QUESTIONS & ANSWERS

# Radio Repair

**Les Lawry-Johns**

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## PREFACE

Repairing radios is a very specialised process, since although a particular model seems to be prone to develop similar faults every time an example of the set is seen, nevertheless practically every repair job is different. This is partly due to potential faults inherent in the radio and partly due to the way the user treats the set – and obviously every owner treats his set differently.

A knowledge of how and why radios work is necessary, but practical experience in diagnosing faults can only be gained at the service engineers' bench. This book has been compiled with this thought in mind and sets a series of questions with practical answers based on bench experience. Readers lacking basic theory should refer to companion titles such as *Questions and Answers on Radio and Television* which will provide an insight into how and why radios work.

Within the pages of this small book it is necessary to restrict ourselves to rapid diagnosis and rectification of faults which occur in equipment which was previously working. If there is a difficulty, it is in deciding what to omit rather than what to include. The object therefore, has been to include the more common faults and to exclude the rare and exotic.

Repairing radios is a challenging and exciting occupation and is rather like a lucky dip – one never knows what is going to come out of it. The fault may be perfectly simple or it may take hours of painstaking investigation and measurement, but the reward is great satisfaction when one hears the set working perfectly again, just as it was when new.

I should like to acknowledge the cooperation of the Editor of *Radio and Electrical Retailing* for permission to use certain diagrams from RER Data Sheets.

Les Lawry-Johns

# CONTENTS

# 1

# POWER SUPPLIES, LOUDSPEAKERS AND OUTPUT STAGES

### *What equipment is needed for radio repairs?*

Basic tools frequently needed include

- Screwdrivers, 1/8 in, 1/4 in, 3/8 in and Phillips, all with insulated handles
- Electrician's pliers, with insulated handles
- Snipe or duckbill pliers
- Nut spinners, various sizes, e.g. 0, 2, 4 and 6 BA
- Side cutters
- Tweezers
- Plastic or brass trimmer tools, for adjusting i.f. and oscillator coil cores
- Small soldering iron, about 10–15 W
- Large soldering iron
- Desoldering braid or a desoldering 'sucker'
- A simple signal injector
- Switch cleaner fluid which does not attack plastics
- Aerosol freezer

The most important single item in all servicing work is a good quality multirange meter and no economy should be made in its selection. An overload cut-out is essential to protect the meter should it be connected to a current or voltage greater than the range the meter is set for – at some time in his life this happens to even the best service engineer.

In this book it is assumed that the reader does not have access to a signal generator, an oscilloscope or the more expensive instruments which are desirable for locating the more elusive fault conditions.

### *If the radio is not functioning at all, what is the first move?*

To establish that the necessary power is present where it is required. If the set is battery driven, check the condition of the battery or the individual cells and their connections. All too often the connections are corroded and need to be replaced or thoroughly cleaned. In some sets this is easy, in others it is very difficult. For example, some receivers use six 1.5 V SP2 or SP11 cells recessed in a housing which forms part of the cabinet with only a small opening provided for insertion of the cells.

Having established that the supply is fully present at the battery end, it must be followed either to the on/off switch or to the alternative power supply switched socket if there is a mains supply facility. It is quite common for contact to be lost at this switch which can also be corroded or merely found to have lost spring tension. While this sounds very simple, in fact it can be tricky because of inaccessibility in some makes of receiver. The on/off switch itself can be responsible for the power not getting any further and some makes of switch are far more likely to fail than others. One quickly learns to recognise the suspect types and to know whether the cure is replacement or merely the injection of some cleaning fluid.

Operation from a mains source is a little more involved since there are more separate items which can fail. A mains flex is likely to fracture, particularly where it enters the plug and/or socket. It is quite common for the supply to be taken direct to a transformer rather than through a more desirable separate switch, particularly in the smaller type of receiver (Fig. 1). There is a tendency for the primary winding in the smaller transformers to become open circuit resulting in the set working well on batteries but not from the mains. The secondary winding of the transformer is far less likely to give trouble, simply because the wire used has a heavier gauge to carry the heavier current at the low voltage required. The

