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SPECIFICATION

Frequency Response Harmonic Distortion Input Impedance: Tape Head: 120 mV at 600Ω
Tuner: 15 mV at 600Ω
7.25 mV at 1000Ω

All input voltages are referenced to 300mV. Tape and P.U. inputs equalled to RIAA curve within ±1dB from 20Hz to 30kHz.

Base Control: ±10dB @ 1kHz

Triple Control: ±10dB @ 3kHz

Filters: Rumble (High Pass) 100Hz

Scratch (Low Pass) 250Hz

Signal/Noise Ratio: 100db better than -60dB

Input overload: ± 14dB

Supply: ± 3 volts @ 200mA

Dimensions: 200mm x 55mm x 45mm

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Switches

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Tail Strips

6 way 2p Single 1p

Valves - New and Boxed

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<td>DY86</td>
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<td>40p</td>
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<td>EF184</td>
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<td>PL83 56p OTHERS</td>
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<tr>
<td>AC127 10p 30V 25p</td>
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<td>1 240 BTX18-200 30p</td>
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<td>1 240 BTX30-200 30p</td>
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<td>Matched pair 8p BCY70</td>
<td>6.5 300 BT102-300R 42p</td>
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<td>AF116 12p BCY71</td>
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<td>AF138 25p BD132</td>
<td>6.5 500 BT108 90p</td>
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<td>AF178 40p BD135</td>
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<td>AF180 45p BF115</td>
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<td>BF239 30p BF179</td>
<td>20 600 BTWS2-600 3.00</td>
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<td>BC107/89 7p BFX51</td>
<td>15 800 BTX98-800R Pulse</td>
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<td>BC147 8p BFX52</td>
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<td>BC148 8p BFX29</td>
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<tr>
<th>BRIDGE RECTIFIERS</th>
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<tr>
<td>1.600 BYX10 30p 1</td>
<td>Centercel 5p</td>
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<tr>
<td>1.42 BY164 35p 1</td>
<td>IN916 6p</td>
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<td>Encapsulated with built-in heat sink 15p</td>
<td>BA145 14p</td>
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<tr>
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<tr>
<td>BFX38-600 2.5 600 25p</td>
<td>1 1.600 BYX10 30p</td>
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<tr>
<td>BFX38-1200 2.5 1200 30p</td>
<td>1 140 OSH100 200 30p</td>
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<td>BFX43-300 2.5 300 25p</td>
<td>1 42 BY164 35p</td>
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<tr>
<td>BFX49-900 2.5 900 28p</td>
<td>0.6 6.110 EC433</td>
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<tr>
<td>BFX49-1200 2.5 1200 30p</td>
<td>Encapsulated with built-in heat sink 15p</td>
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<tr>
<td>BFX49-300 2.5 300 25p</td>
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<tr>
<td>BFX49-900 2.5 900 28p</td>
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<tr>
<td>BFX49-1200 2.5 1200 30p</td>
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<tr>
<td>BFX60-2000 6 600 45p</td>
<td>800 volt 30p</td>
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<td>0.25MFD 800 volt 30p</td>
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<td>1MFD 400 volt 15p</td>
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<td>2MFD 250 volt 20p</td>
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<td>BFX72-500R 6 500 32p</td>
<td>2MFD 1.5 kv 50p</td>
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<tr>
<td>BFX72-500R 6 500 32p</td>
<td>15MFD 150 volt 25p</td>
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<td>8 way Cinch standard 0.15 pitch edge socket 20p</td>
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<tr>
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<td>U.E.C.L. 10 way pin connector 286000 OA1P10 20p</td>
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<td>BFX72-500R 6 500 32p</td>
<td>U.E.C.L. 20 way pin connector 2860000A1P20 30p</td>
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<tr>
<td>BFX72-500R 6 500 32p</td>
<td>TIE CLIPS 12 way edge socket 30p</td>
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<tr>
<th>OPTO ELECTRONICS</th>
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<tr>
<td>ORP12 43p</td>
<td>Amp Volts</td>
</tr>
<tr>
<td>Photo transistor</td>
<td>150 Ohm, 250 Ohm 5K</td>
</tr>
<tr>
<td>BPX40 25p</td>
<td>4p each</td>
</tr>
<tr>
<td>BPX29 80p</td>
<td></td>
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<td>BPX42 80p</td>
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<td>BPY10 75p</td>
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<td>BPY77 75p</td>
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<td>Diodes</td>
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<td>BPY68 75p</td>
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<tr>
<td>BPY69 15p</td>
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<tr>
<td>BPY77 75p</td>
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<tr>
<td>BFW10 40p</td>
<td>Plastic, Transistor or Diode Holder 1p</td>
</tr>
<tr>
<td>BS79 90p</td>
<td>Transistor or Diode Pad 1p</td>
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<tr>
<td>BS80 80p</td>
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<tr>
<td>N. Channel</td>
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<tr>
<td>BSBV1 M.O.S.T.</td>
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<tr>
<td>BFS28 Dual M.O.S.T. 90p</td>
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<tr>
<th>PAPER BLOCK CONDENSER</th>
<th>ALL ORDERS OVER £3 POST FREE OVER £6 V.A.T. FREE</th>
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<tbody>
<tr>
<td>0.25MFD 800 volt 30p</td>
<td>8 way Cinch standard 0.15 pitch edge socket 20p</td>
</tr>
<tr>
<td>1MFD 400 volt 15p</td>
<td>U.E.C.L. 10 way pin connector 286000 OA1P10 20p</td>
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<tr>
<td>2MFD 250 volt 20p</td>
<td>U.E.C.L. 20 way pin connector 2860000A1P20 30p</td>
</tr>
<tr>
<td>2MFD 1.5 kv 50p</td>
<td>TIE CLIPS 12 way edge socket 30p</td>
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<tr>
<td>15MFD 150 volt 25p</td>
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<tr>
<th>PHOTOLUMINESCENT SWITCH</th>
<th>DEE PLUG</th>
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<tr>
<td>BPX66 PNPN 10 amp</td>
<td>12 volt red or mains neon amber, push fit round, chrome bezel 15p each</td>
</tr>
<tr>
<td>£1</td>
<td>Rotor with neon indicator, as used in Seafarer, Pacific, Fairway depth finders 20p each</td>
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<tr>
<th>E.T.'s</th>
<th>100MFD</th>
<th>250/275V electrolytic can 20p</th>
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<tbody>
<tr>
<td>Philips iron Thermostat</td>
<td>100MFD</td>
<td>20p each</td>
</tr>
<tr>
<td>Bulgin 2-pin flat plug and socket</td>
<td>250/275V</td>
<td>20p each</td>
</tr>
<tr>
<td>McMurdo PP108 8 way edge plug</td>
<td>500/275V</td>
<td>20p each</td>
</tr>
<tr>
<td>300 ohm moving coil insert</td>
<td>220V</td>
<td>20p each</td>
</tr>
<tr>
<td>41030 13 1/2&quot; diameter.</td>
<td>220V</td>
<td>20p each</td>
</tr>
<tr>
<td>ideal mike or speaker for communication work</td>
<td>220V</td>
<td>20p each</td>
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<p>| TESTED UNMARKED OR MARKED AMPLE LEAD | TIE CLIPS |</p>
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<tr>
<th>EX NEW EQUIPMENT</th>
<th>Nylon self locking 33⁄4&quot; 1p; 7 2p</th>
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<tbody>
<tr>
<td>AC128 6p</td>
<td>OAC4 6p</td>
</tr>
<tr>
<td>AC171-20 8p</td>
<td>OC71 6p</td>
</tr>
<tr>
<td>BCY70/1/2 8p</td>
<td>OC72 6p</td>
</tr>
<tr>
<td>BCY30-34 10p</td>
<td>OC200-5 6p</td>
</tr>
<tr>
<td>BY127 8p</td>
<td>2N2926 5p</td>
</tr>
<tr>
<td>BY28 Series 6p</td>
<td>Germanium</td>
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<tr>
<td>OAS/7/10 10p</td>
<td>diode 3p</td>
</tr>
<tr>
<td>OA47/81 4p</td>
<td>GET111 20p</td>
</tr>
<tr>
<td>OA200-6 6p</td>
<td>GET120 120v</td>
</tr>
<tr>
<td>OC23 20p</td>
<td>(AC128 in 1&quot; sq) 30p</td>
</tr>
<tr>
<td>OC23 25p</td>
<td>heat sink 20p</td>
</tr>
</tbody>
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SERVICING
THE
TRANSISTOR PORTABLE

Part 1
by
Vivian-Capel

Professional tips on tracing faults in completely dead receivers and in receivers with distorted output are given in this article. A concluding article to be published next month, will deal with low sensitivity and the procedure of alignment.

The reader hardly needs to be told that the portable medium and long wave transistor radio is now part of the present-day scene. Unfortunately, these radios do not always remain serviceable and, for the radio service engineer, this means a continuous crop of faulty units brought in what seems a never-ending trail into the workshop.

Many dealer's service departments refuse to repair these sets because the process is just not economic. Service information is often sparse and spares difficult to obtain, and under these conditions labour costs can almost equal the price of a new set, especially the cheaper imported variety. Other dealers accept them but with a time limitation, so that if the engineer cannot find the fault in, say, a quarter of an hour, the repair is regarded as uneconomic. An exception is the better-class more expensive radio with a well-known brand-name, for which spares and technical information are available.

TRADE TIPS

The overall result of the situation is a large number of faulty radios for which the owners are not able to obtain service. For the amateur who makes radio his hobby offering a repair service could provide an interesting and profitable side-line, because he does not have the overheads and labour-cost problems of the professional service department. Service engineers who do handle these receivers usually have a time-saving routine of checks and tests based on experience of the most likely faults, and which will show up 90% of them. In these two articles the author will describe some of the things the professional engineer looks for and pass on some trade tips. A number of common faults are illustrated in Fig. 1.

A frequent fault is given when the receiver is completely dead. In theory a large number of things could be responsible, but in practice they can be narrowed down to a few, so these can be checked first. Often, batteries are left in the set until they leak and cause corrosion of the springs and terminals holding them. While the owner may replace the batteries the corrosion remains and prevents a good contact with the new batteries. It is also common for the set to be left switched on, since the switch on many sets does not give a positive click, and so although the owner may say that the batteries are new they can in fact be flat. It is not uncommon for a set to be brought into the workshop with some other faults, but still switched on, so that if the batteries were not the cause of the original trouble they will be dead by the time the set is put on the bench for repair.

The first test then is always to measure the battery voltage, not directly across the battery but across the wires that go from the battery to the set, since this will check the battery contacts as well as the battery itself. Furthermore, this test should be carried out with the set switched on, because some exhausted batteries give an almost full reading off-load, whilst their voltage drops dramatically when the load is connected.

If the battery is a few volts down one may still expect the set to work although, perhaps, with distortion and low volume. This is not always the case, however, as some oscillators will refuse to work below a certain voltage, hence preventing the set from reproducing signals. Anything below three-quarters of correct battery voltage should be suspect.

Another very common cause of a dead set is the on-off switch. Usually these are an integral part of an edge-type volume-control, and are impossible to repair economically. If the switch is open-circuit, then a complete new control will be required. Fortunately, these are in most cases a standard value at 5kΩ, but the physical size varies. If the replacement is too big it will jam in the case-slot, and if it is too small it cannot be reached by the user. Some component firms make two or three different sizes and styles but unfortunately there are other sizes in use for which replacements are not obtainable. The problem can and has been overcome on a number of occasions by breaking up the old control to obtain the plastic wheel, selecting a replacement that is smaller, then cutting a hole in the old wheel with a hot pin just big enough to take the new control. Finally, the new control is fixed in the old wheel with
one or two dabs with a hot iron to weld the plastic together. This procedure takes a little time, but it does get over the difficulty of providing a new volume control.

The disposition of the control and switch contacts may not line up with those of the old one in the printed-circuit panel, but this can usually be overcome by bending some of the contacts and soldering copper wire to those that do not reach. Some controls have the switch mounted externally to the control, in which case a repair can often be effected by simply adjusting the contacts.

**ISOLATION**

If battery, leads and switch are in order one must look deeper. Now it is best to isolate the end of the set, r.f. or audio, in which the trouble lies. First, check with the meter to see if there is a voltage between the volume-control slider and chassis. If not or if it is low, it is safe to make a disturbance test using the testmeter switched to an ohms range. By scratching the meter probe on the slider terminal, a spiky audio waveform will be injected into the audio circuits which should produce a pronounced crackling in the loudspeaker. If it does not, then the audio circuits are at fault.

A large number of troubles with transistor radios are due to falls or physical shock. There are several areas where this is most likely to occur. A blow or undue pressure on the volume control can cause a fracture of the printed board around the area where it is mounted. Any crack in the board will usually mean a crack in the printed circuit conductor as well. Another common position for board fracture is around the holes where the board is fixed to the case. A fall will almost certainly produce a fracture here. If there is no printed conductor in the vicinity, no effect will be produced, but if there is then this too will most likely be broken. It must be stressed that these print faults are not easily visible, but the board fractures can quite readily be observed. In consequence, always look at the board for fracture first.

If, as occurs with some models, the speaker is fixed to the board instead of in the case it, too, can cause a fracture in a fall, whereupon a look around the fixing holes is well worth-while.

Another common damage effect is that suffered by a.f. output and driver transformers. These are fixed to the board by their terminal pins, to which are soldered the fine lead-out wires from the windings. A shock, as occasioned by a fall, will wrench the transformer from its pins, thus breaking the lead-out wires. A quick look will often not reveal that anything is wrong, because the transformer is still sitting more or less in place on the board, but a closer examination will show the broken lead-out wires.

So common are these troubles that some engineers make a physical examination of the areas mentioned for fractures, and also the transformers for broken wires, as well as the ferrite aerial coil leads – another prolific source of trouble – before even showing the meter to the set or making any electrical tests at all. They are often rewarded by spotting the trouble within a few minutes.

**THE LOUDSPEAKER**

If there is no crackling when the test on the volume control is made, it is worth checking the loudspeaker. The high impedance models (around 300) used in many transistor sets use very fine wire for the speech coil, and these often go open-circuit. The earphone socket is another possibility as these include a speaker muting-switch which can be damaged by clumsy insertion of the earphone plug. Check also the collector voltage of the driver transistor, this comes via the primary of the driver transformer which can go open-circuit.

If the audio stages are lively, then operation of the wavechange switch will give a clue as to whether the trouble is in the i.f. stages, or the mixer and r.f. stages. A healthy crackle will in most cases eliminate the i.f. stages. If a check has not already been made on the ferrite aerial coil wires these are the next suspects. A broken wire can give rise to different symptoms, depending on the circuit which is affected. A common wire for both long wave and medium wave coils or a common coupling coil can mean complete loss of signals, otherwise only one waveband is out. A rather
puzzling effect is that of breakthrough from one band into the other as occurs if, for instance, the Radio 2 programme on 1,500 metres comes through on Radio 4. This is not a tuning or oscillator fault as may be imagined, but usually an open-circuit aerial coil.

Look out for vertically mounted components such as capacitors that may have become displaced, being forced over so that the wire has pulled away from the print. Components near the battery compartment are particularly prone to this sort of trouble, suffering from the attempts of ham-handed owners to replace the batteries!

TESTMETER CHECKS

These few checks plus a visual examination take but a few minutes, and if not actually revealing the fault (which in many cases they will) do at least narrow down the search to the particular section concerned. The next step is to check the transistors and print within the suspected section, as these two are the next most likely to cause trouble. Print faults in this case may not be accompanied by a board fracture which makes them easy to detect, but may consist of tiny hair-line cracks almost invisible to the naked eye. The meter will now be needed to check voltages.

If service data is not to hand, which in most cases it will not be, there will be no voltage figures to compare. Furthermore there is often confusion as to whether the chassis is common to the positive or negative supply lines, and whether therefore the transistor collectors are high or low voltage to earth. The best course is to ignore the chassis connection and clip the meter positive lead to battery positive. Most transistors used at present in radios brought in for service are still p.n.p. types, so this will enable the normal arrangement of voltages, high at the collector and low on the base and emitter, to be measured without mentally inverting. If the radio is known to have n.p.n. transistors, or if the first few checks show that this must obviously be the case, then the testmeter negative clip is connected to battery negative and voltages measured by way of the positive meter lead.

Collector voltages vary according to the transistor function and circuit, so without service data not much can be deduced from precise readings. However, half to three-quarters of the battery voltage is the usual range encountered, except for first stage audio transistors that are directly coupled to the next stage; here the readings will be very low. The main object of taking the collector reading is really to see if a voltage is there or not. If not then the intervening path to the supply line is broken somewhere.

The base and emitter voltage measurements are rather more helpful. Assuming germanium p.n.p. transistors, the base must be slightly more negative than the emitter, so a difference of 0.1 to 0.2 volt should be observed, otherwise the transistor will be cut off. With silicon transistors the base-emitter voltage is about 0.6 volt. A high base voltage could be an internal leak to collector, or an open-circuit bottom potential divider bias resistor. A low base voltage could indicate an open-circuit top divider resistor. No emitter voltage is the result of an open-circuit transistor unless, of course, the emitter has no series resistor. If there is emitter and base voltage and low collector voltage there may be excessive current due to an internal leakage. All voltages the same indicates a short-circuit transistor.

Emitter and base voltages in receivers with p.n.p. transistors will generally be about 0.5 to 1 volt as measured from the positive line, although the voltage may vary with some circuits. There may also be a series resistor between the main positive line and battery positive which would increase all such readings.

If a transistor is suspected, it is not always necessary to remove it in order to try a replacement unless the original has a leak. The new transistor can be soldered temporarily across the existing one and it will work, the old transistor having little, if any, effect. This saves time and possible damage through heat to the old transistor if it proves to be serviceable after all. If the transistor is proved faulty, then it can be removed and the replacement fitted properly.

