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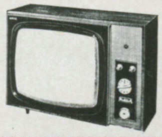

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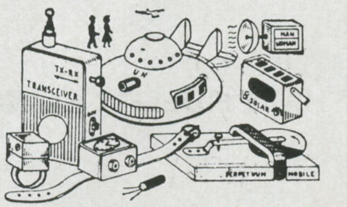

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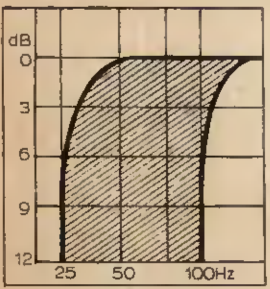
New for Project 60

Active Filter Unit

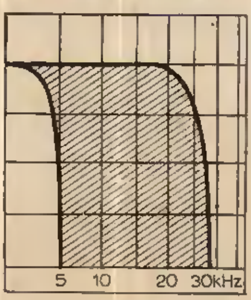
The Sinclair Active Filter Unit is a new addition to our Project 60 range of high fidelity modules and is designed to complement the other modules in the range. Its performance is such, however, that users of other amplifier systems might well consider adding it to their assemblies.

The purpose of a filter unit is to reject frequencies above (scratch) or below (rumble) a specific cut off frequency when these frequencies contain unwanted interference. The Sinclair A.F.U. is unique in that the cut off frequency is continuously variable for both the scratch and rumble units and, as the attenuation in the rejection band is rapid (12dB per octave), the removal of interference can be achieved with less loss of the wanted signal than has previously been possible.

Each channel of the A.F.U. has an overall gain of unity and, as the imput impedance is high and the output impedance is low, it may be connected between the pre-amplifier and power amplifier sections of any amplifier. Both amplitude and phase distortion have been made quite negligible by the careful design and the large amount of negative feedback employed.



HIGH PASS

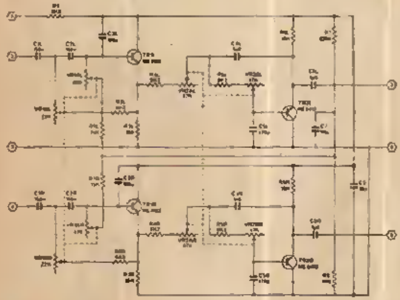


LOW PASS

Specifications

Designed for connection between the Stereo 60 pre-amplifier and two Z-30 or Z-50 power amplifiers.
Employs two Sallen & Key type active filter stages, the first being a rumble (high pass) filter and the second a scratch (low pass) filter. The two stages use complementary transistors to minimise distortion.
Supply voltage 15 to 35V Current 3mA max.
Gain at 1kHz, filters flat 0.98 (—0.2dB)
H.F. cut off (—3dB) variable from 28kHz to 5kHz
H.F. filter slope 12dB/octave
L.F. cut off (—3dB) variable from 25Hz to 100Hz
L.F. filter slope 12dB/octave
Distortion at 1kHz (35v supply) 0.02% at rated output (250mV R.M.S.)
Frequency response, flat position, 35Hz to 20kHz—1dB
25Hz to 28kHz—3dB

Built, tested and guaranteed **£5.19.6**



Circuit Diagram of Sinclair Active Filter Unit

Z-50 FORTY WATT R.M.S. (80 WATT PEAK) HIGH FIDELITY POWER AMPLIFIER

The Z-50 has been designed for applications requiring higher output power than the Z-30. The maximum supply voltage is raised to 50 Volts and the output power is **40 watts continuous R.M.S. in to 3 or 4 ohms and 30 watts continuous into 8 ohms.** The Z-50 is otherwise identical to the Z-30 in design and specification, the increased power being obtained by using much higher current power transistors used well within their rated limits.

The Z-50 is, of course, compatible with the other Project 60 modules, such as the Stereo 60, and since the price is only 20/- higher than that of the Z-30, customers may like to consider the advantages of buying two Z-50's for their systems now in case higher power is required later.

Where the full output power is not required the Z-50 may be used with the PZ-5 or PZ-6 but for the full output power the PZ-8 should be used. This unit is a stabilised power supply providing 45 volts at up to 3 amps. It is supplied without mains transformer as it is designed for use with a readily available "Radiospares" unit.

SINCLAIR Z-50.

Z-50 built, tested and guaranteed **£5.9.6** *PZ-8* **£5.19.6**

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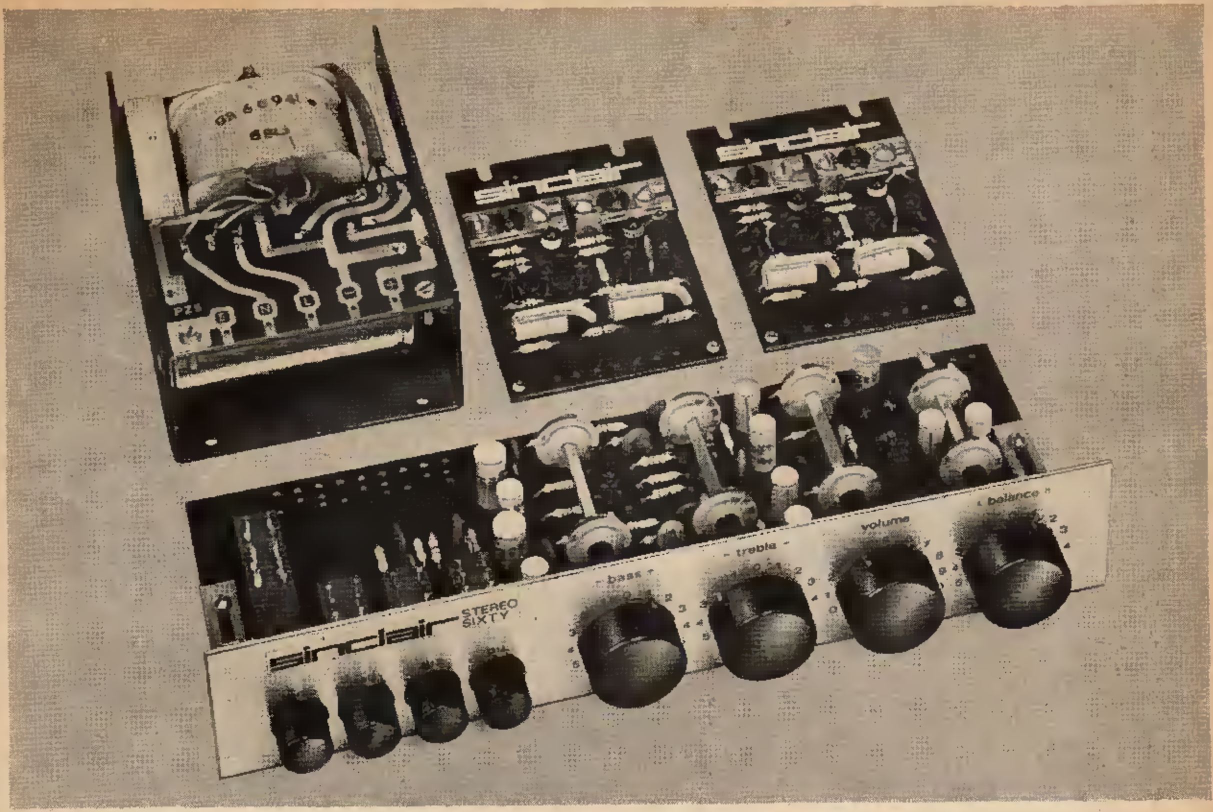

Project 60 an exciting alternative

It is not likely that anyone purchasing an amplifier today would have difficulty in finding one that met all his requirements, although the price might not be as low as could be wished. But one's needs can change, also the technically correct amplifier may be physically inconvenient. If there is an amplifier available, of the right size and price, to meet all your needs for the foreseeable future, then that is your best buy. If not, we offer a possibility which we believe to be an exciting alternative approach. That alternative is **Project 60.**

Project 60 now comprises a range of modules which connect together simply to form a complete stereo amplifier with really excellent performance. So good, in fact, that only 2 or 3 amplifiers in the world can compare in overall performance. Now with the addition of three new modules to the range, the constructor has choice of assemblies with either 20 or 40 watts output per channel, with or without filter facilities.

The modules now are: **1.** The Z-30 and Z-50 high gain power amplifiers, each of which is an immensely flexible unit in its own right. **2.** The Stereo 60 pre-amplifier and control unit. **3.** The Active Filter unit with both high and low audio frequency cut—offs. **4.** The PZ-5 and PZ-6 power supplies. A complete system could comprise, for example, two Z-30's, one Stereo-60, and a PZ-5. The P-Z6 is stabilised and should be used where the highest possible continuous sine wave rating is required. An A.F.U. may be added later. In a normal domestic application, there will be no significant difference between using PZ-5 or PZ-6 unless loudspeakers of very low efficiency are being used, in which case the PZ-6 will be required. For assemblies using two Z-50's there is the new PZ-8 stabilised supply unit to ensure maximum performance from these amplifiers.

All you need to assemble your Project 60 system is a screwdriver and soldering iron. No technical skill or knowledge whatsoever is required and, in the unlikely event of you hitting a problem, our customer service and advice department will put the matter right promptly and willingly. Project 60 modules have been carefully designed to fit into virtually all modern plinth or cabinets and only holes need be drilled into the wood of the plinth to mount the control unit. Any slight slip here will be covered by the aluminium front panel of the Stereo 60. The Project 60 manual gives all the buildings and operating instructions you can possibly want, clearly and concisely. Perhaps the greatest beauty of the system is that it is not only flexible now but will remain so in the future as the latest additions to the range show. A stereo F.M. tuner is next to come. These and all other modules we introduce will be compatible with those already available and may be added to your system at any time. And because Sinclair are the largest producers of constructor modules in Europe, Project 60 prices are remarkably low.

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Z.30 TWENTY WATT R.M.S. (40 WATT PEAK) HIGH FIDELITY POWER AMPLIFIER

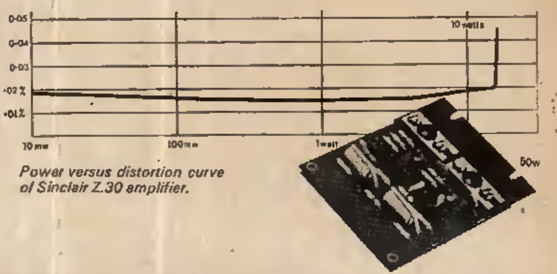
The Z.30 is a complete power amplifier of very advanced design employing 9 silicon epitaxial planar transistors. Total harmonic distortion is incredibly low being only 0.02% at full output and all lower outputs. As far as we know, no other high fidelity amplifier made can match this specification, no matter what the price. Thus you can be utterly certain that your Project 60 system will do full justice to your other equipment however good it may be. The Z.30 is unique in that it will operate perfectly, without adjustment, from any power supply from 8 to 35 volts. It also has sufficient gain to operate directly from a crystal pickup. So in addition to its use in a high fidelity system you can use a Z.30 to advantage in your car or a battery operated gramophone for your children, for example. These, and many other applications of the Z.30 are covered in the manual of circuits and instructions supplied with every Z.30 high fidelity power amplifier.

SPECIFICATIONS

Power output—15 watts R.M.S. into 8 ohms using a 35 volt supply: 20 watts R.M.S. into 3 ohms using a 30 volt supply.
Output—Class AB.

Frequency response:	30 to 300,000 Hz ± 1dB.
Distortion:	0.02% total harmonic distortion at full output into 8 ohms and at all lower output levels.
Signal-to-noise ratio:	better than 70dB unweighted.
Input sensitivity:	250mV into 100Kohms.
Damping factor:	>500.
Loudspeaker impedances:	3 to 15 ohms.
Power requirements:	From 8 to 35 V. d.c.(The Z.30 will operate ideally from batteries if required.)
Size:	3½ x 2¼ x ½ inches.

APPLICATIONS
Hi-fi amplifier; car radio amplifier; record player amplifier fed directly from pick-up; intercom; electronic music and instruments; P.A.; laboratory work, etc. Full details for these and many other applications are given in the manual supplied with the Z.30.



Power versus distortion curve of Sinclair Z.30 amplifier.

Z.30
Built, tested and guaranteed, with circuits and instructions manual

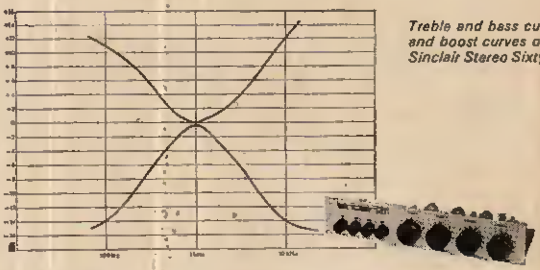
89/6

STEREO 60 PRE-AMPLIFIER AND CONTROL UNIT

The Stereo 60 is a stereo preamplifier and control unit designed for the Project 60 range but suitable for use with any high quality power amplifier. Again, silicon epitaxial planar transistors are used throughout and great attention has been paid to achieving a really high signal-to-noise ratio and excellent tracking between the two channels. Input selection is by means of push buttons and accurate equalisation is provided for all the usual inputs. The tone controls are also very carefully designed and tested.

SPECIFICATIONS

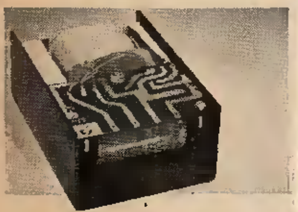
- Input sensitivities—Radio—up to 3mV Magnetic Pickup—3mV; correct to R.I.A.A. curve ± 1dB; 20 to 25,000 Hz. Ceramic Pickup—up to 3mV; Auxiliary—up to 3mV.
- Output—250mV
- Signal-to-noise ratio—better than 70dB.
- Channel matching—within 1dB.
- Tone Controls—TREBLE +15 to —15dB. at 10 KHz: BASS +15 to —15dB at 100 Hz.
- Power consumption 5mA.
- Front panel—brushed aluminium with black knobs and controls.
- Size 8¼ x 1½ x 4 ins.



Treble and bass cut and boost curves of Sinclair Stereo Sixty

Ready for immediate installation **£9. 19s. 6d.**

SINCLAIR MAINS POWER SUPPLY UNITS



PZ-5 *30 volts unstabilised—sufficient to drive two Z.30's and a Stereo 60 for the majority of domestic applications.* **£4.19.6**

PZ-6 *35 volts stabilised—ideal for driving two Z.30's and a Stereo 60 when very low efficiency speakers are employed.* **£7.19.6**

PZ-8 *45 volts power supply unit for use with Z.50 amplifiers (less mains transformer)* **£5.19.6**

BUILDING A PROJECT 60 ASSEMBLY

The illustration here shows quite clearly how easily Project 60 can be contained in one of today's slim, modern plinths. Very little space is required to house these Sinclair units, and within the space of the motor plinth, you can install a stereo amplifier of the very highest quality. If, for example you have already put together an assembly as illustrated here, adding the Active Filter Unit would be very easy.

GUARANTEE

If at any time within 3 months of purchasing Project 60 modules from us, you are dissatisfied with them, we will refund your money at once. Each module is guaranteed to work perfectly and should any defect arise in normal use we will service it at once and without any cost to you whatsoever provided that it is returned to us within 2 years of purchase date. There will be a small charge for service thereafter. No charge for postage by surface mail. Air-mail charged at cost.

IC.10 MICROMATIC AND Q.16. *Please see next page*

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SINCLAIR IC.10

MONOLITHIC INTEGRATED CIRCUIT HI-FI AMPLIFIER COMBINED WITH PRE-AMP

The Sinclair IC-10 is the world's first monolithic integrated circuit high fidelity power amplifier and pre-amplifier. The circuit itself, a chip of silicon only a twentieth of an inch square by one hundredth of an inch thick, has 5 watts R.M.S. output (10w. peak). It contains 13 transistors (including two power types), 2 diodes, 1 zener diode and 18 resistors, formed simultaneously in the silicon by a series of diffusions. The chip is encapsulated in a solid plastic package which holds the metal heat sink and connecting pins. This device is more rugged and reliable than any previous amplifier and has considerable performance advantages. The most important are complete freedom from thermal runaway and very low level of distortion.

The IC-10 is primarily intended as a full performance high fidelity power and pre-amplifier, for which application it only requires the addition tone and volume control network and a battery or mains power supply. The IC-10 may be used simply in many other applications including car radios, electronic organs, servo amplifiers (it is d.c. coupled throughout). Stabilised power supply, oscillator, etc. The pre-amp section can be used as R.F. or I.F. amplifier. We give a full guarantee on every IC-10 knowing that every unit will work as perfectly as the original and do so for a lifetime.

SPECIFICATIONS

Output:	10 Watts peak. 5 Watts R.M.S. continuous
Frequency response:	5 Hz to 100 kHz ± 1dB
Total harmonic distortion:	Less than 1% at full output.
Load impedance:	3 to 15 ohms.
Power gain:	110dB (100,000,000,000 times) total.
Supply voltage:	8 to 18 volts.
Size:	1 x 0.4 x 0.2 inches.
Sensitivity:	5mV.
Input impedance:	Adjustable externally up to 2.5 M ohms.

3 transistors are used in the pre-amp and 10 in the power amplifier. Class AB output with closely controlled quiescent current which is independent of temperature. Generous negative feedback round both sections, completely free from cross-over distortion at all supply voltages, making battery operation eminently satisfactory.

With comprehensive manual of circuits & instructions Post free. **59/6**

SINCLAIR MICROMATIC

In kit complete with earpiece, case, instructions and solder in fitted pack.

49/6

Ready built, tested and guaranteed, with earpiece.

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Mallory Mercury Cell, RM675 (Two needed) 2/9 each.

A powerful high quality radio smaller than a matchbox

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Q.16 an outstandingly fine loudspeaker

Developed on entirely original design principles, this compact, beautifully styled shelf-speaker accepts up to 14 watts R.M.S. loading at 8Ω. Frequency response 60—16,000 Hz. Size 9¾" square x 4½" deep, on plinth. Teak surround, with all-over cellular foam front and special seamless sealed sound chamber.

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Sinclair Project 60—see previous three pages

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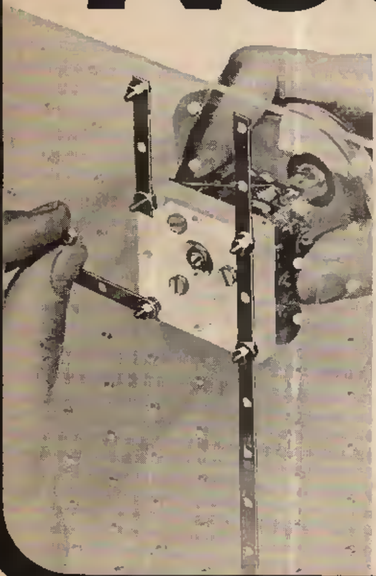

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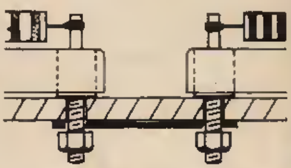

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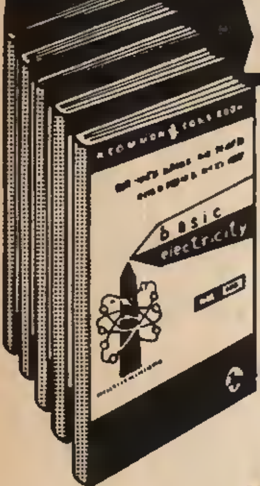

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2N711A	7/6
2N721	11/-
2N743	4/-
2N744	6/-
2N753	5/-
2N865	12/6
2N914	4/6
2N916	4/6
2N918	7/6
2N919	4/-
2N920	5/-
2N922	8/6
2N930	7/6
2N1090	6/-
2N1091	6/6
2N1131	6/-
2N1132	8/-
2N929	4/6
2N1303	4/6
2N1304	5/-
2N1305	5/-
2N1306	5/-
2N1307	5/-
2N1308	6/-
2N1309	5/-
2N1420	18/6
2N1483	9/6
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2N2147	17/6
2N2160	15/-
2N2287	25/-
2N2297	9/6
2N2484	7/6
2N2646	10/6
2N2784	10/-
2N2904	8/6
2N2905	10/-
2N2925	4/-
2N2926	2/6
2N3011	7/6
2N3053	5/-
2N3054	12/6
2N3055	15/-
2N3133	8/-
2N3136	6/-
2N3142	7/6
2N3232	15/-
2N3233	15/-
2N3235	30/-
2N3228	10/-
2N3528	9/6
2N3702	3/6
2N3703	3/6
2N3704	4/-
2N3705	8/6
2N3707	4/-
2N3709	3/6
2N3710	3/-
2N3135	6/-
2N3794	2/6

2N3711	3/6
2N3730	10/-
2N3731	12/6
2N3819	8/-
2N3820	19/6
2N3823	17/6
2N4058	5/6
2N4061	4/-
2N4286	3/-
2N4288	3/-
2N4289	3/6
2N4290	3/-
2N4291	3/-
2N4292	3/-
40361	12/-
40362	13/6
2S001	10/-
2S002	10/6
2S003	9/6
2S004	9/6
2S005	15/-
2S012	25/-
2S012A	22/6
2S013	20/-
2S013A	25/-
2S017	15/-
2S018	17/6
2S020	50/-
2S024	50/-
2S025	60/-
2S026	100/-
2S034	12/6
2S036	25/-
2S102	10/-
2S103	12/6
2S104	12/6
2S131	7/6
2S301	6/-
2S302	7/6
2S303	10/-
2S304	12/6
2S305	15/-
2S320	9/-
2S321	6/-
2S322	7/6
2S323	10/-
2S324	12/6
2S501	8/6
2S502	8/6
2S503	9/6
2S512	9/6
2S701	8/6
2S702	11/-
2S724	50/-
2S731	8/6
2S732	8/6
2S733	9/6
2S743	50/-
2S745A	30/-
AA129	4/-
AA178	8/6
AAY11	2/-
AAY12	5/-
AAZ12	4/-
AAZ13	2/6
AAZ17	2/-
AC126	5/-
AC127	5/6
AC127Z	12/6
AC128	5/-
AC154	8/-
AC169	3/-
AC153	4/-
AC176	5/-
AC187	5/-
AC188	6/-
ACY17	6/-
ACY18	4/-
ACY19	5/-
ACY20	4/-
ACY21	4/6
ACY22	3/6
ACY28	3/6
ACY34	4/-
ACY36	5/-
ACY39	9/6
ACY40	3/-
AD140	11/-
AD149	12/6
AD161	7/6
AD162	7/6
ADT140	10/-
ADZ11	24/6
ADZ12	29/6
AEY11	10/-
AEY12	12/6
AF102	15/-
AF114	6/6
AF115	6/-
AF116	6/6
AF117	5/-

AF118	12/6
AF124	6/-
AF125	5/-
AF126	4/-
AF127	4/-
AF139	6/-
AF178	9/6
AF181	8/6
AF186	9/-
AF239	8/-
AFY19	22/6
AFZ11	8/-
AFZ12	10/-
ASY26	6/6
ASY27	7/6
ASY28	6/6
ASY29	6/-
ASY36	5/-
ASY50	3/6
ASY51	8/-
ASY67	9/6
ASY83	6/-
ASY86	6/6
ASZ21	8/6
ASZ23	20/-
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AU101	30/-
B3M	19/6
BA110	5/-
BAY31	2/-
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BC108	2/9
BC109	3/-
BC113	6/-
BC116	8/-
BC118	7/6
BC134	7/6
BC135	6/-
BC136	7/-
BC137	8/-
BC138	8/-
BCY30	5/6
BCY31	8/6
BCY32	10/-
BCY33	5/-
BCY34	6/-
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BFY20	12/6
BFY50	5/-
BFY51	4/6
BFY52	5/-
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BLY10	20/-
BLY11	22/6
BPY10	19/6
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BSX21	5/-
BSX76	4/-
BSY27	4/-
BSY28	5/-
BSY29	5/-
BSY50	5/-
BSY51	5/-
BSY53	5/-
BSY64	5/-
BSY65	5/-

BSY66	5/-
BSY67	5/-
BSY95A	4/6
BSY95	3/-
BTY42	18/6
BTY79/400R	35/-
BTY84	12/6
BTY88	15/-
BUY10	12/6
BUY11	18/6
BY100	3/6
BY103	4/6
BY114	5/-
BY126	5/-
BYX22/600	5/3
BYZ10	10/-
BYZ11	9/-
BYZ12	8/-
BYZ13	5/-
BYZ15	20/-
BYZ16	12/6
BZY88C3V3	4/-
BZY88C4V7	4/-
BZY88C5V6	4/-
BZY88C5V1	4/-
BZY88C6V8	4/-
BZY88C7V5	4/-
BZY88C8V2	4/-
BZY88C9V1	4/-
BZY883V0	4/-
BZY886V2	4/-
BZY94C10	4/-
BZY94C11	4/-
BZY94C12	4/-
BZY94C15	4/-
BZY94C16	4/-
CP404	12/6
CRS1/05	5/-
CRS1/10	5/-
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CRS1/30	8/-
CRS1/35	8/6
CRS1/40	9/6
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DD006	3/9
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DK110	1/6
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FST1/1	3/-
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FST2/1	3/-
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FST3/8	6/-
FST3/05 AF	3/-
GET102	6/-
GET103	4/6
MPF102	8/6
MPF103	7/-
MPF104	7/6
MPF105	8/-
OA5	3/-
OA7	4/-
OA9	3/-
OA10	4/-
OA47	2/-
OA70	2/-
OA71	2/-
OA73	2/-
OA74	2/-
OA79	2/-
OA81	2/-
OA85	2/6
OA86	4/-
OA90	2/-
OA91	1/6

OA95	1/6
OA200	1/9
OA202	2/-
OA210	6/-
OA211	9/6
OAZ200	11/-
OAZ201	10/-
OAZ202	8/6
OAZ203	8/6
OAZ204	9/6
OAZ205	8/6
OAZ206	8/6
OAZ207	9/6
OAZ208	6/6
OAZ209	6/6
OAZ210	6/6
OAZ211	6/6
OAZ212	6/6
OAZ213	9/6
OAZ222	9/6
OAZ223	7/6
OAZ224	7/6
OAZ225	7/6
OAZ228	7/6
OAZ229	9/6
OAZ231	9/6
OAZ234	7/6
OAZ238	9/6
OAZ241	4/6
OAZ242	4/6
OAZ244	4/6
OAZ245	4/6
OAZ246	4/6
OAZ247	4/6
OAZ272	4/6
OAZ290	7/6
OAZ291	7/6
OAZ292	7/6
OC16	10/-
OC19	7/6
OC20	19/6
OC22	9/6
OC23	12/6
OC24	12/6
OC25	7/6
OC26	5/-
OC28	12/6
OC29	12/6
OC35	10/-
OC36	12/6
OC41	5/-
OC42	6/-
OC43	8/-
OC44	4/-
OC44M	4/-
OC45	3/6
OC45M	3/6
OC46	5/6
OC57	12/-
OC58	12/-
OC59	13/-
OC70	3/-
OC71	3/-
OC72	5/-
OC73	6/-
OC74	6/-
OC75	5/-
OC76	5/-
OC77	8/-
OC78	5/-
OC78D	2/6
OC79	4/6
OC81	5/-
OC81D	4/-
OC81M	5/-
OC81DM	3/-
OC81Z	7/6
OC82	5/-
OC82D	3/-
OC83	5/-
OC84	5/-
OC122	10/-
OC123	10/-
OC139	5/-
OC140	7/6
OC141	15/-
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ACY17	3/–	2G303	2/6
AF114	4/–	2N711	10/–
AF115	3/6	2N1302-3	4/–
AF116	3/6	2N1304-5	5/–
AF117	3/6	2N1306-7	6/–
AF239	12/6	2N1308-9	8/–
AF186	10/–	2N3844A	5/–
AF139	10/–	**Power Transistors**	
BFY50	4/–		
BSY25	7/6	OC20	10/–
BSY26	3/–	OC23	10/–
BSY27	3/–	OC25	8/–
BSY28	3/–	OC26	5/–
BSY29	3/–	OC28	7/6
BSY95A	3/–	OC35	5/–
OC41	2/6	OC36	7/6
OC44	2/6	AD149	10/–
OC45	2/6	AUY10	30/–
OC71	2/6	2S034	10/–
OC72	2/6	2N3055	15/–
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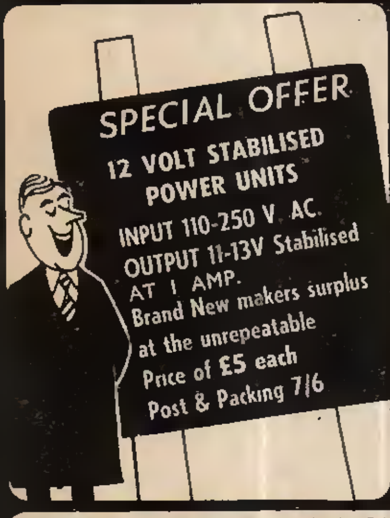

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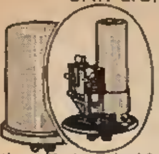

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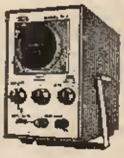

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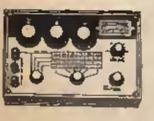


A new portable bridge offering excellent range and accuracy at low cost. Ranges: R. 1Ω-11·1 megΩ 6 Ranges ±1%. L.1 μH - 111 HENRYS 6 Ranges -2%. C. 10pF -1110mFd. 6 Ranges ±2%. TURNS RATIO 1:1/1000-1:11100. 6 Ranges ±1%. Bridge voltage at 1,000 cps. Operated from 9 volts. 100μA. Meter indication. Attractive 2 tone metal case. Size 7½: 5:2in. £20. P. & P. 5/-.

UNR-30 4-BAND COMMUNICATION RECEIVER

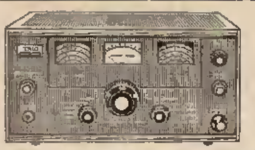
Covering 550 Kc/s-30 Mc/s. Incorporates BFO. Built-in speaker and phone jack. Metal cabinet. Operation 220/240V. a.c. Supplied brand new, guaranteed with instructions. Carr. 7/6 **13 gns.**

TRIO JR-310 NEW AMATEUR BAND 10-80 METRE RECEIVER. In stock. £77.10.0.

LAFAYETTE SOLID STATE HA600 RECEIVER

5 BAND AM/CW/SSB AMATEUR AND SHORT WAVE 150 kc/s-400 kc/s and 550 kc/s-30 Mc/s F E T front end ● 2 mechanical filters ● Huge dial ● Product detector ● Variable BFO ● Noise limiter ● S meter ● 24in Bandspread ● 230V a.c./12V d.c. neg. earth operation ● RF gain control. Size 15in × 9½in × 8½in. Weight 18lb. EXCEPTIONAL VALUE. £45. Carr. 10/-. S.A.E. for full details.

TRIO COMMUNICATION RECEIVER MODEL 9R-59DE

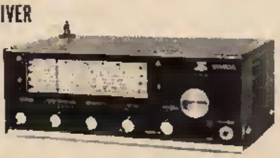


4 band receiver covering 550Kc/s to 30Mc/s. continuous and electrical bandspread on 10, 15, 20, 40 and 80 metres. 8 valve plus 7 diode circuit. 4/8 ohm output and phone jack. SSB-CW ● ANL ● Variable BFO ● S meter ● Sep. bandspread dial ● IF 455Kc/s ● Audio output 1·5W. ● Variable RF and AF gain controls. 115/250V A.C. Mains. Beautifully designed. Size: 7 × 15 × 10in. With instruction manual and service data. £42 Carriage paid.

TRIO COMMUNICATION TYPE HEADPHONES Normally £5.19.6.
OUR PRICE £3.15.0 if purchased with above receiver.