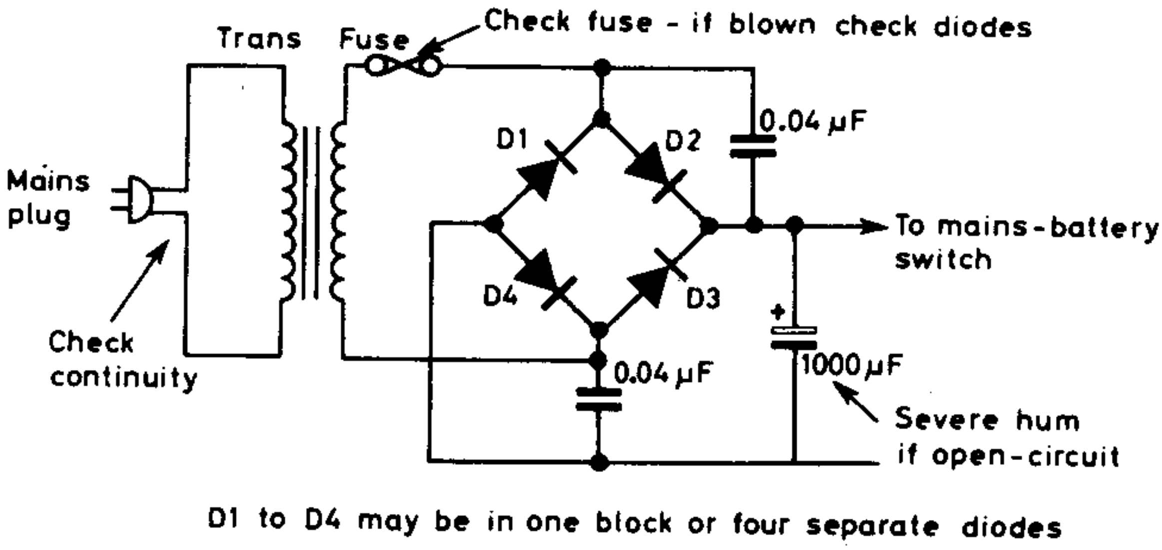


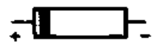

*Fig. 1. A typical bridge rectifier circuit*

secondary may be a single winding to supply a bridge rectifier or a tapped winding to supply two separate diodes. These components of power units are a frequent source of trouble.

## *How can power units be tested without the mains connected?*

The multimeter should be switched to the low ohms range (X1) and used to check the transformer primary which will have a resistance of say 500 Ω for a small transformer. A large power transformer will have a much lower reading of say 50 Ω but at the moment we are concerned with the smaller type usually found in small radios. Separate diodes conduct in one direction but not in the other. When the meter leads are applied with the positive probe to the cathode (normally marked with a band) and the negative probe to the anode, a reading of roughly 30 Ω for a silicon type can be expected (Fig. 2). When the meter leads are reversed the reading will be much higher, depending upon the circuitry, and infinity if the diode is separated from the circuit.

A bridge rectifier will give similar results if the positive probe is applied to the + terminal end and one of the a.c. inputs touched with the negative, infinity when reversed; low with the negative applied to the – terminal and the positive probe to the a.c. input. A low reading with the leads reversed indicates a faulty bridge and probably a blown fuse if one is fitted.

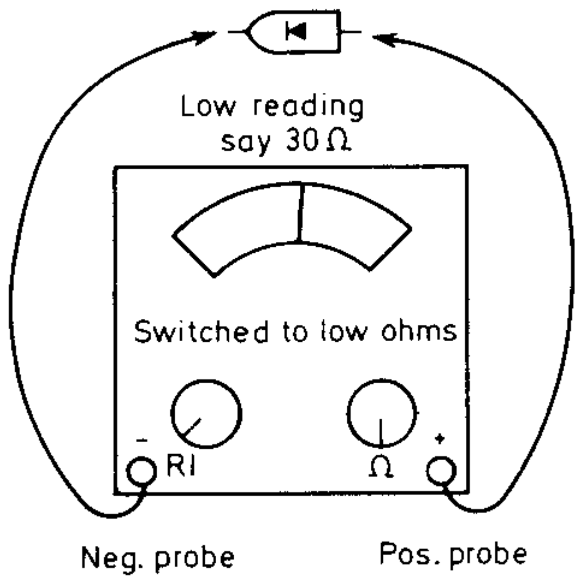




*Fig. 2. Using an ohmmeter to check silicon diodes. For the reverse reading, switch to a high ohms range and reverse the leads. There should be no deflection*

If a fuse is not fitted, the transformer could well be the casualty and therefore if a transformer is found defective it is necessary to check for shorts before a new one is fitted.

### *What other items are concerned with the supply?*

The other basic minimum item is a reservoir electrolytic capacitor for smoothing. The value of this depends on the receiver. If little current is drawn and the loudspeaker is small, the capacitance would be something like 500 $\mu$F. In larger equipment requiring more current and where the loudspeaker is capable of responding to a degree of hum, the value could be 5000 $\mu$F. This capacitor is liable to short and will provide a low reading across the supply line.

Other items which may be encountered in more elaborate receivers include a voltage regulator. The attendant circuitry could well include a zener diode which is designed to clamp a particular point to a particular voltage, conducting heavily as the voltage rises (or rather tries to rise) above this figure. It is also very common for the bridge rectifier which has four 'legs' to be replaced by four separate diodes, any one of which can short-circuit (as shown by full scale deflection of the ohmmeter whichever way the leads are applied) or become open circuit to produce a hum ripple and lower voltage.

### *If the voltage is present at the power unit but not at the receiver proper, where is it likely to be lost?*

At the battery/mains switch or switched socket. All too often corrosion is present at this point or more simply, the contacts may have lost spring tension. Check with the ohmmeter if contacts are exposed, or if the power is on, short across the relevant leads or contacts.

### *Are there many exceptions to the systems mentioned?*

Quite a few. To mention one, the Philips 13RS273 (Stella ST4503) is a clock radio produced some years ago and many are now in need of service. For mains operation only, this employs a small transformer which feeds 18 V to a tag panel. One secondary lead is taken to a chassis tag, the other via a 22 Ω resistor to a tab type rectifier. The positive output of the rectifier supplies the reservoir capacitor and a smoothing resistor of 56 Ω supplies the line voltage, smoothed by another electrolytic and stabilised at 6.2 V by a zener diode (Fig. 3).

This is an example of a half-wave rectifier circuit and is worthy of note because these models and a similar one without the clock were distributed in large numbers. Although the circuit is extremely simple it seems to confuse many who are asked to service it for the first time. This seems to be purely because the zener is not recognised for what it is (a voltage stabiliser).