Many imported sets use transistors with type numbers that no-one seems to have heard of, many even without type numbers at all. Fortunately transistors, unlike valves, have a high degree of compatibility, so one can usually fit as replacement any transistor that is of the same polarity and in the same class (i.e. mixer, r.f., a.f., or output). With cheap radios minor performance differences are unimportant; in fact the results with the replacement transistor may even be better than with the original! The output stage is the only one where some care will be needed in choosing a replacement, and alteration of the base forward bias may be needed. After replacing the output transistors with a pair of another type, check that the quiescent current is reasonable for the type of set, 9 to 18mA being usual, and that the distortion level is acceptable.

Incorrect transistor voltages may be due to print faults, but often the faults are such that little or no

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ELECTRONICS CONSTRUCTOR

A good testmeter is invaluable in the service workshop, particularly for tracing the more complex faults. This instrument, the Model 128 manufactured by Taylor Electrical Instruments, Ltd., offers a large number of ranges and has a d.c. sensitivity of 20,000 ohms per volt
voltage discrepancies result. Finding these faults can be tedious and time-consuming, especially without a circuit diagram. One method of dealing with this type of trouble is to first locate the stage or stages wherein the fault lies, as previously shown, and then run the soldering iron briefly over all the printed strips in that area, melting the solder along the print and also where components are connected. Take care not to inadvertently bridge adjacent strips with excess solder. It is often found after this operation, which should only take a few minutes, that the fault has been cured.

DISTORTION

Another very common complaint is distortion. In by far the majority of cases the trouble lies in the output stage, so diagnosis should be straightforward. Make sure that the battery voltage is well up though first.

A frequent source of trouble is failure of one half of the push-pull output pair. If of the series configuration (identified by the absence of an output transformer) take voltage readings to find if the collector of the bottom transistor and the emitter of the top one are at about half the battery voltage. See Fig. 2 (a). If there is an appreciable difference, one transistor is most likely either open-circuit or short-circuit, depending on which way the reading is, high or low. The quickest and easiest diagnosis in this case is to disconnect the collector of each transistor and solder a new pair across. Before doing so, though, one may check the base-bias resistors and take another voltage measurement with the speaker disconnected. The capacitor feeding the speaker may be leaking, thus causing an abnormal reading. In this case disconnection of the capacitor will return the reading to normal.

If the output stage is of the transformer type, as in Fig. 2 (b), voltage readings will not be of much help. Defective transistors will not have a great effect on the voltage because of the low transformer winding resistances in series with them. Voltage should still be measured, of course, to make sure that bias is present and that the output transformer windings are continuous. One way of testing whether one half of the stage is working is to short-circuit the base to the emitter of the appropriate transistor. This removes the forward bias and of course the signal. If the stage section is working there will be a drop in volume and further deterioration of quality, or if the other section is not working, complete loss of signals; if there is little difference, then the section with the short-circuit is not working. This test is not always conclusive because, with some circuits having a low d.c. resistance driver transformer, the bias will be removed from the other transistor as well. However, it is a quick test worth a try.

If one transistor is found to be defective, discretion can be used as to whether to replace the other one as well. Unless one is going to replace with a matched pair it is not usually necessary to change them both, as there is just as likely to be a wide production deviation between two new ones as between the remaining old one and a single new one. If transistors of a different type are to be used, then of course the pair must be changed.

Another cause of distortion is the loudspeaker itself. The trouble is due to the speech-coil rubbing against the poles of the magnet. The magnet is easily displaced, and a fall can be responsible. This fault is not always easy to identify because the effect can be very similar to output stage distortion.

One tip to distinguish between them is to listen at both low and high volume levels. Speaker distortion is usually worse at lower levels because the higher levels mask the rubbing sounds, whereas output-stage distortion is worse at the higher levels. There can be exceptions, but this rule applies in the majority of cases.

Often, the rubbing can be felt by gently pushing the cone in and out with the fingers. Hooking up another speaker is the most decisive test. Impedance is not very critical, and a speaker of slightly lower impedance can be used for a brief period, if the volume is kept moderate without damage to the output stage. Volume will be lower in this case but it will be sufficient to hear whether the distortion is still present.

So then, battery voltage low, one half of the push-pull output pair defective, bias incorrect, or speaker fault, are the four most usual causes of distortion. There are others, but these will have to be found by normal fault-finding techniques.

(To be concluded)
EMI LAUNCHES ITS FIRST STEREO HI-FI AMPLIFIER AND QUADRAPHONIC DECODER

The introduction of a medium-priced solid-state stereo amplifier and a quadraphonic decoder marks EMI’s intention to increase its stake in the mushrooming hi-fi hardware market, after many years as a manufacturer of high quality loudspeaker systems. Both EMI developments, the new 15 watts per channel amplifier and the decoder, which utilises the popular SQ Quad technique, were launched recently at a trade preview by EMI Pathe, a division of EMI Sound & Vision Equipment Ltd., Hayes, Middlesex.

Stereo Amplifier
Known as the EMI 1515, the versatile teak-veneered amplifier is recommended to sell at £46.50 retail, including VAT, and offers a specification and performance above most equipment in its price range. It is designed to reproduce sound, in high quality mono or stereo form, originating from as many as six different sources. These include magnetic and ceramic disc turntables, magnetic tape decks, stereo radio tuner, microphones, and equipment such as electric musical instruments. Separate plug-in facilities are provided for each of these inputs.

A special feature of the 1515 unit is its ability to provide the electrical supply for a complete unit stereo system. Equipment such as disc or tape decks and tuner can be plugged into two switched mains sockets at the rear, thus eliminating the untidy clutter of wiring to the mains normally associated with unit stereo.

For personal listening, the amplifier incorporates a socket for stereo headphones. In this mode, the sound is automatically cut from the main loudspeakers and reduced to a low level.

Quadraphonic Decoder
Designed to equip conventional stereo systems with the increased capability of playing the new SQ four-channel records, the EMI quadraphonic decoder’s function is to separate the four channels of sound contained on the two-channel SQ Quad discs produced by EMI Records and other leading companies.

WIPING CLOTHS FOR DELICATE WORK

For cleaning delicate equipment in industry and commerce Clean Tread Services Limited have introduced special wiping cloths. Made of a non-woven fabric, they are lint-resistant with a limited life.

They are particularly suitable for computer rooms, telephone exchanges, electronic equipment, etc. They are, of course, equally suitable for light dusting of desks, tables, etc.

Yellow in colour, cloths have an overall controlled impregnation by a special dust-attracting chemical – thus ensuring the removal of dirt and dust without the necessity for heavy pressure. They have an average life of a week.

Clean Tread Services supply 16” x 16” cloths in boxes of 50, at a price of 5p per cloth.

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BURGLARALARMS

Following the success of the "Household Burglar Alarm" featured in our last issue, we can now give some news of a relatively highly sophisticated, minicomputer-controlled, security network which has been put into operation by a major bank in Pittsburgh, Pennsylvania, to watch windows, doors and bank vaults, and to call the police if the bank is robbed. In fact, officials of the Mellon Bank and Trust Co. claim their new automatic security system has already been instrumental in the capture of one would-be bank robber at one of their branches. The bandit was arrested less than two minutes after police headquarters received a teletype alert printed out on the command of a Computer Automation Alpha 16 minicomputer incorporated in the bank's new Diebold DGM-320 Security System.

This police alarm was an automatic function of the system, which continuously monitors security sensitive areas in the bank's headquarters and 22 area branch offices, through electronic sensors plugged into a private data communications network, as well as a closed-circuit television surveillance system.

It is claimed to be the most comprehensive security installation ever developed for a financial institution.

As a tailpiece to this news item, we read an amusing anecdote in a recent issue of Mobile News, the journal of the Amateur Radio Mobile Society. It appears that one of their members was tuning up his mobile rig when he noticed that the local burglar alarms were ringing and that they came on and off as he tuned. "We beat it quick!" was the comment.

IN BRIEF

• Her Majesty the Queen has been graciously pleased to confer Her Award To Industry in 1973 upon English Electric Valve Company in recognition of outstanding achievement in technological innovation in respect of Ceramic Hydrogen Thyratrons.

• It was in 1968 that EEV first received the Queen's Award To Industry for technological achievement in respect of the Image Isocon "see in the dark" TV camera tube.

• The British Amateur Radio Teleprinter Group, following the success of their first Convention last year, are holding a second one at the Meopham Village Hall, Meopham, near Gravesend, Kent on Saturday 30th June, from 11.0 a.m. to 6.0 p.m.

• There will be lectures, demonstrations of both unusual and popular teleprinter machines, a live amateur station, G4ATG, also trade exhibitors etc.

For further information write to G. Sharville, G3VZY, 2 Orchard Close, Toddington, Dunstable, Bedfordshire, tel: Toddington 2470.

• The 50th anniversary of official German broadcasting will be celebrated within the framework of the International Radio and TV Exhibition to be held from 31st August to 9th September in Berlin.

• The Hon. Treasurer of the Radio Society of Great Britain has announced that subscriptions to the R.S.G.B. will be increased to £5 per annum, for Corporate members, as from 1st July 1973. Unfortunately for members, V.A.T. is payable on subscriptions so the total amount is £5.50.

• The Society is not however increasing the subscription rate of the younger members and the V.A.T. on those subscriptions is being borne by the Society.

• An entirely new concept of naval communications is the basis of a multi-million pound contract placed with Marconi Communications Systems Ltd.

The new system, designated ICS 3, will give the Royal Navy the most sophisticated and comprehensive communications system in the world.
REGULAR READERS WILL RECALL that last month's article in the "Suggested Circuit" series described a triac circuit by means of which a 100 watt domestic light bulb could be switched on and off by a low control current which was completely isolated from the mains supply. The control current could, indeed, be obtained from such sources as the outputs of t.t.l. logic gates. The article also discussed triac operation and pointed out that, in a simple application where a triac functions effectively as an on-off switch in an a.c. circuit, the minimum gate triggering current is different for alternate half-cycles of the applied alternating voltage. The gate current has to be greater than that required by the triac on the half-cycles when it is less sensitive if reliable switching is to occur. Ideally the gate current, in taking the triac from the off to the on condition, should increase abruptly from zero or a very low value to the full triggering level required.

LIGHT CONTROL

The circuit described in the present article also incorporates a triac which controls a 100 watt domestic light bulb. In this instance the triac is operated by a photoconductive cell which causes the triac to become conductive when ambient light level outside a house or building falls, and to become non-conductive when the ambient light level rises again. The circuit can, in consequence, be employed for automatic switching of, say, a porch or garage lamp, the lamp being switched on when night falls and switched off the following morning. Readers may be able to visualise other applications. Triac operation in the unit to be described can be overridden by two switches which are incorporated in the circuit, with the result that the device may be used merely to turn on the lamp as ambient light falls, or to turn it off as ambient light increases.

In the preceding article, a triac was controlled by a circuit incorporating a photoconductive cell type ORP12, and this circuit demonstrated that the triac could be held in a state midway between non-conduction and full conduction at intermediate levels of illumination of the cell. It is obvious that a circuit of similar type would not meet present requirements since, as ambient light level gradually decreased during the evening, or gradually increased at dawn, the controlled bulb would pass through a period in which it was not fully illuminated. What is required is a trigger circuit which changes virtually instantaneously from the trigger-off to the trigger-on condition, and from the trigger-on to the trigger-off condition.

It is also necessary for the triac trigger circuit to have either a long time constant of operation or to have marked hysteresis. Either of these will obviate the condition where, as the ambient light outside the house or building is around triggering level, the triac is turned continually on and off by such things as passing clouds. Of the two requirements, it is easier to arrange for hysteresis rather than for a long time constant of operation and it is, in fact, a relatively simple matter to design a trigger circuit which turns on the triac at an ambient light level which is significantly lower than the subsequent ambient light level which turns it off again.

The circuit of the automatic lamp switch is given in Fig. 1. In this diagram S1 is the main on-off switch for the unit and it applies the a.c. mains to the triac and the controlled 100 watt bulb in series. S2 short-circuits the triac for occasions when automatic control is not required. When S2 is closed, S1 switches the 100 watt bulb on and off in normal manner. The triac is an R.C.A. device type 40430 (available from Electrovalue Ltd.) and its Main Terminal 2 connects to the controlled bulb, its Main Terminal 1 to the neutral side of the mains supply, and its gate to the source of triggering current. The triac becomes conductive when a sufficiently high triggering current, of either polarity, is allowed to flow between its gate and Main Terminal 1.

Closing S1 also applies the mains supply to the primary of mains transformer T1. The 8 volt secondary of this transformer couples to the bridge rectifier given by D1 to D4, and a rectified voltage of around 10 volts appears across reservoir capacitor C1. The positive side of this d.c. supply is common with Main Terminal 1 of the triac.

The photoconductive cell which senses changes in ambient light level is the ORP12 which is connected in the PCI position. An ORP12 exhibits a resistance in excess of several megohms in the fully dark condition and a resistance of 3000 or less when fully illuminated. It is connected in series with R1 and VR1, the base of TR1 coupling to the junction of these two resistors. Since the resistance of the photoconductive cell increases as its illumination decreases, a fall in ambient light level (assuming that VR1 slider is not at the extreme upper end of its track) causes the base of TR1 to go negative. R1 is a limiting resistor which limits possible dissipation in the photoconductive cell.

RADIO & ELECTRONICS CONSTRUCTOR
TR1 and TR2 are wired in a Schmitt trigger circuit. If, in this circuit, the base of TR1 is at the same potential as the negative 10 volt supply rail, this transistor is off and sufficient current flows through R2 and R3 to turn TR2 off. The emitter current in TR2 causes a voltage to be dropped across R4 and this voltage is applied to the emitter of TR1. If the base of TR1 is now caused to go positive this transistor will remain turned off until the base voltage reaches a level which is equal to the voltage dropped across R4 plus the normal base-emitter voltage drop for the transistor. TR1 now commences to pass current and, if the base voltage is taken slightly further positive, draws sufficient current through R2 to remove the base bias for TR2. TR2 cuts off, the voltage across R4 reduces, and TR1 becomes fully conductive.

If, next, the base voltage of TR1 is reduced, a level is reached where this transistor draws reduced current. A bias current now flows in TR2 base via R2 and R3, causing this transistor to conduct and to produce an increased voltage drop across R4, thereby biasing TR1 further towards cut-off. The circuit then reverts to its initial state, with TR1 off and TR2 turned on.

Because of the amplification offered by the two transistors and the regenerative couplings between them, the transitions from the first state to the second and from the second state to the first are very swift. Circuit operation here is comparable with the swift transitions of state in a multivibrator. Hysteresis, or "backlash", is inevitable in a Schmitt trigger, and is demonstrated here by the fact that the positive voltage at TR1 base which is needed to turn this transistor on is higher than that needed to turn it off. In the present circuit, the values for R2 to R5 have been purposely selected to provide a high level of hysteresis; with the prototype TR1 base had to be raised to about 4 volts positive of the negative supply rail to turn it on, and then reduced to about 1 volt to turn it off again.

The triac is triggered on, and the controlled bulb is lit, when TR2 is conductive. The triac gate current then flows from the negative supply rail through R4, the transistor and R6. It follows that the triac is conductive when TR1 is off, as occurs when the base of TR1 has a low voltage. Since this low voltage is given when PC1 has a high resistance due to low ambient light level, the requisite chain of control from decrease of ambient light level to switch-on of the bulb is achieved.

As will be noted, the Schmitt trigger gives the hysteresis and rapid switch-on and switch-off requirements for the triac which were mentioned earlier. An incidental advantage of the trigger circuit is that the amplification offered by the two transistors in it enables TR2 to pass a triac gate current of about 50 mA whilst a base current of only some 50 µA or less is needed by TR1 when this transistor becomes conductive.

The sensitivity of the unit is set up by means of pre-set potentiometer VR1. The control is triggered when ambient light levels as the resistance inserted by this potentiometer increases.

CONSTRUCTION

All the components in the unit are standard types. A retail source for the triac has already been given. In the prototype, this component was mounted on a flat heat sink about 1/2 in. square. Transformer T1 was an 8 volt bell battery, of the type available from Woolworth's stores. However, the power supply section is not critical and any supply offering a reasonably smooth d.c. output at around 10 volts may be employed instead. Switches S1 and S2 can be standard wall-mounting on-off switches of the type normally employed for controlling domestic lamps. The controlled bulb can, if desired, have a rating lower than 100 watts. The photoconductive cell type ORP12 may be referred to in some sales literature as a 'light dependent resistor'.

The components, with the exception of PC1 and, of course, the controlled bulb, should be fitted in an enclosed case made of insulating material with S1 and S2 mounted on the outside. All the parts run cool and only a small amount of ventilation, if any, is required. Layout is unimportant. A hole in the case is required for adjusting VR1.

Both PC1 and the 100 watt bulb couple to the remainder of the circuit via 2-core wires. The bulb is mounted in its intended position, whilst the photoconductive cell is fitted at a point where it can monitor the ambient light outside the house or building. A simple method of carrying this out consists of fitting the cell in a round tube made of any convenient insulating material in the manner shown in Fig. 2. This tube can be positioned, with its open end pointing up at about 60° to the horizontal, at a convenient window. If the tube is mounted inside the window there is no need to provide weatherproofing, but provision must be made to shield the open end of the tube from interior lighting. The tube should not, of course, be directed towards any street lights or similar artificial sources of illumination. A lens, not mentioned, and should not be fitted to the tube.
An interesting feature is that the overall circuit functions as a very high gain 'light amplifier', since quite small changes in light intensity, within the Schmitt trigger hysteresis range, at the photoconductive cell cause a very large change in light intensity at the controlled bulb. In consequence it is possible for the system to become unstable if some of the light from the controlled bulb is allowed to fall on the photoconductive cell. The latter does not offer an instantaneous change in resistance when the light intensity by which it is illuminated varies, and the result of this 'feedback' may be a continual flickering on and off of the controlled bulb. The circumstances needed for this condition to appear are, admittedly, rather critical, but the point should be mentioned in case it is encountered by the constructor. The effect cannot occur if the tube in which the photoconductive cell is fitted is directed well away from the controlled bulb.

A further important point is that all the wiring and components in the circuit, including the leads to the photoconductive cell and to the controlled bulb, are at mains potential.

The control circuit and the photoconductive cell must be mounted in fully insulated housings and all precautions against shock must be carefully observed.