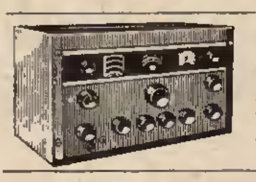
TRIO JR-500SE 10-80 Metre AMATEUR RECEIVER £65	**TRIO TS 510 AMATEUR TRANSCEIVER with speaker and mains P.S.U. £180**

UR-1A SOLID STATE COMMUNICATION RECEIVER



4 bands covering 550 Kc/s-30 mc/s continuous. Special features are use of FET transistors, S meter, built in speaker and telescopic aerial, variable BFO for SSB reception, noise limiter, bandspread control, sensitivity control. Output for low impedance headphones. Operation 220/240 volt A.C. or 12 volt D.C. Size 12½" × 4½" × 7". Excellent value. ONLY £24. Carr. 7/6.

LAFAYETTE HA.800 6-BAND AMATEUR RECEIVER. £57.10.0. Carr. Paid.



RCA COMMUNICATION RECEIVER AR88D

Latest release by ministry BRAND NEW in original cases. 110-250V a.c. operation. Frequency in 6 Bands. 535Kc/s-32Mc/s continuous. Output impedance 2·5-600 ohms. Incorporating crystal filter, noise limiter, variable BFO, variable selectivity, etc. Price £65. Carr. £2.

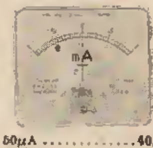
LAFAYETTE PF-60 SOLID STATE VHF FM RECEIVER

A completely new transistorised receiver covering 152-174 Mc/s. Fully tuneable or crystal controlled (not supplied) for fixed frequency operation. Incorporates 4 INTEGRATED CIRCUITS. Built in speaker and illuminated dial. Squelch and volume controls. Tape recorder output. 75Ω aerial input. Headphone jack. Operation 230V. A.C./12V. D.C. Neg. earth. £37.10.0. Carr. 10/-.

TELETON MODEL CR 10T AM/FM STEREO TUNER AMPLIFIER

A new model from Teleton. 31 solid state devices. 4 + 4 watt output. Inputs for ceramic/crystal cartridge. Frequency range AM 540-1600 KHz FM 88-108 MHz. Automatic FM stereo reception. Stereo indicator. Controls: Tuning, function selector, Tone and R & L volume controls. AFC switch. Stereo headphone socket. Size: 13½" × 3½" × 9½" approx. Price £34. Carr. 7/6.

CLEAR PLASTIC PANEL METERS

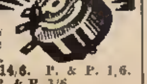


First grade quality Moving Coil panel meters.
Type MR 38P. 1 21/32in square fronts.

	500-0-500μA 27/6	50mA 27/6	150V. D.C....27/6
	1mA 27/6	100mA 27/6	300V. D.C....27/6
	1-0-1mA 27/6	150mA 27/6	500V. D.C....27/6
	2mA 27/6	200mA 27/6	750V. D.C....27/6
	5mA 27/6	300mA 27/6	15V. A.C.....27/6
	10mA 27/6	500mA 27/6	50V. A.C 27/6
50μA 40/-	750mA 27/6	3V. D.C......27/6	150V. A.C....27/6
50-0-50μA 37/6	1 amp 27/6	10V. D.C.....27/6	300V. A.C....27/6
100μA 37/6	2 amp 27/6	20V. D.C.....27/6	500V. A.C....27/6
100-0-100μA 35/-	5 amp 27/6	20V. D.C.....27/6	S meter 1mA. 32/-
200μA 35/-	20mA 27/6	100V. D.C....27/6	VU meter....42/-
500μA 40/-			

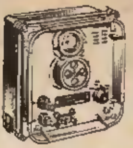
Full range of other sizes in stock. Send s.a.e. for leaflet.

POWER RHEOSTATS



High quality ceramic construction. Windings embedded in vitreous enamel. Heavy duty brush wiper. Continuous rating. Wide range ex-stock Single hole fixing, ¼in. dia. shafts. Bulk quantities available.
25 WATT. 10/25/50/100/250/500/1,000/1,500/2,500 or 5,000 ohms, 14/6. P. & P. 1/6.
50 WATT. 10/25/50/100/250/500/1,000/2,500 or 5,000 ohms, 21/-. P. & P. 1/6.
100 WATT. 1/5/10/25/50/100/250/500/1,000 or 2,500 ohms, 27/6. P. & P. 1/6.

CRYSTAL CALIBRATORS No. 10



Small portable crystal controlled wavemeter. Size 7" × 7½" × 4". Frequency range 500 Kc/s. 10 Mc/s (up to 30 Mc/s on harmonics). Calibrated dial. Power requirements 300 V.D.C. 15mA and 12 V.D.C. 0.3A. Excellent condition. 39/6. Carr. 7/6.

T.E.40 HIGH SENSITIVITY A.C. VOLTMETER

10 meg. input 10 ranges: ·01 / ·003 / ·1 / ·3 / 1 / 3 / 10 / 30 / 100 / 300V. R.M.S. 4c/s.-1·2Mc/s. Decibels −40 to +50dB. Supplied brand new complete with leads and instructions. Operation 230V a.c. £17.10.0. Carr. 5/-.

LELAND MODEL 27 BEAT FREQUENCY OSCILLATORS

Frequency 0-20 Kc/s on 2 ranges. Output 500Ω or 5kΩ. Operation 200/250V. A.C. Supplied in perfect order. £12.10.0. Carr. 10/-.

TE-65 VALVE VOLTMETER

High quality instrument with 28 ranges. D.c. volts 1·5-1,500V. A.c. volts 1·5-1,500V. Resistance up to 1,000 megohms. 220/240V a.c. operation. Complete with probe and instructions. £17.10.0. P. & P. 6/-. Additional Probes available: R.F 35/-. H.V. 42/6.

COSSOR 1049 DOUBLE BEAM OSCILLOSCOPES

D.c. coupled. Band width 1kc/s. Perfect order. £25. Carr. 30/-.

AM/FM SIGNAL GENERATORS

Oscillator Test No. 2. A high quality precision instrument made for the ministry by Airmec. Frequency coverage 20-80Mc/s. AM. C.W./FM. Incorporates precision dial, level meter, precision attenuator 1μV-100mV. Operation from 12V d.c. or 0/110/200/250V A.C. Size 12 × 8½ × 9in. Supplied in brand new condition complete with all connectors fully tested. £45. Carr. 20/-.

PLESSEY SL 403A

3 watt Integrated Amplifier Circuit
49/6 POST PAID

EDDYSTONE VHF RECEIVERS MODEL 770R. 19-165 Mc/s. Excellent condition. £150

TE-15A Transistorised Signal Generator. 5 ranges 400 kHz-30 mHz. An inexpensive instrument for the handyman. Operates on 9v battery. Wide, easy to read scale. 800 kHz modulation. 5¼ × 5¼ × 3½. Complete with instructions and leads. £7.19.6. P.&P. 4/-.

HOSIDEN DH-02S STEREO HEADPHONES

Wonderful value and excellent performance combined. Adjustable headband. 8 ohm impedance. 20-12,000 cps. Complete with lead and stereo jack plug. ONLY 47/6. P.&P. 2/6.

AUTO TRANSFORMERS

0/115/230v. Step up or step down. Fully shrouded.

150 W.	£2.2.6.	P. & P. 3/6
300 W.	£2.19.6.	P. & P. 4/6
500 W.	£4.10.0.	P. & P. 6/6
1,000 W.	£6.10.0.	P. & P. 7/6
1,500 W.	£7.19.6.	P. & P. 8/6
7,500 W.	£15.10.0.	P. & P. 20/-

G. W. SMITH & CO (RADIO) LTD.
Also see oppos. page

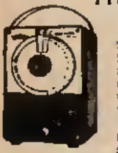
ARF-100 COMBINED AF-RF SIGNAL GENERATOR

A.F. SINE WAVE 20–200,000 c/s. Square wave 20–30,000 c/s. O/P; **HIGH IMP. 21V.** P/P600 Ω 3·8 V; P/P. TF 100 kc/s–300 Mc/s. Variable R.F. attenuation int/ext. modulation. Incorporates dual purpose meter to monitor AF output and % mod. on R.F 220/240 V a.c. **£32.10.0.** Carr. 7/6.

TE-20D RF SIGNAL GENERATOR

Accurate wide range signal generator covering 120kc/s to 500Mc/s on 6 bands. Directly calibrated. Variable RF attenuator, audio output. Xtal socket for calibration. 220/240V a.c. Size 140 × 215 × 170mm. Brand new with instructions. **£15.** Carr. 7/6.

TY75 AUDIO SIGNAL GENERATOR



Sine Wave 20c/s to 200kc/s. Square Wave 20c/s to 30kc/s. High and low impedance output. Output variable up to 6 volts. 220/240 volts a.c. Size 210 × 150 × 120mm. Brand new with instructions. **£16.** Carr. 7/6.

MARCONI TF142E DISTORTION FACTOR METERS. Excellent condition. Fully tested. **£20.** Carr. 15/-.

LAFAYETTE TE46 RESISTANCE CAPACITY ANALYSER

2pF–2,000 mfd 2 ohms–200 megohms. Also checks impedance, turns ratio, insulation, 200/250V a.c.
Brand New £17.10.0. Carr. 7/6.

ADVANCE TEST EQUIPMENT

Brand new and boxed in original sealed cartons.

J1B. AUDIO SIGNAL GENERATOR. 15 c/s to 50 Kc/s. Sine wave. Output 600 ohms or 5 ohms. **£30.0.0.**

VM79. UHF MILLIVOLT METER. 100 Kc/s to 1,000 Mc/s. a.c. 10 mV to 3V. D.c. 10 mV to 3V. Current 0·01 μA to 0·3 mA. Resistance 1 ohm to 10 megohm. **£125.0.0.**

TT1S. TRANSISTOR TESTER. Full range of facilities for testing PNP or NPN transistors in or out of circuit. **£37.10.0.**
Carriage 10/- per item.

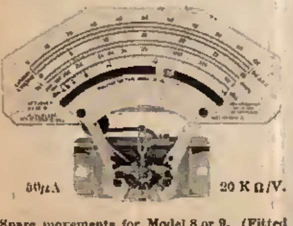
TO-3 PORTABLE OSCILLOSCOPE

3in. tube. Y amp. Sensitivity 0·1v p-p/CM. Bandwidth 1·5 cps–1·5 MHz. Input imp. 2 meg Ω 25pF X amp. sensitivity 0·9v. p-p/CM. Bandwidth 1·5 cps –800 KHz. Input imp. 2 meg Ω 20pF. Time base. 5 ranges 10 cps–300 KHz. Synchronization. Internal/external. Illuminated scale 140 × 215 × 330 mm. Weight 15½ lb. 220/240V. A.C. Supplied brand new with handbook. **£37.10.0.** Carr. 10/-

TE111. DECADE RESISTANCE ATTENUATOR

Variable range 0–111dB. Connections. Unbalanced T and Bridge T. Impedance 600 Ω range (0·1dB × 10) + (1dB × 10) + 10 + 20 + 30 + 40dB. Frequency: d.c. to 200kHz (−3dB). Accuracy: 0·05dB. +indication dB × 0·01. Maximum input less than 4W (50V). Built in 600 Ω load resistance with internal/external switch. Brand new **£27.10.0.** P. & P. 5/-.

AVOMETER MOVEMENTS



50μA 20 KΩ/V.

Spare movements for Model 8 or 9. (Fitted with Model 9 scale) or basis for any multimeter. Brand New and Boxed 69/6. P.&P. 3/6.

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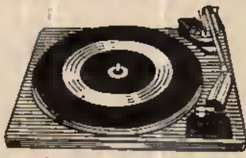
SL65B	£14.19.6		
SL72B	£25. 0.0		
AP75	£16.19.6		

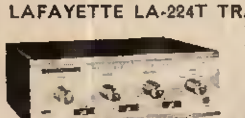


Carriage 7/6 extra each item.

TEAK PLINTHS AND PERSPEX COVERS
1. For SP25, SL65, SL55, 3000, 2025T/C, 2025, 1000. **£4.10.0**
2. For AP75, SL75, SL95. **£5.19.6**
3. For SP25 etc. to operate with lid in place **£5.19.6**

Carriage 7/6 extra each type. Full range of Garrard accessories available.

LAFAYETTE LA-224T TRANSISTOR STEREO AMPLIFIER



19 transistors, 6 diodes, 1HF music power, 30W at 8 Ω. Response 30–20,000 ± 2dB at 1W. Distortion 1% or less. Inputs 3mV and 250mV. Output 3–16 Ω. Separate **L** and **R** volume controls. Treble and bass control. Stereo phone jack. Brushed aluminium, gold anodised extruded front panel with complementary metal case. Size 10½ × 3 9/16 × 7 13/16in. Operation 115/230V. A.C. **£24.** Carriage 7/6.

MULTIMETERS *for EVERY purpose!*

TE-51. NEW 20,000 Ω/VOLT MULTIMETER with overload protection and mirror scale. 0/6/60/120/1,200V a.c. 0/3/30/60/300/600/3,000V d.c. 0/60μA/12/300mA d.c. 0/60K/6 megohm. **92/6.** P. & P. 2/6.

TE-900 20,000 Ω VOLT GIANT MULTIMETER

6in. full view meter. 2 colour scale, overload protection. 0/2·5/10/250/1,000/5,000V a.c. 0 / 25 / 12·5 / 10 / 50 / 250 / 1,000 / 5,000V d.c. 0 / 50μA / 110 / 100 / 500mA 10A d.c. 20K / 200K / 20 MΩ. **£15.** P. & P. 5/-.

MODEL AS-100D. 100K Ω/VOLT, 5in., mirror scale. Built-in meter protection. 0 / 3 / 12 / 60 / 120 / 300 / 600 / 1,200V d.c. 0/6/30/120/300/600V a.c. 0/10μA/6/60/300MA/12 Amp. 0/2K / 200K / 2M / 200M Ω. −20 to +17dB. **£12.10.0.** P. & P. 3/6.

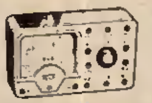
MODEL TE-10A. 20k Ω/Volt, 5/25/50/250/500/2,500 V, d.c. 10 / 50 / 100 / 500 / 1,000V, a.c. 0/50μA/2·5 mA./250mA. d.c. 0/6K/6 megohm. −20 to +22dB. 10–0, 100 mfd. t 0 0·100–0·1 mfd. **69/6.** P. & P. 2/6.

MODEL TE-90 50,000 O.P.V. MIRROR SCALE OVERLOAD PROTECTION 0/3/12/60 / 300 / 600 / 1,200V d.c. 0/6/30/120/300/1,200V d.c. 0·03/6/60/600MA d.c. 16k Ω / 160k Ω / 1·6/16M Ω. −20 to +63dB. **£7.10.0.** P. & P. 3/-.

MODEL TE 80. 20,000 O.P.V. 0 / 10 / 50 / 100 / 500 / 1,000V. a.c. 0/5/25/50, 250 / 500 / 1,000V d.c. 0·5μA. 5/50/500mA/0/6K/60/K/600K/6 Meg. **£4.17.6.** P. & P. 3/-.

MODEL TE-70. 30,000 O.P.V. 0/3/15/60/300/600/1,200V. d.c. 0/6/30 / 120 / 600 / 1,200V. a.c. 0/30μA / 3/30 / 300mA. 0/16K/160K/1·6M / 16megohm **£5.10.0.** P. & P. 3/-.

MODEL TE12. 20,000 O.P.V. 0/0·6/30/120/600/1,200 / 3,000 / 6,000V d.c. 1/6/30/120/600/1,200V a.c. 0 / 60μA / 6 / 60 / 600MA. 0 / 6K / 600K / 6meg./60. Megohm 50PF. 2 MFD **£5.19.6.** P. & P. 3/6.



MODEL PT-34. 1,000 O.P.V. 0/10/50 / 250 / 500 / 1,000V a.c. and d.c. 0/1/100/500 mA d.c. 0/100 K Ω **39/6.** P. & P. 1/6.

LAFAYETTE 57 Range Super 50,000 O.P.V. Multimeter. D.c. Volts 125V–1,000V A.c. Volts 1·5V–1,000V D.c. Current 25μA–10 Amp. Ohms. 0·15 Meg Ω dB.—20 to +81dB. Overload Protection. **£12.10.0.** Carr. 3/6.

★ TRANSISTORISED FM TUNER ★

6 TRANSISTOR HIGH QUALITY TUNER. SIZE ONLY 6 × 4 × 2½in. 3 I.F. stages. Double tuned discriminator. Ample output to feed most amplifiers. Operates on 9V battery. Coverage 88–108 Mc/s. Ready built ready for use. Fantastic value for money. **£6.7.6.** P. & P. 2/6.
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TRANSISTORISED TWO-WAY TELEPHONE INTERCOM

Operative over amazingly long distances. Separate call and press to talk buttons, 2-wire connection. 1000's of applications. Beautifully finished in ebony. Supplied complete with batteries and wall brackets.
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PZ6 Power Supply **£7.19.6**
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Full range of Amplifiers, Kits, Speakers in stock.

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Wonderfully comfortable. Lightweight adjustable vinyl headband. 6ft. cable and stereo jack plug. 25–17,000 cps. 8 ohm imp. **67/6** P. & P. 2/6.

HOSIDEN DH04S 2-WAY STEREO HEADSETS

Each headphone contains a 2½in woofer and a ⅝in tweeter. Built in individual level controls. 8 Ω imp. 25–18,000c/s. with cable and stereo plug. **£5.19.6.** P. & P. 2/6.

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COSMOCORD ¼-track heads. High imp. record/playback **65/-**. Low imp. erase **20/-**. **MARRIOTT** ¼-track heads. High imp. record/playback **65/-**. Low imp. erase **20/-**. Post extra.

RACAL MA.168 TRANSISTORISED DIVERSITY SWITCH. Brand New Condition **£15.** Carr. 10/-.

AMERICAN TAPE

First grade quality American tapes. Brand new Discount on quantities.

3in. 225ft. L.P. acetate	3/6
3¾in. 600ft. T.P. mylar	10/-
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5in. 900ft. L.P. acetate	10/-
5in. 1,200ft. D.P. mylar	15/-
5¾in. 1,200ft. L.P. acetate	12/6
5¾in. 1,200ft. L.P. mylar	16/-
5¾in. 1,800ft. D.P. mylar	22/6
5¾in. 2,400ft. L.P. mylar	38/6
7in. 1,200ft. std. acetate	12/6
7in. 1,800ft. L.P. acetate	15/-
7in. 1,800ft. L.P. mylar	20/-
7in. 2,400ft. D.P. mylar	25/-
7in. 3,600ft. T.P. mylar	45/-

Postage 2/-. Over £3 post paid.

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Top quality in plastic library boxes.
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VOL. 6 No. 6
June 1970

PRACTICAL ELECTRONICS

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A HOBBY FOR ALL

WHILE electronic design and construction is an absorbing and stimulating hobby in itself, the end product can be the means for widening the scope of other leisure activities and making these even more attractive and rewarding than before.

There are indeed good grounds for suggesting that electronics is destined to become a hobby for *all* hobbyists. Already it penetrates into a multitude of other pastimes and casts its influence upon various areas of recreation that would not ordinarily be considered as having any natural affinity with this technology. In fact it is difficult to think of a pastime which cannot in some way or another make use of electronics.

The list of electronic gadgets employed as ancillary, if not essential, aids to other hobbies is already large. And further additions will continue to be made to this list—not least in relation to outdoor activities, which loom large in our thoughts this time of the year. Outdoor recreative pursuits as varied and diverse as, for example, motoring, boating, camping, photography, archaeology, rifle shooting, fishing, and model control all stand to gain from the exploitation of modern electronic developments.

The compact size of many electronic units and their capability of operating from small dry batteries, or car batteries, endow them with characteristics especially favourable for the "outdoor life". (Those who believe the transistor radio receiver to be the principal contribution made by semiconductor technology to the happiness and enjoyment of the citizen-at-large need to be corrected on this point!) In a quiet unobtrusive manner electronics can perform many useful functions in outdoor activities without despoiling in any way the natural scene.

It is hardly necessary to mention that opportunities for innovation in the application of circuitry are limitless. When spurred along by the special requirements of some other hobby or interest, the mind is likely to be exceedingly productive in ideas.

This is a two-way traffic. Electronics is constantly being explored in the search for solutions to novel problems. The solution of one problem generally leads to further ideas concerning applications in other fields and so the total overall effect arising from some humble requirement is never predictable. The general utility of electronics is thereby expanded, while countless different recreative pursuits are enlivened or enhanced in some manner by contributions electronics alone can provide. In terms of the individual constructor, the satisfaction derived from his own handiwork is twofold, and lasting.

F.E.B.

THIS MONTH

Our July issue will be published on Monday, June 15

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FROM the response to earlier articles on electronic aids for the amateur photographer, it is obvious that a large number of readers are interested in both subjects. This is not surprising as the photographer of today relies largely on mechanical and electronic skills for the high standard of his end product.

Impact photography, as shown in photographs in this article, relies very much on electronic circuitry to get the striking effects required.

Find out now how you can make a . . .

SOUND TRIGGER FOR PHOTO FLASH

By
R. Fletcher

A FEW YEARS ago the problem of recording impact phenomena was considered to be a laboratory project using specialised equipment, but thanks to the availability of thyristors and inexpensive silicon planar transistors, this is no longer the case.

This easily constructed self-contained synchroniser unit can be built for about £3 and enables the photographer to fire his electronic photo flash by the sound emitted at the instant of impact. To obtain this synchronisation, the positive side of the electronic flash trigger lead is connected to the anode of a thyristor and the negative side to its cathode. The impact sound is picked up by a miniature crystal microphone insert, amplified by the multistage silicon planar amplifier, converted to a rectified pulse which in turn fires the thyristor and operates the flash gun.

SOUND TRIGGERING

The low priced resin encapsulated silicon planar transistor type 2N2926 is chosen for the synchroniser as it possesses a low noise factor and is obtainable in the high h_{FE} ratings desirable for the early stages. The first three stages provide a high voltage gain at a total supply current of less than one milliamp.

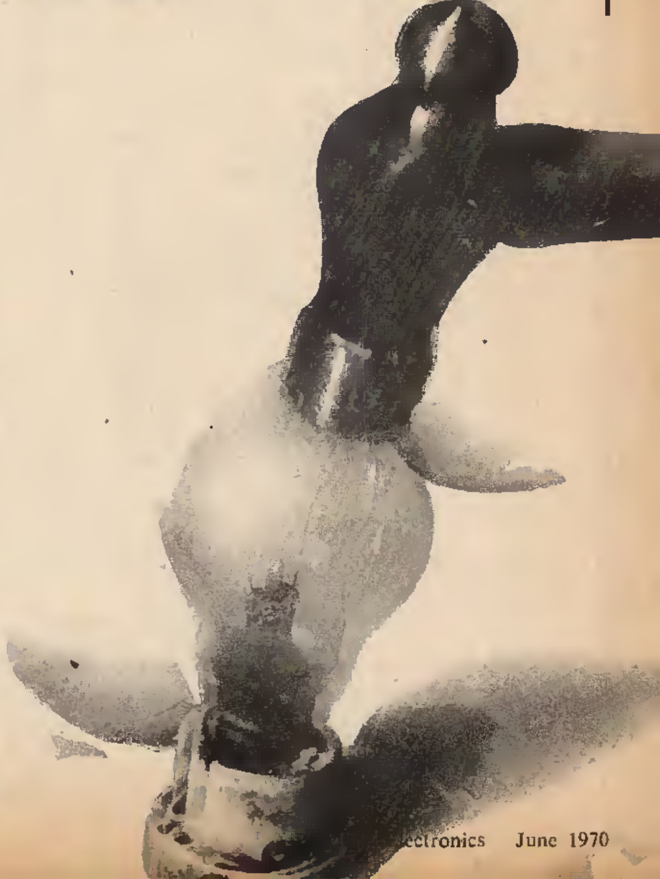
It is possible to couple the base of a silicon transistor directly to the collector of the previous stage as the working base-emitter voltage (V_{BE}) of a silicon transistor is of the order of 0·6V. These devices will function with a base voltage equivalent to, or even higher than, their collector voltage.

The amplifier is quite stable with the components specified, d.c. feedback being effected over R2 and VR1. The simplest form of gain control is to bi-pass the a.c. component via C1 to the negative rail. This also ensures that no d.c. changes occur if adjustments are made in sensitivity with the equipment switched on, which could result in spurious operation of the flash unit.

The amplified signal across the collector load of TR3 is applied via C2 to the unbiased transistor TR4 where rectification takes place and feeds a pulse of current via the gate and cathode of the thyristor SCR1. Provided correct polarity exists across this device from the photo flash, it switches on and the flash is fired. The thyristor is automatically reset after firing as, during conduction, the trigger coil voltage is reduced to zero.

CONSTRUCTION

The circuit is constructed on a 2½in × 1in 0·15in matrix Veroboard. Fig. 2 shows the underside of this board and it will be seen that six breaks have to be made in the copper foil strips in the positions shown. This can readily be undertaken with the aid of a spotface cutter or ⅛in drill. A sharp knife can be used but care must be taken not to damage the adjacent copper strips.



It will be seen that each hole in the board is code numbered and the ones used for a soldered connection have been blacked in.

After preparing the board, it is turned over and the components are mounted on its face as illustrated by Fig. 3. It may be necessary to solder wires on to the tags of the pre-set skeleton potentiometer VR1 if they do not coincide with the holes specified for its fixing. A short jumper lead is connected from its slider tag to hole *9D*. The strap between holes *16D* and *16G* completes the negative rail connection of C1.

It is advisable to fit a short length of thin sleeving on the centre (collector) leads of the transistors, especially in the case of TR2 and TR4 where the sequence of lead connections is different from the *e—c—b* sequence from the transistor.

External connections can be made after the components have been mounted and soldered on the board. Usually one lead of the crystal microphone insert is connected to its metal case (black on the type specified). This should be soldered to the negative rail, i.e. strip *G*. The battery connections are self explanatory, the positive on *A* and negative on *G*, wired via the on–off switch.

CONNECTION TO FLASH GUN

The seven-feet long flash extension lead calls for comment, as this must be correctly connected polarity wise. First, trim off the connector not required for coupling to the flash unit, a few inches from the end of the cable and bare the two centre conductors. Connect the other end of the lead to the electronic flash unit and switch on.

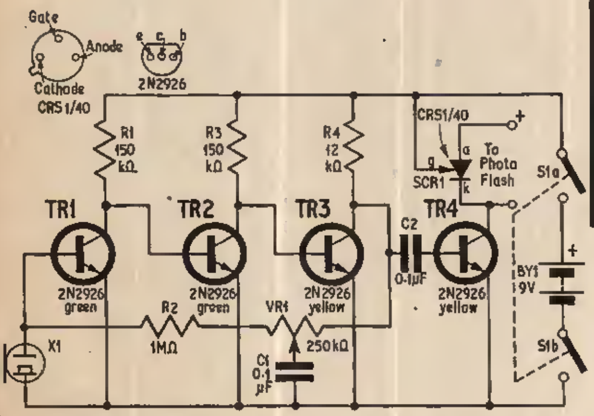


Fig. 1. Circuit diagram of the trigger unit

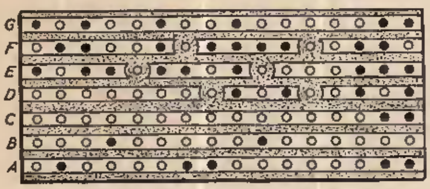


Fig. 2. Underside of the board showing breaks in the copper strips

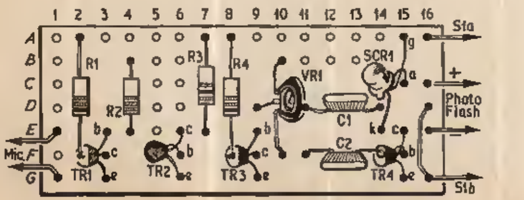


Fig. 3. Components assembled on the top of the board

COMPONENTS . . .

Resistors
R1 150kΩ   R3 150kΩ
R2 1MΩ   R4 12kΩ
All 5%, $\frac{1}{4}$ watt carbon

Potentiometer
VR1 250kΩ carbon skeleton preset

Capacitors
C1, C2 0·1μF polyester (2 off)

Transistors
TR1, TR2 2N2926 (Green) (2 off)
TR3, TR4 2N2926 (Yellow) (2 off)

Thyristor
SCR1 CRS 1/40

Switch
S1 Double pole, on-off, slide switch

Microphone
X1 $\frac{3}{4}$in crystal insert

Battery
BY1 9V (type PP3)

Miscellaneous
Veroboard 0·15in, matrix $2\frac{1}{2}$in × 1in
Battery connector
Flash extension lead 7 feet
Plastics Box $4\frac{3}{8}$in × 3in × $1\frac{1}{4}$in

With the aid of a voltmeter switched to the 250 volt range ascertain the polarity of the bared conductors. Be prepared to disconnect the meter quickly if reverse polarity is indicated. The measured voltage will vary with different flash units, but the object of the exercise is only to check polarity. The positive lead must be connected to foil strip *16C* (anode of thyristor) and negative lead to *16E*.

Most modern flash units have the positive side of the trigger coil primary wired to the centre of the connector but it is as well to check. Actually a reversed connection will not damage the semiconductors in the synchroniser, but of course the thyristor would fail to conduct.

On completion of the wiring, the unit should be checked for any obvious errors, dry joints, or bridging contacts between the foil strips. If all is well, VR1 should be set to mid-position and a milliameter connected in series with one of the battery leads before connecting to the 9V battery.

on–off switch and crystal microphone insert together with the completed unit board. The simplest method of securing the various items is with strips of $\frac{3}{8}$in expanded polystyrene ceiling tile as shown.

A $\frac{1}{4}$in hole is drilled in the end of the plastics box to coincide with the aperture in the face of the crystal microphone insert. The miniature slide switch is secured at the opposite end by two 8B.A. countersunk screws, after a slot has been filed for the knob.

SEQUENCE OF OPERATION

The photographs must be taken in the dark using the open shutter flash technique. If a slow speed film is used, a dark room safe light may be utilised to assist the operator. This technique is recommended as the use of say a 50 A.S.A. film facilitates the production of needle sharp enlargements and allows a normal powered flash gun to be placed reasonably close to the subject.

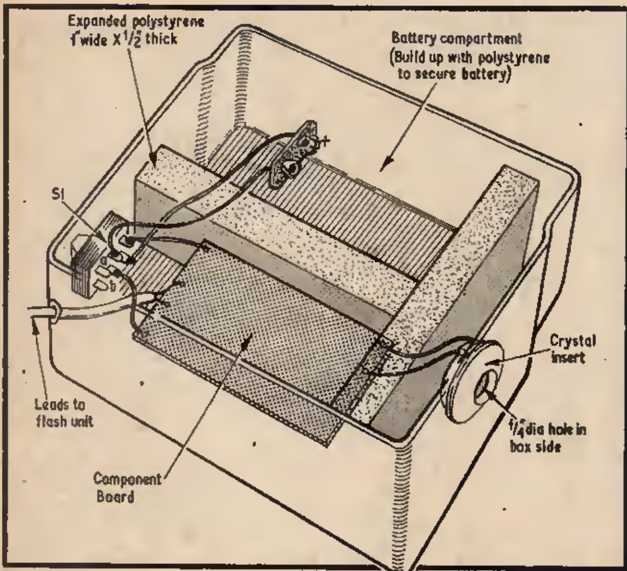


Fig. 4. Layout and wiring of complete trigger unit

Three examples of triggered photoflash photograph

TESTING AND SETTING UP

The unit should now be switched on; the meter should indicate a battery drain of between 0.75mA and 1mA. A sharp whistle a foot or so from the microphone should result in a perceptable increase in supply current. If these tests are satisfactory the meter may be withdrawn and battery connected in the normal manner.

The switched-on photo flash may now be connected to the synchroniser via the extension cord and connector. If the hands are now clapped, or fingers snapped within a few feet of the microphone the flash unit should fire.

Adjustment of the preset control VR1 will produce a wide range of sensitivity and on maximum gain the trigger unit can be set to fire the flash at the drop of a pin. The completed unit can now be suitably housed in a container of the constructor's choice.