In fact, in the majority of cases, the only repair required is the replacement of the small tab rectifier which seems to become open-circuit. A silicon diode such as the 1N4001

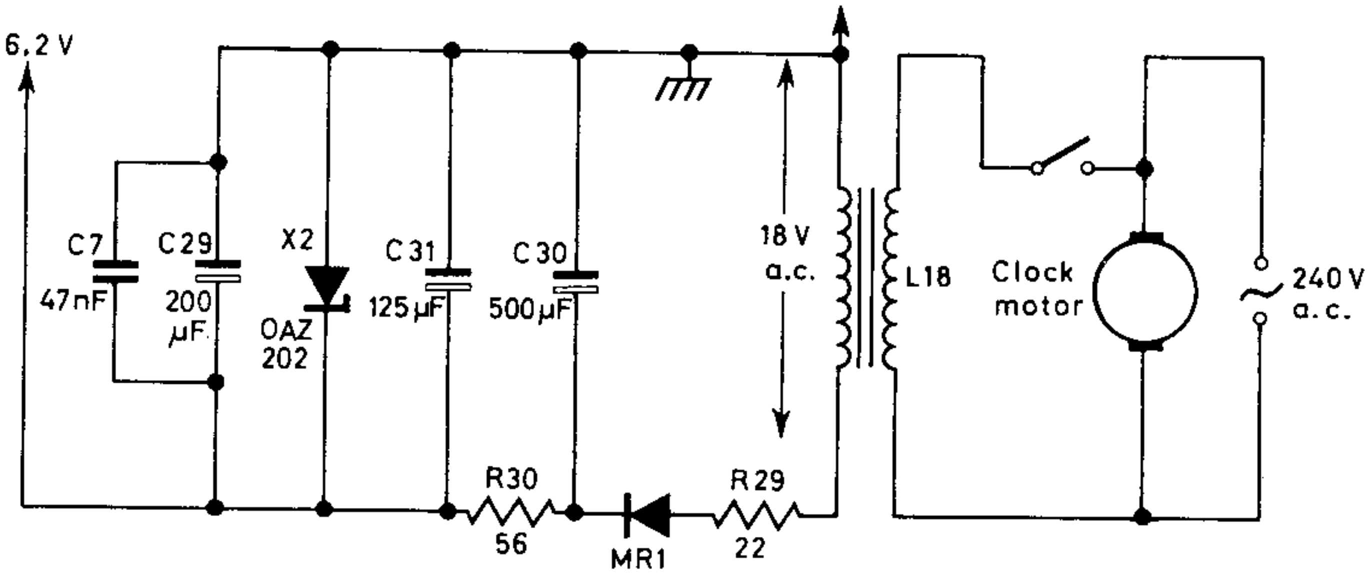



*Fig. 3. The mains supply used in the Philips/Stella clock radio. This is a half-wave circuit with the output clamped to 6.2V by X2. The main cause of trouble is MR1*

with the cathode (marked) end to the electrolytic tag, and the anode to the 22 Ω resistor tag is the only action necessary. The 6.2 V output from an 18 V a.c. source is quite in order in this case.

### *If the power supply is in order, what next?*

Make sure the set is really dead by turning up the volume control and listening carefully for some sign of life from the loudspeaker. If there is none, first prove the loudspeaker, if possible at the actual tags. With the multimeter switched to the low ohms range (X1) apply the prods to the tags (Fig. 4). There should be an audible click and the meter should record approximately the resistance of the speech coil (typically 8 Ω but this is usually marked on the unit together with its power rating). If there is no response, recheck the meter by touching the prods together with obtain full scale deflection. It is easy to incorrectly switch the meter or for something to