After the unit has been completed it may be checked out by directing the photoconductive cell, in its tube, at different levels of light and ensuring that the controlled bulb turns on and off as desired. Sensitivity can be varied by adjusting VR1. It should be noted that the photoconductive cell loses control if the slider of VR1 is fully at or very near the upper end of its track, since TR1 is then held permanently in the off condition. Remember, when handling the photoconductive cell, that the leads which connect to it are at mains potential.

The photoconductive cell may then be mounted in its final position. When the outside ambient light level is low, i.e. considerably less than that given in the late morning and early afternoon VR1 is set up. It should be initially adjusted to insert maximum resistance into circuit, after which the resistance, if it inserts is slowly reduced until a setting is reached at which the controlled bulb turns on. VR1 is then left at that setting.

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**RECENT PUBLICATIONS**

**MAKING AND USING OSCILLATORS.** By W. Oliver.
120 pages, 135 x 215mm. (£3 6s. 6d. net.) Published by W. Foulsham & Co. Ltd. Price £2.00.

It is, probably, only when one chooses to reflect on the matter that one realises what an exceptionally wide variety of oscillators is employed in electronics at the present time. Apart from standard LC feedback oscillators there are crystal oscillators, RC oscillators and oscillators which function due to a particular facet of semiconductor performance. This book deals with many of the oscillator circuits currently in use.

The first chapter in the book explains how oscillators work. The second deals with the classification of oscillators, giving circuits which include the Hartley oscillator, the phase shift oscillator and the multivibrator. The next chapter discusses crystal-controlled oscillators, and is followed by a chapter on variable frequency oscillators as would be employed in transmitters. Two chapters on receiver and audio oscillators appear next, to be succeeded by chapters describing oscillators for test equipment and for electronic musical instruments. The remaining chapters in the book are devoted to specialised oscillators, including the neon relaxation and tunnel diode oscillators; valves, semiconductors and components for oscillators; integrated circuit oscillators; the operation and troubleshooting of oscillators; and sources of supplies and information on oscillators.

Representative circuit diagrams for each oscillator type dealt with are given in the book. These are intended mainly to illustrate the typical basic features of the circuits discussed and are not necessarily meant to be used as designs for practical interpretations.

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**ELECTRONICS IN MUSIC.** By F. C. Judd.
189 pages, 150 x 230 mm. (6 x 9in.) Published by Neville Spearman Limited. Price £3.15.

The marriage of music and electronics has certainly been fruitful. Apart from the incidental fact that electronics permits the recording and reproduction of music which very closely approaches the original, the two arts in congress have produced new sounds and techniques which would have been considered completely impossible some 30 years ago. "Electronics In Music" sets out to introduce the reader to all that is happening currently in this field, and it covers virtually the entire scene ranging from such simple devices as the Theremin to the Moog Synthesizer. The book commences with a chapter dealing with the basic attributes of musical sounds, including tone generation, vibrato and tremulo, filters and sound reproduction; then carries on to electronic musical instruments, discussing amongst other things the electronic organ and the electronic guitar. The third and fourth chapters deal with the electronic sound and electronic music respectively, the fifth to tape recorders and their operation, and the sixth to music reproduction. Each subject is dealt with in considerable detail. For instance, just a few of the points covered in the chapter on electronic music are sine wave, square wave and noise generators, musique concrete and Oramics. Circuit diagrams for filters and generators are given, and the book includes 20 pages of photographs. These mainly show manufactured equipment, together with some home-constructed items and a picture of the lavishly equipped Putney studio of Dr. Peter Zinovieff.

The book fills a gap in the literature very effectively, and will have appeal for the reader who is interested in this exciting and creative new art form.
The ‘SLIDING JUNIOR’

AMPLIFIER

by

Sir Douglas Hall, K.C.M.G., M.A. (Oxon)

In a previous article describing the author’s ‘Hiflex’ personal receiver, it was stated that an a.f. amplifier, especially designed for use with it, was on the way. This article describes the amplifier. It incorporates a speaker and is supplied by a 3 volt battery which also provides the power required by the ‘Hiflex’ receiver.

The ‘Sliding Junior’ amplifier can also be used with other apparatus having a low impedance output of the order of 10kΩ or less, for which purpose an input socket is provided. There must, however, be a capacitor in series with the output of the apparatus, such a capacitor being required to fulfill a requirement, which will shortly be made clear, in the basic operation of the amplifier. If such a capacitor is not present, a 0.1μF capacitor should be added in series. If the apparatus has a high output impedance or resistance, the amplifier may not function satisfactorily even when a series 0.1μF capacitor is added, as the sliding bias effect could be excessively moderated. With the ‘Hiflex’ receiver the required capacitor is automatically provided by C3 in the receiver circuit.

Amplifier output is fairly modest at about 100mW, but a sensitive 8in. by 5in. loudspeaker gives plenty of volume at that level. Sensitivity is ample for all the louder signals received on the ‘Hiflex’, but is less than that provided by the author’s earlier ‘Sliding Challenger’. With some apparatus a pre-amplifier would be required. The present amplifier gives a good output when used with the author’s DRC3 short-wave receiver, but is not fully loaded by the earlier DRC2.

As a digression, the author would remind constructors that it is useless to judge probable results on amplifier output power alone without taking into account speaker sensitivity. Modern speakers vary enormously in sensitivity. Some have a high electro-acoustic efficiency whilst others have a very low efficiency. Very small speakers are relatively inefficient; and some high fidelity systems have very low sensitivity even though they may give excellent quality. Fortunately, most inexpensive speakers which are not smaller than about 8in. by 5in. have a high electro-acoustic efficiency, and are well suited for use with an amplifier of the present type.


The complete assembly, with the ‘Hiflex’ receiver fitted into the top of the ‘Sliding Junior’ case
**THE CIRCUIT**

The circuit of the amplifier is shown in Fig. 1. The input signal is applied to the base of TR1, a high gain silicon p.n.p. transistor. R2 and C1 form a filter which reduces the level of any residual radio frequencies that may be present. Part of the audio signal is rectified by D3, through which the standing bias for the base of TR1 is passed. The rectifying circuit is completed by the series capacitor in the output of the apparatus coupled to the amplifier, as was mentioned at the beginning of this article. The level of the standing bias at the base of TR1 is set by means of pre-set potentiometer VR1. The incoming signal thus increases the negative bias available for the base of TR1, the increase being proportional to the amplitude of the signal. Diodes D1 and D2, across VR1, maintain the voltage across this potentiometer at a virtually constant figure despite the gradual fall in supply voltage as the battery ages, and the slider of VR1 is set so that TR2 passes about 8mA when no signal is applied to the amplifier.

Since TR1 is directly coupled to TR2, the base bias for TR2 is the collector current of TR1. Assuming a current gain of about 80 for TR2, its base current, for a collector current of 8mA, is about 100µA. TR1 will perform perfectly satisfactorily at this level of current. At maximum signal peaks, which automatically increase the bias on TR1 base, TR2 will momentarily pass a current of about 80mA and TR1, consequently, about 1mA. The circuit is, of course, a simple form of 'sliding bias' amplifier and, although it gives the economy of Class B operation, it works effectively in Class A. The author prefers this type of amplifier to the much more common Class B designs.

TR2 operates as an emitter follower output device, with the output signal taken from its emitter circuit. An output transformer with a low d.c. resistance is used in preference to a high impedance speaker in order to prevent the otherwise excessive voltage drop which would be caused by the resistance of the speaker's signal coil at maximum output. The use of the transformer enables the whole of the volt supplied by the battery to be usefully employed in providing output.

C2 and R3 provide negative feedback. This is essential to ensure that the signal voltage is always less than the direct voltage resulting from rectification by D3, so that overloading is avoided. The values of C2 and R3 are such as to deliberately introduce a little treble cut. This compensates for a tendency towards excess of treble in the output of the 'Hiflex' receiver due to an inductor in its output circuit. Experimenters may vary the values of C2 and R3, remembering that if R3 is made too large there will be distortion due to overloading. Increasing the value of C2 introduces bass cut, and decreasing the value of R3 increases treble cut.

C3 is the usual large value electrolytic capacitor across the battery.

In the Components List the diodes are specified simply as silicon diodes. Any silicon diode or small silicon rectifier, such as the 1N4002, may be used here. Note that an additional 100Ω resistor, which is not shown in Fig. 1, is needed. This resistor is added to the 'Hiflex' receiver, and is shown in the Components List as R4. A 6-way tagboard measuring approximately 2½ in. by 2½ in. is required for the amplifier. This tagboard is available from Home Radio under Cat. No. BR151. If difficulty is experienced in obtaining the 1.5kΩ skeleton potentiometer specified for VR1, this may be obtained.

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**COMPONENTS**

<table>
<thead>
<tr>
<th>Resistors</th>
<th>Capacitors</th>
<th>Semiconductors</th>
<th>Inductor</th>
<th>Switch</th>
</tr>
</thead>
<tbody>
<tr>
<td>(All values 1/4 watt 10%). RA is added to the 'Hiflex' receiver)</td>
<td>1,000pF paper or plastic foil</td>
<td>TR1 2N4289</td>
<td>T1 Output transformer type TT56 (Repanco)</td>
<td>S1 S.P.S.T., toggle</td>
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<tr>
<td>R1 1kΩ</td>
<td>C1 0.1µF paper or plastic foil</td>
<td>TR2 BFY51</td>
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<td>R2 10kΩ</td>
<td>C2 800µF electrolytic, 4V. Wkg.</td>
<td>D1, 2, 3 Silicon diodes (see text)</td>
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<tr>
<td>R3 220kΩ</td>
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<td>VR1 1.5kΩ pre-set, miniature skeleton</td>
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<td>RA 100Ω</td>
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**Miscellaneous**

- Phono socket
- 6-way tagboard 2½ in. by 2½ in.
- Speaker gauze
- Plywood, hardboard, pegboard, Fablon or Contact, etc.

**Battery**

3 Volt No. 800 battery (Ever Ready)

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**Fig. 1. The circuit of the 'Sliding Junior' a.f. amplifier**
CONSTRUCTION

Construction commences by cutting out six pieces of \( \frac{3}{4} \) in. plywood, as shown in Figs. 2(a) to (e). Two pieces are required, as in Fig. 2(d); and one each as in Figs. 2(a), (b), (c) and (e). As will be gathered from the photographs the final assembly constitutes a frame into which the ‘Hiflex’ receiver can be fitted. All the 5 in. dimensions in Fig 3 assume that the ‘Hiflex’ panel has been cut exactly 5 in. square. If, in practice, it is a little larger, the 5 in. dimensions in Fig. 2 should be modified accordingly.

It is suggested that the speaker panel of Fig. 2(c) be completed first. A suitable aperture is cut out for the speaker and the panel front is then covered with Fablon or Contact before the speaker is screwed into place over a piece of metal gauze. The battery switch and input socket are also mounted after the panel has been covered.

Fig. 2(a) shows the baseboard, and this may next be cut out. Holes should be drilled for the three 4BA bolts shown in this diagram. The two outside bolts are 2 in. long and the central one \( \frac{3}{4} \) in. long, and all three are

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**Fig. 2 (a).** The baseboard of the amplifier assembly. The 3 volt battery and the piece of plywood which holds it in position are shown in broken line.
(b). The upper shelf. The three strips designated X, Y and Z carry connections for the ‘Hiflex’ receiver.
(c). The speaker panel with components mounted.
(d). Dimensions of the two side struts.
(e). The cover for the battery.
(f). How the sections of the frame are assembled.
countersunk types. The bolt heads are below the baseboard, so that the bolt ends point towards the reader. Solder tags are placed, above the board, under the nuts securing the central bolt and left-hand bolt, as seen in Fig. 2(a). The battery, which is a 2-cell cycle lamp type, is placed between the two outside bolts so that the positive terminal strip makes contact with the left hand bolt and the negative terminal strip makes contact with the central bolt. The right hand bolt merely assists in holding the battery in position. Next cut out and drill the piece of plywood shown in Fig. 2(e). This piece is passed over the two outside 4BA bolts of Fig. 2(a) when the battery is fitted and, by means of two 4BA nuts passed over the bolt ends above it, holds the battery down firmly.

Place the tagboard and transformer T1 approximately in position, as shown in Fig. 2(a), but before screwing these components down to the baseboard hold the speaker panel temporarily up against it in the position shown in Fig. 2(f) to make sure that none of the components will foul each other. Then screw the tagboard and T1 in position. T1 may be mounted by means of solder tags soldered to the feet of its clamp.

Cut out the section shown in Fig. 2(b) and fit the four pieces of springy brass strip, as illustrated. In the prototype these were taken from old No. 800 batteries. These should be positioned so that the ends of the four lin. 4BA bolts used as 'legs' for the 'Hiflex' makes contact with them when the 'Hiflex' is placed on the shelf. The 'Hiflex' takes up a position such that the volume control and wavechange switch are towards the speaker panel. Only three of the strips, those indicated as X, Y and Z, are used for making contact and it is useful to tin these with solder to reduce contact resistance. Also, solder tags are fitted, below the shelf, under the nuts of the bolts which secure strips X, Y and Z in position. No solder tag is needed at the fourth strip, and this strip need not be tinned. It is provided merely to ensure a level standing for the 'Hiflex'. The letters X, Y and Z are used in later drawings to identify the brass strips and the 'Hiflex' bolts which connect to them. The 6BA bolt shown in Fig. 2(b) is fitted later.

Next, cut out the two plywood pieces shown in Fig. 2(d). Then turn to Fig. 3(a) and wire up small components on the tagboard as illustrated. The leads of some of the components are shown, for clarity, longer than they need be. In practice, all component lead-outs should be reasonably short. Assemble the frame, as shown in Fig. 2(f). The two pieces of Fig. 2(d) are used as supports, being screwed to the baseboard and shelf at the \( \frac{1}{4} \) in. by \( \frac{3}{8} \) in. cut away sections. Finally, complete the wiring illustrated in Fig. 3(b). Note that connections are made to the solder tags at the two battery connection bolts, and at the three bolts identified as X, Y and Z.

**SETTING UP**

The only setting up process required is the adjustment of VR1. Initially, this potentiometer should be set up

**RADIO & ELECTRONICS CONSTRUCTOR**
Fig. 3 (a). The smaller components are assembled on a 6 way tagboard (b). How the tagboard is wired into the complete circuit.

such that its slider is at the end of the track which connects to the positive supply line. As shown in Fig. 3(a), this is fully anti-clockwise. A 3 volt battery is then temporarily connected to the battery connection bolts with a current-reading meter in the positive supply line. The amplifier is switched on and VR1 adjusted for a reading of 8mA in the meter. It will be found that the slider is then fairly close to the other end of the track.

No case as such is made, but two pieces of hardboard, each measuring 9\text{in.} by 5\text{in.}, are cut, covered with Fablon or Contact and screwed to the sides of the frame of Fig. 2(f). The screws pass into the edges of the speaker panel and the two plywood struts at the rear. The hardboard panels should not be finally fitted until modifications to the 'Hi-flex' receiver have been carried out. A piece of pegboard, 9\text{in.} by 5\text{in.} serves as the back, this being screwed to the edges of the two struts. The back is not covered, but an inch or so of Fablon or Contact at the top will ensure a neat appearance when the assembly is viewed from the top. A cavity is now available at the top which takes the ‘Hi-flex’ receiver.
'HIFLEX' MODIFICATIONS

Modifications have next to be carried out on the 'Hiflex'. Three of the four 4BA bolts used as 'legs' are wired up to provide suitable circuit connections with the brass strips on the amplifier shelf. Details are given in Fig. 4. The bolt at Z connects to the 'Hiflex' output, and the additional 100Ω resistor, shown as RA, is wired in series with the positive supply. The 100Ω resistor provides decoupling in association with the large value electrolytic capacitor already connected across the supply rails of the 'Hiflex', whereupon the large amplifier battery can also supply the receiver circuits without introducing instability.

Also, a switch is added to the 'Hiflex' so that its battery cells are automatically cut out when the receiver is dropped into the compartment at the top of the amplifier. The switch is home-constructed and consists of two pieces of springy brass strip, one passing under the other at right angles and bent so that the two are in contact until it is pressed away. In the prototype, a negative terminal strip taken from a No. 800 battery was used for the fixed contact. This already has approximately the shape required and is able to straddle the other contact. The latter can be a positive battery terminal strip, screwed to the panel at one end only. Both strips are tinned with solder over the areas at which they make contact.

The negative battery lead of the 'Hiflex' is cut and rewired through this new switch. It is intended that, when the 'Hiflex' is fitted in its compartment, the end of the 6BA screw in the shelf of Fig. 2(b) pushes the moving contact of the added switch away from the fixed contact. The 6BA bolt is fitted in the requisite position on the shelf, this position being marked off with the aid of the receiver. The bolt may be 1 in. long in the first place, but it will probably need to be clipped down a little with a pair of pliers to make it exactly the right length to operate the switch correctly. The two hard-board sides of the amplifier assembly should not be fitted while the exact position required for the 6BA screw is being found and while, later, it is being cut to the desired length. The operation of the added switch can then be readily observed.

There is now no need to remove the two battery cells from the 'Hiflex' when it is being used with the amplifier. But it is necessary to turn the 'Hiflex' switch to the Off position if it is removed from the amplifier, as this action will otherwise turn the receiver on. When the 'Hiflex' is used with the amplifier, only the amplifier's switch needs to be employed to control both the amplifier and the receiver. If the amplifier is used with other apparatus, the 'Hiflex' must be removed from its compartment.

Clearly, if the constructor does not object to removing the cells from the 'Hiflex' each time this is used with the amplifier, there is then no need to make and fit the new switch.

RESULTS

Employing the 'Hiflex' receiver in conjunction with the 'Sliding Junior' amplifier results in a combination having surprisingly pleasant output quality with plenty of bass and ample power for normal domestic listening. As regards economy of operation it should be remembered that, other things being equal, the power which can be delivered by a battery may be expected to be roughly proportional to its weight. The No. 800 battery used here weighs just six times as much as, say, a PP3 type: but, at the time of writing, the PP3 is the more expensive!