A $4\frac{3}{4}$in × 3in × $1\frac{1}{4}$in plastics box as specified in the components list would be quite suitable and easily obtainable. Fig. 4 illustrates the position of the

The sequence of operations is as follows:

1. Set up camera (on "bulb" position) and subject, together with flash gun as for a normal flash exposure.
2. Connect synchroniser to flash gun, switch on synchroniser and then the flash unit.
3. Turn off main lights leaving only the "safe" light on.
4. Open camera shutter, preferably with cable release and hold open.
5. Commence action which will create impact sound. Flash will operate on impact.
6. Close camera shutter.
7. Turn on main lights.

The synchroniser is very sensitive to sound and its gain can be preset to reduce to a minimum false firing by extraneous noise but respond reliably to the impact sound. Sound travels at approximately 1,100 feet per second thus the delay in firing the photo flash can be adjusted by placing the unit one foot away from the subject for every $\frac{1}{1000}$ second delay required.

For more ambitious results, two or more flash units can be fired by separate synchronisers placed at predetermined distances from the subject to give a superimposed sequence of events or stroboscopic effect.

SPURIOUS FLASH

If it is desired to avoid spurious flashes when setting up the equipment the following sequence should be followed:

1. Switch on synchroniser unit.
2. Connect to flash gun.
3. Switch on flash gun.

The reason being that the surge current that occurs on switching on the synchroniser is sufficient to fire the thyristor. Also, if the photo flash is switched on before connection to the synchroniser, the depletion capacitance of the thyristor may be sufficient to draw a pulse of current from the trigger circuit large enough to fire the flash. After connection, however, the equipment may be recycled as many times as desired and the flash will only be fired on receipt of sound pick-up of sufficient amplitude.

VARYING FLASH TIME

The average duration of flash from a modern general purpose electronic flash unit is of the order of $\frac{1}{1000}$ second or a little less, according to the operating voltage used to charge its main electrolytic storage capacitor and power output of the flash unit in joules.

The larger the capacitance of this electrolytic the larger will be the output ($\frac{1}{2}CV^2$) in joules, but at a cost of increased duration of flash. If the same output is maintained by using a lower capacitance operating at a higher voltage, then the duration of flash is reduced.

If a real "freezer" flash is required for "stopping" very high speed phenomena, we can use these principles to modify an existing flash unit. The simplest approach is to replace temporarily the existing main storage capacitor with an ordinary smoothing capacitor of $16\mu F$ or $32\mu F$ of correct working voltage. This will reduce the flash duration to as little as $\frac{1}{5000}$ second, but at a very much reduced power output.

A revised guide number can easily be obtained for this reduced output, by making a test film and recording a range of apertures and distances. The distance in feet between the flash gun and object, multiplied by the stop setting that produced the best negative, is the new guide number.

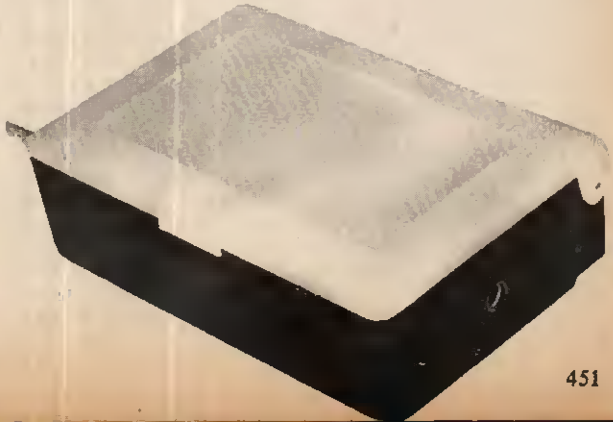
It is emphasised that the above modification is only required for exceptional use and the photographs submitted by the author were all taken with an unmodified commercial flash gun.

A typical example of speed of operation is shown in the "striking match" photograph. As soon as the match *starts* to move, the flash gun fires. The continued motion of the flame is registered even though the match appears to be still on the box, because the aperture is still open and light from the match photographed on the film.

howing a burst balloon (left), striking match (centre), smashed bulb (right)

The "burst balloon" also shows some movement of the balloon during collapse.

Several other examples of application can be tried with some success. Any form of impact, crash or explosion can be photographed using this technique in dark conditions. ★



SOUNDS INCREDIBLE-2

By R.C. MILLS..... B.B.C. RADIOPHONIC WORKSHOP

THIS, the second and last part, will describe special editing techniques and effects used in the BBC Radiophone Workshop.

EDITING TECHNIQUES

Tape, being such a flexible medium, contributes the major facility to the manipulation and treatment of sound. Even the most simple and most basic operation, editing, can be applied in other ways than just sticking pieces of recorded tape together.

Let us take an example: Suppose a note from an electronic organ has been recorded; it can be represented as in Fig. 3a. It can be joined up to the leader tape as in Fig. 3b but, due to the usual oblique splicing, there will be a momentary tape hiss before the note sounds. This is due to the unrecorded piece of tape marked x. If the splice cuts into the sound to prevent this a false "attack" is put on to the note, and it sounds as if it has been rapidly faded in Fig. 3c.

To make sure of obtaining the true sound the tape must be spliced to approximate to the original note attack, i.e. by making *almost* a right-angle cut. Perfect right-angle cuts in the tape are liable to produce a click on replay with a perfectly aligned replay head azimuth,

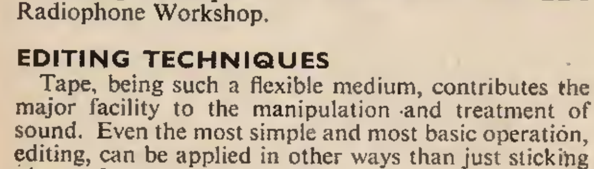


Fig. 3. Special editing to avoid hiss and artificial "attack"

so it is practicable to use a near vertical cut to achieve the effect required without too much risk of this occurring (Fig. 3d).

Many different musical instruments sound almost identical when their characteristic starting transients, which in fact identify the instrument to us, are removed intentionally or otherwise.

With the use of an exaggerated angle of cut, spread over two editing blocks (Fig. 3e), the cut in the tape is much nearer to being parallel to the tape edge, so that a very long cross fade of sounds can be achieved without mixing. It takes plenty of patience and care to make these cuts well, but is shows how editing can be creative as well as remedial.

TAPE LOOPS

Remaining with tape for a moment, a valuable asset used to study sounds, and to aid investigation of their properties, is the tape loop.

Many signature tunes made in the Radiophonic Workshop are constructed from a single sound source. For example, suppose an empty wine bottle is struck with the palm of the hand over the mouth of the bottle, and the sound recorded. Then suppose a tape loop is made from this recording. This basic sound tone can be replayed at different speeds to make up a musical scale of "notes", without constantly rewinding the tape for each note selection.

Similarly, having a constant running loop enables filtering to be selected at leisure. This useful dodge makes it easier to construct or compose background music from two or three running loops. Each loop can be brought in at any time and made synchronous, or otherwise, by adjusting loop lengths or starting times.

MUSIC CONSTRUCTION

Signature tunes are usually constructed in a standard manner. A melody line, a bass line and harmony, and decorations are patiently built up separately. Then all three tracks are played in synchronism, using the three standard tape machines while the mixture is recorded on a fourth.

Each music line is built up note by note, and the tempo, in terms of crotchets to a bar, is transposed to read 1 crotchet = x inches of tape. Each note must be recorded at precisely the right level and carefully given the right attack by editing, as described earlier; any timed leaders are also inserted.

Before playing with the other two similarly constructed sound tracks, each track may be treated with filters or echo, to give it the desired sound quality and aural perspective. Sometimes it is preferable to add echo when all tracks are heard together; the degree of treatment on one of the tracks may have been misjudged and perhaps quite inaudible against the other two.

It may be thought that this is a long-winded way of doing things, when perhaps multi-track tapes could be used? However, the Radiophonic Workshop have found that it is easier to keep sound tracks separate, both physically and electronically. In this way, each component sound can be fully controlled. If the result is not satisfactory after a final mix, it is easier to correct individual faults on a separate tape, than on one track out of four, or even eight, on a single wide tape.

PROBLEMS WITH PURE TONES

Throughout the Workshop's history of sound manipulation, of all the sounds handled the most difficult to process were those from the signal generators, particularly the sine waveforms. These are practically unmixable, using the conventional stud faders, as each step is immediately noticeable on the pure tones. With more complex waveforms, the effect is not so apparent.

This problem was overcome by the development of a noiseless fader, which worked by means of a photo-electric cell arrangement. Figs. 4a and 4b show how these operate.

Opening or closing the fader alters the brilliance of a lamp, which in turn alters the resistance of a photo-cell in the programme circuit. Any "steps" due to the stud fader are absorbed by the filament of the lamp, and not noticed in the sound output. To achieve some sort of standard, the lamp voltage is adjusted so that, with the fader closed, the lamp filament just glows.

This principle has been extended, and provides a means by which one sound can amplitude modulate another; the modulating sound is used to vary the lamp brilliance.

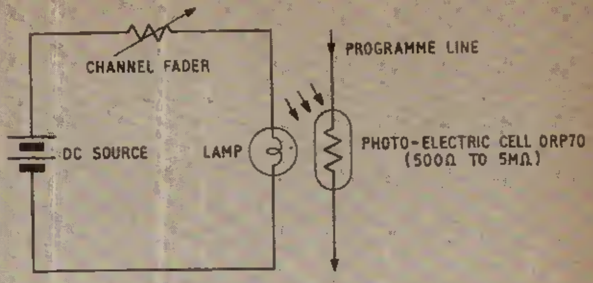
Another problem, also encountered when using tones, is that it is very difficult to edit or switch the tones without getting a click. Therefore, to get a uniform start to oscillator notes, a small keying unit is employed; depressing a note on the keyboard, results in a rapid fade up of the oscillator output, in about 10ms.

A further development provided networks to vary this "attack" time, and also the decay time, so that "shape" could be given to the output of the signal generator. This hides the fact that the signal generators do not all start from the same part of the frequency cycle when initially switched on. Synchronised waveforms are achieved by using a single oscillator with multiplying or dividing networks.

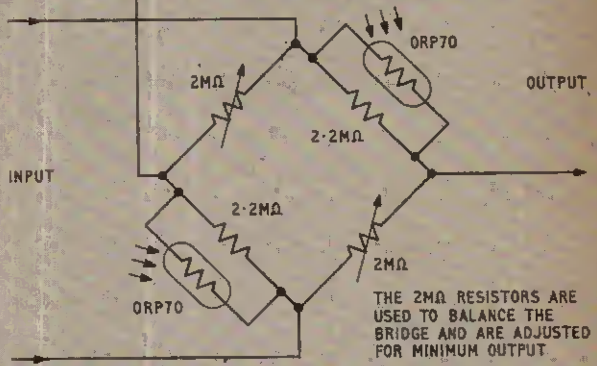
Let us now continue into the treatment of sound by means of more sophisticated equipment.

NON-STANDARD EQUIPMENT

At first sight the jackfields associated with the control desk seem quite unmanageable, but it must be remembered that each programme chain is similar, i.e. sound source→amplifier (if necessary)→filter→fader,



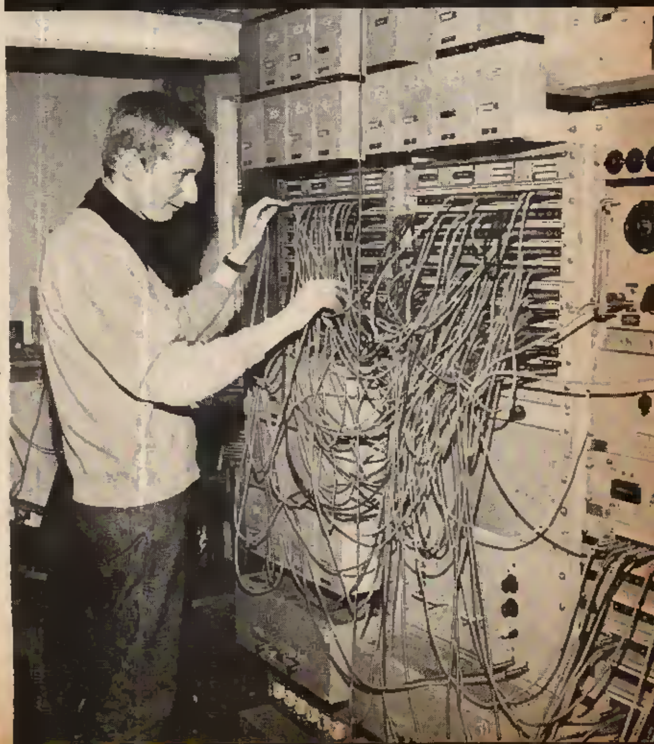
(a) Simple theoretical circuit using a photocell



(b) Bridge circuit used in the Radiophonic Workshop. The lamp and photocell are housed in a light proof fader body

Fig. 4. Noiseless fader circuits

The jackfield rack where equipment is linked up



and most of the connecting cord arrangements are merely repetitions for different channels.

The reason for not tidying up on these arrangements is that access to every point in each programme chain is very desirable, from the creative point of view, as well as the maintenance one. For instance, a tape delay system can be inserted into an echo circuit, and various filters, especially the non-standard types which are used as and when the occasion demands, are plugged into various positions in the chain.

A point worth making here: whilst not upsetting the programme and effects set-up, any part of it can be checked, and usually is. However, the creator's ear is the final judge of performance—not the programme meter.

The special filters are used in isolated cases and, because they are limited in number, are used in conjunction with "group switching". Every sound source on arrival at the control desk, has a choice of routes: independent, group 2 or group 3. In the independent mode, only filters normally associated with particular sound source are operable. Groups 2 and 3 may well have a different filter associated with each, although when switched to a group, the sound source retains its original filter.

For instance, the filter normally associated with one particular source, may not be capable of giving the desired effect. By selecting another group, another filter may be tried. Furthermore, a large number of sources all requiring similar filter settings can all be switched to one group, and one filter will suffice.

Most of the foregoing has been normal studio practice, but a number of special devices have evolved, to assist the sound manipulator.

TAPE LOOP STAND

Starting with the simplest, the tape loop stand enables loops of any length to be played, and has a spring tensioned guide to maintain tape tension. It is usually placed in front of the associated tape machine, whilst there is a miniature version that is used on the tape deck itself when playing very small loops.

For very long loops, it can be advantageous to use another tape machine to help pull the loop round. In some cases, it can divert the tape path to avoid obstructions such as room pillars and equipment.

It often occurs that an interrupted signal is required. One way of achieving this effect is to make up a tape loop made up of alternate tape and leader sections; the sound is recorded on to, and simultaneously played back from this loop. The length and frequency of interruption depends upon the size of the segments of tape and leader, and on tape speed.

Another method of interrupting a sound is by means of a relay unit, to switch sound on and off. Refinements on this principle include a control to vary the operating speed of the relay, and the length of the pause. An additional input is provided to enable other sounds to be injected into the pause.

RING MODULATOR

Still on the subject of interruptions, a device much heard of these days in electronic music concerts, is the ring modulator. This consists of a network of rectifiers and two centre tapped transformers (Fig. 5).

Any sound fed into input 1 can be modulated by another sound applied at input 2. A certain amount of breakthrough of the modulating frequency can be experienced, but, by using a field effect transistor, this problem has been overcome.

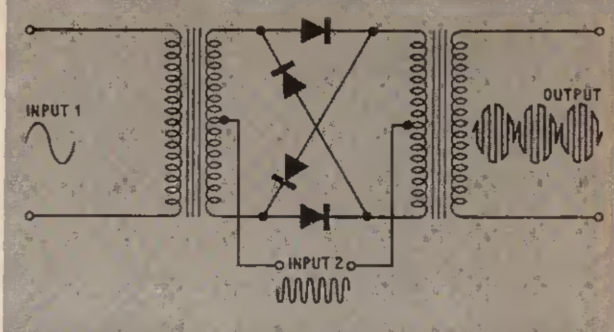


Fig. 5. Basic ring modulator principle

An ingenious, but rather clumsy, form of vibrato, has been achieved by means of a separate replay head moving to and fro against the tape. It is moved by a system of cranks linked to an old gramophone motor. A more sophisticated method used today is a rotary scanner with an associated delay line. It is also possible, using this device, to feed the stators of the scanner with a number of different sounds; the rotating pick-up samples each in turn, producing a pattern of sounds.

HOWL ROUND STABILISER

A piece of equipment used to stabilise public address systems and prevent "howl round" between microphone and speakers, has proved to be very useful to the sound creator. The stabiliser raises or lowers the frequency of sounds fed to it by a few hertz. When the output is mixed with the original sound a low beat frequency is heard, being the difference in frequency between the two sounds.

This stabiliser can be inserted into a feedback circuit, so that any sound subjected to the treatment will get higher and higher, or lower and lower, in pitch, depending on the setting of the system.

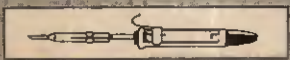
Phasing or "skying", another technique in fashion in pop music, can be achieved using two tape machines recording, and simultaneously replaying, the same sound. (The machines must *not* be connected to their own inputs). If one of the machines is made to run slightly slower than the other, by simply keeping a thumb on the left hand spool, the slight speed difference causes a slight difference in time between the outputs, and frequency cancellation occurs. This effect can also be achieved with two pre-recordings of the same sound.

There is nothing especially created in the line of apparatus to give the Radiophonic Workshop any extra special techniques. It is fair to say that most of the equipment is standard to normal professional sound studios, the only difference is in the imaginative way, unorthodox if you like, that the equipment is used.

FILM EQUIPMENT

A large part of the Workshop's output is for television, and of this a good proportion is for films. The latest additions to the equipment list are, a film viewing desk, a 16mm magnetic recorder and a synchronising machine. This means that a sound sequence can be tailor made to fit the film sequences, as all the sounds can be transferred to sprocketed tape and laid against the film to ensure accurate synchronisation.

continued on page 479



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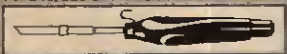

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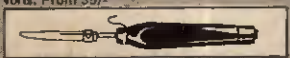

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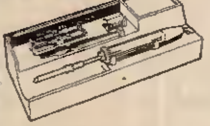

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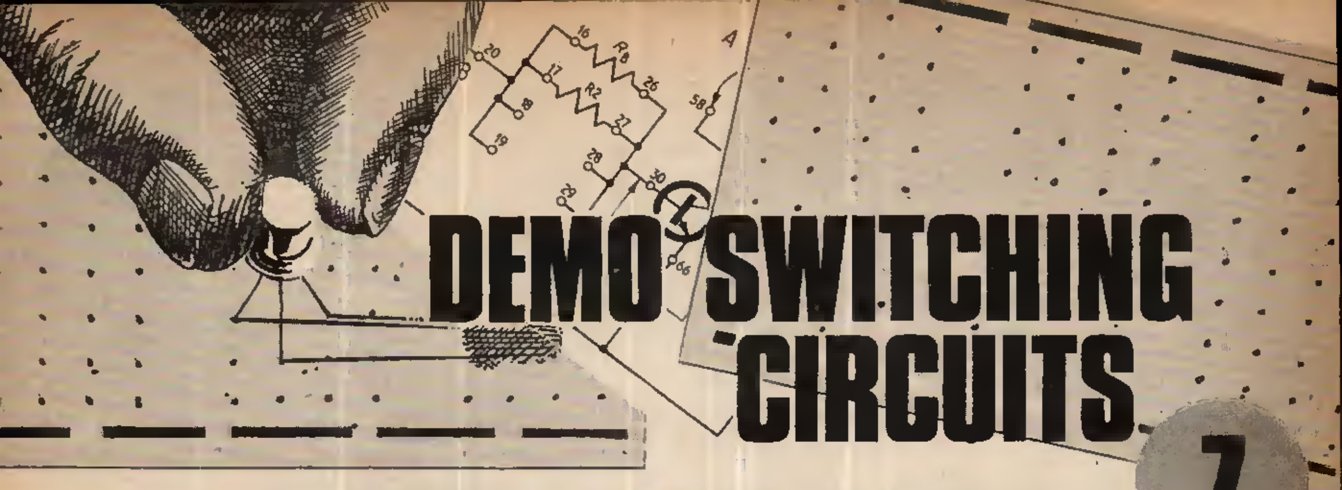


DEMO SWITCHING CIRCUITS 7

BINARY DIVIDER

By B. Pounder

CONTINUING the discussion on dividers, this month's article (the last) looks into the use of binary dividers for decimal counting.

BINARY CODED DECIMAL COUNTER

It is frequently necessary for a counter to work to a base of 10. This can be achieved by means of feedback loops included in the binary chain. See Fig. 7.1.

Immediately after receipt of the eighth input pulse, the $\overline{Q}$ outputs are 0 0 0 1. Further, the $\overline{Q}4$ output has changed to the "1" state from a "0" state; that is, the collector voltage on TR1 of binary 4 has dropped from V_{CC} to almost zero. Because this change is negative-going, it can be made to switch other binaries in the chain.

Suppose $\overline{Q}4$ output is fed back to inputs T2 and T3, then the negative-going change on $\overline{Q}4$ causes binaries 2 and 3 to switch so the outputs of these two change state. In so doing, Q3 changes from "1" to "0" so it has no effect on binary 4. These changes are illustrated in Table 7.1 which shows a state 8′ immediately following state 8.

On receipt of the trigger pulse number 9, all the Q outputs are "0"s and all the $\overline{Q}$ outputs are "1"s, so the system is returned to its initial state by trigger pulse 10 and ready to repeat its output sequence over the receipt of another ten pulses. Because the circuit reverts to its initial state every ten trigger pulses, it can be used as a decade divider. Two such cascades divide by 100, three by 1,000, and so on.

Note that in order for the decade dividers to operate satisfactorily, there must be a time delay built into the feedback loops in order that state 8 is set up before the feedback pulses arrive at T2 and T3 to cause switching to state 8′.

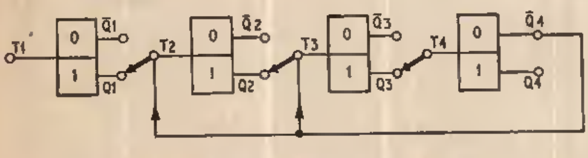


Fig. 7.1. Application of feedback to a binary chain to give a decimal counting system

Table 7.1. BINARY CODED DECIMAL LOGIC OUTPUTS

Input	$\overline{Q}_1$	$\overline{Q}_2$	$\overline{Q}_3$	$\overline{Q}_4$	Q_1	Q_2	Q_3	Q_4
7	1	1	1	0	0	0	0	1
8	0	0	0	1	1	1	1	0
8′	0	1	1	1	1	0	0	0
9	1	1	1	1	0	0	0	0
10	0	0	0	0	1	1	1	1
11	1	0	0	0	0	1	1	1
12	0	1	0	0	1	0	1	1

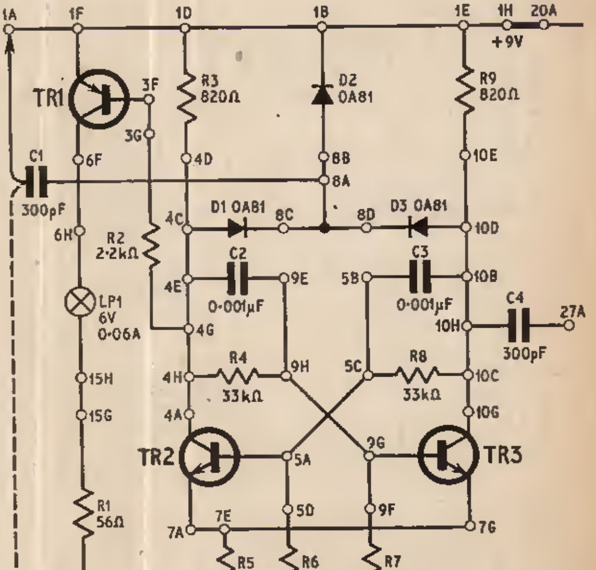


Fig. 7.2. Circuit of two stage binary counter with T-Dec connections. Two of these can be built on one board

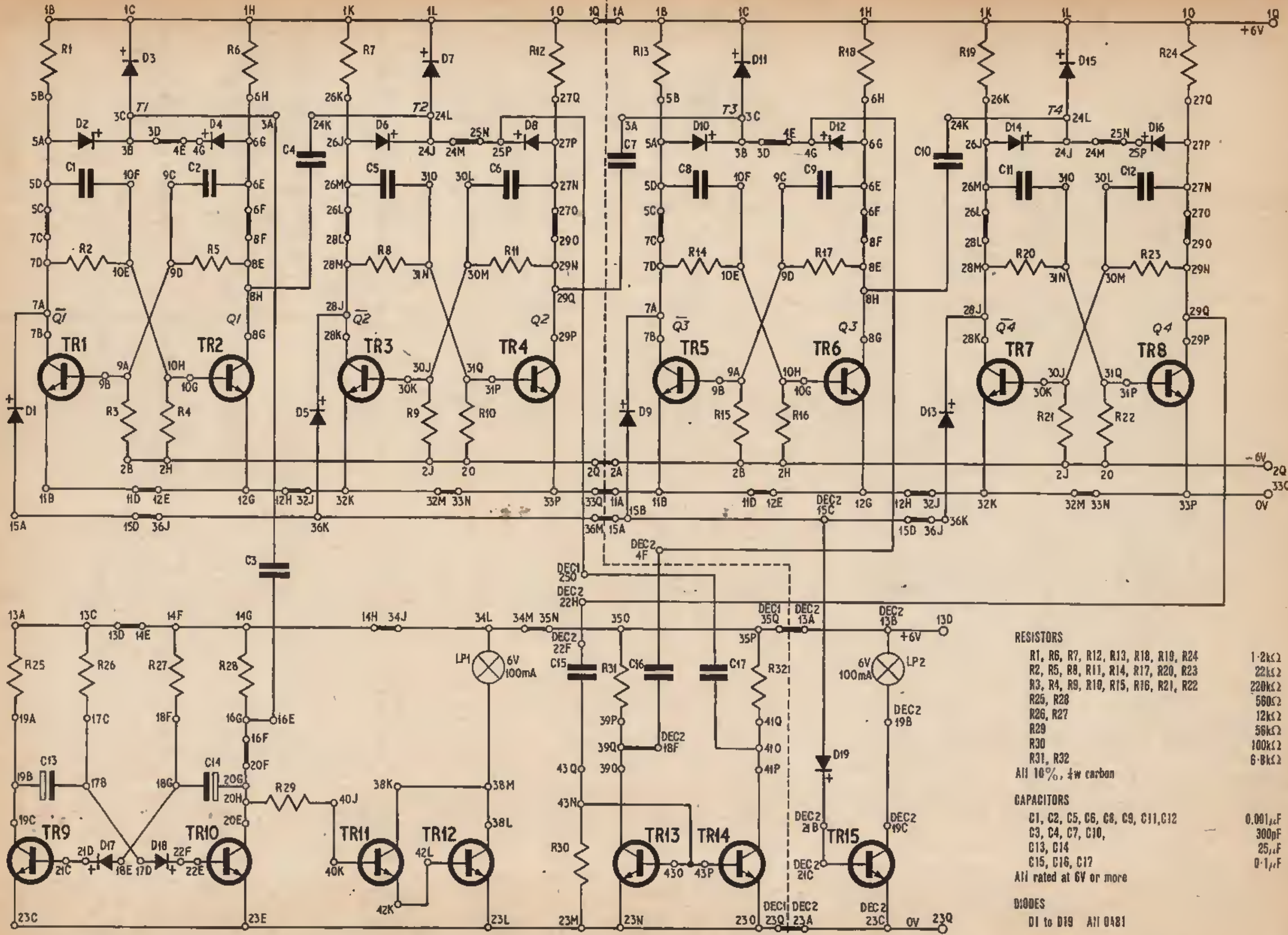


Fig. 7.4. Circuit of the decade divider with μ-Dec connections. Dec-1 is left and Dec-2 is right of the dotted line except where otherwise indicated

RESISTORS

R1, R6, R7, R12, R13, R18, R19, R24	1·2kΩ
R2, R5, R8, R11, R14, R17, R20, R23	22kΩ
R3, R4, R9, R10, R15, R16, R21, R22	220kΩ
R25, R28	560Ω
R26, R27	12kΩ
R29	56kΩ
R30	100kΩ
R31, R32	6·8kΩ

All 10%, ¼w carbon

CAPACITORS

C1, C2, C5, C6, C8, C9, C11, C12	0.001μF
C3, C4, C7, C10,	300pF
C13, C14	25μF
C15, C16, C17	0·1μF

All rated at 6V or more

DIODES

D1 to D19 All OA81

TRANSISTORS

TR1 to TR15 All npn silicon type (see Part 1)

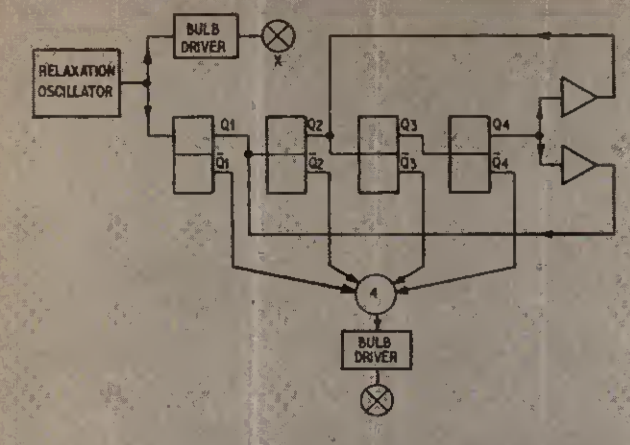


Fig. 7.3. Block diagram of a decade divider

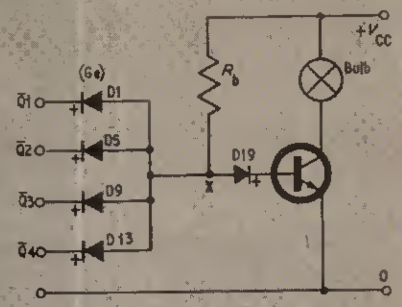


Fig. 7.5. NAND gating circuit used in the decade divider

BINARY DEMONSTRATION CIRCUIT

A circuit for a 9V emitter-coupled two-stage binary counter with lamp bulb indication is shown in Fig. 7.2. This can be built on half a T-Dec as shown, with the similar layout to that in Fig. 6.4. Two circuits can then be built on one T-Dec. Component values are calculated according to the design procedure given previously.

If the bulb driver transistors are TO5-canned types capable of dissipating a few hundred milliwatts, the base current resistors can be made large enough to under-run the bulbs. If necessary, a 56 ohm resistor could be included in series with each of the bulbs.

DECADE DIVIDER

As can be seen from the block diagram of Fig. 7.3, the decade divider is a complex system and would need about six S-Decs for a neat assembly. However, it can easily be accommodated on two μ-Decs. A μ-Dec layout is shown in Fig. 7.4 on the previous page.

Referring to Fig. 7.4, the relaxation oscillator output from TR10 is indicated by means of a 6V bulb and is fed into four binaries in cascade. The oscillator, lamp driver, the first two binaries and feedback amplifiers TR13 and TR14 are assembled on one of the μ-Decs. The other two binaries are assembled in exactly the same way, proceeding from left to right across the board and using corresponding socket connections.

The second Dec takes the third and fourth binaries and the decimal indicator lamp driver TR15.

On receipt of the eighth input pulse, stage Q4 turns from on to off so its collector voltage rises as a "step", which is differentiated by the CR coupling between Q4 and the feedback amplifiers. Thus negative-going spikes appear at the collectors of these stages. The spikes are fed-back directly to the collectors of $\bar{Q}2$ and $\bar{Q}3$ in order to switch off stages Q2 and Q3, and achieve the 8′ state shown in Table 7.1.

The NAND circuit is used to provide a visual indication whenever all the $\bar{Q}$ outputs are at the supply voltage, so operates at a frequency of one tenth that of the relaxation oscillator. The operation is as follows.