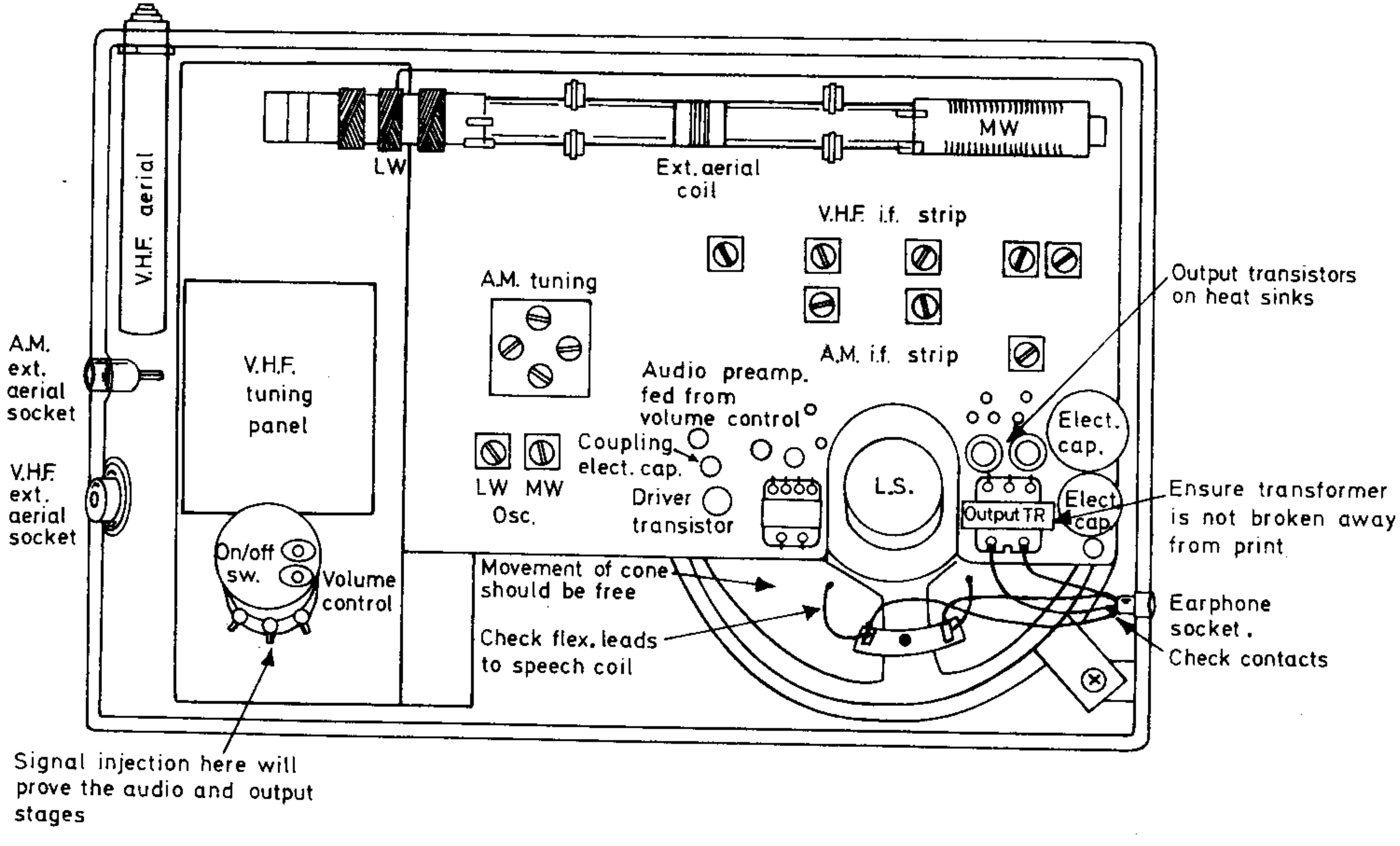



*Fig. 4. A simplified interior view of a typical a.m./f.m. portable showing loudspeaker contacts and wiring*

happen at the moment of testing. If the meter is in order, recheck across the tags and if there is still no reading the loudspeaker unit will have to closely examined to ensure that the fine braid connecting flex is making good contact with the tags. Quite often the flex has an inner nylon thread which keeps it close to the tag although the flex may actually be broken. This can often be the cause of intermittent results as the cone is moved. If the flex is intact electrically, it must be assumed that the speech coil is open circuited if there is no response with the meter prods applied to the cone ends of the flex; there may not be access for this final check.

A replacement loudspeaker should be of the same size and impedance as the original. If for example the original had an impedance of 8 Ω, the replacement should be 8 Ω or more, never less unless the equipment is specifically designed for this increased loading. Having proved the loudspeaker, it is next necessary to check the earphone socket, which in the case of a small radio is very simple and it is a matter of moments to ensure that the contacts which break when the earphone plug is inserted actually do make when the plug is removed. This is not quite so easy on more elaborate equipment where the contacts may be inside the body of the jack socket. In this case it is necessary to prove the relevant contact leads externally or more simply, plug in a pair of headphones.

### *How common are faults in loudspeaker and earphone connections?*

Very common and it is essential to prove these points before proceeding further.

### *Can a signal injector be used for testing loudspeakers?*

Yes, particularly if the injector has a low impedance output switch. A faint tone will be heard when the device is used normally, as there is usually a capacitor in the output of the injector to block d.c. voltages and this limits the output applied across a low impedance such as a loudspeaker. A low impedance switch overcomes this and the test tone is much louder. Therefore the injector can be used to check the loudspeaker and the earphone socket as well as the more usual r.f. and a.f. stages. An injector can also be used to test most types of microphone, which is a point to bear in mind for future use.

### *How is the output stage checked?*

It depends upon the design. Most earlier receivers used a transformer to match the output stage to the loudspeaker (Fig. 5) but it is far more common now to dispense with the transformer and feed the loudspeaker via an electrolytic capacitor (Fig. 6). While transformers can give trouble with open circuit windings, this is not common. On the other hand electrolytic capacitors do tend to dry up or to become open-circuit internally.

If the circuit diagram is available, it is simple to see at a glance which system is used. However, the circuit is often not to hand and although a transformer may clearly be seen on the panel it may not be the output transformer. There are some designs which use an audio driver transformer although the output current drives the loudspeaker through a capacitor.

Therefore it is prudent to follow the loudspeaker leads back to the panel or board to decide which method is used and if there is a capacitor it can be checked either by injecting an audio signal through it or disconnecting one side and applying the test prods of the meter switched to the high ohms range (X10 k or X1 k), negative test prod to the + side of the capacitor, positive test prod to the – side. The meter should swing over towards full scale and then settle back slowly towards a high reading depending upon the capacitance of the component. A few tests on known good capacitors will give an indication of the sort of reading to be expected. Very little deflection or a constant reading denotes a suspect, sufficient to warrant hooking up a replacement of similar value. Depending on the design, a value of between 100 $\mu$F and 500 $\mu$F may be encountered.