Before concluding this article the author would like to state that he has now designed a short wave receiver covering a range from below 6MHz to greater than 18MHz which also operates from a 3 volt supply. This may be used on its own as a personal receiver or it may be fitted to the 'Sliding Junior' amplifier in the same manner as the 'Hiflex' receiver. This new receiver will be described shortly in Radio and Electronics Constructor.
At first sight an electrical combination lock may seem to require a simple circuit such as that of Fig. 1, in which two 1-pole 12-way switches are connected in series. For clarity, only 6 of the ways are shown in Fig. 1. When the correct switch settings have been selected the relay energises, and its contacts cause a solenoid to operate and withdraw a bolt which otherwise holds closed a box to which the switches are fitted.

The number of possible combinations in Fig. 1 is 143 (12 times 12 minus 1 for the 'at rest' position). However, it would only take a minute or so to find the combination by the 'round and round' method. This consists of turning S2 through all its positions for each of S1's positions. It would therefore be necessary to fit an alarm system, but the speed at which this lock can be opened means that assistance might arrive too late. A better approach, of course, is to try and prevent the combination being found. With this aim in mind the basic circuit of Fig. 2 was arrived at.

CHARGING CAPACITORS

When S1 of Fig. 2 is in position 1, C1 charges to the supply potential. When S2 is set to position 2, the charge is shared equally with capacitor C2, giving the latter a potential across its plates equal to half that of the supply. This is not enough to trigger the relay, therefore S1 is returned to position 1 to recharge C1 and then back to position 2 to bring C2 up to three-quarters of the supply voltage. If S2 were pressed now the contacts of relay RLA would tremble but not close. So for a third time S1 is changed to position 1 and then back to position 2 to bring the voltage on C1 and C2 to seven-eighths of the supply.

Pressing S2 will now pass sufficient charge to C3 to enable the relay to be energised. Contacts RLA1 change over, causing the relay to be held on via S3. At the same time, contacts RLA2 close and operate the opening mechanism. If C3 is omitted the relay simply 'chatters' when S2 is pressed. S3 is pressed when it is desired to release the relay.
The circuit of Fig. 2 does not prevent the 'round and round' type of switching from charging C2. If, however, S1 is changed for a 12-way switch, additions can be made which guard against this method of operation.

The requisite circuit is shown in Fig. 3. S1 is a 12-way switch of which, for clarity, only 6 ways are shown. No connections are made to the remaining contacts. R3 and R4 have been placed across capacitors C1 and C2 to continually discharge them. This sets a limit to the time that can be taken opening the lock. R2, connected in this example to contacts 1 and 5, provides the arrangement that prevents 'round and round' switching from opening the lock. If S1 is rotated in either direction R2 discharges C1 first via contact 1 or contact 5. C2 is then discharged into C1 via contact 6 or contact 4. This prevents C2 from attaining the required charge to energise the relay. R2, of course, cannot be connected to any contacts on the track between the supply and the 'charge C2' contact (i.e. it cannot be connected to contact 3).

The values of R3 and R4 may be changed to suit individual requirements. It is desirable for their values to be approximately equal.

The combination for the circuit of Fig. 3 is 242424 open. If someone who did not know this wanted to open the lock, and assuming he knew it took 6 digits, which in itself is unlikely, he would be faced with over 1,000,000 possible combinations. In the even less likely case of him knowing that it required the first two digits repeated twice to open the lock there would be just over 120 combinations he would try.

FURTHER COMBINATIONS

For those who think this number of combinations not high enough, a further increase is possible with the circuit of Fig. 4. S1 is changed to a 2-pole 12-way switch and, after C2 has become sufficiently charged, this has to be set to position 5 before the relay can be energised via S2. In this example the combination is 2727275 -
open.

The attraction with both these locks is that it takes six or seven digits to open them, but there are only two or three to remember. Another attraction is that, apart from the instance when the lock is being opened, current will only be drawn if S1 is left with R1, C1 and R3 across the supply. It should therefore always be a rule that, on locking, S1 must be returned to position 1.

Although the supply is only 12 to 14 volts, the back e.m.f. from the relay, when switching off, is quite high. It is enough to give a mild shock to anyone holding relevant wires or terminals at the time. To eliminate this D1 is placed across the relay coil.

The relay can be any small type having to changeover contacts or one changeover contact and a make contact, together with a coil resistance of 200 to 700Ω and an operating voltage lower than 12 volts. It will be apparent that some experiment may be necessary and it may be desirable to employ electrolytic capacitors having different values to those shown. A suitable source of supply will be given by three 4.5 volt bell batteries connected in series.

New Products

NEW MINIATURE PORTABLE SOLDERING IRON

Soldering with the new 8" long portable, lightweight soldering iron – which is rechargeable and can be used far from a power source – launched by the VAN DUSEN AIRCRAFT SUPPLIES COMPANY in the U.K. and Europe. The "ISO-TIP" soldering iron, weighing less than 6 ounces, has been designed to handle, with speed and efficiency, every industrial or domestic soldering requirement.

The VAN DUSEN AIRCRAFT SUPPLIES COMPANY have launched a portable, lightweight, miniature soldering iron – which is rechargeable and can be used far from a power source to handle, with speed and efficiency, every industrial or domestic soldering requirement.

The new 8" long "ISO-TIP" soldering iron – weighing less than 6 ounces – is now available for the first time in the U.K.

The cordless soldering iron is simple to use and eliminates all the usual over-heating risks. A normal solder should be used and the iron – which combines low voltage with high wattage performance – is, at the press of a button, instantly ready for use.

In addition, the specially constructed soldering "ISO-TIP" eliminates all need for earthing and removes the possibility of electrical leakage – which could damage highly sensitive electronic components – occurring.

The iron is ideal for use in restricted spaces where manipulation is difficult and for all general purpose soldering repair work on domestic wiring systems, printed circuit boards and general radio and television work.

The "ISO-TIP" soldering iron – with a tip performance of up to 50 watts and a capacity for up to sixty joints, dependent on size, per charge – reaches soldering temperature in 3–5 seconds. The well balanced iron is comfortable to hold and has a built in pilot and work light to ensure the accurate positioning of solder joints when working in enclosed areas.

A choice of two special recharging stands – to plug into mains 240V or 120V supply – are supplied with the iron and this will charge the nickel cadmium batteries which provide the power source from "dead" to full charge overnight.

The price of the entire unit and stand is £8.75 and replacement tips are available for 80p.

Full technical details of the new, "ISO-TIP" soldering iron, are available from the VAN DUSEN AIRCRAFT SUPPLIES COMPANY, Oxford Airport, Kidlington, Oxon.

THE ‘CONCORDE PROFESSIONAL’ TRIMMING KNIFE

The "Concorde Professional" is a new trimming knife introduced by Spiralux and intended for use by the man who uses a trimming knife all day, every day. It is designed to fit the hand and to be gripped with ease. It is well balanced and has appreciable weight to ensure constant accuracy of cut. Blade replacement is quick and easy – no fiddling with coins or screwdrivers. The base of the knife simply twists off and the body swivels to allow the used blade to be removed and a new blade inserted. The die-cast body of the Concorde Professional will house five spare blades and the recommended retail price is 75p.

Details from Hollands & Blair Ltd., Bensham Grove, Thornton Heath, Surrey.

JUNE 1973
There are many types of programmes radiated on the short wave bands, some have entertainment value whilst others present cultural material, a few have formats of learned content and there are those which feature religion, either partly or wholly, as a matter of policy. Most stations offer newscasts of both local and world events, such reviews are sometimes factual whilst others are ‘coloured’ to some degree, many being downright propaganda and little else. Those stations broadcasting the latter type of news service also tend to have programmes of the same type.

Propaganda stations of one sort or another abound but probably those of most interest are the so-called clandestine transmitters. Some of these, like Radio Espana Independiente on 15185 (19.75m), are well known, whilst others are not and it is some of these that we feature below.

CLANDESTINE

On 6240 (48.07m) we have the latest ‘underground’ station to engage the attention of Dxers, this being a transmitter of the PAIGC (African Party for Independence of Guinea and Cape Verde). This station was first heard by Al Martin of St. Helens in early March and by many others since. The language used is Portuguese and the station closes with an unknown anthem at 2300. We logged it at 2238 when a programme of African-type music with Portuguese announcements was being radiated. The station is cleverly ‘sited’ for on 6250, just 10kHz away, is Santa Isabel, Equatorial Guinea. (Acknowledgement to ‘Bandspread’ for this item).

Liberation Radio has a scheduled European Service in English from 2030 to 2045 on 10010 (29.97m) and on 12117 (24.75m) although 'Bandspread' reports it on 14992 (20.01m) in parallel with 12117, having dropped the 10010 channel. The station also has a 30-minute English transmission at 1100, 1230, 1430 and at 2330 (scheduled) on 7470 (40.16m) and on 10010. Liberation Radio is based in Hanoi. (Pro-communist).

Voice of the Patriotic Militiamen’s Front, reportedly operated by the American CIA, is still (at the time of writing) active on 9430 (31.81m) according to ‘Bandspread’, being heard at 1415 with accordion, cymbals, interval signal and clear identification. This one is probably based in South Vietnam.

Voice of the Front of United Nationalities in Iran reportedly operates from 1500 to 1600 on 9600 (31.25m) being in Persian, Arabic and Baluchi. (Pro-communist).

Voice of the Revolutionary Party for Reunification operates on 4563 (65.74m) from 1000 to 1400 and from 2100 to 2300 in Korean. (Pro-communist).

CURRENT SCHEDULES

SWITZERLAND

SBC Berne radiates programmes in English from 0645 to 0730, 1100 to 1130, 1300 to 1345, 1515 to 1600, 1800 to 1815 and from 2100 to 2130 on 3985 (75.28m) from 1515 only on this channel, 6165 (48.66m) and on 9535 (31.46m).

HOLLAND

Radio Nederland operates an English transmission schedule as follows, from 0930 to 1050 on 6140 (48.85m) and on 7275 (41.23m), from 1400 to 1520 on 6020 (49.83m), 11740 (25.55m), 17810 (16.84m) and on 21480 (13.96m); from 1830 to 1950 on 6020 and on 6085 (49.30m).

INDIA

All India Radio operates a General Overseas Service in English to the U.K., Africa and Europe from 1745 to 1945 on 7215 (41.58m), 9525 (31.49m), 11620 (25.81m), 11945 (25.11m) and on 15080 (19.89m); from 1945 to 2045 on 7215, 9515 (31.52m), 9525, 9912 (30.26m), 11620, 11960 (25.08m) and from 2045 to 2230 on 7215, 7260 (41.32m), 9525, 9912, 11620 and on 11740 (25.55m).

MALI

Radiodiffusion Nationale du Mali, Bomako, operates a Home Service from 0600 sign-on to 2400 sign-off. The part of the service that can best be heard here in the U.K. is from 1800 to 2400 (mostly in French) on 4783 (62.72m), 4835 (62.04m) and on 5995 (50.04m). Bomako also radiates during this period on 3380 (88.75m) but rarely heard here in the U.K.

ALGERIA

Algers has an External Service, in Arabic, to the Arab World from 1800 to 2100 on 7270 (41.26m), 9685 (30.97m) and on 11920 (25.16m); from 2100 to 2300 on 11835 (25.34m) and on 15420 (19.45m).

PHILIPPINES

Voice of the Philippines, Malolos, has a schedule in English from 0700 to 2200 on 9580 (31.31m), most of the programmes are for far Eastern consumption and none are directed to the U.K. or Europe.

NORTH VIETNAM

The Main Service now radiates in English (1st transmission) from 2230 to 2300 and from 0100 to 0130 on 10040 (29.88m) and 15105 (19.86m) and at 1000 to 1030, 1300 to 1330 and from 1530 to 1600 in the 2nd transmission on the same two channels. Also from 1800 to 1830 on 1030 (42.61m) and on 10040.

TUNISIA

The Tunisian Home Service, in Arabic, can be logged on 11900 (25.21m) and 11925 (25.15m) from sign-on at 1458 through till 1600, also on 6195 (48.42m) from 1600 to sign-off at 2330.

AROUND THE DIAL

AUSTRALIA

Radio Australia has been logged on 9580 (31.31m) at 2030 in English to New Zealand and the Pacific area after station identification, also on 15265 (19.65m) at 2123 in English to S.E. Asia with “Listeners Letters” programme.

POLAND

Warsaw may be heard in English, newscast and programme, at 2030 on 9540 (31.44m).
VATICAN
Vatican Radio may be heard with an English programme at 2045 on 7250 (41.37m).

ITALY
Rome offers a newcast of local events in English at 1930 on 9710 (30.89m).

ROMANIA
Bucharest may be logged with a programme in English at 1115 on 17820 (16.83m).

CANADA
Radio Canada can also be heard on the above channel with local news and events at 1515. Sackville can also be heard in English at 2115 on 11860 (25.29m).

SOUTH AFRICA
Johannesburg can be logged with local services on the LF bands, listen on 4875 (61.53m) around 2200 for the English Service or on 4965 (60.42m) at 2100 for the news in English after station identification.

NIGERIA
Benin City can often be logged in the late evenings, we heard it at 2245 on the regular 4932 (60.82m) channel when a typical programme of African music and songs was being radiated. Also Lagos on 4990 (60.12m) at 2211, similar programme.

GHANA
Signals from this country can be heard on 4980 (60.24m) also in the late evenings, we logged them at 2245 when the news in English was being radiated.

GAMBIA
Radio Gambia, Bathurst, is now one of the best African signals on the 60m band and logged here often. Recently heard at 1955 with a talk in English about Maritime Law, 5 short and 1 long pip at 2100 then relay of the BBC World Service newscast, listen on 4820 (62.24m).

TIME-CHECK
All the foregoing transmissions are listed here in time order for the convenience of readers who wish to plan their listening sessions.

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ANOTHER CLANDESTINE
During the course of collating and writing this article, the writer has several times logged "The Voice of the Thai People" on a measured 9422.5 (31.83m) from 1510 through to sign-off around 1600. As would be expected, the programme is mostly composed of exhortations in Thai, alternately by male and female announcers, with short interludes of military music. At 1530 a series of chimes can be heard prior to identification. Sign-off varies from 1559 to 1605 when slogan sign repeated several times followed by a short anthem or march-type tune.

60 METRE BAND DX
Probably the broadcast band most favoured by the dyed-in-the-wool Dxe-r is that lying between the limits 4750 and 5060. Within these two frequencies are many low powered local service stations scattered throughout the world, the reception of most of them being difficult in the extreme. To spend any time at all with any hope of success on this band, quite apart from the propagation conditions existing at the time, one must persevere adopt an owl-like existence – much of the DX being around between the time limits 2100 to 0430 or so. During the winter months, as a general rule, one can log the Far East from around 1500 through to 1630 but the band is best noted for the Latin American stations that abound, especially during the summer months. Some that we have recently logged are listed here.

BRAZIL
4755 ZYF23 Radio Difusora do Maranhaos, Sao Luis, with recorded dance music, European-style, announcements in Portuguese at 0108. This one signs-off at 0300 and is 5kW, quite often logged here in the U.K. (63.09m).

4805 ZYS8 Radio Difusora do Amazonas, Manaus, Latin American music, announcements in Portuguese at 0051. Closes at 0200, is 5kW, heard fairly regularly. (62.43m).

4886 ZYG26 Radio Pioneira de Teresina, with identification followed by talk in Portuguese at 2332. Listed 4885, this one has been heard as early as 2107 and can vary from 4885 to 4886.5 at times (we've measured it). Closes at 0300 1kW (61.39m). Teresina is the capital of Piaul state.

VENEZUELA
4810 YVMG Radio Popular, Maracaibo, featuring LA songs and music at 0210. Closes at 0300, can be heard when conditions are good for LA, 2kW (62.77m).

4830 YVOA Radio Tachira, San Cristobal, LA music after identification at 0247. Closes at 0400, can be heard when conditions are good, 1kW (62.11m).

4860 YVQE Radio Maracaibo, heard with talk in Spanish after station identification at 0215. Closes at 0400, logged quite often, 10kW (61.72m). Maracaibo is a seaport on the west bank of the narrow entrance to Lake Maracaibo (brackish, 60 miles wide, 120 miles long, oil wells on fringes and into lake bottom).

COSTA RICA
4832 T11HB Radio Capitol, San Jose, talk in Spanish after station identification (quite often made during programmes) at 0015. This one has a 24 hour schedule, 1kW (62.08m), quite often heard here in the U.K. San Jose is the capital of Costa Rica.

DOMINICAN REPUBLIC
5010 HIMI Radio Cristal, Santa Domingo, with LA songs and music after identification at 0200. HIMI has a 24 hour schedule and can be heard often at the time stated (and earlier), 1kW (59.88m).

Latin Americans are not, of course, the only stations that can be heard on the 60 metre band, how about –

CHINA
4800 Radio Peking with talk in Chinese by YL at 2150 (62.50).

4815 Radio Peking signing-off with Internationale at 2355 (62.30m).

4833.5 Shenyang with YL in Chinese at 2124 (62.06m).

4905 Radio Peking with OM in Chinese at 2139 (61.16m).

4975 Foochow with OM and YL alternately in Chinese (60.30m).

JUNE 1973
A receiver is based on the Ferranti ZN414 integrated circuit. Described by its manufacturer as a 'silicon network', this I.C. incorporates 10 transistors and is housed in a TO18 encapsulation. In addition to detection it provides all the r.f. amplification needed for an a.m. receiver, and it has a typical power gain of 70dB. With suitable operating conditions it requires only a tuned circuit at the input, as in Fig. 1, to give sufficient output for headphones or an a.f. amplifier. Since the ZN414 is of similar size to an ordinary transistor, and since it has only 3 lead-outs, it allows small receivers to be made up with very little wiring.

The network employs automatic gain control feedback. From the constructor's point of view the main advantages are that a receiver incorporating the ZN414 has no regeneration control, as occurs with most t.r.f. circuits, and has no aerial, oscillator and i.f. transformer circuits to align, as with superhets. For interest, a photograph showing the internal construction of the ZN414 accompanies this article.