If any one or more of the input diodes D1, D5, D9, and D13 shown in Fig. 7.5 is at zero potential, it or they will conduct through R_b so that the potential at point X will be V_f, the diode forward bias voltage drop. Now X is connected to the bottom rail via D19 and the base-emitter junction of the transistor. Hence the base current will be negligible and the transistor essentially cut-off.

However, when all the input diodes are at the supply voltage, none will conduct since they are all reverse biased. Hence D19 will conduct through R_b and the transistor turns on. The system should be assembled in stages and each stage tested before proceeding to the next.

First, the operation of the relaxation oscillator can be checked by means of its bulb driver circuit. The same bulb circuit can be coupled to the output of each binary as they are assembled in turn to check their operation by seeking an indication of successive division by two of the train of input pulses.

Note that this and other circuits, which consist of a cascade of binaries, will not operate satisfactorily unless a very low impedance power supply is used. A half exhausted battery will not be good enough! ★

POINTS ARISING

MINIATURE CONVERTER (*April 1970*)

The Mullard pot core used in the minature converter consists of the following parts:

FX2243 Ferroxcube pot cores (2 off)
DT2206 single section coil former (1 off)

The above numbers and quantities must be quoted when ordering, *not just* FX2243 as given in the components list.

TRANSISTOR D.C. MULTIMETER

By W. CLELAND

A VALVE voltmeter, or a transistorised version, such as the multimeter described here, has an increased power sensitivity that gives it a useful role in circuit testing.

In the transistorised d.c. multimeter, the sensitivity of a moving-coil milliammeter is increased up to 100,000 times by preceding it with a solid-state amplifier, and at the same time the moving-coil meter is protected against overload. The amplifier uses silicon planar transistors throughout, and has an input current of picoamps.

Silicon planar transistors are less affected by temperature than field-effect transistors—the nearest solid-state counterpart to valves—and are more uniformly matched in their temperature variation. The completed instrument has a temperature drift of something like 15 microvolts per degree centigrade, making measurement possible in the millivolt and nanoampere region.

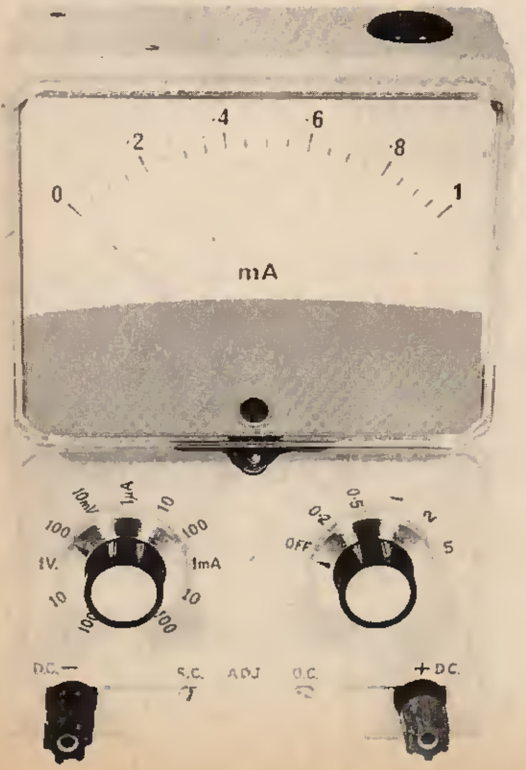
RANGES

One advantage of the large number of ranges (as listed in Table 1) is that most readings can be taken on the upper half of the scale, and this enables measurements to be made with a more consistent accuracy. Only a single scale is available for all ranges, but the basic ranges increase in powers of ten, and the multiplying factors are 0·2, 0·5, 1, 2 and 5, so that only doubling or halving the reading is required on ranges where the factor is not unity.

The scale of the meter is marked in even digits only, and these become consecutive when halved. Separate scales would be better, but it is not too awkward to halve or double the readings.

Direct currents and voltages can be measured on a total of 40 different ranges. There are also 18 superfluous ranges, shown in white panels in Table 1, differing only in impedance, that are not included in the total of 40. On ranges of from 0·2 volt to 500 volts f.s.d., an input impedance of 20 megohms is obtainable; sufficiently high not to disturb conditions in almost all circuits. On lower ranges, the input impedance reduces to 2 megohms, and on the millivolt ranges to 200 kilohms.

Ranges of current are also included, and extend down to 10 nanoamperes f.s.d., using the 2 millivolt range for the purpose.



VARIATIONS AND APPLICATIONS

The analogue testmeter is intended as a d.c. instrument, but an external adaptor for a.c. measurement could be added, using diodes or a thermocouple; a calibration curve might then be required.

Resistances can be measured over a very wide range using an external battery and potentiometer. Although there is no ohmmeter scale, the input resistance increases in steps of ten times on the current ranges from 0·1 ohm to 10 kilohms, and then on the voltage ranges from 200 kilohms to 20 megohms. Mid-scale readings of from 0·1 ohm to 20 megohms should therefore be obtainable, and insulation resistance could be measured with suitable circuit arrangements.

As a high-impedance millivoltmeter, the analogue testmeter can be used as a null detector to compare resistances accurately in a bridge circuit, and this method was used in making the 0·1 ohm resistance for the 100 mA range (R27).

INPUT/OUTPUT RATIO

A meter amplifier must include some form of feedback loop. Precision amplification depends upon feedback and is closely equal to the feedback ratio. The amplification without feedback is much greater, and is utilised in reducing the error margin. Feedback, applied over the amplifier is thus able to establish a definite ratio between input and output. The accuracy of this relationship can be tested by switching the milliammeter between the output and input circuits, with resistances included to keep the loading on the input source unchanged.

Table 1. MULTIMETER RANGES

RANGE SWITCHES S1 ▼ S2 ▶	FULL SCALE DEFLECTION ON EACH RANGE (Accuracy—within ±5% on all ranges) 0·2	0·5	1	2	5	INPUT IMPEDANCE
100V	20V	50V	100V	200V	500V	20·2MΩ
10V	2V	5V	10V	20V	50V	20MΩ
1V	200mV	500mV	1V	2V	5V	20MΩ
100mV	20mV	50mV	100mV	200mV	500mV	2MΩ
10mV	{2mV, 10nA}	5mV	{10mV, 50nA}	{20mV, 100nA}	50mV	200kΩ
1μA	0·2μA	0·5μA	1μA	2μA	5μA	10kΩ
10μA	2μA	5μA	10μA	20μA	50μA	1kΩ
100μA	20μA	50μA	100μA	200μA	500μA	100Ω
1mA	200μA	500μA	1mA	2mA	5mA	10Ω
10mA	2mA	5mA	10mA	20mA	50mA	1Ω
100mA	20mA	50mA	100mA	200mA	500mA	0·1Ω

BASIC ARRANGEMENT

A simplified diagram, Fig. 1a, shows the basic feedback arrangement. Actually the differential arrangement of Fig. 1b is used in the analogue testmeter. This is completely symmetrical, and if only half is considered, the action is similar to Fig. 1a.

Corresponding to the large current amplification in the feedback loop, the input current to the amplifier is extremely small, and most of the current from the input terminal, through R_i, will flow past the input of the amplifier to become feedback current in the feedback resistor, R_f. This is equivalent to subtracting the feedback current from the input current to leave a small amplifier input. The output current in R_L is a multiple of the current from the input terminal, nearly equal to R_f/R_L.

In terms of voltages, the action is like tipping a balance; as one end goes up, the other end comes down, and similarly a voltage at the input produces a voltage of opposite polarity at the output. The amplifier input voltage is automatically reduced to bring it nearly to the fulcrum or zero position, although always short of zero by a small residual that is amplified to give the output. The input and output voltages will be in the ratio R_i/R_f, and the input impedance will be R_i.

In Fig. 1b, two of the Fig. 1a systems are, in effect, combined in a push-pull version, and the action is like two balances tipping equally in opposite directions at the same time.

CIRCUIT DESIGN

In the version of Fig. 1b, with a direct-coupled amplifier, feedback is applied symmetrically. There is a doubled input impedance, and both terminals are floating. To fix the potential of one terminal would unbalance the feedback and considerably increase drift. Offset is much less of a problem when the system is completely symmetrical, both terminals tending to remain at the same zero-signal potential. The effects of stray capacitances also tend to cancel.

A differential output stage overcomes any uncertainty about the value of R_L. Intermediate stages of this type also have advantages, and a differential input stage is essential to overcome offset and temperature drift.

Each stage in the amplifier thus consists of a pair of transistors, and by making the impedance in the emitter circuit as large as, or preferably much larger than, the collector load impedances, amplification of common-mode inputs can be avoided. A third transistor can be added in the emitter circuit of a differential stage to act as a high effective impedance, or constant current generator, keeping the total collector current constant. This gives a high common mode rejection ratio and makes the stage largely independent of voltage levels elsewhere in the amplifier, although still sensitive to differential inputs.

AMPLIFIER OPERATION

The amplifier is formed of three differential stages, together with emitter-followers. A configuration of five *npn* transistors is repeated, and between these two

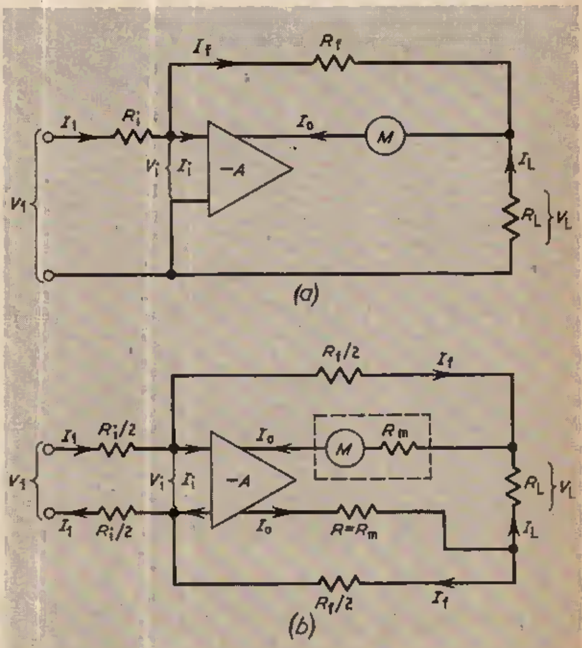


Fig. 1. Principle of the transistorised d.c. multimeter. (a) Basic arrangement of an inverting d.c. amplifier as a current or voltage follower. (b) Differential system incorporating a fully differential d.c. amplifier

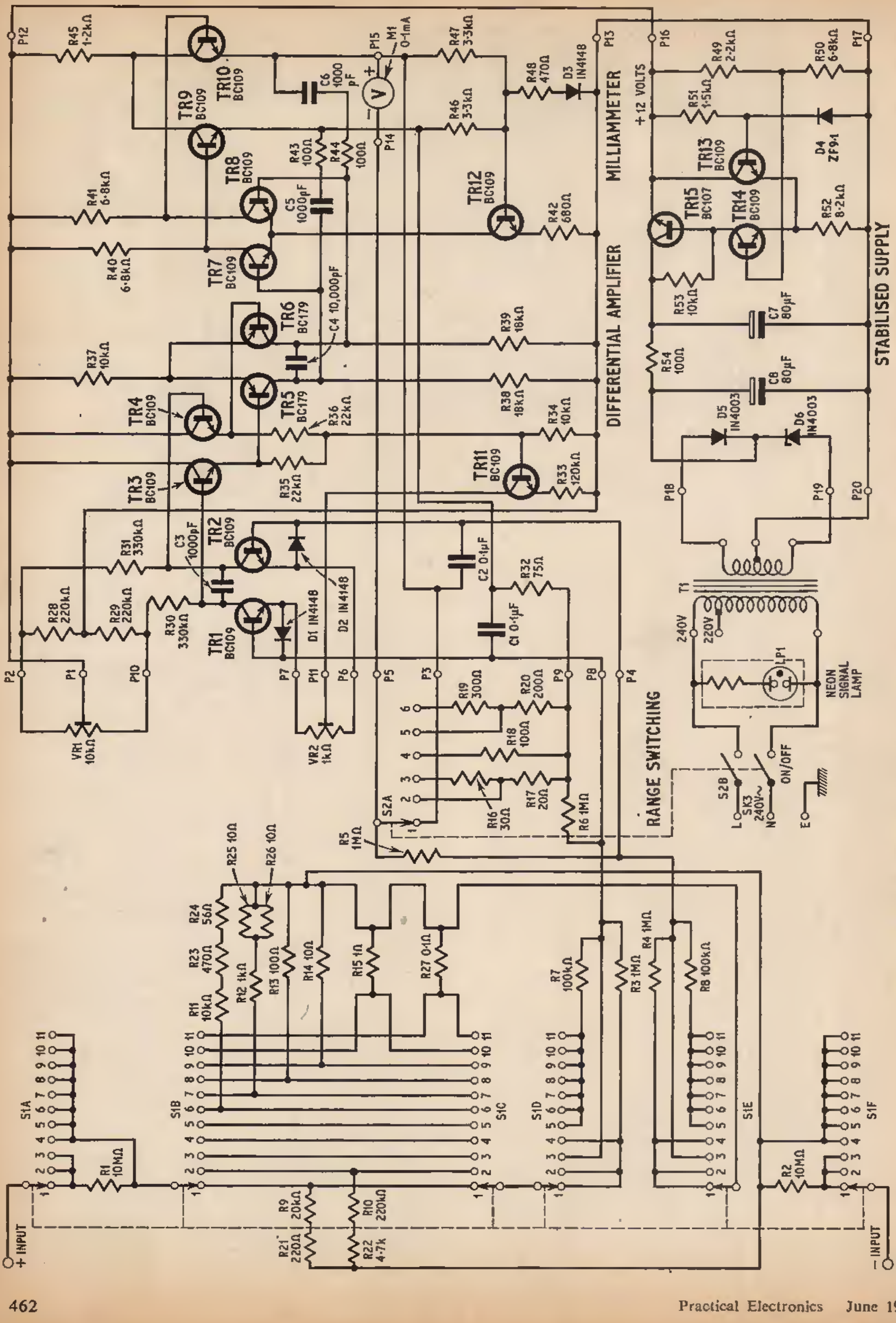
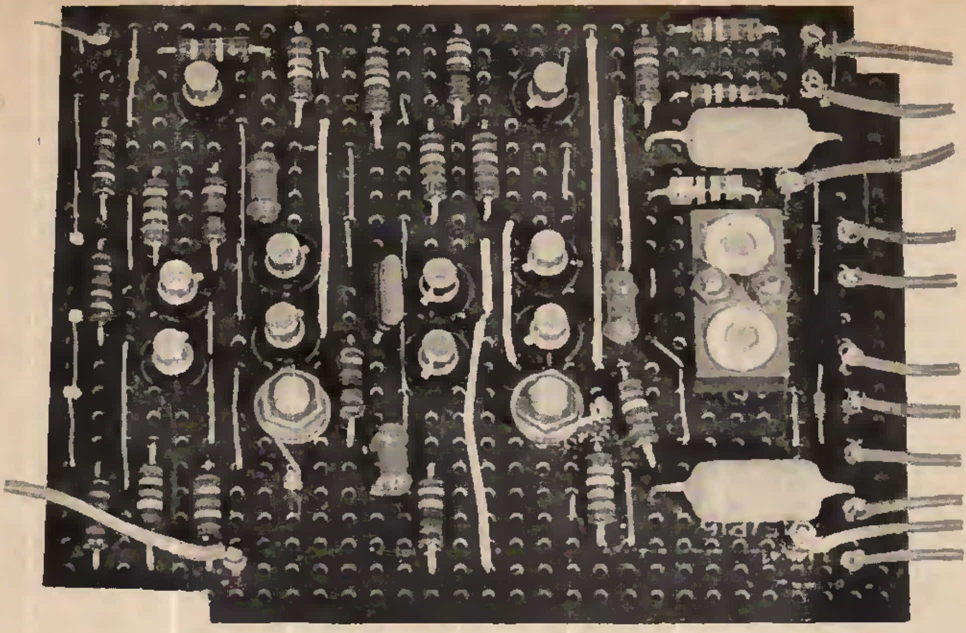


Fig. 2. The circuit diagram of the transistorised d.c. multimeter



Completed amplifier board with connecting wires attached

sections, a *pnp* stage is included (see Fig. 2) to reverse the stage by stage increase in voltage levels that usually occurs in a direct coupled amplifier, enabling d.c. feedback to be more readily applied between the output and input. In the *npn* configurations, the small amplification round the minor stabilising loop, helps to fix the voltage levels, and improves the symmetrical response to signals.

Amplification is only required at a low frequency, making it easier to achieve a very high amplification. The bandwidth is restricted to exclude mains frequency by including capacitors in the feedback network. Phase shift in the rest of the amplifier could produce oscillation, and to prevent this, two networks, each consisting of a 100 ohm resistor in series with 1,000 pF capacitor, are connected from the emitters of the output stage to the bases of the preceding stage. These effectively suppress oscillation at a low radio frequency, but v.h.f. oscillation can still occur, and must be prevented by connecting an additional capacitor of 10,000 pF between the collectors of the *pnp* stage.

VOLTAGE LEVEL VARIATION

Some variation in voltage levels is to be expected every time an amplifier is constructed because of component tolerances. The ratios of resistances associated with the constant-current stages will have the main effect, but the variations will not be amplified in successive stages because of the high common-mode rejection in the amplifier stages.

A diode in the second constant-current stage is for temperature compensation, to avoid a small shift in voltage level with temperature which would be passed back to the input of the amplifier. The diode adds slightly to the tolerance spreads in the amplifier.

A transistorised voltmeter will not check voltage levels in its own amplifier because of feedback effects. A simple form of high-impedance voltmeter will enable approximate checks to be made on amplifier conditions.

AMPLIFIER PANEL

The amplifier panel is shown in Fig. 3, and consists of 0·15 inch pitch veroboard.

An insulated backing sheet of thin material is fitted behind the amplifier panel, separated from it by the thickness of the 2 B.A. nuts on the milliammeter terminals. This is intended to provide some additional insulation between the amplifier and the neon mains indicator situated under the amplifier board.

The holes for the 2 B.A. meter terminals are carefully positioned as shown in Fig. 3. Two of the perforations on the Veroboard are drilled to take the 8 B.A. bolts that hold the small heat sink in position.

The positions of the breaks in the copper strips are shown in Fig. 3. Additional links are of 24 s.w.g. tinned copper wire,this gauge is thin enough to enable two links to be inserted in the same hole when necessary; the longer links should preferably be sleeved.

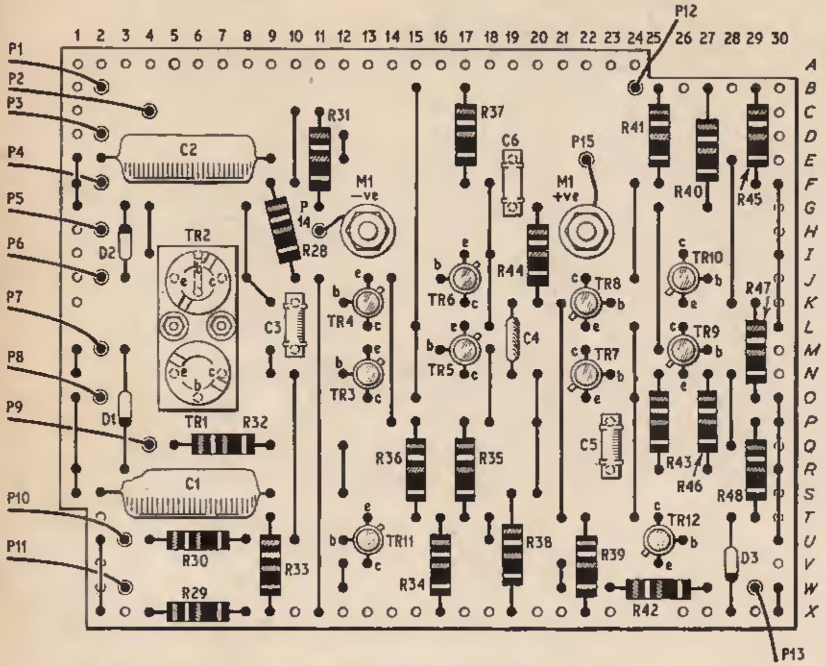
Veropins inserted into the amplifier board serve as soldering points for external connections. Those for the 0·15 inch pitch Veroboard are of larger diameter than those for the 0·1 inch pitch Veroboard that is incorporated in the range-switching assembly detailed later. The veropins are put in on the component side, soldered to the copper strips on the other side, and clipped short so that they do not project into the backing sheet.

TRANSISTORS

There are altogether a dozen transistors on the amplifier board, all of TO18 construction. Two of the transistors, TR5 and TR6, are *pnp* types (BC179) and should be kept carefully separate from the others which are all of the *npn* type (BC109).

The two *pnp* transistors form the intermediate voltage amplifying stage, and provide a convenient means of

AMPLIFIER BOARD



Pin numbers on the lead-out wires will be explained in the final wiring diagram

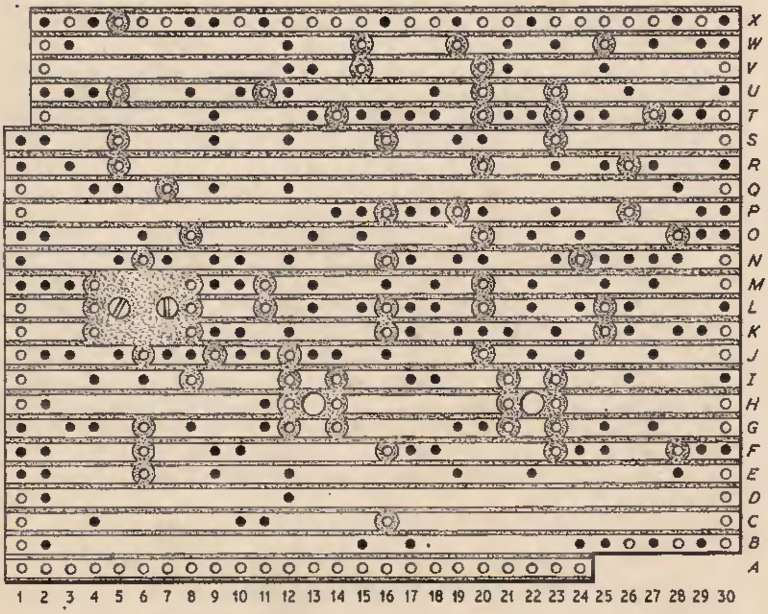


Fig. 3. Amplifier panel layout and wiring

COMPONENTS . . .

AMPLIFIER

Resistors

- R28 220kΩ
- R29 220kΩ
- R30 330kΩ
- R31 330kΩ
- R32 75Ω
- R33 120kΩ
- R34 10kΩ
- R35 22kΩ
- R36 22kΩ
- R37 10kΩ
- R38 18kΩ
- R39 18kΩ
- R40 6·8kΩ
- R41 6·8kΩ
- R42 680Ω
- R43 100Ω
- R44 100Ω
- R45 1·2kΩ
- R46 3·3kΩ
- R47 3·3kΩ
- R48 470Ω

All ±5% ½W carbon film

Capacitors

- C1 0·1μF polyester
- C2 0·1μF polyester
- C3 1,000pF ceramic
- C4 10,000pF polyester
- C5 1,000pF ceramic
- C6 1,000pF ceramic

Semiconductors

- D1–3 1N4148 (3 off)
- TR1–4 BC109 (4 off)
- TR5–6 BC 179 (2 off)
- TR7–12 BC 109 (6 off)

Miscellaneous

- Veroboard 4⅝in × 3¾in, 0·15in matrix
- Veropins
- Heatsink 2 × TO18 (Redpoint 18DC/HA)
- S.R.B.P. 4⅝in × 3¾in (backing panel)

STABILISER BOARD

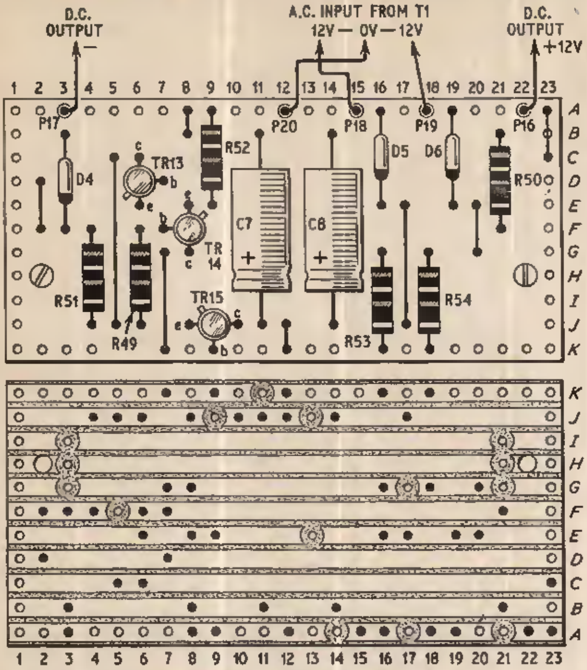


Fig. 4. Stabiliser board layout and wiring

COMPONENTS . . .

STABILISER

Resistors

R49 2·2kΩ	R52 8·2kΩ
R50 6·8kΩ	R53 10kΩ
R51 1·5kΩ	R54 100Ω

All ±5% ½W carbon film

Capacitors

C7 80μF elect. 25V
C8 80μF elect. 25V

Semiconductors

TR13, 14 BC 109 (2 off)
TR15 BC 107
D4 ZF 9·1
D5, 6 1N 4003 (2 off)

Miscellaneous

Veroboard 3¾in × 2¼in, 0·15in matrix
Veropins
S.R.B.P. board 3¾in × 2¼in (backing board)

bringing down the output to the same voltage level as the input, without introducing potential dividers or zener diodes.

In a feedback amplifier, temperature variation in the base-emitter potential of the input transistors is likely to be the only significant temperature variation causing drift, and its effect can easily be reduced by making the input circuit of high impedance, and by using a differential pair of transistors. There is considerable uniformity as regards the base-emitter temperature characteristic, so unmatched transistors can be used in differential stages. It is probably worthwhile, however, to sort out the BC109 transistors into pairs, and to use the best matched pair for the input stage. The transistors should be from the same production batch, and can be matched in β at a current of about 10μA. Transistors matched at 1mA may not be so well matched at a lower current.

HEAT SINK

Very constant conditions are maintained in the input stage, and the completed instrument has a sufficiently stable zero even on the 2 millivolt range. If the temperature characteristics of TR1 and TR2 are not alike, a rise in junction temperature will produce unequal effects, and drift will occur from switching on. However, the dissipation is very small, as the collector current is only 10 microamperes, and this should help to reduce the initial drift. Short term drift is very undesirable, as it can occur during a measurement. Long term drift takes place through changes in room temperature, and will be about 15μV per degree Centigrade.

If the two transistors were mounted separately, a slight difference in heating would cause a shift of zero position on the meter. It is necessary, therefore, to equalise the temperatures by mounting them close together in a heat sink.

Before insertion, the transistors should be turned so that the leads are in the correct position to pass through the perforations on the amplifier board. Both transistors require the same orientation, with the small lugs parallel, and with the base lead of each transistor on the centre line of the heat sink.

The heat sink is raised sufficiently from the amplifier board to allow for the spread of the transistor leads. A small piece of insulating material serves as a spacer.

STABILISER

It is just as necessary to overcome drift due to mains voltage variation, and this can be done by stabilising the 12 volt supply with a three transistor circuit (TR13 to 15 in Fig. 2). A high degree of stabilisation can easily be achieved, since the amplifier requires only a few milliamperes of current.

Positions of the components on the stabiliser board is shown in Fig. 4, this also shows the breaks in the copper strips. The two electrolytic capacitors are mounted centrally.

The finished board is mounted vertically at the side of the amplifier nearest to the miniature mains transformer T1, by means of an aluminium bracket to which it is fastened by 6 B.A. bolts. These also pass through the insulated backing piece from which it is spaced by insulating washers, case details and board positioning will be given later.

Next month: Further construction details

THE ancestry of many electronic circuits in common use today can be traced back to the invention of the thermionic triode by Lee de Forest in 1907. For example, Eccles and Jordan published the circuit of a "two-state" or bistable electronic switch in 1919, which was based on the triode, and this circuit later became the building brick of modern digital computers. The important thing about de Forest's invention was that it introduced for the first time the active principle of amplification to circuit design.

When transistors began to appear in quantity after 1950, they were initially regarded merely as substitutes for the thermionic triode, and old circuits were adapted to accommodate them. However, increasing knowledge of semiconductor principles soon led to the development of new devices and circuits, which bear little resemblance to those of the triode.

TRIODE

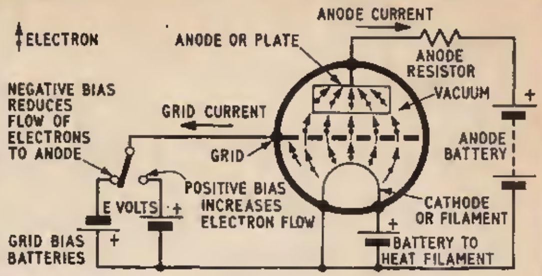


Fig. 3.1a. Working principle of a thermionic triode

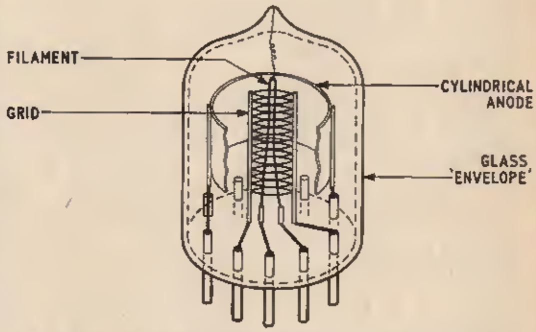


Fig. 3.1b. Physical construction of a triode valve

THERMIONIC TRIODE

A basic triode consists of a thin wire filament (cathode), a wire grid, and a metal plate (anode), all contained in a vacuum, see Fig. 3.1. Electrons are thrown off by the vibrating atoms of the heated filament and travel across the vacuum space towards the positively charged anode, thus forming an electric current. There can be no flow in the other direction because the anode does not emit electrons, and there are no other current carriers present in the vacuum.

The function of the grid is to control the electron flow to the anode, and it exerts a large influence on the electrons because it is close to the filament. Thus, a small voltage change on the grid results in a large current change at the anode.

A resistor placed externally, in series with the anode connection, will convert a change of anode current into a change of anode voltage. Thus a small change in grid input voltage results in an amplified change in anode voltage. The valve acts as an amplifier.

TRANSISTOR ACTION

It was explained in Part 2 that a diode is formed by the combination of *p* and *n* type semiconductor materials. If a "sandwich" is made with two *n* type materials on the outside and a *p* type filling or central layer, this will obviously give two diodes back to back, as shown in Fig. 3.2a. Similarly when the materials are arranged in a sandwich of *pnp*, but the diodes will then be the opposite way round, as in Fig. 3.2b.

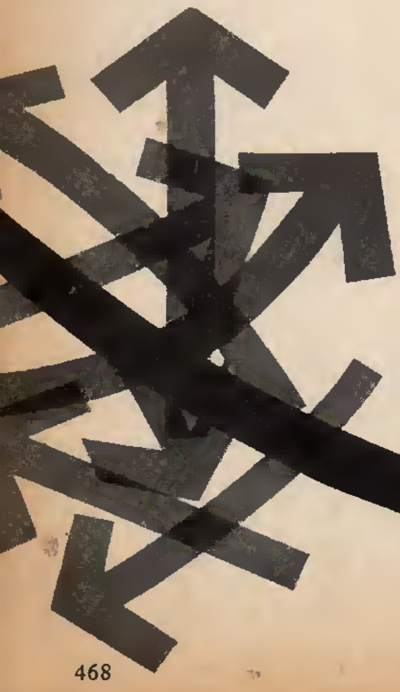
Both devices of Fig. 3.2 are incapable of conducting a significant current between the terminals marked *emitter* and *collector* when the *base* terminal is unconnected because one of the diodes will always be reverse biased, and act as an insulator.