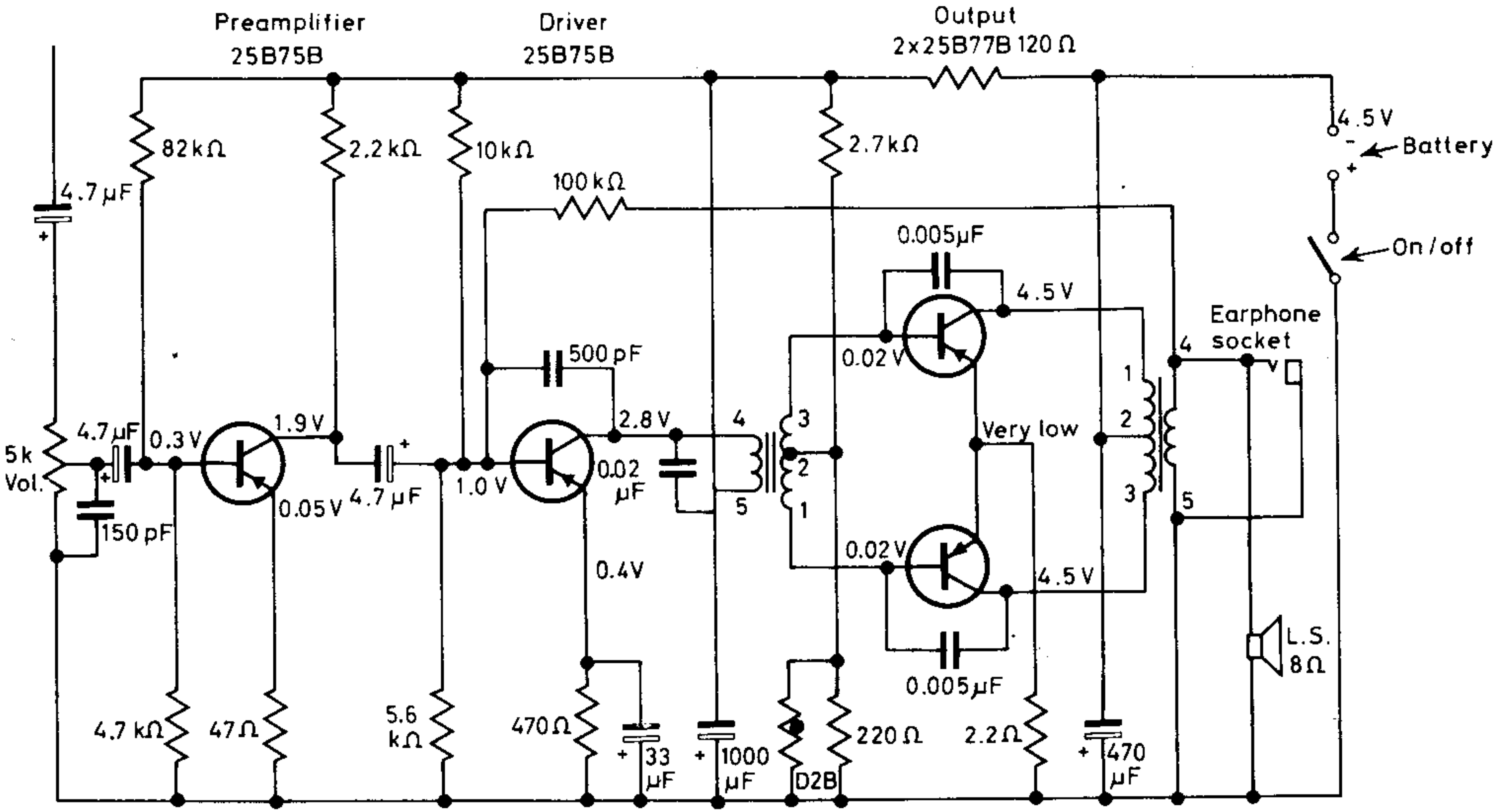



*Fig. 5. The audio and output stages of a typical small radio using driver and output transformers (Ekco PT 306, about 1967). All transistors are pnp types. If one of the output transistors becomes open-circuit, the stage continues to function but at reduced efficiency*