**RECEIVER CIRCUIT**

The complete receiver circuit is shown in Fig. 1. L1 and L2 are the medium and long wave windings of the ferrite rod aerial, switch S1 short-circuiting L2 for medium wave reception. Tuning is carried out by VC1, which is a 300pF variable capacitor. Frequency coverage is approximately 2,000kHz to 600kHz with S1 closed and 550kHz to 180kHz with S1 open.

Operational information for the ZN414 indicates that selectivity can be comparable with superhet designs. It is possible, however, for very strong signals to swamp the front end of the circuit, whereupon it becomes necessary to reduce pick-up on the ferrite rod by suitably rotating the receiver.

The prototype receiver readily provided satisfactory reception of those transmissions which were normally best received in the locality. It was found that use of a Litz-wound ready-made ferrite rod aerial increased selectivity a little over the home-wound type incorporated, but it was felt that the latter was quite satisfactory in practice.

The audio output of the ZN414 is developed across R2. The operating voltage of this part of the receiver should be 1.1 to 1.8 volts, and the requisite voltage is provided by the potential divider given by R4 and R5.

VR1 is the volume control, and its slider couples to TR1, which drives TR2 and TR3 in a directly coupled transformerless output stage. This requires relatively few components and gives good audio results.

**Fig. 1. The circuit of the silicon network receiver. The number below each receiver leg indicates the terminal number.**

F. G. Rayer, Assl
Incorporating the Ferranti integrated circuit type ZN414, this medium and long wave receiver requires a relatively small quantity of additional components. There are no alignment problems.

The ZN414 silicon network provides the r.f. stages and detector for an a.m. radio. The complete circuit is provided on a chip area of less than 0.6 sq. mm., and the chip is encapsulated in a 3-lead transistor package (chip area enlarged 70 times).

Photo: Courtesy Ferranti Ltd.
The fixed resistor values should be as given in the Components List. Some of the other items can be different to those specified, to make use of components on hand or for other reasons. The use of alternative components will, in some cases, necessitate the provision of a larger case than that used by the author.

L1 and L2 could be the medium and long wave sections of a ready-made transistor receiver ferrite rod aerial, the unwanted coupling windings being removed. If space permits, VC1 could be an air-spaced component of around the same value, or a 208 + 176pF 2-gang capacitor with both sections in parallel. The 'Dilemin' capacitor quoted in the Components List for VC1 is available from Home Radio under Cat. No. VC40B.

Alternative values for VR1 are 10kΩ and 20kΩ log. The potentiometer employed by the author was a 5kΩ edge-operated miniature component which was capable of being secured by a bolt passed through the centre of its body. If the type obtained by the constructor is designed for mounting by its solder tags, two small tinplate or brass brackets should be devised to which two of the potentiometer tags may be soldered. The brackets are then secured to the side of the case. On-off switch S2 is incorporated with VR1.

Of the capacitors, both C6 and C8 may be 0.4 or 0.5µF. C4 can in practice have any value between 2 and 25µF, with a working voltage of 2 volts or higher. A value of 150µF or more is satisfactory for both C5 and C9, but C5 must not have a working voltage lower than 10 volts.

The speaker used by the author is the type TP26G from Electrovalue. This is nominally 75Ω (but may be marked ‘80Ω’) and is 2¾ in. in diameter. Any speaker impedance from 30 to 80Ω is satisfactory, but alternative types may not fit into the particular case and layout employed for the prototype.

The case used by the author was chosen from a range of bait and tackle transparent boxes available from sports shops and shops selling fishing tackle. Its size is 3½ by 4½ by 1½ in. and this is just sufficient to accommodate the components with no awkward crowding. The controls are located so that there are no projections on the front and long sides. Where a transparent case is not wanted, the box should be painted, on the inside, before fitting the parts. Any household or similar oil paint is suitable.

If preferred, a case could be made up from ⅛ in. Perspex sheet, or similar material. Somewhat similar trinket boxes are also available in some shops. A metal box cannot be used.

The ferrite aerial used in the prototype was wound on a rod approximately 2½ in. long with a diameter of ⅛ in. This can be broken from a longer rod by carefully filing at the requisite point and then breaking the rod.

The ZN414 integrated circuit is available from Henry's Radio.

Resistors

(All fixed values 1 watt 5%)

| R1 | 100kΩ |
| R2 | 1kΩ  |
| R3 | 2.2kΩ |
| R4 | 560Ω |
| R5 | 2.7kΩ |
| R6 | 270kΩ |
| R7 | 220kΩ |
| R8 | 680Ω |
| R9 | 47Ω  |
| R10| 2.2Ω |
| R11| 2.2Ω |
| VR1| 5kΩ potentiometer, log, miniature edge operated, with switch S2 |

Capacitors

(See text for alternative values)

| C1 | 0.01µF plastic foil |
| C2 | 0.1µF plastic foil |
| C3 | 0.1µF plastic foil |
| C4 | 10µF electrolytic, 2.5V, Wkg. |
| C5 | 200µF electrolytic, 10V, Wkg. |
| C6 | 0.047µF plastic foil |
| C7 | 0.01µF plastic foil |
| C8 | 0.047µF plastic foil |
| C9 | 320µF electrolytic, 6V, Wkg. |
| VC1| 300pF variable, 'Dilemin' (Jackson Bros.) |

Inductors

L1, L2 Ferrite aerial windings (see text)

Semiconductors

| IC1 | ZN414 (Ferranti) |
| TR1 | BC149 |
| TR2 | AC127 |
| TR3 | AC128 |

Switches

| S1 | Miniature slide switch |
| S2 | On-off switch, part of VR1 |

Speaker

75Ω or 80Ω speaker, 2½ in. round, Type TP26G, (Electrovalue)

Battery

9-volt battery type PP3 (Ever Ready)

Miscellaneous

| Knob |
| Plain Veroboard, 0.15 in. matrix, 3½ × 1 in. |
| 8 Veroboard pins |
| Ferrite rod 2½ × ⅛ in (see text) |
| Battery clips |
| Plastic case (see text) |

COMPONENTS
RECEIVER BOARD

The receiver components are wired on a piece of plain Veroboard (i.e., without copper strips) of 0.15 in. matrix. If this is cut to have 20 rows of holes one way and 6 rows the other, components can be located exactly as in Fig. 2. With the speaker and case used by the author, a rectangular cut-out is needed to clear the speaker. The position and dimensions of the cut-out, relative to the Veroboard holes, can be judged from Fig. 2. A 6BA clear mounting hole has to be drilled before any components are mounted on the board.

Begin by inserting Veroboard pins at positions 1 to 8, then fit the capacitors, noting the polarity of C4, C5 and C9. The component lead-outs pass through the board to make connections underneath, as illustrated in Fig. 2. Put insulated sleeving on any leads which may touch other leads or joints, and snip off excess wire.

After the resistors and capacitors are fitted, it is advisable to check the wiring around R4 and R5 to ensure that there is no risk of applying excessive voltage to the ZN414. Connect a high resistance voltmeter, or a test meter switched to a suitable voltage range, across R4, and apply a 9 volt battery to Veroboard pins 4 and 7 with positive to pin 7. The meter should indicate about 1.4 to 1.5 volts. If the voltage is higher, the connections to R4 and R5, together with their values, must be checked and the error rectified before proceeding further.

Next fit the ZN414 and the three transistors. Extension wires may be soldered to the lead-outs of TR1 and passed through the Veroboard holes. Make sure the four semiconductor components are all wired correctly and put sleeving on their leads if there is any risk of short-circuits. Solder in the usual way for semiconductors: it should only be necessary to hold the iron in contact with the joint for a few seconds. Lengthy heating may cause damage.

Fig. 2. Details of the circuit board. The component side appears in the upper section and the underside in the lower section of the diagram.
CASE PREPARATION

Transparent plastic boxes of the type used for the prototype seem quite strong, but they will crack whilst making holes if the drill is forced. There is no danger of this if the drill is sharp and is applied with fairly light pressure.

The speaker fits behind five rows of \( \frac{1}{4} \) in. or \( \frac{3}{8} \) in. holes in the bottom of the box, which now becomes the front panel of the receiver. Slots for the slide switch and for VR1 are made by drilling one or two small holes to allow the introduction of a file. The slots are then gently filed out until these parts fit correctly. VC1 requires a hole for its spindle and two holes for the small short bolts provided.

If of the type used by the author, VR1 is fixed to the front panel with a small bolt. Other types of potentiometer may be mounted in the manner just described. VC1 and S1 can also be fitted at this stage. If the speaker is of the type quoted in the Components List it will have a rim which can be smeared with adhesive (such as clear Bostik 1). The speaker can then be put in position and left until the adhesive sets.

FERRITE ROD

The ferrite rod aerial is wound as in Fig. 3. Begin L1 about \( \frac{1}{4} \) in. from one end of the rod at ‘A’ and wind 60 turns of 26 s.w.g. d.c.c. or d.s.c. wire in a pile which is about \( \frac{1}{4} \) in. long. Leave a space of about \( \frac{1}{4} \) in. and wind on 150 turns of 34 s.w.g. s.s.c. or enamelled wire for L2, in the same direction as L1 so that the two coils, when connected in series, are mutually aiding. L2 is wound in a pile similar to L1. The turns may be held in position by a touch of adhesive at the ends, or by adhesive tape. Solder the adjacent ends of L1 and L2 together, to provide point ‘B’. The finish of L2 is lead ‘C’.

A \( \frac{3}{8} \) in. 6BA bolt passes through a hole drilled in the front panel of the case, and through a strip of card passed round the rod. Extra nuts, or a spacing pillar, cause the rod to be held about \( \frac{1}{4} \) in. away from the rear surface of the front panel.

Connect lead ‘A’ to the fixed vanes tag, ‘F’, of VC1. Point ‘B’ connects to one tag of S1 and lead ‘C’ of the other tag. Lead ‘C’ then continues to the moving vanes tag, ‘M’, of VC1. Only two of the tags available on S1 are used; the remaining tag (or tags) is ignored.

BOARD FIXING

A 6BA bolt with a spacing pillar or extra nuts holds the circuit board in the position shown in Fig. 3, with the ZN414 adjacent to L2. The location of the hole required in the case side is marked off with the aid of the board itself. The spacing between the board and the inside of the case side need only be sufficient to provide clearance for the wiring under the board.

The following wiring steps are next carried out. Connect pin 1 of the board to the fixed vanes tag, ‘F’, of VC1. Connect pin 2 to the moving vanes tag, ‘M’, of VC1. Connect pin 3 to the slider of VR1. Connect pin 4 to the low-volume end of VR1 track, and continue the lead to one tag of S2. Connect pins 5 and 6 to the speaker. Connect pin 7 to the battery positive clip using thin red flexible wire. Connect pin 8 to the high-volume end of VR1 track. Using thin black flexible wire, connect the remaining tag of S2 to the negative battery clip.

USING THE RECEIVER

There is no means of adjusting frequency coverage except by moving L1 or L2 on the ferrite rod (assuming these are initially wound on paper sleeves) or by changing the number of turns in these windings. Normally, there should be no need for any adjustments whatsoever.

The audio output of the receiver should be at the level given by the usual type of small pocket portable radio, and quality should be good. A current-reading meter inserted in one of the battery leads should indicate a current consumption of about 10 to 12mA, this rising a little at maximum volume. In difficult situations, the effect of rotating the receiver to take advantage of the directional aerial should be tried.

Since a small receiver of this kind is excellent for personal listening, an earphone outlet may be added, if desired. A suitable circuit for a miniature 2.5 mm. or 3.5 mm. switched jack socket is given in Fig. 4, and this causes the speaker to be silenced when the jack plug is inserted. The jack socket is an optional extra, and is not included in the Components List. It may be positioned near VR1. It will be found that a complete headset of about 100Ω will give excellent results, and headsets of this type can sometimes be obtained at inexpensive surplus. A single earpiece may also be employed, or a headset of 30Ω to 500Ω. Earphones with an impedance of less than 30Ω should not be used.

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The text continues with diagrams and further instructions.
In this concluding article our contributor discusses possible additions to robots such as Cyclops.

SECOND ORDER REFLEX

Having several conditioned reflex units active simultaneously means that it is feasible to establish second order reflexes, or even third order reflexes, as outlined in Part 5 of the 'Cyclops' series (published in the November 1972 issue).

If, as we shall see later, we introduce a sound sense, we could condition Cyclops such that sound means magnet, so stop. If we then establish the existing conditioned reflex, that magnet means food, so 'home' into magnets, then, if we make a sound, we will find that Cyclops will cease scanning as if to home into the sound. This is exemplified by Fig. 1 which shows this second order reflex in diagrammatic form.

MORE SENSES

Cyclops at present has five senses, namely light, touch, presence of magnets, presence of loads, and a sense which detects when he is moving. In order to make him a more versatile animal, more senses are necessary.

In human beings, there are also five recognised senses: those of sight, hearing, smell, taste and touch, the latter incorporating a temperature sense as well as a general touch sensing mechanism. Out of these, it would be quite an improvement if hearing were added to Cyclops' sensory repertoire.

The previous articles on Cyclops* dealt with constructing a robot using a design which has been proven to work. In this article suggestions are made for possible improvements, although exact details are not given. These suggestions, it is hoped, will provide food for thought and may fire the imagination of some constructors to go even further than the ideas outlined here.

FURTHER STIMULI

Cyclops, in his present condition, can learn only one thing at a time. If, when he is programmed to learn to carry weights, a set of meaningful stimuli are presented to him which are not directly concerned with load-carrying, he will ignore them. This is obviously a disadvantage, and the way to solve this problem is to construct several circuits to the design of the present Board 2, excluding the circuitry around TR15 and TR16 except where needed, and wiring the inputs of these separate conditioned reflex units directly to the input stimuli presented to the switching unit, then removing the switch altogether. This means that the set of meaningful stimuli, say for conditioning to touch, is permanently connected to a conditioned reflex unit, and thus Cyclops

AUDITORY SENSING

Auditory sensing is more difficult to synthesize than is realised. The human ear can detect amplitude, phase, and thus direction; pitch (to a very high degree of accuracy); and can analyse several incoming audio signals and, in conjunction with the brain, separate out the one which is significant.

It would obviously be impossible to simulate anything approaching this complexity without the generous use of digital computers, and so a suggested auditory sense for Cyclops would be such that he could detect the presence of two different tones.

Two alternative methods of doing this will next be described. The first uses filters, whereas the second uses a digital counting technique. The advantage of the former method is that the circuitry can work correctly even when both tones are broadcast simultaneously, but it requires several amplifiers. The second method uses a more digital technique, and can be expanded very easily, but will not give an output if more than one tone is broadcast.

Reference to Fig. 2 shows that the heart of the first method lies in the use of a parallel-T rejection filter incorporated in the feedback loop of an amplifier. Little negative feedback from amplifier output to input is provided at the frequency at which the filter offers greatest attenuation, and the amplifier offers a high gain at this frequency. On the other hand the feedback level is high at frequencies that are some way removed from the filter frequency and the amplifier gain is low at these frequencies. This means that the amplifier-filter combination output is high at the maximum attenuation frequency of the filter and is low at others. The output can thus be rectified and smoothed, then fed to a Schmitt trigger, whereupon the output of the latter will be high at the filter frequency and low at other frequencies.

The second system amplifies the input signal, squares it with a high-speed Schmitt trigger, and feeds the pulses from this to a high speed monostable, whose quasi-stable period is shorter than the period required for one cycle of the highest frequency signal to be detected. The output of the monostable passes via a diode to a capacitor which integrates the incoming pulses to give a mean direct voltage output. The voltage on the capacitor is dependent on the frequency of the input, because the greater the input frequency, the greater the number of monostable pulses.

The output from this capacitor is amplified by a buffer and fed to several voltage detectors, which detect when a voltage is within a certain range. This is accomplished by having two Schmitt triggers at each detector. One trigger is set to the level of the voltage at the bottom end of the desired range, and the other is set to the voltage at the upper end of the range. The output of the latter Schmitt trigger is inverted, so that in the range required, a logic 1 exists on the lower threshold Schmitt, and a logic 1 also exists after the inverter connected to the higher threshold Schmitt. It merely remains to take these two outputs to an And-gate, whose output will then be at logic 1 when the voltage presented to the Schmitts is in the desired range. Any number of voltage detectors can be placed after the buffer amplifier, each detecting a certain voltage range, and thus, a certain frequency range. This method is displayed pictorially in Fig. 3.

LOCATION OF AUDIO SOURCES

The audio frequency detectors just described detect only the presence of an audio signal and not its location. The human ear and brain uses a combination of factors for determining the position of sounds. These factors are phase and amplitude, and the brain, taking into account a complicated analysis of all the reflections, resonances and distortions of the original sound, comes up with what is usually a highly accurate answer as to the position of the original sound.

Our technique for recording stereo sound is to use a pair of microphones with suitable polar responses, placed one above the other at right angles to each other. This approach, known as the Blumlein technique, is illustrated in RADIO & ELECTRONICS CONSTRUCTOR.
Fig. 4, and could be adapted for use in a robot similar to Cyclops.

If a pair of these microphones are mounted on the scanning head, the outputs being fed to a differential amplifier, these outputs will be identical when the sound source is on the axis of symmetry of the microphones, causing the output from the differential amplifier to be zero. The sound source will thus be either directly in front of the microphones, or directly behind. To eliminate the latter possibility, some sound-absorbing material, such as a wad of glass fibre, could be placed directly behind the microphone combination, to ensure that there would be no ambiguity as to the direction of the sound once the differential amplifier output was zero.

(a) Sound absorbent material to limit response of microphones to sounds at rear
(b) Sound source object on axis of symmetry
(c) Microphone

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If the output from this system were inverted, such that when a sound was heard on the axis of symmetry a logic 1 would be present on the inverter output, the resulting system would be exactly analogous to the light detecting system already incorporated in Cyclops. By connecting this system into the basic reflex circuitry, a robot similar to Cyclops could be made to home into sound sources as well as into light sources.