Suppose now that the central semiconductor layer is made very thin, typically less than one thousandth of an inch, and the sandwich layers are doped with differing amounts of impurity atoms.

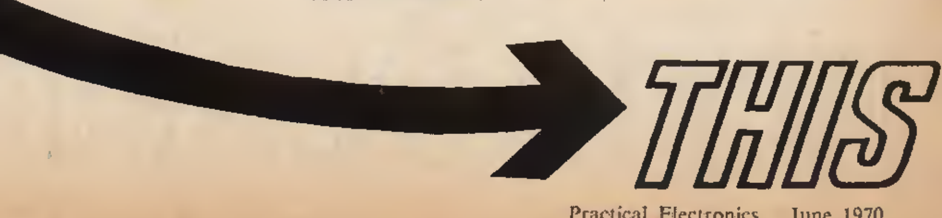
The diode junctions will be physically so close that they will tend to interact with each other, and variation of doping levels will cause an unbalance in the combining of electrons with holes. This is the basis of transistor action, where the current passed through one diode influences the current flowing through the other.

BIASING

Fig. 3.3a shows the three layers of an *npn* transistor, an *n*-type collector material with a normal doping of free electrons, a thin *p*-type central layer forming the base which is lightly doped with just a few holes, and a heavily doped *n*-type emitter containing a large number of free electrons.



A NEW SERIES FOR THE BEGINNER



TRANSISTOR

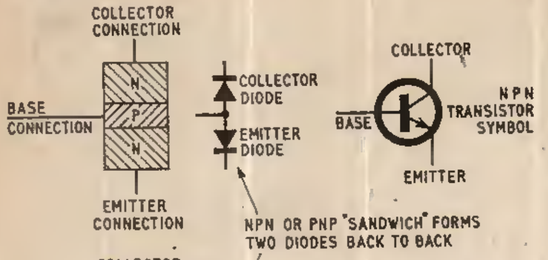


Fig. 3.2a. NPN transistor shown in block form (left); theoretical circuit (centre); circuit symbol (right)

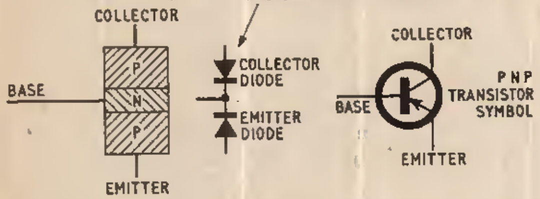


Fig. 3.2b. PNP transistor shown in block form (left); theoretical circuit (centre); circuit symbol (right)

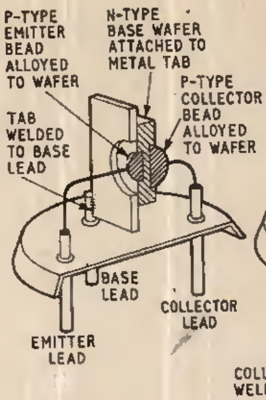


Fig. 3.2c. Cross-section view through a germanium alloy pnp transistor

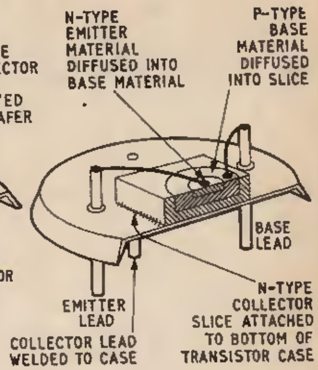


Fig. 3.2d. Cross-section view through a silicon planar npn transistor

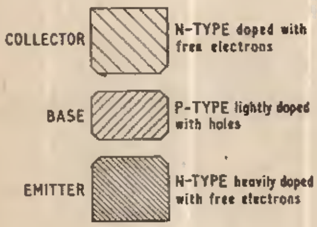


Fig. 3.3a. Different impurity doping levels in a transistor sandwich

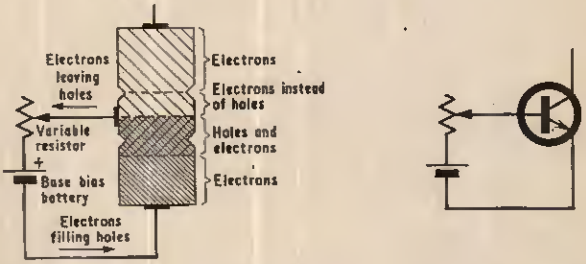


Fig. 3.3c. Free electrons move into collector insulator region when emitter junction is forward biased

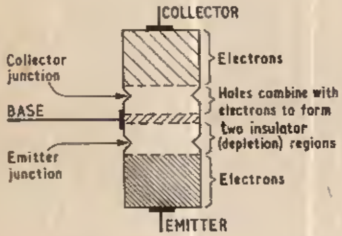


Fig. 3.3b. Two insulator regions formed in an unconnected transistor

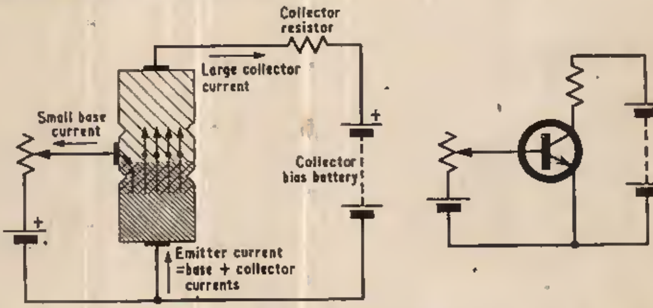


Fig. 3.3d. With base and collector bias, more electrons are carried across the collector junction than are passed through the base bias battery, thus giving amplification of the base current

WAY TO ELECTRONICS 3

AMPLIFICATION

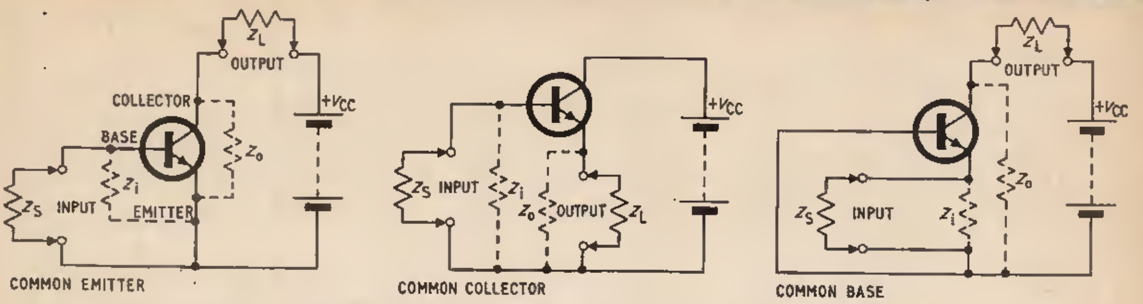


Fig. 3.4a. The three transistor configurations connected as current amplifiers

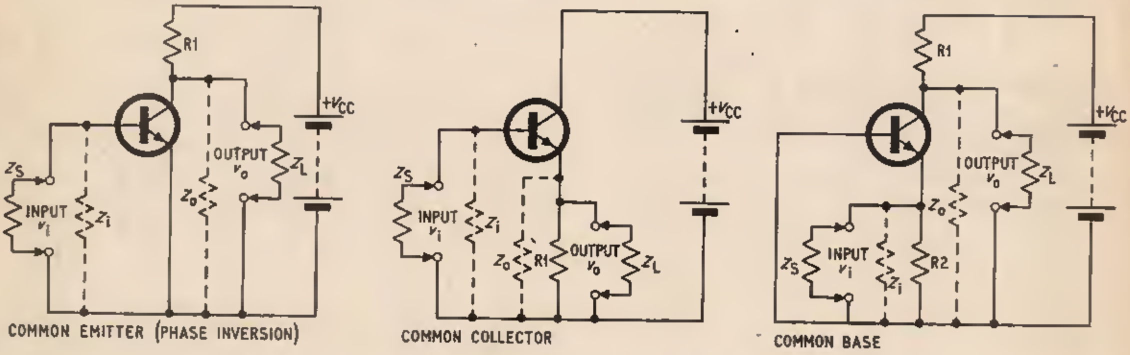


Fig. 3.4b. The three transistor configurations connected as voltage amplifiers

When the three layers are merged, free electrons and holes combine to form two insulator or depletion regions; one at the junction between base and collector, the other at the base-emitter junction (Fig. 3.3b).

If a base bias battery is now connected across the base and emitter, as in Fig. 3.3c, with a variable resistor in series to adjust the level of base current, the emitter diode will be forward biased. The emitter insulator region therefore disappears, and electrons will flow by the mechanism of filling and leaving holes.

However, the emitter has many free electrons, while the base material has only a few holes. So, while some electrons from the emitter are kept busy filling holes, others will be swept along by the current to find no holes vacant. These uncommitted electrons tend to repel each other, and quickly diffuse throughout the base material, into the region of the collector junction insulator.

It will be remembered that a diode insulator can only exist as such when there are holes on one side of the junction and free electrons on the other. The presence of free electrons instead of holes in the vicinity of the collector junction tends to "spoil" the diode insulator, and thus converts the junction into a conductor.

AMPLIFICATION

When a battery is coupled to the collector and emitter terminals (Fig. 3.3d) the uncommitted electrons from the emitter proceed to flow across the collector junction, under the influence of a positive charge, thus creating a collector current.

Any increase of base bias current will cause a corresponding increase of collector current, but because the base material is very thin, more electrons tend to find their way to the collector material than are "used up" by the base bias. This is called current gain or amplification. If 50 electrons cross the collector junction for every one taken by the base current, the gain of the transistor will be 50.

A *pnp* transistor functions in much the same way, except that the role of free electrons and holes is exchanged, and base and collector supply polarities are reversed. The arrowheads in the transistor symbols of Fig. 3.2 indicate the direction of "conventional" flow, not electron flow. (See Part 1 for explanations.)

THREE CONFIGURATIONS

A transistor is primarily a current amplifying device, but a current flowing through a resistance will give rise to a voltage drop across that resistance ($V = I \times R$). Therefore, a transistor can be considered as a voltage amplifier when the internal resistances of the device, and the values of external resistors connected to it, are taken into account.

There are three main ways in which a transistor can be employed to amplify small currents or voltages, in circuits termed "common emitter", "common collector", and "common base". Table 3.1 lists the main features of each configuration, and the circuits appear in Fig. 3.4 under the headings current and voltage amplifiers. For the sake of clarity, base biasing has been omitted and will be dealt with later.

IMPEDANCE MATCHING

Although an amplifier is energised by a d.c. supply, it is used to increase the voltage or current from a

Table 3.1. TRANSISTOR AMPLIFIER CHARACTERISTICS

Configuration	Common emitter	Common collector	Common base
Current gain	medium	medium	unity
Voltage gain	high	unity	high
Power gain	high	low	medium
Input impedance Z_i	low	high	very low
Output impedance Z_o	medium	very low	very high

Table 3.2. ABBREVIATIONS USED IN THIS ARTICLE

V_{CC}	Collector bias battery voltage
v_i	Input signal voltage
v_o	Output signal voltage
Z_i	Input impedance of transistor circuit
Z_L	Impedance of load applied to output terminals
Z_o	Output impedance of transistor circuit
Z_S	Impedance of signal source or generator
R_L	D.C. resistance of applied load
R_S	D.C. resistance of signal source
V	Voltage
I	Current
R	Resistance

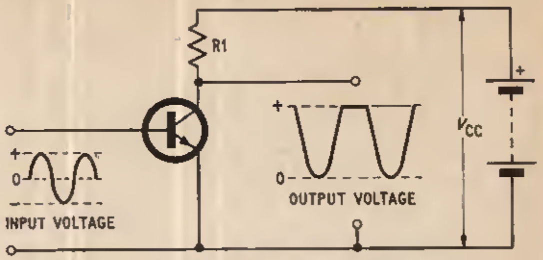


Fig. 3.5a. Common emitter a.c. amplifier without base bias. The transistor only amplifies alternate positive half-cycles and inverts the waveform

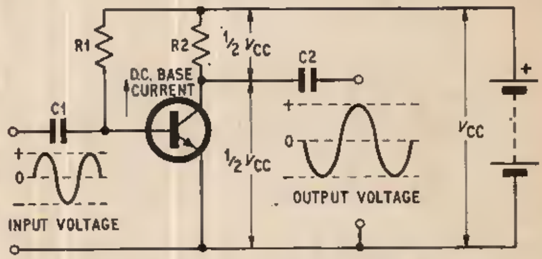


Fig. 3.5b. Common emitter a.c. amplifier with base bias and coupling capacitors. The transistor amplifies the complete sine wave and inverts it

separate a.c. or d.c. source which is connected to its input terminals. Such a source will have a certain known internal resistance.

If the source is d.c., its resistance is of value R_s; if the source is a.c., its resistive effect has to take into account variations according to the inductive and/or capacitive components of the source. In this case, the combined resistive effect is called impedance and is denoted by to the symbol Z_s.

Similarly, the load applied to the output can be a pure resistance and is termed R_L, or in the case of inductive and/or capacitive loads applied to a.c. is termed Z_L.

For simplification, the source and load are considered in Fig. 3.4 as impedances Z_s and Z_L so that they can apply to d.c. or a.c. If a d.c. source is applied, then $Z_s = R_s$ and $Z_L = R_L$.

It would be natural to assume that the input and output impedances of the amplifier itself would be the same as the internal resistances of the transistor, plus the values of any external resistors, but this is not so. The existence of amplification in a transistor circuit has the effect of modifying real resistive values to give an "apparent" value of input and output impedance denoted by dotted lines in the circuits of Fig. 3.4 and marked Z_i and Z_o respectively. If the amplifier is to work efficiently it should be "matched" to the source and load impedance, i.e. Z_s should be nearly the same as Z_i, and Z_L should be approximately equal to Z_o.

With the exception of the common emitter amplifier of Fig. 3.4b, all the circuits in Fig. 3.4 will give an output which increases as the input increases. In the case of the common emitter voltage amplifier, however, the output voltage is at maximum when the input voltage is at minimum, and decreases as the input voltage increases. The term for this is "phase inversion".

UNBIASED BASE

If the circuits in Fig. 3.4 are made up without base biasing, they will be found to amplify only input currents or voltages of single polarity. For example, the common emitter circuit of Fig. 3.4b will accept and amplify positive input voltages, but will ignore negative input voltages.

When the input voltage is zero or negative there will be no collector current, therefore the output voltage will be maximum and equal to almost the full battery voltage, V_{cc}. It follows that the output can only vary between V_{cc} and zero in response to a positive input voltage.

Fig. 3.5a shows what happens when an unbiased common emitter amplifier handles an a.c. signal. Positive half-cycles are amplified and appear at the output upside-down (phase inversion), but negative half-cycles at the input produce no change of output. How then can a complete a.c. cycle be amplified?

BASE BIAS

The following measures are taken to convert the unbiased amplifier into an a.c. amplifier. Firstly, the transistor base is supplied with d.c. bias from the battery positive terminal via R1, see Fig. 3.5b.

This base current is amplified by the transistor to yield a collector current (since the emitter is common to both circuits) which causes about half the total battery voltage to appear across R2 and the other half across

D.C. STABILITY

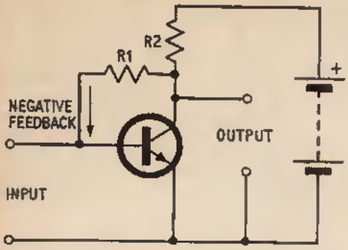


Fig. 3.6a. Base current bias with d.c. negative feedback

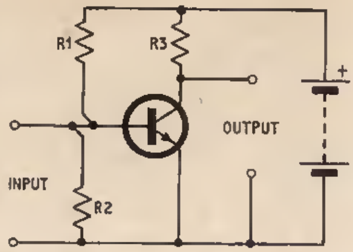


Fig. 3.6b. Base voltage bias provided by a potential divider

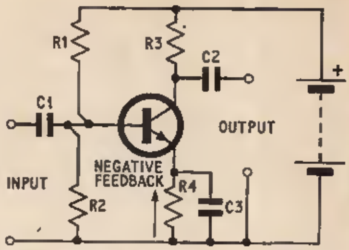


Fig. 3.6c. Base voltage bias with d.c. negative feedback and a.c. decoupling capacitor

the output terminals. So, on receipt of a signal, the output voltage can now either increase or decrease about the mean value of $\frac{1}{2}V_{cc}$.

Having established d.c. bias values, it is important to ensure that they will not be disturbed when an external circuit is connected to the amplifier input or output. A capacitor has the property of preventing a flow of d.c., but will "pass" an a.c. signal.

Capacitors C1 and C2 are therefore placed in series with the input and output terminals, and the amplifier will now respond to a.c. signals, with positive and negative half cycles appearing at the output, as depicted in Fig. 3.5b.

D.C. STABILITY

A single resistor R1 is used to set the d.c. operating conditions of the amplifier in Fig. 3.5b, but this simple method of biasing has two disadvantages. The value of R1 must be altered to suit individual transistors of slightly different current gain. The circuit is also sensitive to changes of temperature. It will be remembered from Part 2 that the resistance of a semiconductor decreases with rising temperature, and tiny changes of base current are, of course, amplified.

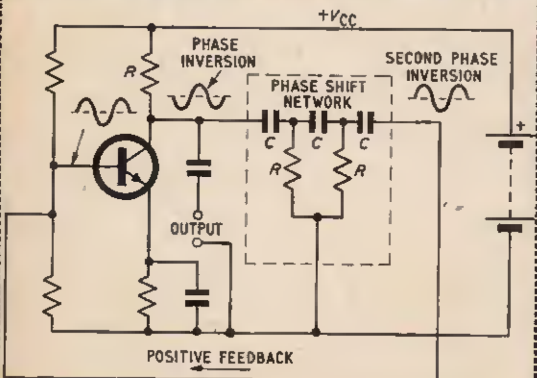


Fig. 3.7. Transistor phase shift oscillator. Frequency of oscillation is approximately 80,000/RC where R is in ohms and C is in microfarads

If R1 is connected to the collector terminal, instead of the positive battery terminal, as shown in Fig. 3.6a, d.c. stability is improved. As ambient temperature increases so does base and collector currents, but the voltage at the collector falls, thus counteracting an increase of base current and nullifying the effects of temperature.

The circuit will now accept transistors of differing gain without the need for adjusting the value of R1. Unfortunately, these improvements are obtained at the expense of amplification. The phase inverted output at the collector is fed back via R1 to the base, and is subtracted from the input; this is called *negative feedback*.

VOLTAGE DIVIDER

A prefered method of biasing is where two resistors, R1 and R2 (Fig. 3.6b) form a voltage divider across the battery, from which the base of the transistor is supplied with a voltage bias. The d.c. operating conditions of the circuit in Fig. 3.6b are moderately stable, but can be much improved if a small amount of amplification is sacrificed in the form of negative feedback.

Instead of taking feedback from the collector, a similar result can be achieved if a low value resistor R4 is inserted in series with the emitter, as in Fig. 3.6c.

To avoid loss of amplification of an a.c. signal (Fig. 3.6c is shown as an a.c. amplifier) R4 can be bypassed by a capacitor C3, without affecting the d.c. stability of the circuit. Thus, R4 limits the d.c. current for stability, while C3 acts as a short for a.c. and infinitely high parallel resistance path to d.c.

TRANSISTOR OSCILLATOR

An amplifier can be made to oscillate by the application of positive feedback. In the circuit in Fig. 3.7, the common emitter amplifier feeds a phase inverted signal to a network of resistors and capacitors. The network has the property of causing a phase inversion only at one particular a.c. frequency. Two successive phase inversions cancel out to leave a non-inverted or in-phase signal, which, when fed back to the amplifier input, reinforces the input signal and causes a build-up of oscillations. The output from the oscillator is sinusoidal, with the same waveform as mains supplies, and is derived from the laws of circular motion.

Next month we shall be looking at more oscillators, and will go on to pulse and switching circuits.

MARS PROGRAMME FOR THE 1970's

In 1971 two spacecraft will be launched towards Mars and go into orbit around the planet. The orbiting vehicles will each weigh about a ton and will be equipped with special survey cameras and other instruments. They will map about 70 per cent of the surface of Mars and record the changes that appear to be of a seasonal nature. It is expected that continuous information will be relayed back to earth during the three month operational period for which these vehicles have been designed.

Though identical instrumentation will be carried by these two spacecraft, their missions will differ. Both will carry television cameras in pairs, one camera will have a 50mm lens for wide angle coverage and the second will have a telephoto lens of 500mm for detailed survey.

The first of the vehicles to arrive in the vicinity of the planet will be *Mariner 8*. Its mission is the overall reconnaisance and systematic photographing of the surface. The area covered will be from 60 degrees south latitude to 40 degrees north latitude during a 90 day period. The spacecraft will orbit the planet every 12 hours in an elliptical orbit which will range from 1,000 to 10,500 miles.

Mariner 9 will follow and will be inserted in a much more elongated orbit, with a perigee of 1,000 miles and an apogee of 27,000 miles. It will pass over the same area of the planet's surface every fourth day.

The cameras on the *Mariner 9* craft will record the darkening of the surface which has been observed to coincide with seasonal changes. The latest opinions among planetary astronomers do not favour the theory that these changes are due to vegetation, though no specific suggestions have been made as to what the changes might be.

MARS ENVIRONMENT

However, opinion is unanimous that the environment is hostile to man, being frigid and desolate. No water, or life sustaining oxygen has been detected on the surface. The ice caps are composed mainly of carbon dioxide frost. The atmosphere is mostly very thin carbon dioxide gas with perhaps a trace of water present.

Mars resembles the Moon and the Earth yet has its own particular character. The surface is marked with thousands of craters large and small like the moon, but it also shows large features like the continents on the earth. The altitude variations of various features are of the order of 40,000 feet. There are other features which show folds of jumbled and jagged rock formations unlike the moon or the earth.

The two spacecraft will continue to orbit Mars for about 17 years after their scheduled mission is completed.

VIKING EXPLORERS

The dual mission of *Mariners 8 and 9* will be followed in 1975 by the *Viking* series of spacecraft. They will also orbit Mars but will release landing craft to the surface which will make observations and relay the information back to earth via the orbiting mother craft. It is hoped that these experiments will settle once and for all the question of the existence of life in any form on Mars.

The next step after this will be the landing of men on the surface of the planet, marking the second major step in the exploration of the solar system.

MOONGLOW

The moon is bathed in the solar wind and as there is no atmosphere there is a constant blizzard of particles from the sun. These are thought to be the cause of moonglow, as the actual surface of the moon is dark and it is not possible for the moon light to be due to mere reflection from the surface.

The *Apollo 11* crew exposed a thin sheet of aluminium for 77 minutes while they were on the moon's surface and it now seems that the moon is being bombarded by something of the order of 63 million atoms of helium per square metre per second. This enormous flux forms a kind of haze and reflects the sunlight. The particles do not seem to be affected by any electromagnetic forces, if such should exist on the moon.

NATO-ONE SATELLITE

The first North Atlantic Treaty Organisation satellite was put into orbit in March and is being financed by the participating members of NATO. The satellite is in a geosynchronous orbit (22,000 miles plus) over the Eastern Atlantic.

The satellite project costing some 50 million dollars consists of two satellites and 12 terminal stations. The satellites are built in the USA but the terminals are being constructed by the member countries. Extensive tests on the satellites prior to handing over to NATO was carried out by the Research Establishment at Christchurch, England.

All operations are controlled from the satellite communications centre (SATCOM) at the NATO headquarters in Belgium. When the network is completed in 1971 it will be used exclusively by NATO. This will facilitate communications by voice and telegraphy between member governments, and between their representatives at Brussels and leaders at home.

Eight of the terminals will be ready by the end of 1970, two more in early 1971 and the last two by the middle of 1971.

France, Luxembourg and Iceland will not have terminals but will have facilities for "tying in" to the network.

SKYNET CONSCRIPTED

The Royal Navy has its own waveband on the *Skynet* system and has found that its value to them justifies a call for their own satellite in phase two of the project.

The Navy operate with the smallest transmitting and receiving terminal in service, using 2 metre dishes (two to each ship), and consequently the power from the satellite has to be stepped up to obtain adequate signal strength. In order to avoid swamping by the large dishes with a bandwidth of 20MHz the small dishes have a bandwidth of 2MHz and the power is split equally between the pathways.

The modulation system used by *Skynet* is wideband digital and therefore speech has to be digitised. This must then be put through a teleprinter or de-modulated and transformed into speech again.

There are three possible modulation systems using Pulse Code, Delta and Vocoder techniques. Pulse Code Modulation (PCM) systems give high quality speech reproduction but is expensive and complex because the required digitation is 64,000 bits per second. The second possible method, Delta Modulation has the advantage of being simple and can give medium speech quality with 16 to 20 bits per second. The third system is also expensive and complicated, but gives acceptable speech quality using Vocoder-synthesiser techniques. There is also the advantage that it may be possible to link this with computers.

FLASHING LIGHT SHOW

THIS article describes a unit designed to flash up to 200 watts of mains lighting on and off in time to music. With the increasing popularity of "progressive" music which, when performed live, usually has an associated light show, it is felt that a home light show is the obvious next step after stereo hi-fi to obtaining pop concert or dance hall realism in the home. The unit can also be used as a low speed stroboscope.

The design criteria of the unit were as follows:

(a) To be capable of being connected to any existing sound system without affecting the sound system.

(b) A standard mains lighting system should be used as the display.

(c) The unit should obtain all its power from the mains without the need for batteries.

(d) The design should be compact, reasonably cheap and simple to build and maintain.

CIRCUIT PRINCIPLE

Basically the circuit consists of an audio triggered monostable switch, which operates a thyristor (SCR1) and this in turn switches the light on and off.

The monostable is triggered from the sound system, usually from a loudspeaker, and switches whenever the sound exceeds a certain level, which is normally on a drum beat. It then turns on the lights for a set time, after which is returns to its stable state, with the lights off, ready for the next trigger pulse.

The switching circuit consists of four rectifiers in a normal bridge rectifier configuration, with a thyristor connected in place of the load as in Fig. 1.

By P. B. HUTCHINSON

A thyristor is basically a silicon rectifier which only conducts in the forward direction when a small voltage in the order of a few volts is applied to a third terminal called the gate or trigger. Once the thyristor is conducting, the gate voltage can be removed and the thyristor will hold itself on until the current is stopped. The reverse characteristic of the device is the same as for a normal silicon rectifier.

It can be seen that when the thyristor is turned off, the switched circuit is in effect open circuit between A and B. However, when the thyristor is triggered (turned on) the circuit becomes, in effect, a short circuit between A and B.

It should be pointed out that if an a.c. signal is applied to the circuit, as is of course the case, then the trigger pulse has to be re-applied with every half cycle, as the current through the thyristor drops down to zero between each half cycle.

Hence, by connecting the switch circuit in series with a mains bulb, it can turn the bulb on and off by means of a small trigger voltage. It is, however, more convenient, as will be seen later, to put the mains bulbs in series with the thyristor itself as in Fig. 2.

This has no effect on the light output of the bulbs as it simply means they are receiving a full wave rectified mains supply instead of an a.c. mains supply.

TRIGGERING

According to the type of thyristor used, a trigger voltage in the order of 3 volts, at 20mA, relative to the cathode, is required. It was found that the thyristor used could be triggered directly by connecting it across a loudspeaker. However, the lights only stayed on for the duration of each loud sound and they tended to be rather erratic when the music contained loud vocal work. Also the gate current drawn by the thyristor was sufficient to cause a slight crackling sound from the loudspeaker as the device switched on and off. Furthermore, the continuous switching caused slight radio interference and rather reduced the life of the bulbs.

It was therefore decided to incorporate a monostable between the signal source and the thyristor in order to hold the lights on for a certain period before letting them turn off again. This has the effect of making the lights switch on and off more rythmically, and it is also more kind to the bulbs and suppresses radio interference.

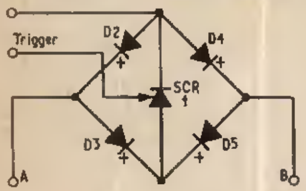


Fig. 1. Thyristor switching circuit

MONOSTABLE

The overall circuit diagram is shown in Fig. 2.

When the monostable is in its stable state, TR2 is on and TR1 off. A negative trigger pulse of sufficient magnitude applied to the base of TR1 will turn it on and its collector voltage will drop towards zero volts. This voltage change is transmitted via C2 to the base of TR2, turning TR2 off. Transistor TR2 then remains off until C2 has charged up, via R5/VR2, to a voltage sufficient to turn it on again; when this happens the circuit reverts back to its stable state.

TRIGGER TRANSISTOR

An output is taken from the collector of TR2 and fed via the trigger transistor TR3 to the gate of the thyristor. The purpose of TR3 is to act as a power amplifier to switch the thyristor, which otherwise may upset the working of the monostable.

When the monostable is in its stable state with TR2 on, TR3 is turned off and hence the gate of the thyristor is at the same potential as the cathode. When the monostable changes state TR3 is turned on and the gate of the thyristor is connected via R8 to the positive supply thus triggering it and turning the lamps on.

CONTROLS

It has already been pointed out that the "on time" of the monostable and hence that of the lights is decided by the time constant $C_2(R_5 + R_{VR2})$. By making

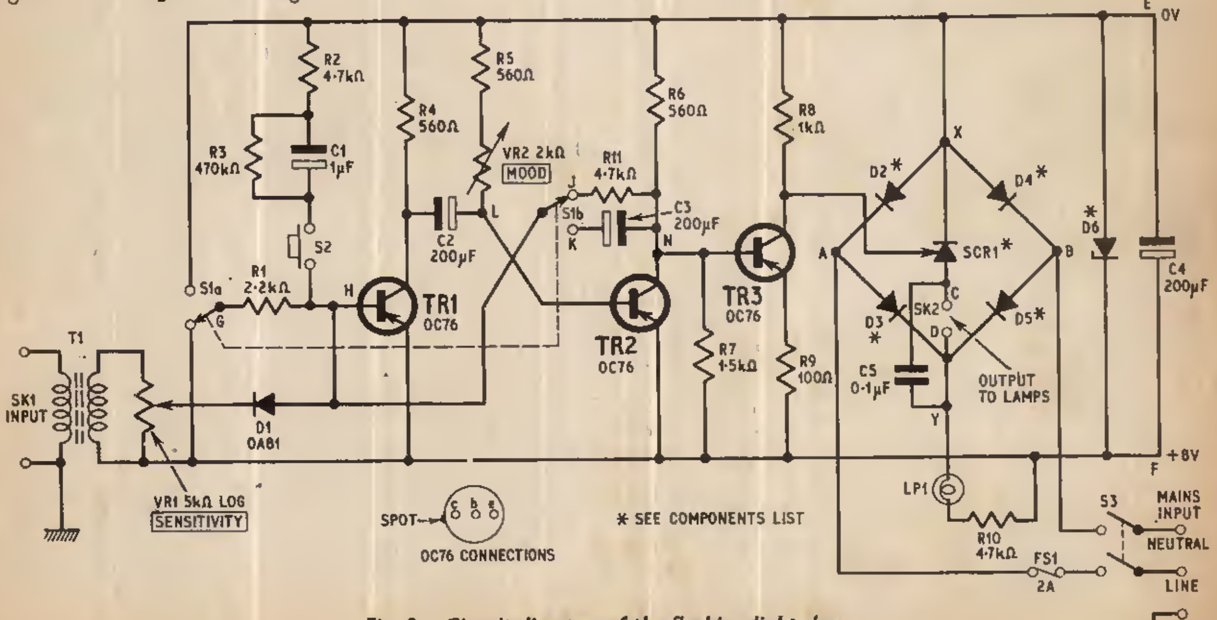
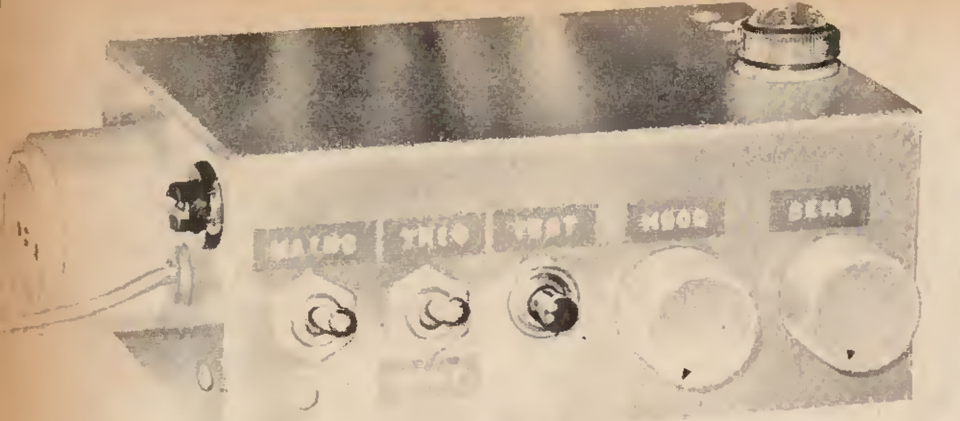


Fig. 2. Circuit diagram of the flashing light show



It should be noted that the flashing light display described in this article could produce an effect, on a few people, that may cause fainting. This usually only occurs when high power flashing lights are used for long periods in conditions of low ambient light.

