

The audio side of the set-up is uncomplicacted: the "Racal" has only a small panel speaker for monitoring purposes, whilst the "CAT" has no loudspeaker of any kind - both, of course, are provided with a variety of outlets for taping and other purposes and these are brought out to suitable sockets on my control panel. The main audio feeds from each are switchable to an old "Tripletone" amplifier (top left) which has the valuable asset of providing control over bass, treble and middle-range audio frequencies - a great asset in eliminating a lot of background 'mush' from a signal. The small box-of-tricks on the top-right of the picture (surmounted by an S-meter connected to the "Racal") is another device for 'cleaning-up' the audio delivered by the receiver and is to a design of ETI's Editor, Halvor Moorshead, when he was associated with "Practical Wireless": briefly, this "Audio Processing Unit" helps to eliminate heterodynes by selective attenuation of some of the audio frequencies.

Some readers suggested - perish the thought! - that our picture was posed, as the pair of headphones I was wearing were not connected to a receiver. Sorry to disappoint you but for reasons of convenience I prefer to use stereo 'phones — they are much more comfortable for late-night listening — so I've duplicated the 'phone output of the "Racal" and the "CAT" on the control panel. In the picture, the "Racal" 'phone socket is feeding directly into the "A.F. Processing Unit" and I am monitoring the resulting signal from the socket on the control panel. One mark for me!

CONTROL PANEL

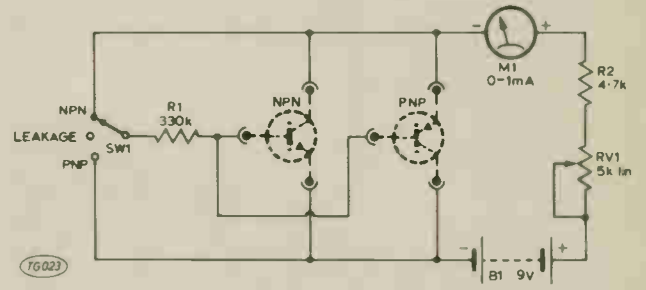
You can not see the complete Control Panel in the picture but it really consists of a hardboard drawer which slides into the racking on which all this gear is mounted, and has a plywood front panel. However often it is said "Electricity is dangerous" so a large red neon glows when any mains-operated equipment circuit is 'live' even if the equipment is switched off. Everyone in the house knows that in an emergency knocking off that red neon-cum-switch puts everything out of action! These DPST plus neon switches are not cheap but their price could be the price of a human life so they are worth fitting even though they may never be needed. Each piece of equipment is switched on-and-off by means of a small push-button switch and has its associated neon indicating that the circuit is 'live'.

The remainder of the panel is taken up with the controls for the "pi-network coupler", mentioned earlier: switches for routing the routing of aerials to the receivers: switches for routing the audio to the amplifier and to tape-recorder sockets and so on. The aim has been to make DXing as easy as possible and to avoid having to stop operating to connect in a tape-recorder or some other gadget. It is a custom-built job and I would recommend anyone embarking on such a project to spend a lot of time in the design stage so as to get something that really suits their needs. Such a panel is expensive to build both in money terms and in time spent on the work and is not easy to modify at a later stage: this is my third essay in this field and 18 months after it was built I can already see that next Winter is likely to have me building Version No. 4 to accommodate various ideas that have since sprung to mind. Some prospect!

That then is my shack, or, at least, part of it. I've not mentioned the lazy DXers best friend — a time switch which allows you to check a channel whilst you are tucked up snug in bed! — nor the tape-recorders, nor the reference works that one needs nor........ But those are all subjects that must wait until next time we talk about shacks. See you next month, but for the present "So long" and Good Dxing! Reports as usual should be sent to me at 16 Ena Avenue, Neath, Glamorgan SA11 3AD and if you want a reply enclose an s.a.e.

eti TECH-TIPS

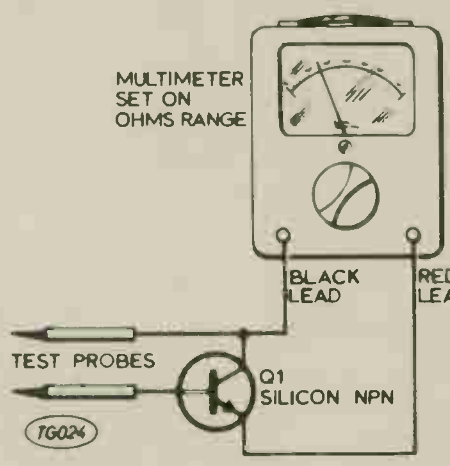
BASIC TRANSISTOR TESTER



There are a number of parameters which determine a transistor's performance but the main ones for low voltage use are leakage and gain. The circuit shown above will indicate both. Two transistor sockets are required, one for NPN devices, the other for PNP; this simplifies switching. With the switch SW1 set on leakage the current passing through the device is indicated on the meter: modern transistors, even germanium types should show only the tiniest reading if any at all. For gain R1 is applied between base and collector. RV1 should be adjusted so that short-circuiting the emitter-collector contacts just registers full scale deflection.

Gain can be directly calibrated onto the scale but this is best done by noting deflections given by inserting transistors of known quality.

MEASURING HIGH RESISTANCE ON LOW SENSITIVITY METERS



Many inexpensive multimeters are unable to give useful readings on the ohms range much above 47k. However, by using almost any silicon NPN transistor (BC107 for example) in the arrangement shown will give considerable deflections for quite high values. The meter's scale will not apply but by noting the readings from high tolerance, high value resistors and some interpolation, fairly accurate measurements can be made. Note that on a multimeter the Black (negative) lead connects to the battery positive on the ohms range.

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- C & G Telecomm. Tech. ☐
- Prac. Rad. Elec. (with kit) ☐
- Radio Amateurs Exam. ☐
- Radio Servicing & Repairs ☐
- Radio & TV Eng. ☐
- Trans. Course ☐
- TV Main. & Serv. ☐

AUTO & AERO
- Aero Eng. ☐
- A.M.I.M.I. ☐
- A.E.C. Cert. ☐
- Auto Engineer. ☐
- Auto Repair ☐
- C & G Auto. Eng. ☐
- Garage Management ☐
- MAA/IMI Dipl. ☐
- Motor Vehicle Mechanics ☐

CONSTRUCTIONAL
- A.M.S.E. (Civil) ☐
- Architecture ☐

Constructional-cont.
- Building ☐
- Building Drawing ☐
- Build. Foreman ☐
- Carpentry & Join. ☐
- Civil & Municipal Engineering ☐
- Constructional Engineering ☐
- Construction Surveyors Institute ☐
- Clerk of Works ☐
- Council Eng. ☐
- Geology ☐
- Health Eng. ☐
- Heat & Vent. ☐
- Hydraulics ☐
- Inst. of Builders ☐
- Inst. Works & Highway Sup. ☐
- Painting & Dec. ☐
- Public Hygiene ☐
- Road Engineer. ☐
- Structural Eng. ☐
- Surveying ☐

GENERAL
- Agricultural Eng. ☐
- Council of Eng. Inst. ☐
- Farm Science ☐
- General Educat. ☐
- Gen. Plastics ☐
- Pract. Maths ☐
- Pract. Slide Rule ☐
- Pure & Applied Maths ☐
- Refrigeration ☐
- Rubber Tech. ☐
- Sales Engineers ☐
- Tech. Report Writing ☐
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