**DIFFERENTIAL LIGHT INPUT**

At present Cyclops monitors only the absolute light level and thus, if put in a room which is uniformly brightly lit, he would sit in the centre of the floor doing absolutely nothing. Admittedly he would be theoretically recharging his batteries all the time, but it would not be a very interesting life! What would be more useful would be a device by means of which he detects the difference in ambient light level and the light level of the area he is looking at. This could easily be accomplished by having the existing photocell connected to one input of a differential amplifier, and a second photocell, covered with frosted glass and placed anywhere else in Cyclops' anatomy, connected to the other input of the differential amplifier. See Fig. 5. The output of the differential amplifier passes to the input of the basic reflex circuitry.

Now, Cyclops will only home into light sources brighter than his habitat's ambient lighting, and will not have any interest in anything else.

In Fig. 5 the preset variable resistors should be set up such that V_b increases only when the light input on the eye photocell is greater than the light on the ambient light sensor. Also, R_x should have a value such that V_a plus V_b is approximately equal to the supply voltage for all values of V_a. R_x was made 100kΩ in an experimental circuit, and it was found that V_a plus V_b was then always within 0.2V of the supply voltage.

**ADVANCED RECOGNITION**

At present, Cyclops' self-recognition circuit requires either a fairly powerful bulb, drawing consequently quite a heavy current from the battery, or a dimmer bulb and the necessity to hold a mirror very close to the eye to enable Cyclops to 'see' himself. One way to get round this problem is to use light modulation. If the recognition lamp is pulsed with light at around 10Hz, then it can be fairly powerful, yet the mean level of power drawn from the battery can be relatively small if the mark-space ratio is fairly low. Fig. 6 shows details of a theoretical system. Furthermore, the output from TR2 (on Cyclops Board 1) can be amplified by another circuit to quite a great extent, and compared with the signal from the lamp modulation circuit. If the two agree then it means that Cyclops can see his recognition lamp and suitable action can be taken. The reason for having a large amount of amplification after TR2 is that this enables even a weak light signal to operate the comparator circuit, the latter giving an output when the two inputs match. Thus, Cyclops will be able to see his reflection quite a long distance away without causing excessive drain on his batteries through using too powerful a recognition lamp.
FINDING BIAS RESISTANCE VALUES
by
J. R. Davies

By making several simplifications, it becomes an easy matter to select bias resistors for small signal silicon transistor circuits.

Two popular methods of employing small signal silicon transistors consist of operating them in the emitter follower mode with a single bias resistor coupling to the upper supply rail, and in the common emitter mode with a single bias resistor returned to the collector. The values selected for the bias resistor in both these methods of operation is often the result of a 'guesstimate' so far as the amateur experimenter is concerned, and the bias resistor value employed may not in many cases be that which offers optimum results. It is, however, possible to find the value of bias resistor required for most applications of these basic circuits in quite a simple and reliable manner. A further advantage of the method to be described is that the bias resistor selected caters for very wide spreads in hfe.

Calculation Approach

Fig. 1 shows the first of the two circuits. The transistor in this diagram is operated in the emitter follower configuration, with R2 as the emitter load and R1 as the bias resistor. What is the value required in R1?

We start by making three assumptions. We assume first that the voltage drop in the base-emitter junction of the transistor is zero. Second, we assume that the current gain of the transistor, which is the number of times that the emitter current is greater than the base current, is equal to its hfe value. And third, we assume that we are going to operate the circuit such that, with a transistor having an hfe which is 'central' within its spread, the standing voltage at the emitter is equal to or close to half the supply voltage.

The first of our assumptions causes us to dismiss the fact that, in practice, there is a drop of about 0.6 volt across the base and emitter of a conducting silicon transistor. As we shall see shortly, it is safe to ignore this voltage drop provided that the supply voltage is reasonably high. Our second assumption, that the current gain is equal to hfe, introduces a slight inaccuracy because the current gain of an emitter follower is equal to hfe + 1.

The '+1' term arises from the fact that the base current flows in the emitter load resistor in addition to the collector-to-emitter current. But the average silicon transistor has a spread in hfe in which the maximum figure is considerably greater than three times the lowest value. When dealing with figures which range as widely as these, the inaccuracy introduced by ignoring the '+1' term is minimal. The third assumption, that the standing emitter voltage for a transistor with a 'central' hfe value is equal to or close to half the supply voltage, represents a good approach in simple amplifier design. When the emitter is at half the supply potential it is capable of maximum voltage swing in both directions.

In Fig. 1, therefore, we have, after taking up our first and third assumptions, the situation where both the lower end of R1 and the upper end of R2 are at a potential which is half the supply potential. In consequence, an equal voltage is dropped across each
resistor. Now, since the current gain in our transistor (from assumption number 2) is equal to $h_{FE}$, then the current in $R_2$ is equal to that in $R_1$ multiplied by $h_{FE}$. It follows that, for equal voltages across each resistor, the value of $R_2$ must be that of $R_1$ divided by $h_{FE}$. Or, put another way, that $R_1$ is $R_2$ multiplied by $h_{FE}$.

In actual fact, this set of circumstances will not cause the emitter of the transistor to be exactly at half supply voltage because we have purposely ignored the fact that in a practical silicon transistor there is a drop of 0.6 volt across the base-emitter junction. So the practical result of making $R_1$ equal to $R_2$ multiplied by $h_{FE}$ will be that the emitter is 0.3 volt below the half supply voltage level and that the base is 0.3 volt above the half supply voltage level. These discrepancies should not be of great significance provided that the supply voltage is of the order of 3 volts or more.

Maintaining the assumption that there is zero voltage drop across the base-emitter junction of the transistor, the circuit of Fig. 1 can be redrawn in the manner shown in Fig. 2, where we have introduced a new resistor, $R_x$, to represent the resistance 'seen' by the lower end of $R_1$ as it 'looks' into the base of TR2. $R_x$ is equal to $R_2$ multiplied by $h_{FE}$. We can now go a stage further. The voltage across $R_x$ (which is the emitter voltage of the transistor) is equal to

$$\frac{R_x}{R_1 + R_x}$$

of the supply voltage.

**PRACTICAL EXAMPLES**

We now proceed to a practical example. Let us say we have a silicon transistor which is specified by the manufacturer as having a minimum $h_{FE}$ of 100 and a maximum $h_{FE}$ of 400. Our supply voltage is 10 volts and we want the standing emitter current to be about 2mA.

Since the emitter will be at half the supply voltage, this sets up the emitter resistance value straightforward. A current of 2mA at 5 volts will flow in a resistance of 2.5kΩ. In practice we will use a near preferred value, which can be either 2.4kΩ or 2.7kΩ. Let us arbitrarily choose 2.7kΩ, which value is shown in Fig. 3(a). We next select a 'central' $h_{FE}$ figure within the spread of the transistor which will also enable the circuit to function adequately with transistors having the minimum and maximum $h_{FE}$ values. The 'central' figure we will choose is not the value which lies half-way between the lower and upper $h_{FE}$ figures, but is one which is about a third of the way up from the lower figure. (The reason for this choice will become clear soon.) The $h_{FE}$ value which is a third of the way up from the lower $h_{FE}$ figure of 100 is 200, whereupon we next say that $R_1$ should be 2.7kΩ multiplied by this figure. 2.7kΩ multiplied by 200 works out at 540kΩ, and we could in practice use a 560kΩ component. Thus, with the emitter load $R_2$ at 2.7kΩ and the bias resistor $R_1$ at 560kΩ we have achieved conditions where the emitter current is close to 2mA and where, with a 200 $h_{FE}$ transistor, the emitter voltage is close to half the supply voltage.

![Fig. 2. The effective resistance between R1 of Fig. 1 and the lower supply rail may be presented as a physical resistor, Rx](image)

![Fig. 3. The emitter voltages resulting from the use of transistors having different hFE values. In (a) the hFE figure is 'central', whilst in (b) and (c) the hFE figures are at the bottom and top of the spread](image)
Let us now see what happens with transistors which have the bottom and top hfe values in the spread. To find what occurs here we return to Fig. 2 and find the voltage across Rx for the two outside spread figures. For an hfe of 100, the effective value of Rx is 100 times 2.7kΩ, or 270kΩ, and the voltage across it (working in terms of kilohms) is therefore

\[
\frac{560 + 270}{560 + 1.080}
\]

of the supply voltage of 10 volts. This is 3.3 volts, as indicated in Fig. 3(b). With an hfe at the upper limit of 400, as in Fig. 3(c), Rx has an effective value of 2.7kΩ multiplied by 400, which is 1.080kΩ. The fraction of the supply voltage across Rx now becomes

\[
1.080 = \frac{560 + 1.080}{560 + 1.080}
\]

The result is 6.6 volts, as illustrated in Fig. 3(c). So, when the transistor has an hfe of 100 the emitter voltage is about 3.3 volts, and when it has an hfe of 400 the emitter voltage is about 6.6 volts. Both these voltages are nicely symmetrical about the half supply voltage figure and the results show that the transistor emitter is left with nearly the maximum voltage swing it can be offered even when its hfe is at its lowest or at its highest rated value.

These results also explain the apparent anomaly of choosing, as a 'central' hfe figure for the initial calculation, a value which is not exactly centred between the two outside hfe figures but one which is about a third of the way up from the lower one. The variation of emitter voltage with hfe is not linear, and the process of choosing a 'central' figure which is about a third of the way up satisfies the distribution in the final results without incurring complicated mathematics.

To sum up the procedure involved in determining the desired base bias resistance for the circuit of Fig. 1, we first of all choose an emitter resistor which will cause the desired emitter current to flow when the emitter is at half the supply voltage. We next check on the spread of hfe figures quoted by the transistor manufacturer, select as a 'central' figure one which is about a third of the way up from the lower hfe limit and then fit a base bias resistor which is equal to the emitter resistor multiplied by this 'central' value. Naturally, in a practical world we choose a near preferred value and work, in most instances, with 10% resistors. There is no necessity to calculate the emitter voltages for the lower and upper hfe figures; this procedure was carried out here for purposes of demonstration only.

**COMMON EMITTER CIRCUIT**

We next turn our attention to the common emitter circuit shown in Fig. 4. In this case, R2 is the collector load resistor whilst R1 is the bias resistor. Once more we make three assumptions. The first of these is that there is zero voltage drop across the base-emitter junction of the transistor. The second is that the current flowing in R2 is equal to the current flowing in R1 multiplied by the hfe of the transistor. Actually, the current in R2 is equal to that flowing in R1 multiplied by hfe + 1 since the current for R1 also flows in R2. But we can, as before, ignore the + 1 term. And finally, we assume that the desired output condition is given when the collector of a transistor having a 'central' hfe value is at a potential equal to half the supply voltage.

The circuit of Fig 4 can be resolved to that of Fig. 5 in which Ry represents the effective resistance above R1. Ry is equal to R2 multiplied by hfe.

The resistor arrangement in Fig. 5 is that of Fig. 2 turned upside down, since the resistance equal to R2 multiplied by hfe is now at the top and R1 is at the bottom. The voltage across R1, and hence the collector voltage for the transistor is equal to

\[
\frac{Ry + R1}{R1}
\]

of the supply voltage. Despite the change in the fraction the 'central' hfe figure we select from the spread is still one third up from the bottom figure in the range.

To take an example let us next say that the transistor we are to use has an hfe spread of 250 to 900 and that we want collector current to be about 3mA. The supply voltage is 10 volts, as before, and the resistance required for a flow of 3mA at 5 volts is 1.7kΩ. In practice, we can use the near preferred value of 1.8kΩ. The 'central' hfe figure one third up between 250 and 900 turns out to be 467. There is no point in working to as exact a value as this and it will be in order to choose 450 as the 'central' value. This results in R1 requiring a value of 1.8kΩ multiplied by 450, or 810kΩ. We can choose a preferred value of 820kΩ.

Thus, with R2 at 1.8kΩ and R1 at 820kΩ, a transistor with an hfe of 450 has its collector close to half supply

---

**Fig. 4.** The common emitter amplifier. Again, input and output capacitors are omitted

**Fig. 5.** Here, Ry represents the effective resistance between the upper end of R1 and the top supply rail
Voltage. These circumstances are shown in Fig. 6(a). Actually, the collector voltage will be 0.3 volt higher than its calculated value because we have chosen to dismiss the 0.6 volt drop in the base-emitter junction of the transistor. Again, for supply voltages of 3 volts or more, we can ignore this discrepancy.

We can now, to see that we are obtaining the best results from our transistor, check the collector voltages which occur at the two extremes of hFE. At the bottom hFE figure of 250 the effective value of Ry (1.8kΩ multiplied by 250) is 450kΩ, so our fraction becomes

\[
\frac{1.8}{820} = 0.35
\]

820

450 + 820.

The consequent collector voltage then works out at 6.5 volts. See Fig. 6(b). (We can expect the collector voltage to rise with reduced hFE because the collector then draws less current through R2.)

With hFE at the top limit of 900, the value of Ry (1.8kΩ multiplied by 900) changes to 1,620kΩ and the collector voltage becomes

\[
\frac{1.8}{820} = 0.35
\]

820

1,620 + 820

of the supply potential. As indicated in Fig. 6(c), this calculates out at 3.4 volts. As can be seen, our design approach has resulted in an almost exactly symmetrical voltage change on either side of the half supply figure, despite a very wide spread in hFE of 250 to 900.

Summing up the situation with the common emitter circuit, we approach the selection of the bias resistor in the following manner. We first choose a collector load resistor which will pass the desired collector current at half the supply voltage. We then check the hFE spread figure for the transistor and select a ‘central’ hFE value which is about one third of the way up from the low end of the range. The value of the base bias resistor is then the nearest preferred value to the collector load resistance multiplied by the ‘central’ hFE figure. In this article we have also checked the collector voltage for hFE figures at the extreme ends of the spread range, but this was done only for the purposes of demonstration. There would be no need for these extra calculations in normal work.

The concepts illustrated by Figs. 2 and 5 may be employed if it is desired that the transistor emitter in Fig. 1 or the transistor collector in Fig. 4 be at a voltage other than half supply voltage. Rx or Ry is given a value which will cause the required voltage to appear at its junction with R1, and the calculations are then carried back to R1. In Fig. 2

\[
V_e = \frac{R_x}{R_1 + R_x} \cdot V_{cc}
\]

and in Fig. 5

\[
V_c = \frac{R_1}{R_y + R_1} \cdot V_{cc}
\]

None of the calculations in this article takes account of base leakage current, which can upset operation if R1 has a very high value. It is necessary to avoid high values in R1 in any case, since these will in practice cause variances in performance between different transistors of the same type number when the latter have low but nevertheless varying base leakage currents.

**BACK NUMBERS**

For the benefit of new readers we would draw attention to our back number service. We retain past issues for a period of two years and we can, occasionally, supply copies more than two years old. The cost is the cover price stated on the issue, plus 6p postage.

Before undertaking any constructional project described in a back issue, it must be borne in mind that components readily available at the time of publication may no longer be so.

We regret that we are unable to supply photo copies of articles where an issue is not available. Libraries and members of local radio clubs can often be very helpful where an issue is not available for sale.
OSCAR — PROGRESS REPORT

by

Arthur C. Gee, G2UK

SINCE BEING LAUNCHED LAST October, OSCAR 6 has made more than 2,000 orbits! A steady stream of amateur radio contacts in many countries have been made through it, the up-link being in the 70cm. band and the down-link being around 29.5MHz. In addition, a telemetry signal has been radiated from the Satellite in the 70cm. band, and also in the 10 metre band. A lot of experience has thus been acquired about the use of an amateur radio satellite for communication purposes, and a not insignificant amount of useful scientific data has been obtained.

Inevitably, various snags have come to light with the present OSCAR, which are being taken care of in the designs now going forward for the next OSCAR. The latest issue of the AMSAT Newsletter, which is issued quarterly by the Radio Amateur Satellite Corporation, gives a most interesting account of some of these designs. In January, for instance, the 70cm. beacon power dropped unexpectedly, to such an extent that only those receiving stations with the very best of 70cm. receiving equipment were able to hear it - it is thought this may be due to a transistor failure. The internal temperature, and particularly that of the batteries, has become much higher than planned; it has gone up to 47°C (117°F), whereas the designed temperature was 15-20°C (60-70°F) - this may lead to a shortened battery life. Internally generated, random switching of some of the experimental control logic circuits has been taking place. This has been overcome by the primary control station in Canada automatically sending a programmed list of commands to the satellite every 2½ minutes during each pass, the instructions being on punched teletype tape. One of the solar panels appears not to be functioning properly. Due to the small dimensions of OSCAR 6, there was less space for solar panels than the designers would have liked, so that the nickel cadmium batteries are not getting all the recharging they should. As a result, use of the satellite's communication facilities has had to be restricted to 6000 hrs. GMT Thursday to 2400 hrs. GMT Mondays.

Much was heard at the beginning of OSCAR 6's flight about those stations which were using excessive power to communicate through it. Using an effective radiated power in excess of 100 watts depresses the gain of the translator and reduces the strength of other signals in the passband. Another problem encountered by many stations was that their 10 metre receiving capability was much poorer than they thought - this was certainly the case with the writer of this note! As Bill Tynan, W3KVM, points out in an article entitled "Operations", in the AMSAT Newsletter, "This may be one reason why some users run too much power. They keep turning the wick up, until they hear a good signal on the downlink." This issue of AMSAT NEWSLETTER, contains a useful descriptive article of a "Preamplifier for 29.5MHz", which will help greatly in this direction.

On the 30th January 1973, the AMSAT Board of Directors, agreed on the plans for the next OSCAR. In the planning stage this will be known as AMSAT-OSCAR-B (A-O-B) and it will be given an OSCAR number designated once successfully in orbit.

It will have three translators, viz a 432-146MHz unit; a 5 watt 146-29.45MHz unit and a 1 watt 146-29.45 MHz unit. There will be a beacon on 435.1MHz; a Codesiore Unit and a Morse Code and RTTY telemetry unit. A second satellite will be constructed at the same time by the WIA Project Australis Group, which will contain the Australis 2 metre to 70cm. FM repeater and telemetry units.