$C_2 = 200\mu F$, $R_5 = 560$ ohms and $R_{VR_2} = 2$ kilohms the on time of the lights can be varied between 0·112 and 0·512 seconds which has been found to be an adequate range. Potentiometer VR2 is called the "mood" control as it determines the length of the flashes and is adjusted to suit the mood of the music.

It is also very easy to convert the monostable into an astable multivibrator and this is achieved by S1. When S1 is closed the circuit is free running and hence the lights are continuously switched on and off like a slow running stroboscope. With S1 in this position, R11 is replaced by a 200μF capacitor (C3) and also R1 is taken to the 0V supply line instead of the + 8V supply line, thus converting the circuit to a multivibrator. When S1 is in the trigger position, the monostable operates normally, being triggered from the audio signal.

A test button S2 is provided to apply a trigger pulse to the monostable in order to test the unit. This is not essential and can be left out.

The other controls are the on/off switch (S3) and the sensitivity control (VR1), both of which are self-explanatory. The best way to set the sensitivity control is described later in the article.

TRANSFORMER DETAILS

It should be realised that the whole of the circuit is at approximately 240 volts d.c. below earth due to the action of the rectifier circuit, and hence the circuit *must* be connected to the signal source via an isolating transformer. The transformer used should have a winding ratio of about 1 : 1, and the breakdown voltage between windings must be greater than 500 volts.

Probably the best transformer to use would be a speaker isolating transformer which is made for just this type of job. However, speaker transformers tend to be unnecessarily bulky and expensive due to the power and frequency requirements. If a transformer of this type is used the case would have to be enlarged to accommodate it. A mains isolation transformer could also be used but may also be rather large and possibly expensive.

The prototype unit used a government surplus transformer that measured 1¼in × 1in × 1in having a winding to winding and winding to case insulation of 500 megohms, measured at 1,000 volts. The transformer has a winding ratio of 2 to 1 and is a miniature valve interstage transformer; it is housed in a metal case and has insulated ceramic stand off terminals. If a transformer with a slight step-up ratio is used, it should be connected so that it steps up the signal coming into the circuit.

The output from the transformer is passed via VR1 and a diode to the base of TR1. The diode ensures that only negative pulses are applied to the base of TR1, otherwise the monostable would be switched back to its stable state prematurely by positive pulses.

POWER SUPPLY

It was decided to derive the power supply for the monostable and trigger transistor from the mains supply rather than from batteries for two reasons. Firstly, because the transistors require a fairly large current, and secondly because a rectified mains supply was already present in the circuit. This brings us to the reason for putting the mains bulbs in series with the thyristor. By doing this the voltage appearing between the points X and Y in Fig. 2 is always the full wave rectified mains voltage irrespective of whether the thyristor is on or off. If the bulbs were put in series with the complete switch then when the thyristor was on the rectified voltage would drop to almost zero.

The rectified voltage is applied via a 4·7 kilohm 10 watt dropping resistor to an 8 volt Zener diode giving a stabilised 8 volt supply to power the transistor circuitry. A 200μF capacitor is connected across the Zener diode and this provides adequate smoothing. The circuit draws approximately 15mA in the off state and 35mA in the on state, the extra current in the on state being the trigger current in the thyristor.

VOLTAGE DROPPER

The mean d.c. value of the rectified mains voltage appearing between X and Y was measured to be 210 volts. Hence the voltage drop across R10—the 4·7 kilohm dropping resistor—has to be 202 volts, which means a current of 43mA must flow through R10. Hence the Zener diode has to pass 28mA when the circuit is in the off state. A Zener diode with at least 50mA rating should therefore be chosen.

If a Zener diode with a current rating appreciably higher that 50mA is used, then some or all of the dropping resistance R10 can be replaced by a small mains bulb. This replacement resistance depends on the surge rating of the Zener, because a bulb passes a large surge current when it is switched on as the cold resistance of the filament is lower than the hot resistance. By leaving some resistance in series with the bulb the surge is reduced. An example of the calculation for a series resistor and lamp is as follows.

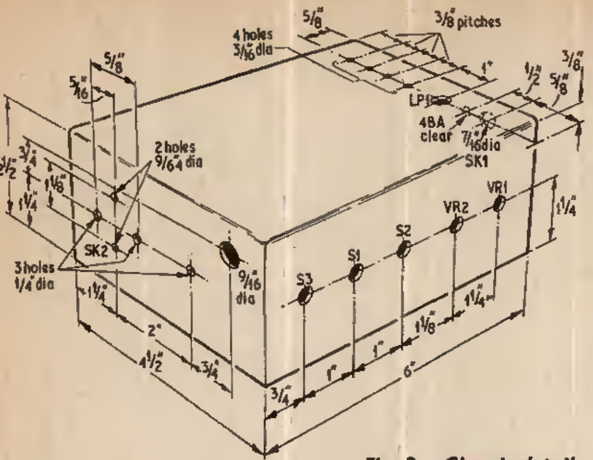


Fig. 3. Chassis details

The hot resistance of a 15 watt mains bulb is given by

$$R = \frac{V^2}{W} = \frac{240^2}{15} = 3{\cdot}9 \text{ kilohms}$$

We want the total resistance to be approximately 4·7 kilohms. Therefore the series resistance should be 1 kilohm.

A reasonable assumption for the cold resistance of the bulb is 1·5 kilohms (bearing in mind that the current will never reach the value given by the cold resistance, owing to the filament heating up). Hence current surge will be approximately 100mA.

Thus we need a Zener diode with a surge rating of 100mA if a 15 watt bulb in series with a 1 kilohm resistor (of 2·5 watts rating) is used as a voltage dropper. This arrangement is convenient because one can obtain coloured miniature bulbs of 15 watts rating for mains indicator use.

CONSTRUCTIONAL DETAILS

The unit should be constructed in a totally enclosed, 6in × 4in × 2½in, aluminium case. The drilling details for the case are given in Fig. 3. These can, of course, be altered in order to suit particular components, but it is felt that the layout shown can be used with most parts and enables the unit to be fitted into the smallest box possible, yet leaves it very easy to work on any particular part of the circuit.

In the prototype unit most of the electronics, including the thyristor and rectifiers, were fitted on two plug-in printed circuit boards; Veroboard can just as well be used and wiring details for Veroboard panels are shown in Figs. 4 and 5.

It should be pointed out that if the thyristor and rectifiers are to be used at anything near their full rating, then they should be mounted on heatsinks. The prototype unit used 3 amp rectifiers and thyristor and is capable of switching 300 watts for several hours continuously. This, however, tends to make the rectifiers rather hot and it is suggested that 200 watts is taken as maximum if the rectifiers are mounted on a printed circuit board; 200 watts is ample for most domestic rooms.

PLUG-IN BOARDS

Having all the circuitry on plug-in boards makes construction easy, enables two layers of components to be fitted in the case, and facilitates easy servicing. The bottom board contains the monostable, and the top board (looking from underneath) houses the trigger and switch circuit. The transistors used can be almost any low power, *pnp* switching transistor capable of passing 25mA. Great care should be taken in assembling the thyristor and rectifier board as some of the

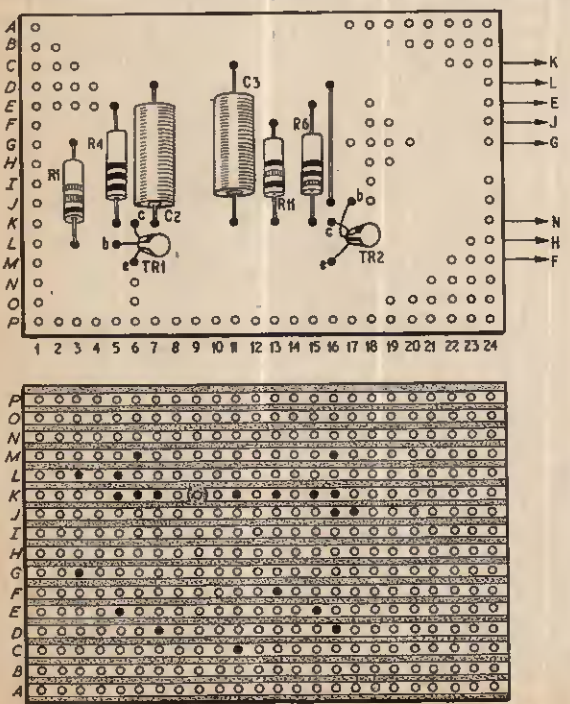


Fig. 4. Layout and wiring of the monostable Veroboard panel

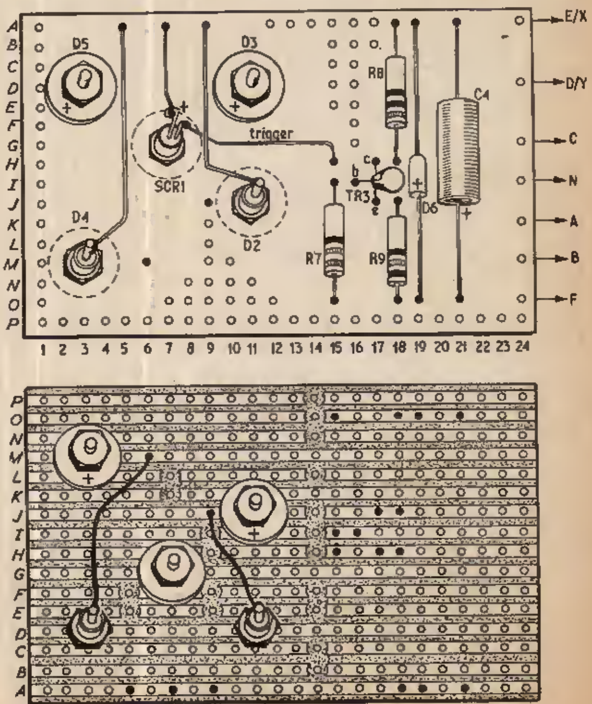


Fig. 5. Layout and wiring of the switching and trigger Veroboard panel

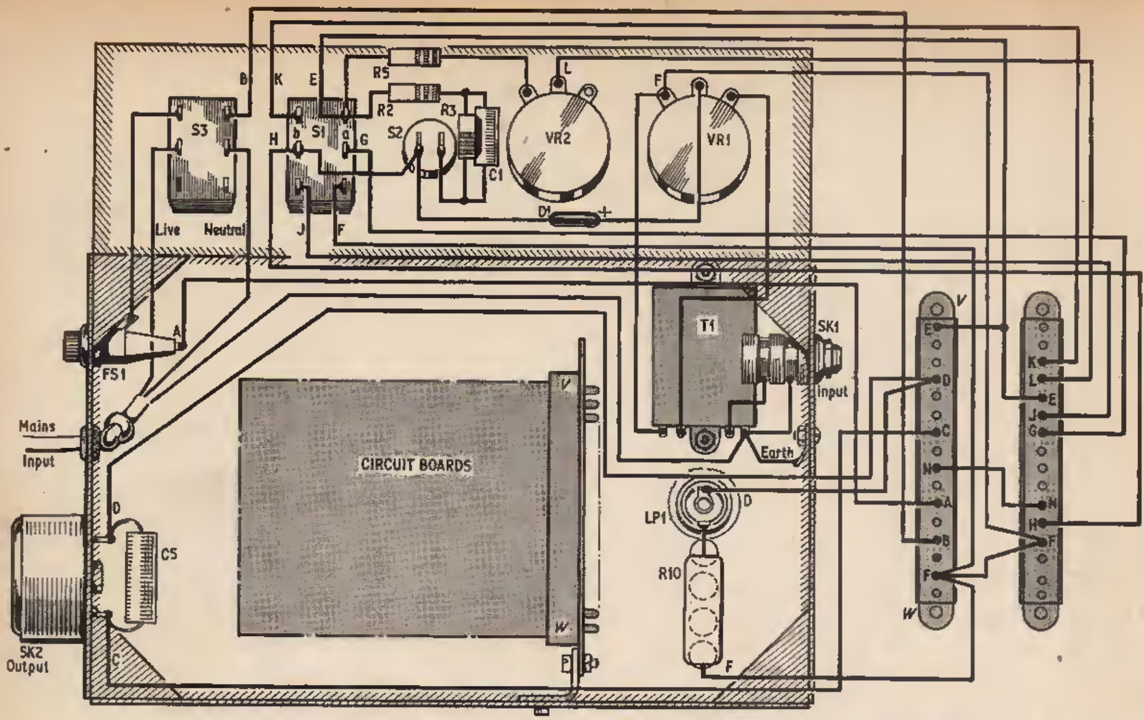


Fig. 6. Component layout and wiring of the chassis mounted components

COMPONENTS . . .

Resistors

R1	2·2k Ω	R7	1·5k Ω
R2	4·7k Ω	R8	1k Ω
R3	470k Ω	R9	100 Ω
R4	560 Ω	R10	4·7k Ω 10W wire wound
R5	560 Ω	R11	4·7k Ω
R6	560 Ω		All ± 10%, ¼W carbon, except R10

Potentiometers

VR1 5k Ω log.
VR2 2k Ω linear

Capacitors

C1 1μF elect. 10V
C2 200μF elect. 10V
C3 200μF elect. 10V
C4 200μF elect. 10V
C5 0·1μF paper 450V

Semiconductors

D1 OA81
D2–5 400 p.i.v. 3 amp silicon rectifiers (4 off)
D6 Zener diode 6 to 12V 50 mA (see text)
TR1–3 OC76 or equivalent (3 off)
SCR1 400 p.i.v. 3 amp thyristor

Switches

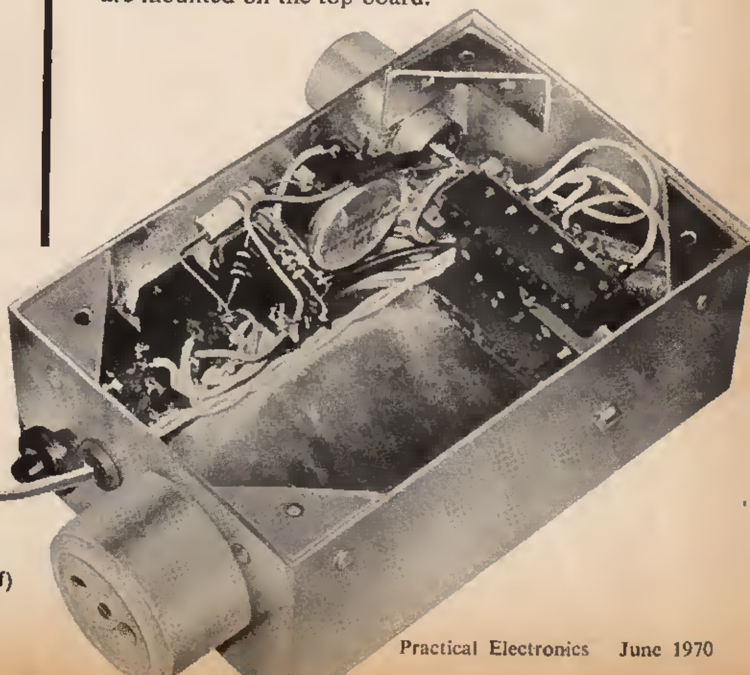
S1 D.P.D.T. toggle
S2 S.P.S.T. pushbutton
S3 D.P.D.T. toggle

Miscellaneous

T1 Transformer (G. W. Smith, see text)
LP1 6V 40mA pilot lamp and holder
SK1 jack socket
SK2 2 pin mains socket
Control knobs (2 off)
Case (see text)
Veroboard 2½in × 3¾in, 0·15in matrix (2 off)
Connectors, edge type for Veroboard 16 way (2 off)

strips carry mains voltages. The connections to the studs of the thyristor and rectifiers are made by the copper strips clamped under the studs. All the copper strips are blanked off at the end of the rectifier section of the board, apart from those actually carrying connections to the pins. This reduces the possibility of accidental shorts. The letters by the pins on the board correspond to various points of the circuit marked in Figs. 2 and 6.

If it is decided to mount the thyristor and rectifiers on heatsinks then it is suggested that the heatsinks are mounted on the chassis (with suitable insulation of course) in place of the bottom board, and the monostable and trigger stage (i.e. all the transistor circuitry) are mounted on the top board.



LAYOUT AND WIRING

The layout and wiring details of the unit are shown in Fig. 6. The wires from the switches and other components mounted on the chassis to the Veroboard sockets are best soldered to the sockets before they are fixed inside the chassis. If the wires are laced together to form a loom, it makes the construction much neater and also enables the sockets to be easily removed from the chassis if necessary. The sockets are in fact sold as Veroboard edge connectors and accept standard Veroboard. They can be mounted on a small right-angled bracket similar to that shown in Fig. 6.

The pilot light (if a resistor is used to drop the voltage for the 8V supply) is a standard 6V 40mA bulb and is wired in series with the dropping resistor R10. The size of hole required for the pilot light obviously depends on the type of holder used and hence no dimension has been put on Fig. 3. The four holes in the chassis next to the pilot light are ventilation holes to dissipate the heat from R10.

A three core mains lead *must* be used to supply the unit, and the chassis *must* be earthed by connecting the earth lead to a solder tag.

ADDITIONAL LIGHTING

By wiring one or more bulbs in parallel with the thyristor the unit can be made to alternate the light between two bulbs, or sets of bulbs, i.e. instead of just one set of bulbs that are either on or off, two sets of bulbs varying between set 1 on, set 2 off, and set 2 on, set 1 off are displayed. The relative brightness of the two sets of bulbs can be altered by varying the number of bulbs in each set.

If one 60W bulb is wired in parallel with the thyristor and two 60W bulbs, paralleled together, are put in the normal position in series with the thyristor, then when the thyristor is off, the single bulb will be almost full on and the pair of bulbs almost off. When the thyristor is on then the single bulb will go off and the pair on.

If just one 60W bulb is put in series and one in parallel with the thyristor, then when the thyristor is off both bulbs will be half on. When the thyristor is on, the bulb in parallel will be off and the one in series on; this gives a softer effect than the previous system.

The whole system can, of course, be made brighter by increasing the ratings of all the bulbs but keeping them in the same configuration, bearing in mind the limitations previously discussed.

SETTING UP

The idea is to set the sensitivity control so that the unit just triggers in the loudest peaks of the music, which is normally the drum beat. The mood control, which varies the "on" time of the lights has to be adjusted to suit the type of music and the effect required, e.g. for slower, relaxing music the most soothing lighting is required and this is obtained by setting the mood control to give the longest "on" time which means the lights flash slowly. If the mood control is set for a shorter "on" time with the same music, it will be found that the lights will flash more regularly, probably giving two flashes to every one before.

For faster music, it is necessary to decrease the "on" time in order to get the lights to flash on each beat.

For a really "progressive" or high impact effect the "on" time wants to be made a minimum and the sensitivity turned up a little above the triggering position. This makes the lights follow the notes rather than the beat of the music. ★

SOUNDS INCREDIBLE

continued from page 454

The Radiophonic Workshop, being a service department within the BBC, very rarely has time or opportunity to create electronic music as an original, and complete art form. However, collaboration with "outside" composers have resulted in public performances, and recently the Workshop has released an LP of a selection of its work. (BBC Radiophonic Music—Radio Enterprises REC 25M.)

A facet recently added, is the dimension of stereo. Various productions have used Radiophonic sounds in stereo, from the total radio production "Rus" to the cockan'bull tale "The Shagbut, the Minikin and the Flemish Clacket". Another offering from the same stable was "The Shadow of Napoleon".

Various innovations such as synthesisers are likely to be used in future. Such apparatus would provide more original sounds but, as has been found with electronic organs, constant use breeds not only contempt, but instant recognition. It may be that the treatments achieved by means of a synthesiser, will be more important than the sounds produced by it.

IMPROVEMENTS

As more and more new equipment becomes available, technical quality continues to improve. Recording tape has increased coercivity, this is important in sound manipulation, as the number of times a tape can be copied and recopied is limited, without the sound quality seriously deteriorating. With modern tape, higher levels can be recorded without distortion, and a higher signal/noise ratio is maintained.

The only thing that seems incapable of improvement, is the humble razor blade (well, not in the way it is used in the Workshop), unless anyone can produce a plastic, non-magnetic one that cuts tape just as well as the steel ones.

This then, is the continuing story of the BBC Radiophonic Workshop, for whilst the fertile minds of the programme authors continue to demand special sound, and music, the Workshop must continue to supply them. ★

NEWS BRIEFS

Liquid Crystals

THE first reported multi-coloured displays using a material called "liquid crystal" have been produced by scientists at Marconi, during development work which promises new types of electronically controlled information displays and optical devices at low cost. "Liquid crystal" is a class of liquids with a regular, crystal-like structure, some of which change their appearance when a voltage is applied. They might one day be used in television screens thin enough to hang on a wall, but immediate practical uses are in data readouts for control panels, animated labelling for keyboard buttons, and see-through map displays which pilots and drivers can read "head-up" without losing sight of the view ahead.

Practical display panels, using "liquid crystal", which operate at room temperature and have no moving parts, have already been made in the Research Division of The Marconi Company. These panels are normally transparent, but words or other information appear in white when a low voltage is applied to the panel.

Report from AUSTRALIA

BY D. F. MOODY

THIRTY-SIX miles out of Canberra, and set in a natural depression circled by mountains, is the Orroral Space Tracking Station. There are three tracking stations situated at a similar distance from the National Capital—a deep space tracking station at Tidbinbilla, another at Honeysuckle Creek and the Orroral which is the largest of the three. Orroral is committed to a 24-hour sky watch and it monitors many of the U.S. scientific space probes during their periods of masking from the U.S.A.

Signals are received via four antennae, the largest one of which is an 85ft 260 ton steerable dish. The signal is recorded on tape on one of four stations, or may be sent live via a p.c.m. line direct to the Goddard Space Flight Center in the U.S.A.

Although the Orroral is not involved in manned space flight missions, they handle a great variety of mundane scientific work. Some of the more well-known scientific probes with which Orroral has been involved are *OAO* (Orbital Astronomical Observatory), *IMP* and *NIMBUS*.

Two antennae are used for the transmission of command signals to switch the satellite on and off before and after its scheduled relay activity. For this type of work a standard and accurate time system is absolutely important. Three G.M.T. time standards are maintained at Orroral and frequent cross-checks are made with other installations not only in Australia but also overseas.

The station is staffed and run by an Australian Company under contract from NASA; which has a capital investment in Australia of over 60 million dollars, making Australia one of the world's leaders in this type of space work.

AMATEURS OSCAR 5

The fifth satellite in the *OSCAR* series, *Australis-Oscar 5*, was launched by an American rocket on January 15 this year. These satellites have one thing in common—they were designed and constructed by enthusiasts, and in fact *OSCAR* stands for Orbiting Satellite Carrying Amateur Radio.

Australis-Oscar 5 was the first amateur satellite NASA have launched and adopted an almost circular orbit 1,000 miles up. The rocket also put a weather satellite into orbit. *Australis-Oscar 5* has two radio transmitters, one at 29·450MHz and the other at 144·050MHz. There is also a command receiver which was used to operate the 29·450MHz transmitter while the satellite is orbiting, and gave amateur radio operators experience in the ground control of satellites.

The satellite contains a bar magnet that stabilises the satellite by aligning it with the earth's magnetic field and so allow signals to be received from it free of spin. Three light intensity sensers sent back information so that the effectiveness of the stabilisation system can be determined. In addition to this the skin temperature, the inside temperature, and the battery voltage and current will be monitored. The signals were received at ground stations in Australia, New Zealand, the U.K. and the U.S.A.

Australian enthusiasts hope that the experience gained from *Australis-Oscar 5* will be invaluable for their next venture, which is already on the drawing board, and is planned for launching within one and a half years. The electronics in this satellite will be designed and built by Australian enthusiasts but will be assembled, packaged and powered by a group of American amateurs. This effort will result in a multi-channel communications satellite which will bounce messages between amateur radio operators around the world.

DOWN TO EARTH

Or to be more specific "Under a Mountain".

It is strange that many people who have not been to Australia think of it as a place that is completely flat, dusty and dry and full of flies. Well the last three items may be true but that it is completely flat is a falsehood. The vast areas of Australia are flat, but there are also fine mountain ranges of which the "Great Divide" is probably the most well known. The Snowy Mountains in this range boasts the highest point in Australia—Mt. Kosciusko at 7,300ft which manages to keep snow most of the year.

It is in this area where the Snowy Mountains Authority undertook their Hydroelectric Scheme—the largest engineering project in Australia, and one of the largest in the world. It involves eight major dams, 100 miles of tunnels and 10 power stations supplying power to Victoria and New South Wales.

The whole scheme is almost too gigantic to envisage, and in fact the roads servicing the work areas take two to three days to explore in a car. One of the most impressive undertakings is the Tumut One Power Station. Although the power station is of modest output (four 80kW generators) it does have a rather peculiar location—1,200ft inside a mountain! That is 1,200ft under the surface, and 1,100ft from the side. The entrance is a modest opening in the mountainside which introduces you to a half-mile long descent leading to the generating and control room. This huge hall, cut out of solid rock, houses the four generators, transformers and water pipes.

Each generator swallows 6,000 gallons of water every second from the Tumut River to produce 80kW of power at 12·5kV (which is then transformed up to 330kV for transmission).

Being down in that hall, one experiences considerable excitement. The uniform but pleasant coolness, the hum of machinery, the banks of control lights and meters, and the feeling of being surrounded by millions of tons of rock. Also one was aware of the feeling of getting something for nothing. Unfortunately this last point is naturally not true as, apart from the machine maintenance, one has to pay for being so far underground to the tune of pumping out 250,000 gallons of seepage water from the station every day.

PROSPECTS for the ELECTRONICS INDUSTRY

BACKGROUND TO THE INDUSTRY

Because electronics is a set of industrial techniques and not a group of products, the industry cannot be defined precisely. For the purposes of this assessment, its coverage is defined as in the table below.

Short title	Sector
Scientific and industrial instruments and systems	Capital equipment
Telephone and telegraph apparatus and equipment	Telecommunications equipment
Radio and electronic components	Components
Other broadcast receiving and sound reproducing equipment	Consumer goods
Electronic computers	Capital equipment
Radio, radar and electronic capital goods	Capital equipment

Defined in this way, the industry accounts for about four per cent of the output of all manufacturing industry, and employs about six per cent of its labour force. In the context of the engineering and electrical industry groups, electronics accounts for about one-sixth of the output, one fifth of the imports and one seventh of the exports of the group.

The industry is concentrated in the South-East, but in recent years much of its growth has been in the development areas, particularly in Scotland.

The U.K. electronics industry is believed to be the fourth largest in the World behind the U.S., Japan and West Germany, and is slightly larger than that of France. (Production in the U.S. is approximately four times as great as that in the other four countries combined.) A number of smaller countries including Holland, Italy, Sweden and Switzerland provide strong competition in individual product groups. The market for electronic products is international in all but a few cases, and is becoming increasingly international in character. As a result, competition is generally severe.

THE above paragraphs are taken from the opening section of an Industrial Report by the Electronics Economic Development Committee. This Report, published last March, is an assessment of the prospects of the electronics industry up to 1972.

The principal task, states the Report, is to improve the efficiency of industry and commerce in the U.K., by making and marketing the systems and devices which will enable higher productivity to be achieved. "There is virtually no area of repetitive industrial action which cannot be automated through the application of electronic technology." In this way, electronics can contribute greatly to the balance of payments.

AREAS FOR GROWTH

The Report forecasts a growth rate of nine to eleven per cent per year, in the period up to 1972. This represents a growth rate of about three times the average for manufacturing as a whole.

About a third of the U.K. market is in the public sector, where the emphasis is shifting away from defence, hitherto the industry's major pre-occupation. A further forty per cent of the market is in private industry and commerce, and the remainder is in the consumer sector.

The Report draws attention to certain areas of opportunity: these include **computers, industrial automation, telecommunications** and **data transmission**, and **microelectronics**. Other areas, which may well become major growth points of the future are **medical** and **educational applications**, and **marine technology**.

CAPITAL AND MANPOWER

Success in the future depends upon greater financial resources. Considerable sums have to be provided for innovation, because of the pace of technological advance.

But while the chief limiting factor in the forecast period is likely to be capital, in certain areas the shortage of skilled labour threatens to become a major constraint after 1972. The electronics industry is a major user of qualified manpower. Its R and D effort is approximately five times as important in relation to capital expenditure as the average for manufacturing industry.

The main areas of manpower shortage are expected to be production and systems engineers and computer "software" personnel. This is likely to be a growing problem as the industry becomes more "systems orientated"

EDUCATION AND TRAINING

A working group has been appointed to examine problems bearing on the "match" between the output of the whole education sector and the requirements of the electronics industry. The EDC attaches great importance to the promotion of a more enlightened attitude towards industrial training.

The EDC welcomes the recommendations of educational bodies for the training of professional engineers, and waits with interest details of the proposals covering technician engineers and other technical support staff.

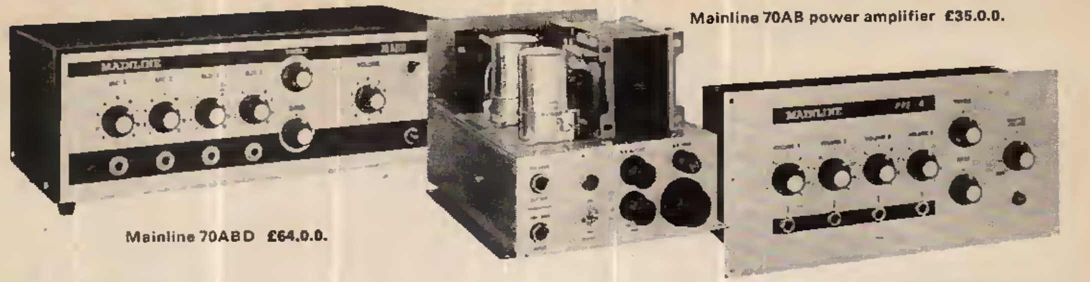
Available evidence suggests that manpower is not used effectively; in particular, that qualified scientists, engineers and technologists are employed on work which should be delegated to other technical support staff.

Finally, the EDC considers that the industry could do much more to improve its image with school leavers. Schools could benefit from more practical assistance from industry, and the importance of projects for arousing and maintaining children's interest in electronics is stressed.

Industrial Report on the Economic Assessment to 1972 by the Electronics EDC, obtainable from NEDO, Millbank Tower, London, S.W.1.

Mainline set the NEW standard in amplifiers

Mainline 70AB power amplifier £35.0.0.



Mainline 70ABD £64.0.0.

Mainline Pre-4 mixer pre-amp control unit £24.0.0.