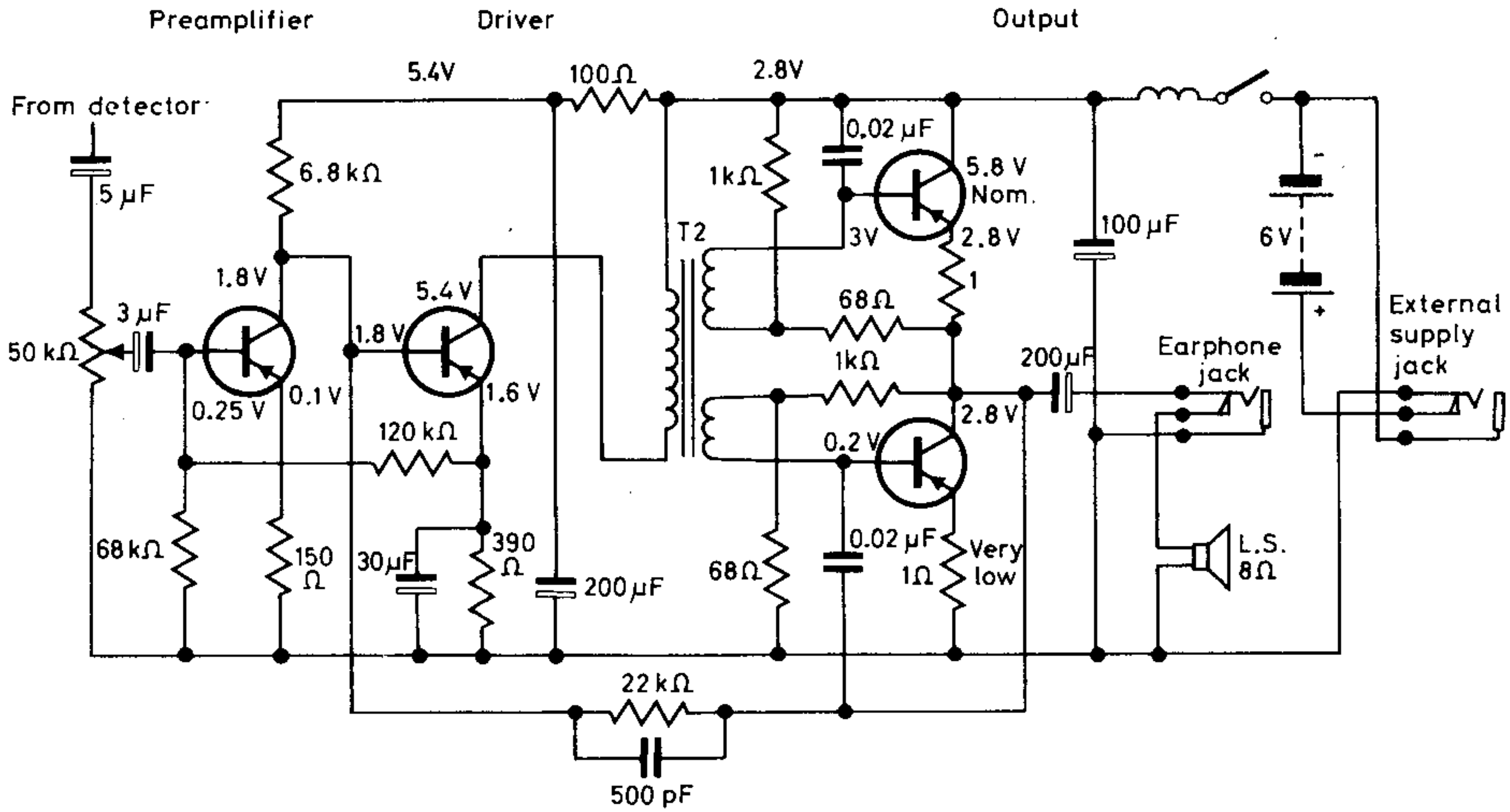



Fig. 6. *An example of a transformerless output, retaining the driver transformer to feed a push-pull output stage, capacitance coupled to the loudspeaker (Alba 666, about 1968). The failure of one output transistor results in almost complete loss of output power*

### *Are there any short cuts in checking output capacitors, avoiding dismantling?*

Yes, there are several; the previous answers described methodical steps. A quick check can be made at the volume control, advancing this and injecting a signal at the centre tag. If this comes through loud and clear, the set is not as dead as it seemed to be, and the audio and output stages are probably in order. If there is no response, the signal can be injected at various points in the audio stages to see where a response is obtained, and where it is not. However, until more experience is acquired, a methodical approach is best.

If an output transformer is used it is a potential weak point in some receivers, simply because it is heavier than most other components and is reluctant to stop moving when the receiver is dropped. Radios which can be carried must carry the risk of being dropped. It is therefore quite common to find one or more lead-outs broken away from the print although this may not be immediately obvious on inspection.

There are usually five connections, two on one side being the secondary feed to the loudspeaker, three on the other being the primary with a centre supply tap and one for each output transistor. An ohmmeter applied directly across the secondary will show the resistance of this in parallel with the resistance of the loudspeaker speech coil. The latter should be disconnected for the test either by unsoldering one loudspeaker lead from the panel or operating the cut-out on the earphone socket to divorce the output from the speaker.

The primary can be checked with an ohmmeter with the set off, with one prod to the centre and the other to each output tap in turn or with the set on with the meter set to the relevant volts range to ensure that the expected reading is present at each contact. Having ensured that the readings are as expected the circuit will have to be studied before the next step can be taken.

### *Are output transformers only found in older sets?*

It depends upon the origin of the set. While transformers will rarely be found in sets of European origin, they will often be found in up to date designs say from the Far East, some using an i.c. for audio amplification, this feeding an audio transformer driving an output pair of transistors coupled to an output transformer. Thus no hard and fast rules can be laid down. For example, the Sony ICF-5500M features v.h.f., marine, short and medium wavebands, has bass and treble controls, tuning and battery meter, power switch timer, ceramic i.f. filters, integrated circuit as mentioned and many input and output facilities. Therefore it must not be assumed that transformers are only confined to older sets or cheaper imports.

***What are the servicing advantages of transformer designs?***

The advantage that is immediately obvious is that each stage is separate and can be tested as such.

The d.c. coupling of transformerless designs means that a fault in an early audio stage can affect the succeeding stages giving incorrect voltage readings throughout. Thus a 'dead' output can be due to the output transistors not being 'turned on' by the driver which is not being 'turned on' by a faulty audio stage. Thus there is more uncertainty involved which is not present where transformers separate the stages.

***How is an output stage checked where a transformer is used?***

If pnp transistors are used, the negative supply is usually taken to the centre tap of the primary and the two outer taps feed the collectors of the transistors. If there is no supply here, it is usually due to a crack in the panel and the print must be examined to find where the circuit is broken. If a break is found, there will usually be others in line due to the panel being fractured and in fact several tracks may have to be made good.

***How is an open circuit located if no cracks are obvious?***

There are two ways of tackling this, one with the set switched on, the other with it off.

With the set on and the meter switched to the relevant volts range, apply the positive probe of the meter to the positive side of the battery or other positive contact, then prove the negative reading at the supply point and follow the track(s) along to where they should go, if necessary using a sharp edge to penetrate varnish or other track protection, until the meter stops reading to indicate the fracture (Fig. 7). With the set off, switch the meter to low ohms, apply one prod to the point where the supply is known to be and the other along the track until the reading stops. When the break is located, it can be cleaned off and tinned before soldering a short 'bridge' of wire across it or a length of lead can be connected from one point to another to take the place of the suspect track. Never apply solder across the crack and leave it at that. This is inviting certain trouble later. Check other tracks which run beside the broken one. If a distinct crack is found on the board, it could extend later and this should be anticipated.