Membership of AMSAT is open to individuals; this will enable them to receive the AMSAT Newsletter, quarterly, in which all the most up to date information on this latest aspect of amateur radio is to be found. For particulars of membership send to AMSAT, P.O. Box 27, Washington, D.C. 20044.
This is the first of two articles describing astable multivibrators, and in it the author discusses the cross-coupled and emitter coupled configurations. Next month's article will deal with frequency and duty cycle control, and with multivibrators incorporating the SN74121 integrated circuit.

The astable multivibrator circuit is a square or rectangular waveform generator which may be free running, triggered, or synchronised to an input waveform. It is used to generate clock pulses which can be logic compatible. It is simple and inexpensive and may be used where frequency stability is not a critical requirement. A mark to space ratio of about 10 to 1 can be obtained without using complex circuits.

BASIC OPERATION

The basic operation for a cross-coupled transistor astable multivibrator is illustrated in Fig. 1. It may be considered as two transistor switches connected together with capacitors. When the supply is switched on, both transistors will tend to conduct because base current can flow through the base resistors. However one transistor (perhaps TR1) will turn on faster than the other, depending on the gains and switching speeds, so a negative pulse will be passed through C2 to the base of TR2, to turn it off. Transistor TR1 will then turn hard on and saturate, while the other transistor, TR2, is held off by a negative potential on its base. C2 will now, however, charge up exponentially through R2 towards Vcc. When the potential on the base of TR2 becomes slightly positive this transistor will conduct, whereupon regenerative feedback occurs and the circuit changes state once more.

Two outputs, Q and not-Q (the term 'not' being indicated by the horizontal bar over the letter), are available at the collectors.
The off period \((t)\) for each transistor depends on the base time constants.

With TR1:
\[ t_1 = 0.69 \times C_1R_1, \]

while, with TR2:
\[ t_2 = 0.69 \times C_2R_2. \]

The total time of one cycle \((T)\) is given by
\[ T = t_1 + t_2, \]
and frequency \((f)\) is given by:
\[ f = \frac{1}{T}. \]

The first two equations assume that the associated transistor comes on when its base has risen to zero potential. In practice a silicon transistor turns on when its base reaches about 0.6 volt, whereupon the off period is slightly longer than that given by the formula. This effect is more significant when a low supply voltage is used.

**EMITTER-BASE REVERSE BREAKDOWN**

In Fig. 1 the emitter-base junction of each transistor is reverse biased by an amount approximately equal to the supply voltage. With some transistors this voltage may exceed the base-emitter reverse breakdown figure. Such breakdown would not be harmful if the current were limited, but it would result in an unpredictable frequency of oscillation. Some germanium transistors, the 2N1308 for example, have a 25 volt reverse base-emitter rating and can be used with supplies of up to 12 volts or more. The silicon 2N706A has a rating of 5 volts only, but it can be used with a 5 volt supply rail where a logic compatible circuit is required.

**TYPICAL CIRCUITS**

Two typical circuits are given in Figs. 3 and 4, using germanium and silicon transistors respectively. Both circuits are designed for medium gain transistors and will work with almost any transistors provided their reverse base-emitter voltage ratings are equal to or greater than the supply rail voltage. In each case a one-to-one mark-space ratio has been chosen; this may be varied if required by altering the capacitor values. If the base resistor values are altered care should be taken to make sure that the values are low enough for the transistors to switch on properly.
EMITTER COUPLED MULTIVIBRATOR

Another type of multivibrator is the emitter coupled version. When a multivibrator of this type is used as a clock pulse generator it has several advantages over the cross-coupled multivibrator illustrated in Figs. 1, 3 and 4. These include the possibility of faster operation with given transistors, a single timing capacitor, less dependence on power supply variations, and a completely free collector output. A frequency variation of 1% for a supply voltage change of ±50%, is typical. Unfortunately the a.c. and d.c. operating conditions are not easily calculated, and so this article will simply give a typical circuit together with a practical example of component values.

The basic circuit of the emitter coupled multivibrator is given in Fig. 5 (a) and the appropriate waveforms appear in Fig. 5 (b). If we assume that TR1 is conducting and TR2 is off, then the emitter current of TR1 is split into two parts. One current, I1, flows through R3, while a charging current, I2, reduces the voltage on the emitter of TR2. Eventually the base-emitter threshold voltage of TR2 is exceeded and TR2 conducts so that some of the current flowing in R4 is diverted through TR2.

The emitter current of TR1 falls, and the collector voltage of TR1 and the base voltage of TR2 rise, and TR2 conducts more heavily. There is, in consequence, a regenerative condition which forces the circuit to the state where TR1 is off with TR2 on.

A similar sequence later brings the circuit back to its original state.

The circuit shown in Fig. 5 (a) has separate supplies for the collectors and emitters. If the ratio between the collector and emitter voltages can be kept constant, very good frequency stability can be obtained. This can be achieved by using only one supply and deriving the base reference from a potential divider.

A practical circuit is shown in Fig. 6. Because of its complexity, no formula is given for frequency and this is best found by experiment. As a starting point it will be found that, with the resistor values shown, a value in C of 0.04µF will give a total period of 28µS (corresponding to a frequency of about 35kHz). Increasing C will increase the period, and vice versa. The mark-space ratio ('mark' corresponding to TR2 on) with the 0.04 µF capacitor is approximately 12:16. Incidentally an electrolytic capacitor may be used for C if low frequencies are required because the polarity of the voltage across this capacitor does not reverse. The polarity is shown in Fig. 6.

The circuit of Fig. 6 can be used up to 1MHz without difficulty, and to 10MHz if higher frequency transistors are employed.

(To be concluded)

RADIO & ELECTRONICS CONSTRUCTOR
This month Smithy the Serviceman digresses from his usual pursuits and demonstrates to his assistant Dick an intriguing and unique item of test equipment. This device is capable of identifying the three lead-outs of almost any bipolar transistor that is connected to it.

**TRANSISTOR IDENTIFIER**

"Hallo," remarked Dick. "What's all this, then?"

Smithy aroused himself from his preoccupation with the equipment and turned to face his assistant. He then looked at the Workshop clock.

"Dear me," he said mildly, "I thought you were taking the day off."

"Oh, come on, Smithy," retorted Dick. "I'm only two minutes late this morning. What's that you've got on your bench?"

"Ah, this," said Smithy, forgetting Dick's perennial lateness in arriving to work. "Well now, this is my latest invention.

He gestured at the unit affectionately.

"It's a device," he pronounced proudly, "for identifying transistor lead-outs. It will also tell you whether a transistor is p.n.p. or n.p.n. I've been making it up as a sort of home-work over the last few evenings."

"Blimey," remarked Dick, impressed. "It certainly sounds useful. Sorting out transistor lead-outs these days is no end of a bind, particularly when there are so many types around which don't seem to be listed in the data books."

"That's very true," agreed Smithy. "Incidentally, before I start telling you about this instrument I'd like to mention that there's a fairly simple dodge for finding the lead-outs of an unfamiliar transistor which merely involves the use of a testmeter. As you know, a transistor can be looked upon as consisting of two diodes connected back-to-back. With a p.n.p. transistor the two diodes have their cathodes in the centre and with an n.p.n. transistor the two diodes have their anodes in the centre.

(Figs. 1(a) and (b).)

It looked as though Smithy was firmly embarked on one of his technical dissertations. Unobtrusively, Dick pulled a stool towards him and settled himself comfortably.

"I suppose," he remarked, "that the testmeter used for this dodge is switched to an ohms range."

"That's right," confirmed Smithy. "Now, almost all standard testmeters have an internal circuit which, when the meter is switched to red resistance, causes the positive test lead to carry a positive voltage. These voltages are provided by the internal battery of the testmeter. In case of doubt, the polarity for any particular testmeter switched to ohms can always be checked for certain by connecting its lead-outs to another testmeter switched to read volts."

"Yes," commented Dick. "I've bumped into this reversal of test lead polarity on the ohms range of testmeters before now. It can be quite muddling if you don't take it into account."

![Fig. 1(a)](attachment:image.png)

**Fig. 1(a). A p.n.p. transistor can be represented as two diodes connected back-to-back with cathodes in the centre**

![Fig. 1(b)](attachment:image.png)

**Fig. 1(b). An n.p.n. transistor may be represented as two diodes of opposite polarity**
account when checking things like diodes.”

“True enough,” concurred Smithy. “Well, if you want to identify the lead-outs of any transistor you switch the testmeter to a fairly high ohms range and apply its test prods to the transistor lead-outs successively until you find a lead-out which shows low resistance to both of the other two lead-outs. That lead-out is that of the base of the transistor. If you get this effect with the positive testmeter lead connected to the base then the transistor is a p.n.p. type. And if you get it with the negative testmeter lead connected to the base then you've got a n.p.n. transistor.”

“That's all right so far,” remarked Dick critically. “But, after you've carried out the rather fiddling business of applying the testmeter to the transistor lead-outs, you've still not been able to do anything more than identify the base. You still don't know which of the other two lead-outs is the emitter and which is the collector.”

“That's where the main part of this dodge comes in,” chuckled Smithy. “After you've found the base lead-out you make the assumption that one of the remaining lead-outs is the emitter and that the other is the collector, and you then connect the test prods to these two lead-outs with the voltage polarities they would receive if the transistor was acting as a common emitter amplifier. The testmeter will indicate a very high resistance and it may happen that its needle won't even be deflected. You next wet two finger tips on your tongue and apply them to the lead-outs of the base and what you assume is the collector. If the resistance indicated by the meter drops very markedly, then the lead-out you have assumed to be the collector is the collector. The fall in resistance indicated is due to increased collector current as a result of the testmeter lead being connected to the collector. But it is possible for some fall in resistance reading to take place when the transistor is wrong way round, because the meter could then read the resistance between your finger tips in series with the collector-base junction. So you reverse the testmeter connections and repeat the operation assuming that the alternative lead-out is the collector. The lead-out with which you get the greater drop in resistance indication is the collector.”

(=Fig. 2=)

“Apply finger tips here.

CIRCUIT MODES

“And I suppose,” remarked Dick, carefully steering the conversation in the desired direction, “that's where you're coming into the picture.”

Smithy drew himself up.

“It's where,” he returned reprovingly, “this instrument of mine comes into the picture, since it is intended to simplify the identification of transistor lead-outs. I must point out before going any further, though, that this instrument is a wee bit in the experimental class and that it might not work satisfactorily with a few transistors. However, it hasn't failed on any of the transistors I've tried out on myself since I knocked it up, and these include germanium and silicon types both in low and in high power categories.”

“How do you use it?”

“You connect the transistor to the three terminals on the front panel, then turn the rotary switch until you obtain a certain pattern of illumination in the four bulbs. The switch position then tells you which transistor lead-outs are emitter, base and collector, and the lights tell you whether the transistor is a p.n.p. or an n.p.n. type.”

“How many positions does the rotary switch have? Three?”

“No, six.”

“Six? How do you have six positions when there are only three lead-outs to identify?”

“The switch has six positions,” explained Smithy, “because the three transistor lead-outs can be connected to the three test terminals of the instrument in six different ways. I'll go through them with you next, and I'll show you then how the instrument responds to the six different methods of connection.”

Smithy reached over the surface of his bench and pulled his note pad towards him. He took a pen from the top pocket of his overall jacket and scribbled out a circuit (Fig. 3(a)).

“Now, the basis of this piece of equipment,” he went on, “is that if three terminals, which I've called terminals 1, 2 and 3, are available for connection to the transistor whose lead-outs are to be identified. Let's refer to this as the 'test transistor.' Terminal 3 connects to the chassis of the equipment; terminal 1 connects to a supply rail, which may be either positive or negative of chassis, by way of a 20kΩ resistor; and terminal 2 connects to the same supply rail by way of a 1kΩ resistor. The instrument functions by sensing whether the voltages with respect to chassis on terminals 1 and 2 are high or low.”

“High or low?” queried Dick.

“Can't you have an instance when the voltage on a terminal may be at an intermediate level?”

“Not in the present case,” replied Smithy. “As you'll soon see when I start explaining things in a bit more detail.”

He indicated the circuit he had just sketched out.

“Now this is my first example of transistor connection,” he continued. “It so happens that I have connected the test transistor such that its emitter goes to terminal 1, its collector to terminal 2 and its base to terminal 3. For the time being, we'll assume that we are checking a p.n.p. transistor.”

(=Fig. 3=)

Smithy's transistor identifying device has three terminals which connect to the test transistor. In (a) the emitter of the test transistor connects to terminal 1, the collector to terminal 2, and the base to terminal 3. The emitter and collector are changed over in (b)
Dick gazed at the diagram.  
"Well," he said slowly, "we've already referred to a transistor as being the same as two diodes connected back-to-back. So far as I can see, it will work in the same way as two diodes here."

"Good," said Smithy approvingly, "you've got the idea right away. The test transistor will act like two diodes whose cathodes connect to chassis. When the supply rail is positive both diodes will conduct and the voltages on terminals 1 and 2 will be low. For a silicon transistor they will be about 0.6 volt and for a germanium transistor about 0.2 volt. Both these levels fall into the category of 'low'. And, when the supply rail is negative neither of the two diodes will conduct. The voltages on terminals 1 and 2 will then rise to that on the supply rail and they can be described as being 'high'."

"These low and high voltages," Dick pointed out, "are of different polarities. The low ones are positive with respect to chassis and the high ones are negative."

"That's correct," confirmed Smithy. "And the instrument does in fact take advantage of this point. Now, let's connect up the test transistor in a different manner."

Smithy drew out a further circuit. (Fig. 3(b)).

"What I've done this time," he went on, "is to connect the collector to terminal 1, the emitter to terminal 2 and the base to terminal 3."

"You'll get the same effect as you had before," remarked Dick. "You'll have the two diodes again, with cathodes connecting to terminal 3. The voltages on the terminals will both be low when the supply rail is positive, and they'll both be high when the supply rail is negative."

"Light," said Smithy briskly, scrawling out another circuit. (Fig. 4(a)).

"In this instance I've connected the base to terminal 1, the collector to terminal 2 and the emitter to terminal 3. What happens now?"

Dick looked at the diagram thoughtfully.

"Why, blow me," he said suddenly, "it's just an ordinary common emitter amplifier circuit. Base current will flow between the base and emitter and this will turn the transistor hard on."

"So?"

"So, since the transistor is a p.n.p. type, both the base and the collector will be low when the supply rail is negative and high when the supply rail is positive."

"Fine," commented Smithy. "In other words, terminals 1 and 2 are both low when the supply rail is negative and are both high when the supply rail is positive. I should add that, due to the different resistor values, this assumes that the test transistor will have a current gain of at least 20, which is almost certain to be the case in practice."

He busied himself once more with his pen. (Fig. 4(b)).

"This time," he said, "I've put the collector to terminal 1 and the base to terminal 2. We once again have a common emitter amplifier circuit, with the transistor biased hard on. The result is that both terminals 1 and 2 are low when the supply rail is negative and are both high when the supply rail is positive."

**REVERSE AMPLIFICATION**

Smithy thought for a moment, then drew yet another circuit. (Fig. 5(a)).

"This is where we come to a tricky bit," he remarked. "As you can see, I've taken the emitter of the test transistor to terminal 1, the base to terminal 2 and the collector to terminal 3. Now, as you'd expect, terminal 2 will go low when the supply rail is negative because the collector-base junction diode will then be conductive. What may surprise you, however, is that the emitter will go low, too."

Dick's jaw dropped. "Come again?" he gasped. "How the heck can that happen? The emitter-base junction diode is the wrong way round for it to pass current when the supply rail is negative."

"What's happening here," chuckled Smithy, "is not diode action but transistor action. Since a junction transistor is a symmetrical device it can offer amplification in the reverse direction, with the emitter working as a collector and the collector working as an emitter. The transistor will, in most instances, be an extremely inefficient amplifier when working in this manner but it will still offer the effect, nevertheless. In this diagram the transistor is operating in the reverse direction as a common emitter amplifier, and the collector is acting as an emitter and the emitter is acting as a collector. Because of the values of the two resistors, the current flowing in the base is about 20 times the maximum current which can flow in the 20kΩ resistor. As a consequence, provided that the transistor can offer a wrong-way-round gain of at least one-twentieth, or 0.05 times, it will come hard on as a reversed amplifier, and both terminals 1 and 2 will be low when the supply rail is negative. They will also, incidentally, be high when the supply rail is positive."

"Gosh," said Dick. "This takes a bit of getting used to! I feel that emitters and collectors should know their proper place in the scheme of things."

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They shouldn't start swapping themselves over like this.

"It's us," returned Smithy, "who are forcing them to swap over. And don't forget that all we're asking of our wrong-way-round transistor is that it offers a gain of 0.05 times, which is considerably lower than unity. All the transistors I've checked in this last circuit have caused the negative voltages on terminals 1 and 2 to go low. Well now, I've shown you five different ways of connecting the transistor, so I'll press on to the sixth and last."

Smithy drew out the final method of connecting the transistor. (Fig. 5(b).) "Here we are," he announced. "I've now connected the base to terminal 1, the emitter to terminal 2 and the collector to terminal 3."

"Will we get the same wrong-way-round amplification as we did previously?"

"It's very doubtful," said Smithy. "A current will flow through the base-collector diode of the transistor when the supply is negative, but this will be only one-twentieth of the current which can flow in the 1kΩ resistor. So, unless the transistor has a wrong-way-round gain of at least 20, which is very unlikely, we'll have terminal 1 low and terminal 2 high when the supply rail is negative. Both terminals will be high when the supply rail is positive."

Smithy placed his pen on the bench and gazed expectantly at his assistant. The latter moved uncomfortably.

"Well?" questioned Smithy.

"Well what?"

"Don't you see what I've just demonstrated to you? I've shown you the six methods of connecting the test transistor and the resulting voltages on terminals 1 and 2."

"I know you have, Smithy," replied Dick warily, "and you've done it very well, too."

"Can't you see," persisted Smithy, "any difference between the voltages which are given in the sixth circuit and those which appeared in the five previous ones?"

Unhappily, Dick turned a look of utter incomprehension at Smithy's circuits. Suddenly, his face brightened.