Mainline 70ABD

The 70ABD is a fully integrated Preamplifier and Power Amplifier to the specifications of the Pre-4 and 70AB. Size 6¾" × 15½" × 4¾".

***Recommended Retail Price* £64.0.0.**

Mainline 70AB power amplifier

The MAINLINE 70AB is a high fidelity power amplifier, which is in every respect one of the finest units available on the market today, regardless of price. One of the main features of this remarkable amplifier is its elaborate protection against short and open circuit, and we can guarantee that it is virtually indestructible. Allied to this is the very high power output (70 watts RMS) a frequency range that is superb, and distortion well below 1% even at full output. The unit is suitable for use in discotheques, groups, P.A., etc., or anywhere that high quality, high output is required. Coupled to our Pre-4 Control Unit the results are quite remarkable. The Mainline 70AB main amplifier can be used with any other good quality control unit.

Specification

POWER OUTPUT 70 watts RMS±1 db at 8 OHMS.
FREQUENCY RESPONSE 20–20,000 HZ±1 db.
SIGNAL/NOISE RATIO—70 db at full output.
HARMONIC DISTORTION less than 5% at full output.
INPUT SENSITIVITY 700 mV at 20–30 K OHMS.
SIZE 7" × 9" × 6¼".
A.C. FUSE 1·5 amps (British Standard).

***Recommended Retail Price* £35.0.0.**

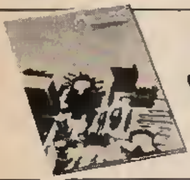
Mainline Pre-4 mixer pre-amp control unit

The MAINLINE Pre-4 is a high quality control unit, which has been designed specifically for use where mixing facilities are essential, and features many facilities not normally found on control units of this type.
The unit has four individual inputs each with its own gain control, plus separate bass, treble and master volume controls, for versatility in use. Inputs 3 and 4 are duplicated on the back panel so that if the unit is panel mounted the two auxiliary inputs (which are suitable for P.U. Tuners, Tape-recorders, etc.) may be connected from the rear. As the Pre-4 is self-powered it can be used with any other Power Amplifier, but has been designed basically as the control unit for our MAINLINE 70AB Amplifier Module.

Specification

INPUTS VOL. 1 8 mV at 50K OHMS (mic).
VOL. 2 8 mV at 50K OHMS (mic).
VOL. 3 50 mV at 500K OHMS (aux).
VOL. 4 50 mV at 500K OHMS (aux).
50 OHM and 600 OHM Mic inputs may be ordered at £2.0.0. extra per input.
1 or 2 meg OHM aux inputs may be ordered at no extra cost.
FREQUENCY RESPONSE 30–20,000 HZ±3 db.
SIGNAL/NOISE RATIO Better than – 65 db.
HARMONIC DISTORTION Less than 5% at 1 volt.
BASS Continuously variable 20 db at 100 HZ.
TREBLE Continuously variable 30 db at 10 KHZ.
SIZE 12¼" × 6" × 4¼".
CUT OUT REQUIRED 11½" × 5".
FUSE 60 ma internally mounted.

***Recommended Retail Price* £24.0.0.**



5/- stops you paying through the nose for your components

You could be paying too much for your semiconductors and electronic components. One *sure* way of saving money is to buy RCA, IR, SGS, Emihus, Semitron, Keyswitch, Plessey, Morganite, Litesold devices (together with manufacturers' application data) direct from us.

For example :-
PLESSEY SL403A

As described in Practical Electronics

Integrated Circuit (Dual in Line Package) Audio Amplifier incorporating its own Pre-Amplifier. A Class A–B Power Amplifier stage capable of delivering up to 3·5 Watts RMS. The SL403A can be used to form the basis of a simple Audio Amplifier using a minimum of external components. Complete with Data Sheet. 44/– each.

Build the NEW Mainline Audio Amplifier Kits - up to 70 watts

The results of the combined resources of SGS and RCA, these Universal Quasi Complementary Symmetry Amplifier kits use rugged NPN Hometaxial base output transistors and provide full power to beyond 20 KHz.

The all silicon circuit with nine transistors and eleven diodes provides outstanding performance for the most stringent requirements of Hi-fi equipment manufacturers.

Each kit is supplied complete with all semiconductors, resistors, capacitors, P.C. board and heat sink.

12A	£7. 0. 0.
25A	£8. 5. 0.
40A	£9. 0. 0.
70A	£10. 10. 0.

Any two will make an outstanding stereo equipment.

To: **MAINLINE ELECTRONICS LIMITED, THAMES AVENUE, WINDSOR, BERKSHIRE.**

Please send me .... Mainline Pre-4 mixer pre-amps control unit(s) ☐
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I am interested in .... Amp Mainline Audio Amplifier kits.
Please send me .... kits ☐ Please send further data ☐
Please send me your price-list guide. I enclose 5/– ☐
Cash or cheques with orders please.
I would like further data on pre-amplifier and power supply kits before I order. ☐

Name ______________________________

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A member of the ECS Group of Companies P.E. 6/70

MINIATURE WAFER SWITCHES

2 pole, 2 way—4 pole, 2 way 3 pole, 3 way—4 pole, 3 way—2 pole, 4 way—3 pole, 4 way—2 pole 6 way—1 pole, 12 way. All at 3/6 each. 36/- dozen, your assortment.

WATERPROOF HEATING ELEMENT
26 yards length 70W. Self-regulating temperature control. 10/- post free.

MICRO SWITCH

5 amp. changeover contacts, 1/9 each, 18/- doz. 15 amp. model 2/- each or 21/- doz.

TOGGLE SWITCH

3 amp. 250V with fixing ring. 1/6 each, 15/- doz.

CONSTRUCTORS PARCEL

1. Plessey miniature 2 gang tuning condenser with built-in trimmers and wave gang switch. 2. Ferrite slab aerial with coils to suit the above tuning condenser. 3. Circuit diagram giving all component values for 6 transistor circuit covering full medium wave and the long wave band around radio 2. The three items for only 7/6 which is half of the price of the tuning condenser alone.

10 AMP 24V BATTERY CHARGER

Ideal unit for garage, boat station, etc., £22.10.0 each plus carriage and cost.

BEHIND THE EAR DEAF-AID

Made by a very famous maker. Thoroughly overhauled, cleaned and re-conditioned. Guaranteed 6 months. Regular price around £50. Our price £10.

ISOLATION TRANSFORMERS 200–250 MAINS

A must if you work on mains equipment. Prevents accidents and shocks even in damp conditions. Input and output separately screened by connection block. 100 watt £3.10.0. 250 watt £5.

SLOW MOTION DRIVES

For coupling to tuning condensers, etc. One end ¼in shaft, the other end fits to a ¼in shaft with grub screws. Price 4/6 each, 48/- dozen.

LARGE PANEL MOUNTING MOVING COIL METERS

Size 5in × 4in Centre zero 200-0-200 micro amp. made by Sangamo Weston. Regular price probably £8. Our price 59/6. Ditto but 100-0-100 79/6.

A.C. AMMETER

0–5 amps. flush mounting—moving iron. Ex-equipment but guaranteed perfect 29/6.

CIRCUIT BOARDS

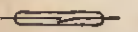
Heavy copper on 3/32 paxolin sheet ideal for making power packs, etc., as sheet is very strong and thick enough to allow copper to be cut away with hacksaw blade. 5in × 5in 1/6 each. 15in × 5in 4/6 each.

6kVA AUTO-TRANSFORMER

In ventilated sheet steel case—tapped 110V–140V–170V–200V–230V. Ex-equipment but guaranteed perfect £19.10.0 carriage at cost.

PP3 BATTERY ELIMINATOR

Run your small transistor radio from the mains—full wave circuit. Made up ready to wire into your set and adjustable high or low current, 8/6 each.



REED SWITCHES

Glass encased, switches operated by external magnet—gold welded contacts. We can now offer 3 types:
Miniature. ¾in long × approximately ⅛in diameter. Will make and break up to ½A up to 300 volts. Price 2/6 each, 24/- dozen.
Standard. 2in long × ³⁄₁₆in diameter. This will break currents of up to 1A, voltages up to 250 volts. Price 2/- each, 18/- per dozen.
Flat. Flat type, 2in long, just over ⅛in thick, flattened out, so that it can be fitted into a smaller space or a larger quantity may be packed into a square solenoid. Rating 1 amp 200 volts. Price 6/- each. £3 per dozen.
Small ceramic magnets to operate these reed switches 1/9 each. 18/- dozen.

0·005mFd TUNING CONDENSER

Proved design, ideal for straight or reflex circuits 2/6 each, 24/- dozen.

SUB-MINIATURE MOVING COIL MICROPHONE

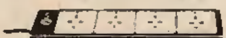
as used in behind the ear deaf aids
Acts also as earphone size only ⅜in × ⅜in × ¼in. Regular price probably £3 or more. Our price 19/6. Note these are ex-equipment but if not in perfect working order they will be exchanged.

A PARCEL OF INTEGRATED CIRCUITS MADE BY THE FAMOUS PLESSEY COMPANY

A once-in-a-lifetime offer of Micro-electronic devices well below cost of manufacture. The parcel contains 5 ICs all new and perfect, first-grade device, definitely not sub-standard or seconds. The ICs are all single silicon chip General Purpose Amplifiers. Regular price of which is well over £1 each. Full circuit details of the ICs are included and in addition you will receive a list of 30 different ICs available at bargain price 5/- upwards with circuits and technical data of each. Complete parcel only £1 post paid; or List and all data 10/- post free. Credited when you order ICs value of 30/- and upward.

24 HOUR TIME SWITCH

Mains operated. Adjustable Contacts give 2 on/offs per 24 hours. Contacts rated 15 amps. repeating mechanism so ideal for shop window control, or to switch hall lights (anti-burglar precaution) while you are on holiday. Made by the famous Smiths Company. This month only 39/6 with Perspex cover, plus 3/6 postage and insurance, a real snip which should not be missed.



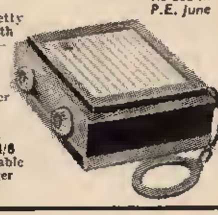
DISTRIBUTION PANELS

Just what you need for work bench or lab. 4 × 13 amp sockets and on/off switch with neon warning light in metal box. Takes standard 13 amp fused plugs. Supplied complete with 7 feet of heavy cable.
39/6 wired up, ready to work plus 4/6 post and insurance.

THIS MONTH'S SNIP

REPAIRABLE RADIOS

As used in P.E. June



7 transistor Key chain Radio in very pretty case, size 2¾ × 2¼ × 1¼in—complete with soft leather zipped bag. Specification:—
Circuit: 7 transistor superheterodyne.
Frequency range: 530 to 1,600 Kc/s.
Sensitivity: 5 mv/m. Intermediate frequency: 465Kc/s. or 455Kc/s. Power output: 40mW. Antenna: ferrite rod.
Loudspeaker: Permanent magnet type.
These radios require attention. Circuit diagram is not available. Price only 24/6 plus 2/6 post and insurance. Rechargeable batteries 8/6 pair. Plug in mains charger 12/6.

VARIAC CONTROLLERS

With these you can vary the voltage applied to your circuit from zero to full mains without generating undue heat. One obvious application therefore is to dim lighting. We offer a range of these, ex-equipment but little used and in every way as good as new. Any not so, will be exchanged or cash refunded.
2 amp £4.19.6. 6 amp £9.10.0. 8 amp £12.10.6. 10 amp £15.19.6.
Note: Some of these are panel mounting types

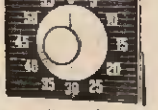
STANDARD WAFER SWITCHES

Standard size 1¼ 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	10 way	12 way
1 pole	6/6	6/6	6/6	6/6	6/6	6/6	6/6	6/6
2 poles	6/6	6/6	6/6	6/6	6/6	6/6	10/6	10/6
3 poles	6/6	6/6	6/6	6/6	10/6	10/6	14/6	14/6
4 poles	6/6	6/6	6/6	10/6	10/6	10/6	18/6	18/6
5 poles	6/6	6/6	10/6	10/6	14/6	14/6	22/6	22/6
6 poles	6/6	10/6	10/6	10/6	14/6	14/6	26/6	26/6
7 poles	10/6	10/6	10/6	14/6	18/6	18/6	30/6	30/6
8 poles	10/6	10/6	10/6	14/6	18/6	18/6	34/6	34/6
9 poles	10/6	10/6	14/6	14/6	22/6	22/6	38/6	38/6
10 poles	10/6	10/6	14/6	18/6	22/6	22/6	42/6	42/6
11 poles	10/6	14/6	14/6	18/6	26/6	26/6	46/6	46/6
12 poles	10/6	14/6	14/6	18/6	26/6	26/6	50/6	50/6

THE 5·5 WATT STEREO AMPLIFIER

Made by one of our most famous makers for a de-luxe player. This amplifier has a quality of reproduction touch better than average. Using a total 16 transistors and a generously sized mains power pack. Controls include bass, treble, balance and volume. Suitable for 8–16 ohms impedance speakers with crossovers for tweeter mid-range and bass thus giving option of 1, 2 or 3 speakers per channel. Offered at about one third of its original price only £9.19.6 plus 6/6 post and insurance.



1 HOUR MINUTE TIMER

Made by famous Smiths company, these have a large clear dial, size 4¾ × 3in, which can be set in minutes up to 1 hour. After preset period the bell rings. Ideal for processing, a memory jogger or, by adding simple lever, would operate micro-switch. 22/6.

A.C. CONDENSERS

These make good voltage droppers for working low voltage appliances from a.c. mains—the big advantage being there is no heat. Also useful in power factor correction, motor starting and in d.c. circuits where reverse voltage is encountered.

1·5 mfd 400V	3/6	5 mfd 570V	9/6	12 mfd 250V	11/6
2 mfd 440V	4/6	6·25 mfd 250V	8/6	15 mfd 250V	13/6
3·4 mfd 440V	6/6	8 mfd 250V	9/6	20 mfd 275V	16/6
3·5 mfd 250V	5/6	8 mfd 440V	11/6		

GRO-LUX LIGHTING

Special tubes give light rich in u.v. and other rays necessary for plants and fish kept indoors away from natural sunlight. 12in 8 watt tube 28/6—control kit comprising choke and starter—tube ends and clips—starter holder and diagram 19/6—post and insurance 3/6 on either or 4/6 on both items.

VARYLITE

Will dim incandescent lighting up to 600 watts from full brilliance to out. Fitted on M.K. flush plate, same size and fixing as standard wall switch so may be fitted in place of this, or mount on surface. Price complete in heavy plastic box with control knob £3.19.6.

NEED A SPECIAL SWITCH?

Double Leaf Contact

Very slight pressure closes both contacts, 1/3 each, 12/- doz. Plastic push-rod suitable for operating, 1/- each, 9/- doz.

50-Way Connector Block

Heavy duty block, size 2¼in × 2¼in × 1¼in approximately. Each of the 50 ways has a multi cable inlet and outlet designed for easy connection. Also, each way has 2 test sockets and a disconnecting plug. Ideal for inserting ammeter or other device without breaking circuit, offered at 69/6 each, which is only a fraction of the regular price, postage and insurance 5/6.

Under-floor Heating Cable

200ft lengths, suitable for dissipating 1,000 watts at 80 volts. Join three in series to make a 240 volt mains operated element of 3kW. Price 20/- per length, 4/6 post on any quantity.

3-Core Leads

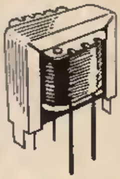
Heavy duty 23/36, average length 5ft 10/- per dozen lengths, plus 4/6 P. & I.

Papst Motors

Est. 1/40th h.p. Made for 110–120 volt working, but two of these work ideally together off our standard 240 volt mains. A really beautiful motor, extremely quiet running and reversible, 30/- each.

Instrument Knobs

⅝in dia. head with ⅜in shank for flatted ¼in spindle, 9d each, 8/- dozen. Ditto but with metal disc, 1/- each, 11/- dozen.



Midget Output Transformer

Ratio 140 : 1. Size approx. 1in × ¾in × ¾in, primary impedance 450Ω. Connection by flying leads, 4/6 each, 48/- doz.

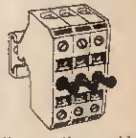
Midget Output Transformer

Ratio 80 : 1. Size approx. 1¼in × 1in × ¾in. Primary impedance 132Ω. Printed circuit board connection. 5/6 each, £3 doz.

4-Gang Air Spaced Tuning Condenser

For AM/FM circuits. AM rf section 200 pf osc section 80 pf both with trimmers.—FM rf section 9·5 pf osc section 11·2 pf—integral slow-motion drive. 9/6 each.

Mains Connector

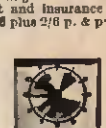


A quick way to connect equipment to the mains safely and firmly—L., N. and E. coded to new colour scheme; disconnection by plugs prevents accidental switching on; has sockets which allow insertion of meter without disconnection; cable inlets firmly hold one hair wire on up to four 7.029 cables. 12/6 each.

DRILL CONTROLLER

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. 19/6 plus 2/6 post and insurance. Made up model also available, 37/6 plus 2/6 p. & p.

ELECTRIC CLOCK WITH 25 AMP SWITCH.



Made by Smith's, these units are as fitted to many top quality cookers to control the oven. The clock is mains driven and frequency controlled so it is extremely accurate. The two small dials enable switch on and off times to be accurately set. Ideal for switching on tape recorders. Offered at only a fraction of the regular price—new and unused only 39/6, less than the value of the clock alone—post and insurance 2/9.

MAINS TRANSISTOR POWER PACK

Designed to operate transistor sets and amplifiers. Adjustable output 6V, 9V, 12 volts for up to 500mA (class B working). 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 16/6, plus 3/6 postage.

Where postage is not stated then orders over £5 are post free. Below £5 add 2/9. Semiconductors add 1/- post. Over £1 post free. S.A.E. with enquiries please.

ELECTRONICS (CROYDON) LTD

Dept. PE, 266 London Road, Croydon CRO 2TH
Also 102/3 Tamworth Road, Croydon

MODEL TRAIN CONTROLLER

By A. ANTHONY

MODEL train controllers of conventional design, using a rheostat, suffer poor performance under variable load conditions. Ideally, an electronic stabilised controller with overload protection must be used for best performance.

The unit described in this article is simple to operate, has smooth control of output, and also has some degree of overload protection.

The circuit (Fig. 1) follows the usual pattern for stabilised power supplies, but has a polarity reversing switch and thyristor overload cut-out circuit.

STABILISER

The mains transformer T1 must be an isolated double wound type for safety reasons. The secondary winding should supply 9V a.c. to the bridge rectifier D1–4 to convert the a.c. to d.c. Smoothing is carried out by C1 before passing to the regulation circuit.

This section consists mainly of a voltage stabiliser TR1–2 and the overload detector TR3. Stabiliser transistors TR1 and TR2 operate as a super-alpha or Darlington pair to reduce the output impedance of the circuit. The base current is supplied by the voltage divider chain R1, VR1, and R2 and is set by the control VR1.

Since this current is to be varied to supply variable output voltage, a Zener diode should not be used. Instead a thyristor SCR1 is inserted to cut off the stabiliser transistors when the line is overloaded or accidentally short-circuited.

OVERLOAD DETECTOR

A heavy increase in current on the line causes the voltage across resistor R5 to increase to such an extent that TR3 will switch on. Collector current will then flow, part of which is picked off to trigger the thyristor.

In the prototype, the voltage across R5 was in excess of 0·6V for triggering. The resistance of R5 will be determined by the normal running load current, using Ohm's Law: $R_5 = 0{\cdot}6/I_L$. This current can be measured by using the high range of a multimeter, under normal working conditions, in series with the output positive line (S3b wiper).

To keep thermal drift and leakage current to a minimum for reliable operation, TR3 should be a silicon transistor; a *pnp* type is used for convenience in this circuit.

Visual warning of overload is given by the indicator lamp LP2 which should be rated at 12V or more. If a lower voltage bulb is used a series resistor must be

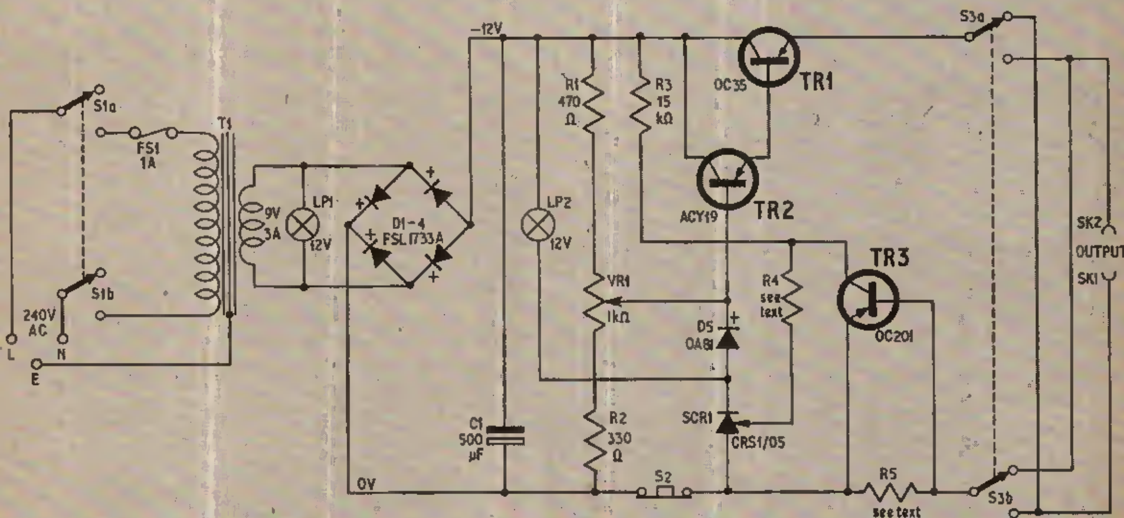
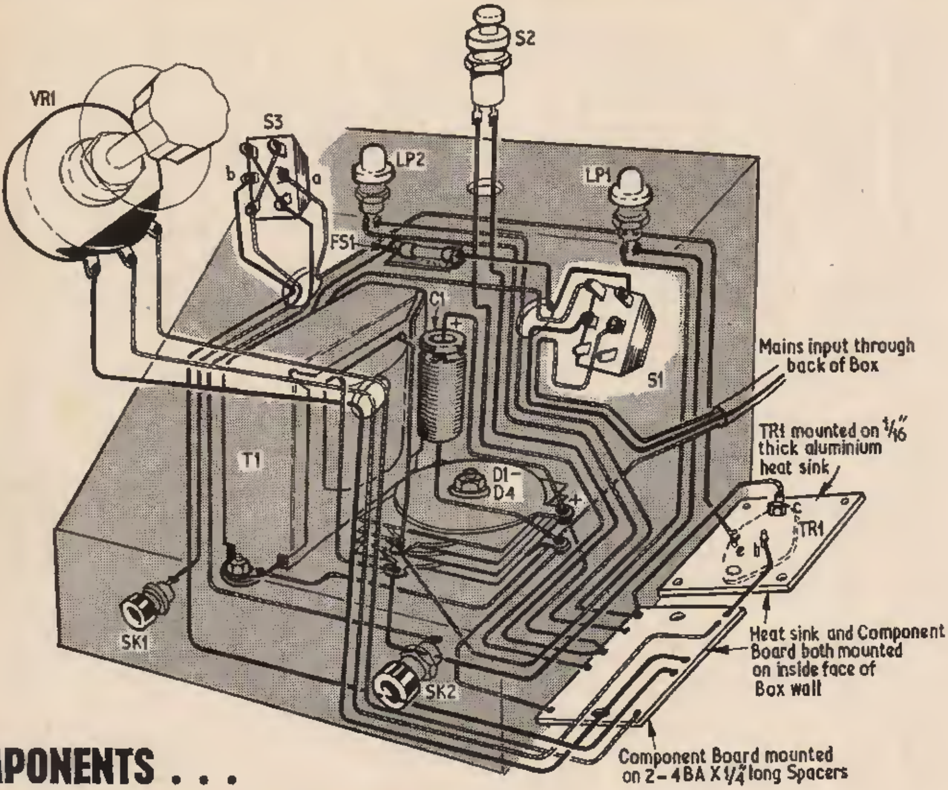


Fig. 1. Circuit diagram of the complete controller

FIG. 2. CONSTRUCTIONAL DETAILS



COMPONENTS . . .

Resistors
R1 470Ω
R2 330Ω
R3 15kΩ
R4 See text
R5 Wirewound (see text)

Potentiometer
VR1 1kΩ wirewound

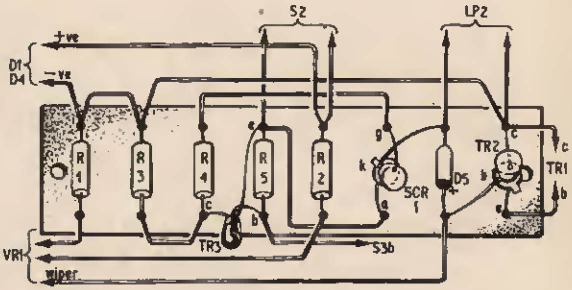
Capacitor
C1 500μF elect. 25V

Transistors
TR1 OC35
TR2 ACY19
TR3 OC201

Diodes and Thyristors
D1–4 18V 2A (S.T.C. type FSL 1733A bridge selenium rectifier)
D5 OA81
SCR1 CRS1/05 (S.T.C.)

Transformer
T1 Mains primary winding, 9V 3A secondary (S.T.C.)

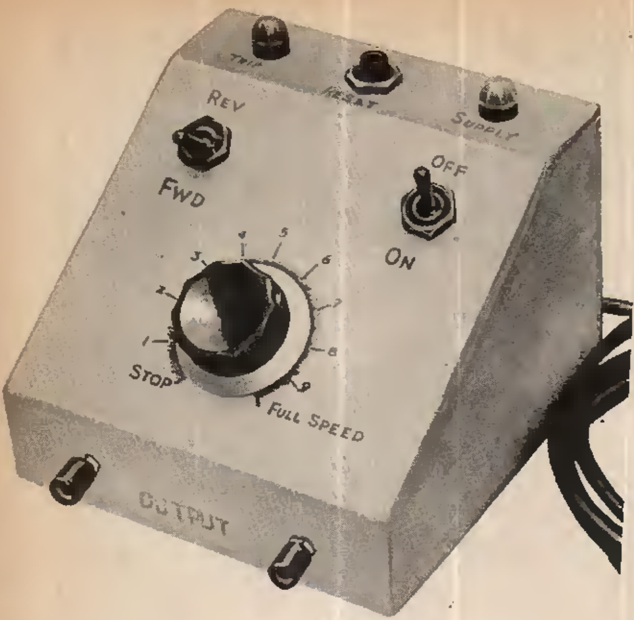
Lamps
LP1, LP2 12V 0·75W l.e.s. (2 off)



Switches
S1 Double pole, on/off, toggle
S2 Push to break, press button
S3 Double pole, changeover toggle

Miscellaneous
FS1 Fuseholder and 2A fuse
Component tag board
Wood for case
Aluminium or copper sheet $\frac{1}{16}$ in. or 18 s.w.g. for heat sink

S.T.C. components available from Electroniques (S.T.C.) Ltd.



inserted to prevent the lamp from blowing. The current rating of the lamp should be as low as possible so as not to interfere with the stabiliser cut-off function.

Once the overload is indicated, the offending load should be removed before resetting the circuit again for normal operation. Switch S2 is a push button "break" switch for resetting, and temporarily cuts the supply to TR3 and SCR1.

POLARITY REVERSAL

The output is taken from TR1 emitter (negative) and TR3 base (positive) to a double-pole changeover switch S3a and S3b. This provides simple polarity changeover facilities for train reversing. The switch and output terminals should be clearly labelled to show the polarity for forward and reverse, but it is not good practice to change direction at full speed. Speed reduction should be arranged first by careful use of control VR1.

CONSTRUCTION

Constructional details (Fig. 2) are given here for guidance but there is no reason why this cannot be altered to the constructor's choice.

Since R5 is likely to be a very low value (about 0·5 ohm), it is best to make this component from eureka or nickel chrome wire and trim the length of wire used according to the results of the voltage measurement described earlier. The thickness of the wire is determined by the absolute maximum load current likely to be encountered under normal conditions. Details of this and the length of wire required can be found in standard wire tables in many reference books. (As an approximate guide, 20in of 24 s.w.g. Eureka wire will be one ohm); 15 yards of 24 s.w.g. copper wire will about 1 ohm).) If the wire is insulated it can be wound on a plastics or cardboard former.

Resistor R4 is selected to limit the current required to trigger the thyristor within the maker's recommendations; this current should be at least 10mA.

All components can be mounted on perforated s.r.b.p. or printed circuit board except TR1, which should be mounted on a heat sink. ★

P.E. WIDEBAND H.F. COMMUNICATIONS RECEIVER

By R. HIRST S.T.C. LTD.

PART NINE LOCAL OSCILLATOR

HAVING described the construction of the three modules that make up the Local Oscillator last month, we must now set them up before installing them in the chassis and completing the final wiring up.

SETTING UP INSTRUCTIONS

Equipment required

(a) **Counter** having a range of 2MHz to 70MHz.
(b) **Power Supply** to give 24 volts at 100mA.
(c) **Valve voltmeter** covering the range 2MHz to 70MHz with a sensitivity of 10mV at not less than 1 kilohm impedance.

PROCEDURE

Variable Oscillator Module

Short PL1/e to PL1/f and apply a positive voltage of 24 volts to PL1/f and the negative of the power supply to earth. Check all the potentials at the base, collector and emitter of the transistors to ensure that they correspond with those indicated in Table 9.1. If these voltages are correct adjust VC1 for maximum capacity (capacitor vanes fully meshed) and connect a counter to SK1. Adjust each coil in turn, starting with L1 so that the output frequencies correspond with those indicated in Table 9.2. To do this the link between PL1/e and f must be removed and each pin shorted to PL1/f in turn.

Crystal Oscillator Module

Apply a positive voltage of 24V to the correct terminal and the negative of the power supply to the earth terminal. Check all the potentials at the base, collector and emitter of all the transistors to ensure that they correspond with those indicated in Table 9.1. If these voltages are correct replace the crystal with the capacitor resistor network shown in Fig. 4.4a. Connect the counter to the output socket, SK2 and adjust the frequency with L6 to read 34MHz as near as possible. Reconnect the crystal, removing the resistor capacitor network, and check the output frequency. Adjust the capacitor VC2 until the output frequency is as near 34MHz as possible. Finally, the output voltage at SK2 should be checked with a valve voltmeter to ensure that the output is approximately 0·5 volts at 34MHz when terminated in a 50 ohm load.

Mixer Module and High Pass Filter

Apply a positive voltage of 24 volts to the correct terminal and the negative of the power supply to the earth terminal. Check all the potentials at the base, collector and emitter of all the transistors to ensure that they correspond with those indicated in Table 9.1. If these are correct, inject a signal at 34MHz into C14 and adjust L7 and L8 for minimum signal at the output socket SK3 by connecting a valve voltmeter across the output. These adjustments should be carried out two

Table 9.1. D.C. VOLTAGES

Stage	Base	Collector	Emitter
TR1	3V	7·7V	2·3V
TR2	5V	10·4V	4·4V
TR3	1·25V	4·5V	0·5V
TR4	4·5V	7V	3·8V
TR5	7V	9V	6·1V
TR6	4·8V	15V	4·2V
TR7	6·5V	15V	5·8V
TR8	4·1V	13V	3·4V
TR9	13V	8·3V	0·5V
TR10	8·3V	16·5V	7·5V

BSR 4-SPEED SUPERSLIM MODEL UA25 RECORD CHANGER

Plays 12", 10" or 7" records. Auto or Manual. A high quality unit backed by BSR reliability with 12 months' guarantee. Size 13½ × 11¼in. Above motor board 3 11/16in. below 2½in. AC 200/250v.