### *What should be looked for in output stages before making tests?*

Emitter resistors are often damaged by excess current flow due to shorted output transistors and these can present a charred appearance, mainly in equipment which has the power to pass the current necessary to do this. Thus such damage will rarely be found in the smaller type of battery operated set but all too often it is found in the output stages of audio equipment and car radios.

### *What are typical values of emitter resistors in output stages?*

Usually between 1 Ω and 2.2 Ω. It is a good idea to look up a few representative circuits in order to get an idea of the values uses for various components so that in the event of the circuit diagram not being available. one is not at a loss.

### *How can transistors be checked using an ohmmeter?*

With the meter switched to the low ohms range, say X1, the test prods can be applied to the collector and emitter to see

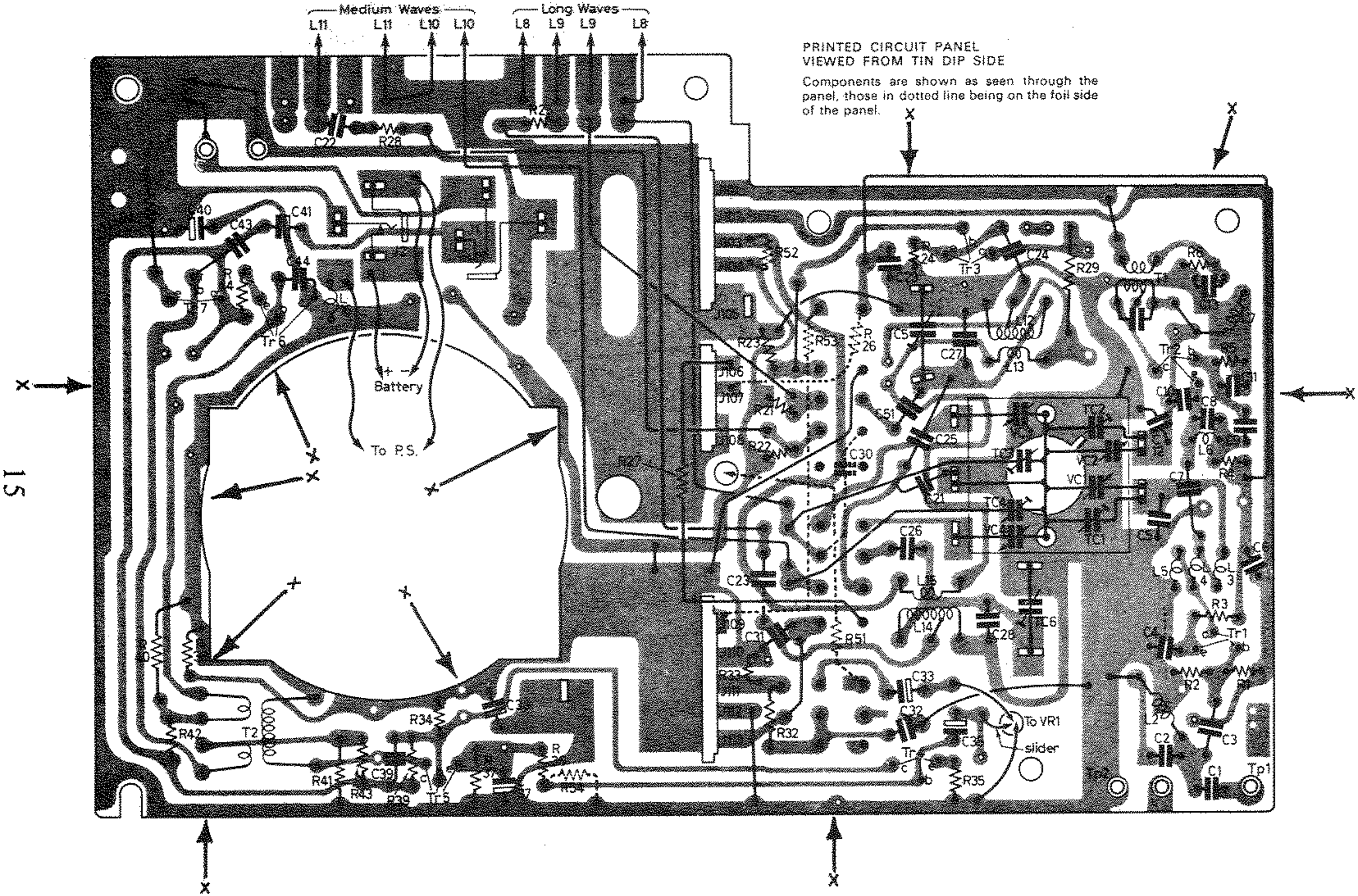



*Fig. 7. A typical printed circuit layout. Look for cracks as indicated by crosses and arrows*

if there is a full scale deflection which would indicate a short. While some reading should be registered due to circuit components, this should never be less than say 10 Ω, and will probably be much higher when the test prods are reversed (Fig. 8). If there is doubt, the suspect should be removed from the circuit and tested separately. The readings then