"Ye gods," he exclaimed, "I've just spotted it! In the first five methods of connecting the transistor, terminals 1 and 2 always operated in pairs. They were either both high or both low. The sixth method of connecting the transistor is the only one which causes the two terminals to be opposite, with one being high and the other low."

"I'm glad you've fathomed that out," said Smithy pleased. "Because it explains the fundamental operation of my transistor lead-out identifying instrument. When this gives an indication that terminal 1 is low and terminal 2 is high, instead of the terminals being both low or both high, then terminal 1 must connect to the base of the test transistor, terminal 2 must connect to the emitter and terminal 3 must con-
connect to the collector.

"That," commented Dick appreciatively, "is really something, Smithy. You certainly had a brainwave when you dreamed up this little lot."

"I tend," remarked Smithy modestly, "to have my odd moments of inspiration. However, let's pass on to a further point. In the six methods of connecting the test transistor which I've just shown you, we've assumed that this is a p.n.p. type. It could also, of course, be an n.p.n. type. An n.p.n. transistor will exhibit exactly the same results as does a p.n.p. transistor but for the opposite supply rail polarities. In the sixth method of transistor connection, therefore, terminal 1 for an n.p.n. transistor will be low and terminal 2 will be high when the supply rail is positive. This fact enables the instrument to tell you if the test transistor is p.n.p. or n.p.n. Anyway, let's get down to the circuit of the complete job."

**COMPLETE CIRCUIT**

Smithy picked up a piece of paper on which he had already drawn a circuit diagram and passed it over to Dick, who studied it closely. (Fig. 6.)

"This," explained Smithy, "is the sensing part of the circuit. The 20k\ohm and 1k\ohm resistors which I previously showed is connected to terminals 1 and 2 appear in this circuit as R5 and R6 respectively."

"What are the arrows at the left-hand end of the circuit which are numbered 1, 2 and 3?"

"Those arrows are the same as our previous terminals 1, 2 and 3," explained Smithy. "They couple to the 6-way rotary switch on the front panel of the unit. This selects different combinations of the three test transistor terminals, and when it selects a combination which causes the test transistor base to connect to terminal 1, the emitter to connect to terminal 2 and the collector to connect to terminal 3, the sensing circuit indicates that terminal 1 is low and terminal 2 is high. The position of the rotary switch is then noted, and the transistor lead-outs are read off from a chart."

"I notice," said Dick, "that the whole lot is powered by a 6.3 volt mains transformer."

"That's right," confirmed Smithy. "This can be any small heater transformer offering 6.3 volts at 0.5 amp or more. The supply rail voltage for the 20k\ohm and the 1k\ohm resistors is given at the junction of R7 and R8, and this is about 2.1 volts r.m.s. with respect to chassis, or approximately 3 volts peak. A voltage at this level won't exceed the reverse base-emitter voltage rating of most of the transistors that are liable to be connected to the instrument. You will note, of course, that we are now working with an alternating supply voltage, so that the circuit responds continually both to positive and negative supply rails."

"What about the transistors TR1 to TR4?"

"They're in circuit to sense whether the voltages on terminals 1 and 2 are low or high. If, for instance, you look at TR1 and TR2, you'll see that these are two-emitter transistors connected as a Darlington pair. They are capable of becoming conductive during the half-cycles when the positive half-cycles of the supply rail and terminals 1 and 2 go positive. TR1 couples to terminal 2 via R1 and D1 with the result that, if terminal 2 goes high on positive half-cycles, lamp PL1 becomes illuminated. Similarly, this lamp becomes extinguished if the voltage on terminal 2 is low during positive half-cycles. There is, also, no current in PL1 during the half-cycles when the upper supply rail and terminal 2 go negative."

"Is diode D1 included," asked Dick, "to ensure that there is no base current to TR1 during the negative half-cycles?"

"Not really," replied Smithy. "Transistors TR1 and TR2 wouldn't conduct on negative half-cycles in any case. The reason for incorporating D1 is to provide a voltage delay of about 0.6 volt so as to ensure good sensing discrimination between high and low levels on terminal 2. TR1 is a silicon transistor and TR2 is a germanium transistor and neither of these transistors will start to conduct until the positive voltage on terminal 2 rises above some 1.5 volts. This ensures reliable sensing of the high and low voltage conditions on terminal 2."

"I see," said Dick slowly. "The next two transistors, TR3 and TR4, are in pretty well the same sort of circuit as TR1 and TR2, except that they couple to terminal 1. I suppose that lamp PL2, in the collector circuit of TR4, lights up when the voltage on terminal 1 goes high."

"It does," confirmed Smithy. "And, also, these two transistors can only become conductive when the supply rail and terminal 1 is positive. TR5 and TR6 come next. These are p.n.p. types and they ensure that lamp PL3 lights up during negative half-cycles on the supply rail and terminal 2 when the voltage on terminal 2 is high. Transistors TR7 and TR8 do the same thing again for terminal 2."

"Do the lamps light up brightly?"

"They shine about half-brilliance," replied Smithy, "because when the associated transistors are conducting they only pass current during alternate half-cycles. The bulb brightness is, nevertheless, more than adequate for present requirements. I've used AD161's and AD162's for switching on the lamps despite the fact that these are somewhat larger than is warranted by the power which is dissipated in them. However, AD161's and AD162's fit very nicely into the circuit even if they are a little under-run here. Also, they're not very expensive and are quite easy to obtain. They don't need..."
to be mounted on heat sinks.”

“There’s something else I’ve spotted,” said Dick. “The series resistors R1 and R3 are only 20kΩ, whilst R2 and R4 are 750kΩ. Why’s that?”

“I found in practice that I had to give R2 and R4 high values,” responded Smithy. “When the test transistor is connected in some modes it provides amplification between terminals 1 and 2 and causes cross-coupling between the different lamp circuits. With my prototype this effect completely cleared when I gave R2 and R4 the high values that I’ve shown in my circuit. Actually, R2 and R4 should have values that are just sufficiently low to bring on the associated transistors when terminal 1 is high. When this part of the circuit has been assembled it should be turned on with no external connections made to terminals 1 and 2. These terminals will then be high on all half-cycles and all four lamps should light up. If PL2 is markedly dimmer than PL1 and PL3, the resistance R2 should be reduced to a value which just allows PL2 to have about the same brightness as PL1 and PL3. The same applies to PL4, and the value of R4 should be carefully reduced if this lamp is significantly low in brilliance. The bulbs employed must be 6 volt 60mA types. Higher current bulbs might require too low a value in R2 and R4.”

**SWITCHING CIRCUIT**

“Well, all that seems very straightforward,” commented Dick. “What about the switching circuit which selects the different test terminal connections?”

Smithy ruffled through some papers and produced another circuit diagram which he had also prepared previously. (Fig. 7.)

“Here it is,” he remarked cheerfully, “and the rotary switch required is a 3-pole 6-way type. If you can’t get a 3-pole 6-way rotary switch already made up, then you can assemble it with R.S. Components ‘Maka-Switch’ parts. Two 2-pole 6-way wafers would meet the bill, with one of the poles being unused.”

“Blimey,” commented Dick, “that switching circuit looks very complicated.”

“It does rather,” confessed Smithy, “but that’s mainly because of the cross-connections involved. I’ve called the three test terminals X, Y and Z, and I’ve included a little table in the diagram showing how these are selected. On position 1 of the switch, terminal 1 goes to X, terminal 2 goes to Y and terminal 3 goes to Z. On position 2, terminal 1 goes to X, terminal 2 goes to Z and terminal 3 goes to Y. Some people might find it easier to wire up the switch working from the table rather than from the circuit.”

Smithy produced a further sheet of paper. (Fig. 8.)

“And there,” he announced, “is a table telling you what each switch position corresponds to. What you do is to connect the test transistor to terminals X, Y and Z, and then switch on the equipment by means of S1. You next rotate S2. A pair of bulbs, either PL1 and PL2 or PL3 and PL4, will always light at every position of S1. But there will be one position where a third bulb will light up in addition to one of the pairs, and that is the position which corresponds to the base of the test transistor going to terminal 1, the emitter to terminal 2 and the collector to terminal 3. If this third light is PL1 then the test transistor is an n.p.n. type because this will allow terminal 2 to be high on positive half-cycles. If the third lamp is PL3, then the test transistor is p.n.p.”

![Fig. 7. The switching section of the equipment](image)

![Fig. 8. This table shows transistor lead-outs connected to the test terminals for different settings of S2](image)

RADIO & ELECTRONICS CONSTRUCTOR
“That's really crafty,” remarked Dick. “I suppose you read off the transistor lead-outs from the table.”

“You do,” agreed Smithy. “If the 3-light display is given when S2 is in position 4, then terminal X connects to the collector of the test transistor, terminal Y to the base and terminal Z to the emitter. Actually, you could dispense with this XYZ business by positioning the table immediately below the three test terminals at the front panel with lines going to the knob of the rotary switch. Like this.”

Smithy drew out the scheme he had suggested. (Fig. 9)

“Why,” remarked Dick, “haven’t you used that idea on your own unit?”

“Because,” confessed Smithy ruefully, “I’ve only just thought of it! I’ll have to make the fitting of this direct-reading table to the front panel my very next job on this unit.”

PACKING UP

Once again, Smithy turned an affectionate glance towards his creation.

“Are there,” asked Dick, “any limitations to the usefulness of this unit?”

“There are a few,” said Smithy. “As I mentioned a little earlier, the main thing is that it can’t give correct readings if the transistor under test has a wrong-way-round gain of the order of 20 or more. A few of the older germanium transistors had fairly high reverse gains and these could possibly approach the 20 figure, although I haven’t encountered any myself. There are, also, a few types knocking around which are described as ‘symmetrical transistors’ and which have been purposely designed to have quite high wrong-way-round gains. The only ones in this category I can think of at the moment are the OC139, OC140 and OC141, which were produced for special computer applications. These three transistors have wrong-way-round gains of at least 21, and could not be checked on my unit. So far as construction of the instrument is concerned there are no particularly critical points except that it is desirable to house the parts in a metal case which is common to chassis. There can be a fair amount of gain in some parts of the circuit and a metal case will assist in providing stability of operation.

With these words, Smithy plugged his equipment into one of the mains sockets at the rear of his bench, picked up a transistor from the cardboard box in front of him and connected its three leads to the test terminals. He switched on the unit, whereupon two of the bulbs on the front panel lit up. Smithy turned the rotary switch until three bulbs became illuminated. The Serviceman indicated to Dick the line on his table which showed the corresponding transistor lead-out connections and then pointed to the third illuminated bulb, which revealed that the transistor was an n.p.n. type.

“Here,” said Dick eagerly, as he picked up another transistor, “let me have a go.”

Dick checked about a dozen transistors, then relinquished the unit to Smithy so that the Serviceman could check some more.

There wasn’t much work done that morning.
Radio Topics

By Recorder

In a recent 'Letter from America', on B.B.C. sound radio, Alistair Cooke recounted the sad tale of the American service engineer who maintains his TV receivers. It appears that this service engineer has hardly any social life at all. If he and his wife are invited to somebody's house for a party, the chances are that before the evening is out he will be summoned by his host away from the other guests to a room in which lurks a television receiver on the blink. He will then be asked for his advice on the best way of getting the set back to normal operation, with the veiled suggestion that he might as well have a stab at repairing it there and then.

That service engineer has now provided himself with a pocket tool kit which he takes with him whenever he is invited out.

SOCIAL PITFALLS

Most of us on this side of the Atlantic have experienced the same sort of thing. If people find out that one is connected with radio or television engineering then the hints start dropping like leaves in Autumn. Only the other evening, for instance, I was misguided enough to hold forth in my local about colour television, explaining that our present PAL system is an off-shoot from the original N.T.S.C. system proposed by R.C.A. in 1953. I should have known better. Within the next few days I was approached by no less than four people who, respectively, (a) had a TV set which took 15 minutes after switching on to settle down to a steady picture, (b) was contemplating buying a new TV and wanted to know what make I recommended, (c) had been presented with an ancient and defunct TV set by his mother and (d) could only get a single ITV signal on u.h.f.

I just managed to sail through these advances, explaining to (a) that delayed warm-up was not uncommon in valve television receivers that had seen some years of service, advising (b) that it was impossible to recommend a particular make of set because all TVs are mass-produced and he might quite easily buy the last set to be assembled before Christmas break at the factory, informing (c) that I could not obtain spare parts for TV sets produced before 1955, and telling (d) that he might, with advantage, point his roof-top aerial in a different direction but that I couldn't help here because I can't stand heights.

I must confess it was a close thing, though, and that I nearly had to change my pub.

Competition in the States must be tougher than it is over here, and that American service engineer with his pocket tool kit must have been forced, to retain his customers, to accede to their occasional blanchishments for a TV repair without payment whenever he was invited, pseudo-socially, to their houses. In this country we can afford to be harder and to put off people who try to scrounge TV service without forking out money for it. Oddly enough, it seems to be only electronics types who have to put up with this social harassment. If one meets a builder one hardly asks him for advice on re-pointing the chimney stack in anticipation of his arrival next evening complete with ladders; nor, if one encounters a doctor, does one make inquiries about the odd vasectomy and expect a quick job to be done on his next day off. It's just radio and TV people who suffer.

I suppose this is the old story of the luxury which, after a few decades, becomes a necessity. The automobile was originally a plaything for those who could afford it, but it nowadays forms an essential part of most peoples' livelihood. The telephone now plays a continual role in modern life-and-death dramas. Similarly, radio is an essential item for the dissemination of news. Or rather, was, since it has now been largely supplanted in this function by television with its occasional, but almost inevitable, unreliability.

So far as the future social eddy is concerned, I intend to confine any comments on my professional pursuits to hagiography; so if anyone wants an odd job done on the Dead Sea Scrolls I can refer them to the British Museum. And for the more pressing type of character who wants a job done on the cheap I might also declare a passing interest in taxidermy.

TELEVISION INTEGRATED CIRCUITS

A press release just received from SGS-ATES (and which quotes the address of this group as Via C. Olivetta 1, 20041 Agrate Br., Milan, Italy) gives details of the two integrated circuits shown in the accompanying photographs. Both of these are intended for television receiver applications and they manage to pack a great deal of circuitry into a very small space.

The first of the i.c.'s is the TCA 511, which is described as a 'TV horizontal and vertical processor'. In addition to a built-in voltage regulator this has a high stability horizontal oscillator, a horizontal a.p.c. circuit with high noise immunity and a large pull-in

The SGS-ATES integrated circuit type TCA 511, designed for use in television receivers. This incorporates a horizontal oscillator, a horizontal a.p.c. circuit with wide pull-in range, and a vertical oscillator and sawtooth generator
HOCUS POCUS

In last month's issue I included a little numerical puzzle which appeared like this:

HOCUS

POCUS

PRESTO

Each letter in this addition sum stands for a different number and the problem is to work out what these numbers are.

Here's the solution:

92836
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105672

MENTAL OHM'S LAW

Every now and again most of us have to sit down and carry out an Ohm's Law calculation. We usually start from the basic Ohm's Law equation which states that resistance in ohms is equal to voltage in volts divided by current in amps. In most instances, however, we have to work in milliamps, with the result that the figure 1,000 enters the calculations and we find ourselves burdened with a large number of noughts either before or after the decimal point. It's very easy to lose a nought, and the results of our computation may be that we get an answer that is either 10 times too small or 10 times too large.

There is a simple alternative approach to Ohm's Law calculations which enables them to be worked out mentally without introducing any serious errors at all. We first of all have to remember four obvious facts which are implicit in the Ohm's Law equation. The first of these is that if the voltage across a resistance increases so also does the current in the resistance. Similarly, if the current through a resistance increases so also does the voltage dropped across it. Thirdly, if the voltage remains constant and the resistance increases, then the current flowing in the resistance reduces. Finally, if the current remains constant and the resistance increases, the voltage across the resistance also increases.

We can now introduce some figures. If we apply a voltage of 1 volt to a resistance of 1 ohm, then 1 amp of current will flow. Should we increase the voltage to 2 volts then 2 amps will flow. If we keep the voltage at 1 volt and increase the resistance to 2 ohms then the voltage will drop to half an amp.

But in electronics we are more interested in currents of the magnitude of milliamps and microamps. So far as milliamps are concerned our starting point is that when a voltage of 1 volt is applied to a resistance of 1 kilohm (kΩ), a current of 1 milliamp (mA) will flow. This must be so, because 1 kilohm is a thousand times greater than 1 ohm and so the current must be a thousandth part of an amp, which is a milliamp. If we apply 10 volts to a 10 kilohm resistor, once again 1 milliamp will flow. Should we have a transistor emitter resistor of 330 ohms and the voltage across that resistor is 1 volt, then the emitter current is approximately 3 milliamps.
LOW COST LINEARS

Motorola Semiconductors Limited, of York House, Empire Way, Wembley, Middlesex, announce a new integrated circuit which, provided sufficient quantities are purchased, results in the availability of operational amplifiers at less than 10p each.

The new Motorola i.e.: the type MC3401P, and this contains four separate op-amps in a single plastic dual in-line housing. In quantities of more than 100 the MC3401P costs 37.3p, putting the price of individual operational amplifiers at less than 10p.

The MC3401P has a unity-gain bandwidth of 5MHz and an open-loop voltage gain of 1,000 minimum. Internally compensated, the device will operate from a single power supply of between 5 and 18 volts over the temperature range of zero to 75°C. Four amplifiers in one package typically draw 5mA from the power supply, and the input impedance of each op-amp is typically 1MΩ. Undistorted output voltage swing can be as high as 13.5 volts, and the isolation between amplifiers is typically 65dB at 50 Hz.

Quite a change from the early days of semiconductors, when the list price of a.f. p.n.p junction transistors was more than £1 each!
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RADIO & ELECTRONICS CONSTRUCTOR
## Resonant Frequencies III

The table gives calculated resonant frequencies, in kHz, for tuned circuits having inductances from 250 to 3,000 µH and capacitances of 50pF, 200pF, 800pF, and 3200pF. Thus, 600pF and 20pF are resonant at 1.45kHz.

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