MONO PRICE £5.19.6 STEREO PRICE £6.19.6 Post 5/6

BSR UA70 Stereo/Mono Transcription Auto Changer. Calibrated Stylus Pressure. £12.19.6

BSR Minichanger UA50 Stereo/Mono. Size 12 × 8¼in. AC 200/250v. Post 5/6. £7.19.6

GARRARD PLAYERS with Sonotone 9TA Cartridges. Stereo Diamond/Mono Sapphire. SP25 Mk II £14.19.6. AT60 Mk II £14.19.6. Model 3000 £12.19.6. Post 5/6.

RECORD PLAYER PORTABLE CABINET Space for amplifier and autochanger. Post 5/-. 75/-

RCS DE-LUXE 3 WATT AMPLIFIER. Ready made and tested. A 2-stage unit using triode pentode valve, giving 3 watts output. Tone and volume controls. Isolated mains transformer. With knobs, loudspeaker and valves ECL82, EZ80. Frequency response 50-12,000 cps. Sensitivity 200mV. Post 5/6. 89/6

GARRARD TEAKWOOD BASE WB.1. Ready cut out for mounting 1025, 3000, SP25, AT60, etc. 77/6

GARRARD PLASTIC COVER SPC.1 for WB.1 BASE. Durable tinted attractive appearance. 77/6

EMI PICK-UP ARM. Complete with mono cartridge 29/6.

EMI JUNIOR 4 SPEED RECORD PLAYER

Mains operated motor, turntable and pick up complete. Post 5/6. 59/6

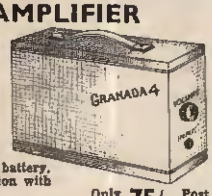
HI-FI PICK UP CARTRIDGES

GP94 55/-; GP93 45/-; GP91 30/-; GP67 19/6, ACOS L.P. only 10/6. All standard fixing complete with stylus.

CRYSTAL MIKE INSERTS

1½" dia. 6/6. ACOS 1½" dia. 12/6. BM3, 1" dia. 9/6

PORTABLE AMPLIFIER



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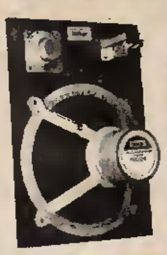

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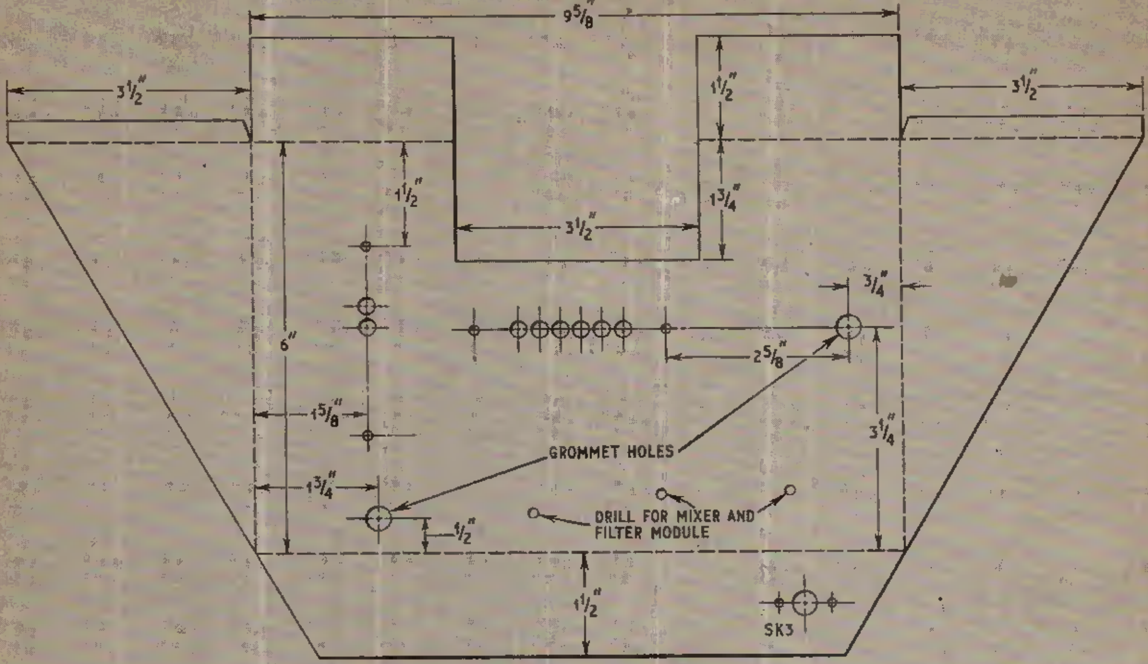


Fig. 9.1. Local oscillator chassis details

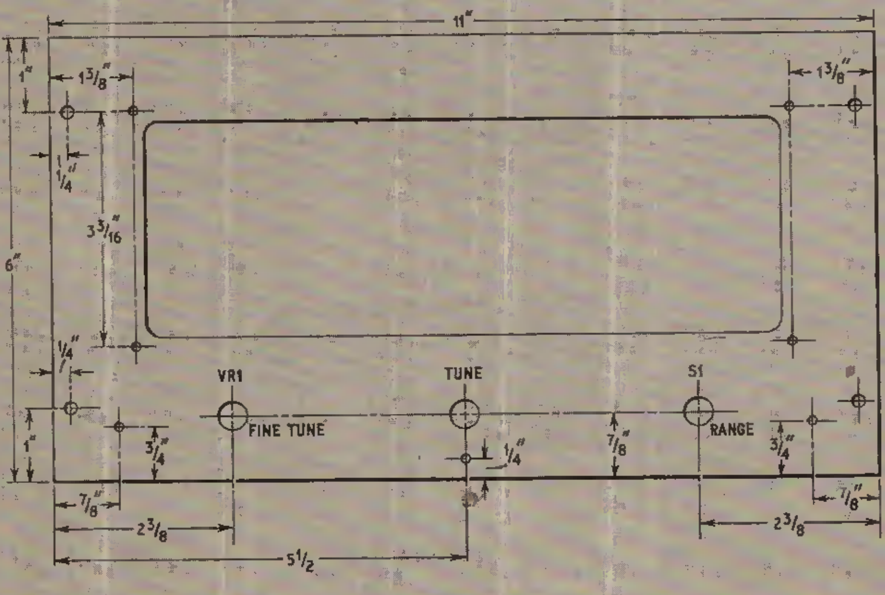


Fig. 9.2. Front panel cutting and drilling details

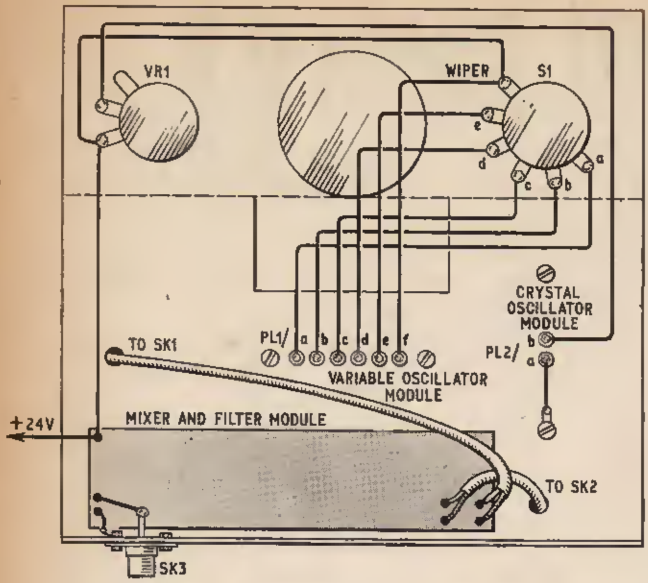


Fig. 9.3. Local oscillator inter-module wiring

or three times as there will be some interaction between the two coils and each successive adjustment should improve the rejection. When this module is finally connected into the chassis assembly the following procedure should be carried out.

Connect the inputs to SK1 and SK2 and then reduce or increase C14 until the output signal, measured with a valve voltmeter across SK3, terminated in a 50 ohm load, is 1dB less than the maximum attainable. This is best carried out when the variable oscillator module is set to 30MHz. Leaving the valve voltmeter connected across SK3, swing the variable oscillator over its full frequency range from 2MHz to 30MHz and ensure that the output voltage at SK3 is not less than 0·4 volts or more than 0·8 volts. If the level is too high introduce a resistor (R19) into the base circuit of TR7 until the signal level at 30MHz—2MHz on the dial—measured across the output socket SK3 is 0·8 volts. If the level of the signal across SK3 at 64MHz—30MHz on the dial—is less than 0·4 volts, introduce C32 and adjust the value until the output at 64MHz is 0·4 volts. Recheck the output at 36MHz to ensure that this has not increased to more than 0·8 volts.

COMPONENTS . . .

LOCAL OSCILLATOR

VR1 100Ω wirewound potentiometer
S1 5 way single pole wafer switch
Eddystone dial assembly No. 898
Insulated flexible spindle connector
Imhoff cabinet and chassis type 1690C and BC511
Knobs to match receiver unit (2 off)
Coaxial plugs (3 off)
Coaxial lead

CHASSIS ASSEMBLY

Details for the cutting and drilling of the chassis unit and front panel are shown in Figs. 9.1 and 9.2. The modules are arranged and wired up as shown in Fig. 9.3.

The wiring to the range switch should be kept clear of the chassis and stiff wire should be used to ensure that these wires remain in position. The mixer module, on the underside of the chassis, is also mounted about half an inch away from the chassis, to avoid the introduction of stray capacity due to the proximity of the chassis acting as an earth return. As previously indicated, if it is found to be advantageous to use the 24 volt supply from the main receiver, it will be necessary to fit a two pin plug and socket arrangement to the receiver and the oscillator unit. This had not been included in the diagrams as some constructors may wish to use the local oscillator unit as a signal generator or, if they have an oscillator of the required frequency range, use that as the signal source for the main receiver.

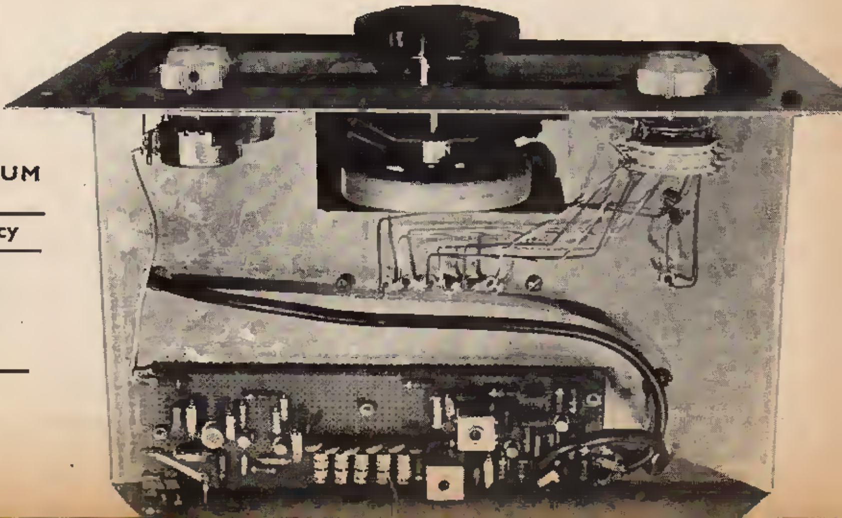
MAIN CHASSIS SETTING UP

Having mounted all the modules and components, the pointer on the dial should be set to the extreme left. The vanes of the capacitor VC1 should be fully meshed and the flexible link connecting the dial assembly to the spindle of VC1 should be locked. It may be desirable to put a counter on the output of the variable oscillator module during this adjustment to ensure that when VC1 is fully meshed the frequencies on each range, with the dial pointer at zero, correspond to those indicated in Table 9.2. It must be remembered that the frequencies coming out of the output socket on the main chassis are 34MHz higher than those coming out of the variable oscillator module or indicated on the dial, in other words the frequency is offset by the value of the first i.f.

Next month: a.g.c. unit and dial calibration

Table 9.2. FREQUENCIES CORRESPONDING TO MAXIMUM VALUE OF VC1

Range	Frequency
A	2MHz
B	3·2MHz
C	5·0MHz
D	8·5MHz
E	16MHz



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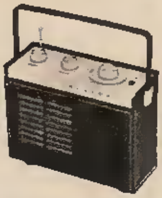

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Aircraft Monitor Receiver
Kit: K/GR-98 - - £27.12.0
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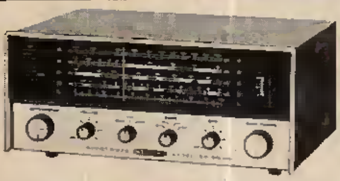

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Technician's Versatile 'VVM'
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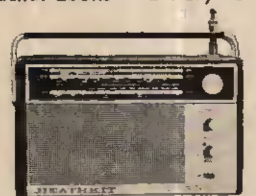

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Readout—
A SELECTION FROM OUR POSTBAG

Correspondents wishing to have a reply must enclose a stamped addressed envelope. We regret we are unable to guarantee a reply on matters not relating to articles published in the magazine. Technical queries cannot be dealt with on the telephone.

Engineering image . .

Sir—Though the divergent views expressed by Mr J. C. Baker and Mr M. A. Stewart in the "Readout" feature of your issue for April 1970 throw the two sides of the argument into even sharper relief, they do not alter the plain fact that in engineering today the possession of authorative qualifications is becoming more and more important.

The prospect of "putting letters after his name" helps to encourage a young man to study and train; to take full advantage of all the aids and facilities so freely available nowadays. The more engineers that are seen to be qualified the better the "image" engineering will gain; and this, surely, is of particular importance to electronic engineering, which has to compete with so many counter attractions in recruiting young people.

The status of the non-graduate engineer has been elevated appreciably over the past five years: the introduction of the Composite Register of Chartered Engineers, Technician Engineers and Technicians should raise it even higher.

E. A. Bromfield,
Secretary,
The Institution of Electrical and Electronics Technician Engineers,
London, W.C.2.

. . . at work

Sir—I have read with considerable interest your recent articles and correspondence on the subject of the non-registered engineer. It is a problem to which this Society has devoted considerable time and energy for many years, and it might help if I re-state our present objectives.

There is first of all the position of the many engineers who are now being excluded from professional level by current developments, and here perhaps I cannot do better than quote Neil Marten M.P. in The House on March 18, 1970 (Hansard Column 568).

"There are certain precedents for what I want. Dentists, veterinary surgeons, architects, National Health Service medical auxiliaries and professions supplementary to medicine, such as chiropody, and so on, had, I believe, exactly the same problem when they wanted to move to a fully qualified profession. In all those professions the people who had been practising for a certain period were allowed to continue to be employed. I do not see why that should not be so with teachers."

Mr Marten was of course dealing with a similar position now arising within the teaching profession; it applies to engineers even more so whilst many of those "without" hold better qualifications than those "within". If we are therefore ultimately to have registration, it must be on a basis which is not only fair, but seen to be just this.

There is then the problem of academic level of entry in the future, and here The Society has always been anxious to see some form of effective bridge which would allow the engineer as well as the academic to reach the professional level. When The Robbins Report on Further Education was issued in 1963, The Society urged the then Government not to rely entirely on academic degrees alone, but to maintain a balance with engineering training, pointing out the steps which should be taken to bring down the costs to what we can afford. This latter is now very apparent. It has maintained these representations over the years, and in the one-day symposium on April 3, 1970, when a number of interesting papers were given, culminating in one dealing with the position in Common Market countries. This also showed the need and understanding for practically educated engineers of the same standard as the pass degree university educated "scientist".

For this The Society has offered to use as a basis its Part II Examination or Design Papers which are required on the basic standard of Higher National Certificate and a minimum of five years experience in engineering. This should enable the candidate to show an assessment at technologist level and is the standard of entry required for Associate Member of The Society.

There will then be management papers coupled with ability to show professional levels of responsibility for Corporate Membership, by which time he has demonstrated quite clearly that he is professionally an engineer, whether "chartered" or not.

L. T. Griffith,
Secretary,
The Society of Engineers,
London, S.W.1.

First class

Sir—What a practical and useful article was that by S. J. Holmes in the April issue on a "Miniature Converter", but without taking up much more of your valuable space he could have been so much more helpful.

While accepting his remarks concerning the desirability of a d.c. output, two classes of people come to mind. One who would be prepared to accept bigger transformers for the advantage of having an output of 50Hz (some appliances must have a.c.). The second, probably much larger, who know that the best way to run a fluorescent tube is at about 10kHz.

Information on how to vary the frequency, plus any modifications in wiring the transformer would have extended the usefulness of the article considerably.

Nevertheless, thank you for the very high standard of the magazine.

I. D. Phillips,
Pershore,
Worcestershire.

Electronics club

Sir—We feel that the following information will be of interest to readers of PRACTICAL ELECTRONICS and we would be grateful if you could give it some coverage in your magazine.

A number of radio societies in the North East have formed a federation known as The North East Amateur Radio Group (N.E.A.R.G.). The purpose of the group is to promote a series of bi-monthly lectures and to publish a newsletter approximately five times a year, free to members. The first meeting, held on March 20th in Durham City, covered the subject of "Aerials". A lecture was given by Mr F. W. V. Ritson G5RI with a very good practical demonstration.

All readers in the North East are cordially invited to attend any meeting, but please if you are coming contact:

Mr. J. Melvin G3L1V, 5 Lancashire Drive, Belmont, Durham, enclosing a stamped addressed envelope for further details.

L. G. Rix G3X5W,
N.E.A.R.G.

Readout—

A SELECTION FROM OUR POSTBAG

continued

Facts of life

Sir—May I, a tyro from the earliest days of the "cat whisker", put in a plea on behalf of newcomers in the field of solid-state for the home constructor.

At the height of the "thermionic" period, it became abundantly clear to any rational mind, that great complexity covered any comprehensive list of available valves, by reason of the codes used for the identity of individual types. The virtual absence of a co-ordinated system has resulted in near impossibility for the less informed, intending user to make a ready choice.

Since we have now entered the same conditions with solid state devices, is it to be assumed "the point of no return" is already past?

If the manufacturers hold a jealous regard for some commercial advantage maintained in the present illogical arrangement, surely, it is not beyond honest imagination to retain two or three letters as a prefix to an otherwise *universally* recognised form of classification. Granting that comparisons are odious, consider the position where purchase of a 60 watt light bulb necessitated one's familiarity with the maker's exclusive marking.

Returning to the "good old days"; enclosed in the carton containing a valve, there used to be a tiny slip of paper, bearing the relevant "facts of life" concerning the valve, for the guidance of the immature purchaser. —Not now brother, not any more.

F.e.t.'s and tunnel diodes must be for the erudite, and of course, readers of P.E. I for one gained a ready appreciation of the enigmatic "holes" in transistors from its helpful pages. Many thanks.

Percy Ashdown,
Lymm,
Cheshire.

Tape stop-foil

Sir—With reference to Mr A. S. Henderson's letter to "Readout" (March P.E.) concerning Mr Price's *Tape Stop-Foil* device, might I suggest that Mr Henderson consults one or two tape recorder circuits. I believe that he will find that most record/playback heads are wired with a large resistance in series with them before connection to coupling capacitors, which would make the current flow through the head during switch on/switch off insufficient to impart much permanent magnetism to the head.

Besides which, the currents through the heads during switch on and switch off are equal and in opposite directions and thus the magnetisation during switch off would be cancelled out by an equal and opposite magnetisation produced during switch on. Thus, provided that the tape recorder is reconnected to the mains by the same method as it was disconnected, no damage to the heads should ensue.

Of course, it is inevitable that after a considerable period of time tape heads subjected frequently to this kind of treatment will become noticeably magnetised, but this does not prevent the use of the stop-foil device as regular demagnetisation of the heads of hi fi tape recorders is now considered part of standard maintenance.

M. Bolton,
Bury St. Edmunds,
Suffolk.

Heavy fall

Sir—I was very interested in your article for the "Electronic Rain Gauge" (see February issue), and decided to construct it for our local Youth Activities Centre's electronic metrological station.

But there was one problem with which I had great difficulty in solving. I constructed the liquid metering module, and started to test it. The problem was that when the bucket tipped, surface tension held a lot of water in the bucket so resulting in extra weight for the other side to tip.

I have been taught at school that to reduce surface tension, detergent has to be mixed in, but knowing that it doesn't rain detergentised water I had to think of something else. I thought about a chrome bucket, but then I found that by smearing a thin coat of silicone grease in the bucket, it cured all my problems.

I thought other readers might have had this problem and would be glad of a solution.

I enjoy your magazine very much and still continue to buy it and patronise your advertisers.

J. Marsh,
Weymouth.

NEWS BRIEFS

New Leaflet on Metric Units

A NEW leaflet "Going Metric—Everyday Units" is now available free from the Metrication Board. The leaflet sets out the more common metric units and correct symbols for 14 everyday quantities including length, area, capacity, temperature and weight.

In the United Kingdom the basis for the metric system, now coming into use, is the International System of Units, known in all countries by the abbreviation SI. The units contained within this system are sufficient for all present needs of technology, science, industry, commerce and daily life.

Copies of the leaflet can be obtained from Information Division, Dept. 4, Metrication Board, 22 Kingsway, London, W.C.2.

Home Entertainment in 1980

A STAINLESS steel console housing a colour television, with remote screen, a radio receiver, tape recorder and a record player, all with stereo reproduction has recently been displayed by the British Radio Corporation. The console was designed by Eric Marshall Associates for British Radio Corporation and consists of two 18in turntables at each end, one for record reproduction and one for radio or TV tuning. The tape recorder is housed in the centre of the console, has 7in reels and a facility for slotting in cassettes.

The photograph shows the console, TV screen and one spherical speaker—a future project for PRACTICAL ELECTRONICS!

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A now famous brand of tape. 7in 2,400ft, 25/–; 7in 1,800ft, 21/–; 7in 1,200ft, 13/6; 5¾in, 1,200ft, 15/–; 5¾in 1,800ft, 22/6; 5in 600ft 9/9; 5in 900ft, 12/6; 5in 1,200ft, 16/–. Please note the postage and packing is FREE.

A TAPE BARGAIN

Emitape 3in 175ft in EMI case **5/-** EACH

SOLID STATE BLOCK MODULES

Phono pre-amp E1311: input, 100K; gain, 28db; max. out, 3-volt; max. in, 50M/V; power, 9V.
Tape pre-amp E1312, as above.
Mic. pre-amp E1313, as above.
Power amplifier E1314: input, 1,000 ohms; gain, 20db, 300M/W; power, 9-volt d.c.
Electronic organ, tone osc. E1315: tone freq., 200–1kHz; output, 80M/W; power, 9V; current, 15M/A.
Dual flasher E1318: flasher time, 1/4 secs; power, 6V; current, 150M/A; lamp, 6V 150M/A.
We also stock the morse code practice modules in this range.

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3 watts r.m.s. power amplifier and pre-amp. Complete with data sheet. Fully guaranteed. **25/-** P. & P. 1/6 each

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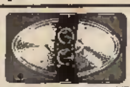

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2½in 25 ohm loudspeaker	5/6 each
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U2 battery holders (blue plastic)	1/– each
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OC81 double heat clips	6d each
S. G. Brown 4,000 ohm phones (used but in good condition)	10/– per pair
Tape recorder rev counters	5/– each

Please include P. & P.
Send 3/– for our Component Catalogue and Flog Lists

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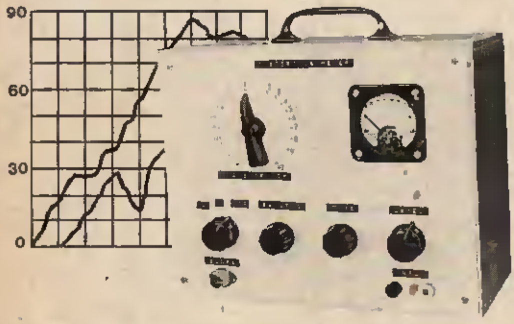

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RESISTORS

Code	Power	Tolerance	Range	Values available	1 to 9	10 to 99	100 up
C	$\frac{1}{3}$W	5%	100 Ω–220k Ω	E12	18d	16d	15d
C	$\frac{1}{4}$W	5%	4·7 Ω–330k Ω	E24	2·5d	2d	1·75d
C	$\frac{1}{4}$W	10%	4·7 Ω–10M Ω	E12	2·5d	2d	1·75d
C	$\frac{1}{2}$W	5%	4·7 Ω–10M Ω	E24	3d	2·5d	2·25d
MO	$\frac{1}{2}$W	2%	18 Ω–1M Ω	E24	9d	8d	7d
C	1W	10%	4·7 Ω–10M Ω	E12	6d	5d	4d
WW	1W	10% $\pm\frac{1}{20}$ Ω	0·22 Ω–3·3 Ω	E12	15d all quantities		
WW	3W	5%	12 Ω–10k Ω	E12	15d all quantities		
WW	7W	5%	12 Ω–10k Ω	E12	15d all quantities		

CODES: C = carbon film, high stability, low noise. MO = metal oxide, Electrosil TR5, ultra low noise. WW = wire wound, Plessey.
VALUES: E12 denotes series: 1, 1·2, 1·5, 1·8, 2·2, 2·7, 3·3, 3·9, 4·7, 5·6, 6·8, 8·2 and their decades.
E24 denotes series: as E12 plus 1·1, 1·3, 1·6, 2, 2·4, 3, 3·6, 4·3, 5·1, 6·2, 7·5, 9·1 and their decades.
Prices are in pence each for quantities of same ohmic value and power rating, not mixed values. (Ignore fractions of one penny on total resistor order.)

COLVERN 3 watt wire-wound potentiometers: 10 Ω, 15 Ω, 25 Ω, 50 Ω, 100 Ω, 150 Ω, 250 Ω, 500 Ω, 1k Ω, 1·5k Ω, 2·5k Ω, 5k Ω, 10k Ω, 15k Ω, 25k Ω, 50k Ω. Price only 5/6 each.

CARBON TRACK POTENTIOMETERS: Double wiper ensures minimum noise level. Long plastic spindles.

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Single gang linear: 220 Ω, 470 Ω, 1k Ω, etc. to 2·2M Ω	2/6
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Any type with ½ amp double pole mains switch: extra	2/3
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Log/Anti-log: 10k Ω, 47k Ω, 1M Ω only	8/6
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FETS n-channel. Low cost general purpose 2N5163, 25V, only 5/– each. Audio/r.f., Texas 2N3819 8/6, Motorola 2N5459 (MPF105) 9/9 each.

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30 WATT BAILEY AMPLIFIER COMPONENTS
Transistors for one channel **£7.5.6.** list, with 10% discount only **£6.11.0.** Transistors for two channels **£14.17.6.** list, with 15% discount **£12.7.5.** Capacitors and/resistors for one channel list **£2.** Printed circuit board free with each transistor set. Complete unregulated power supply kit **£4.17.6.** mono or stereo, subject to discount. Complete regulated power supply kit **£9.5.** subject to discount. Further details on application.

SINCLAIR IC10 Integrated Circuit Amplifier and Pre-amplifier. This remarkable monolithic integrated circuit amplifier and pre-amp is now available from stock. The equivalent of 13 transistor/18 resistor circuit plus 3 diodes and the first of its kind ever. It is d.c. coupled and applicable to an unusually wide range of uses as detailed in the manual provided with it. As advertised post free **59/6** net.
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Small electrolytics, axial leads: 5/10, 10/10, 25/10, 50/10, 1/– each; 25/25, 47/25, 100/10, 220/10, 1/3 each.

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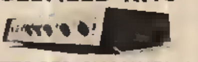

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2N2369A	6/9
2N2646	10/9
2N2924	4/3
2N2925	5/3
2N2926R	2/6
2N2926O	2/3
2N2926Y	2/3
2N2926G	2/3
2N3053	5/6
2N3054	14/3
2N3055	16/6
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2N3325	10/9
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2N4289	3/3
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2N4292	3/3
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AC127	6/–
AC128	6/–
AC176	11/–
ACY22	3/9
ACY40	4/–
AD140	19/–
AD149	17/6
AD161 } AD162 }	16/–pr.
AF118	16/6
AF124	7/6
AF127	7/–
BA102	9/–
BC107	2/9
BC108	2/6
BC109	2/9
BC147	4/3
BC148	3/3
BC149	4/3
BC153	10/–
BC154	11/–
BC157	3/9
BC158	3/6
BC159	3/9
BC167	2/6
BC168	2/3
BC169	2/6
BC177	6/3
BC178	5/8
BC179	6/–
BD121	18/–
BD123	24/3
BF178	10/6
BFX29	10/9
BFX85	8/3
BFX88	7/9
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4 WATT WIRE WOUND RESISTORS 1/6 each.
10% 1·0, 1·8, 2·7, 3·3, 3·9, 4·7, 5·6, 6·8, 8·2 ohms.
5% 10, 15, 20, 25, 39, 50, 100, 200 ohms.

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160V: 0·01μF, 0·015μF, 0·022μF, 0·033μF, 0·047μF, 0·068μF, **7d.** 0·1μF, **9d.** 0·15μF, 0·22μF, **10d.** 0·33μF, **1/3.** 0·47μF, **1/6.** 0·68μF, **2/3.** 1·0μF, **2/6.**
250V: P.C. mounting miniature ±20%: 0·01μF, 0·015μF, 0·022μF, **7d.** 0·033μF, 0·047μF, 0·068μF, **8d.** 0·1μF, **9d.** 0·15μF, 0·22μF, **1/-.** 0·33μF, **1/4.**

MYLAR FILM CAPACITORS
100V: 0·001μF, 0·002μF, 0·005μF, 0·01μF, 0·02μF, **6d.** 0·05μF, 0·1μF, **8d.**

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Selection of ceramic and polyester capacitors 100pF to 1·0μF. Total 100 capacitors, **£2.18.0.**

MINIATURE ELECTROLYTIC CAPACITORS
(−10% +50%)

50μF	6V	10μF	10V	125μF	10V	40μF	16V	8μF	40V
100μF	6V	16μF	10V	200μF	10V	6·4μF	25V	16μF	40V
200μF	6V	20μF	10V	10μF	12V	10μF	25V	50μF	40V
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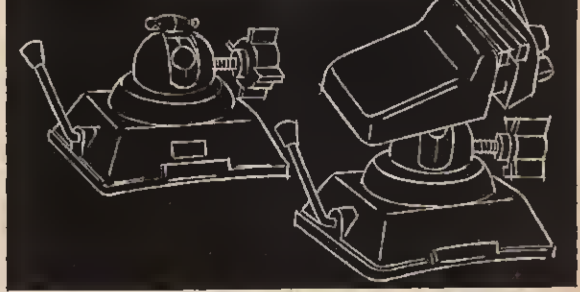

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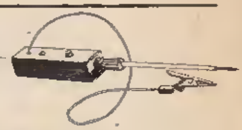

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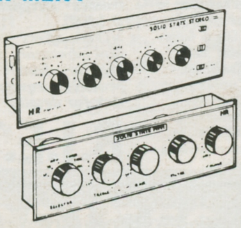

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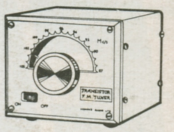

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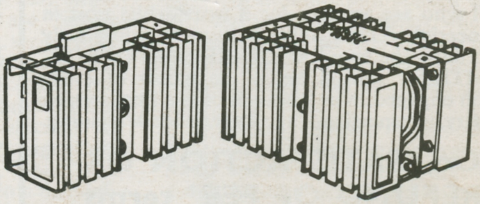

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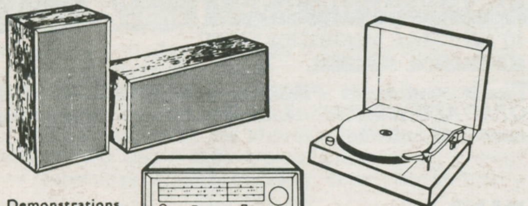

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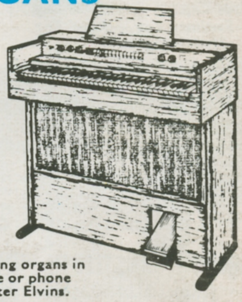

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