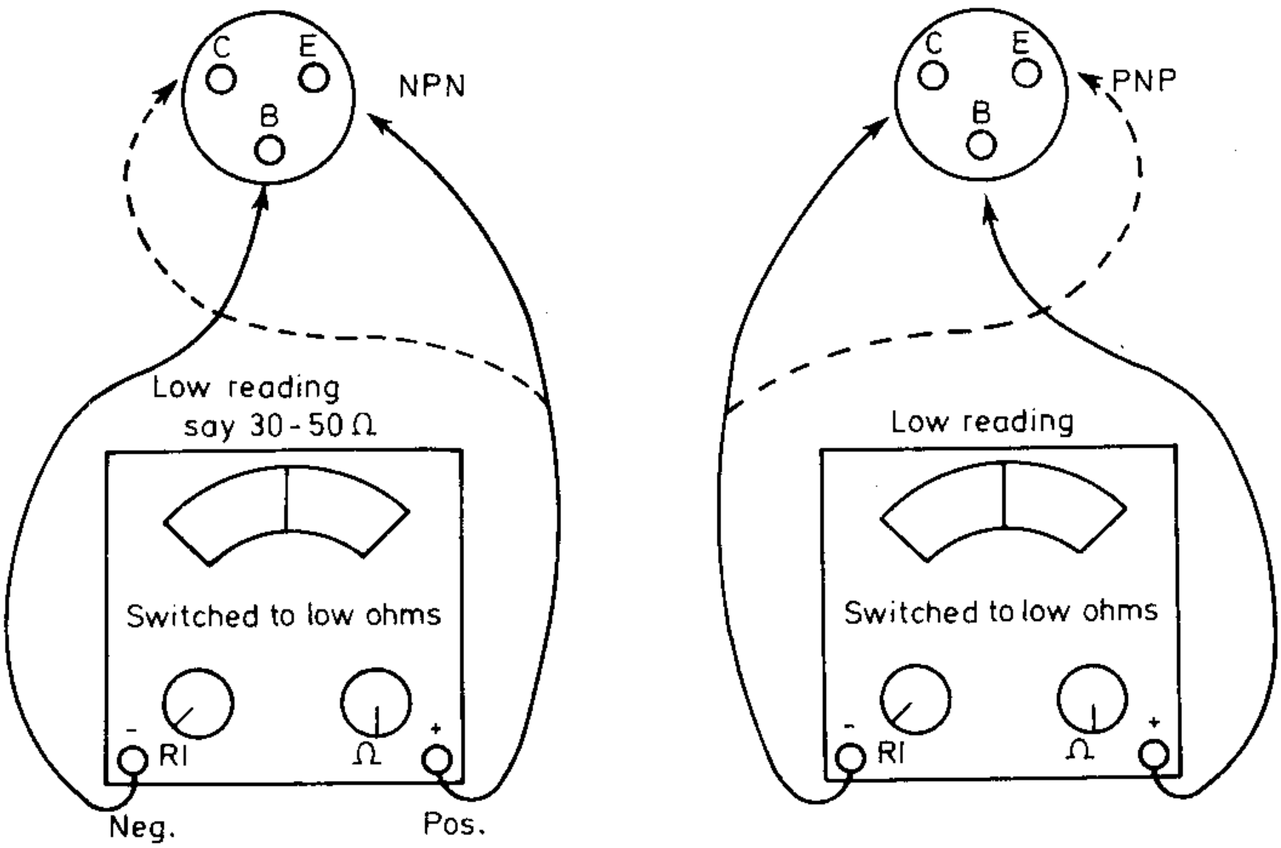



*Fig. 8. Testing small signal transistors. With npn types the reading is much higher when the probes are reversed (positive probe to base) depending on the transistor. For pnp types the reading is high when the probes are reversed (negative probe to base)*

obtained will vary according to the type of transistor. Between the collector and the emitter there should be no reading at all on the low ohms range. For an npn transistor, apply the negative probe to the base contact and the positive to either the collector or the emitter. A fairly low reading should be obtained, between about 10 and 50 Ω, depending on the actual type of device. Reversing the probes (positive to base) should produce no reading on the low ohms range. This method is not conclusive but is a fairly reliable quick check.

For pnp transistors apply the positive probe to the base and the negative to the emitter or collector to obtain the low reading. If the meter does not read at all the transistor is open circuited and cannot pass current. If a full scale deflection is obtained in both directions (whichever way the probes are applied) there is a short in the device. If the short is between base and emitter this will remove the 'turn on' bias and the device cannot conduct. If the short is between collector and emitter this is the reason for the heavy current drain.

# 2

# AUDIO STAGES AND OUTPUT DRIVING

***If the output transistors are in order but are not conducting, what is wrong?***

The transistors are not being turned on. For a pnp transistor to conduct, the base must be negative with respect to the emitter, the exact amount depending upon the design of the stage and the type of transistor. For an npn the base needs to be positive, i.e. for either type to conduct, the base must be nearer the collector potential than the emitter. This can rapidly be checked with the voltmeter, remembering that for reasons of battery economy, the 'turn on' bias may be very small, the signal voltages doing the majority of swinging the transistors into full conduction. In fact, it is rare to find lack of base bias in receivers using a driver transformer as the resistors which determine this do not often change value. However, they could be broken by rough handling or the base windings of the transformer could have become disconnected from the printed circuit.

Where there is d.c. coupling, i.e. no transformer, the output is turned on by conduction of the preceding stage or stages (Fig. 9). It is therefore necessary to prove that the preceding transistor or transistors are supplied and are conducting.

Most people have their own pet method of doing this and due to variation of circuit design, it is difficult to lay down any hard and fast rules. A small error voltage in an early part of the audio stage can result in complete shut down or overloading in the output. Therefore the stages cannot be viewed separately and the only way is to start at the pre-amplifier or first audio stage to ensure that the base bias here is correct and then plod on through checking voltages and testing suspects, viewing each transistor and capacitor (particularly electrolytics) with suspicion.

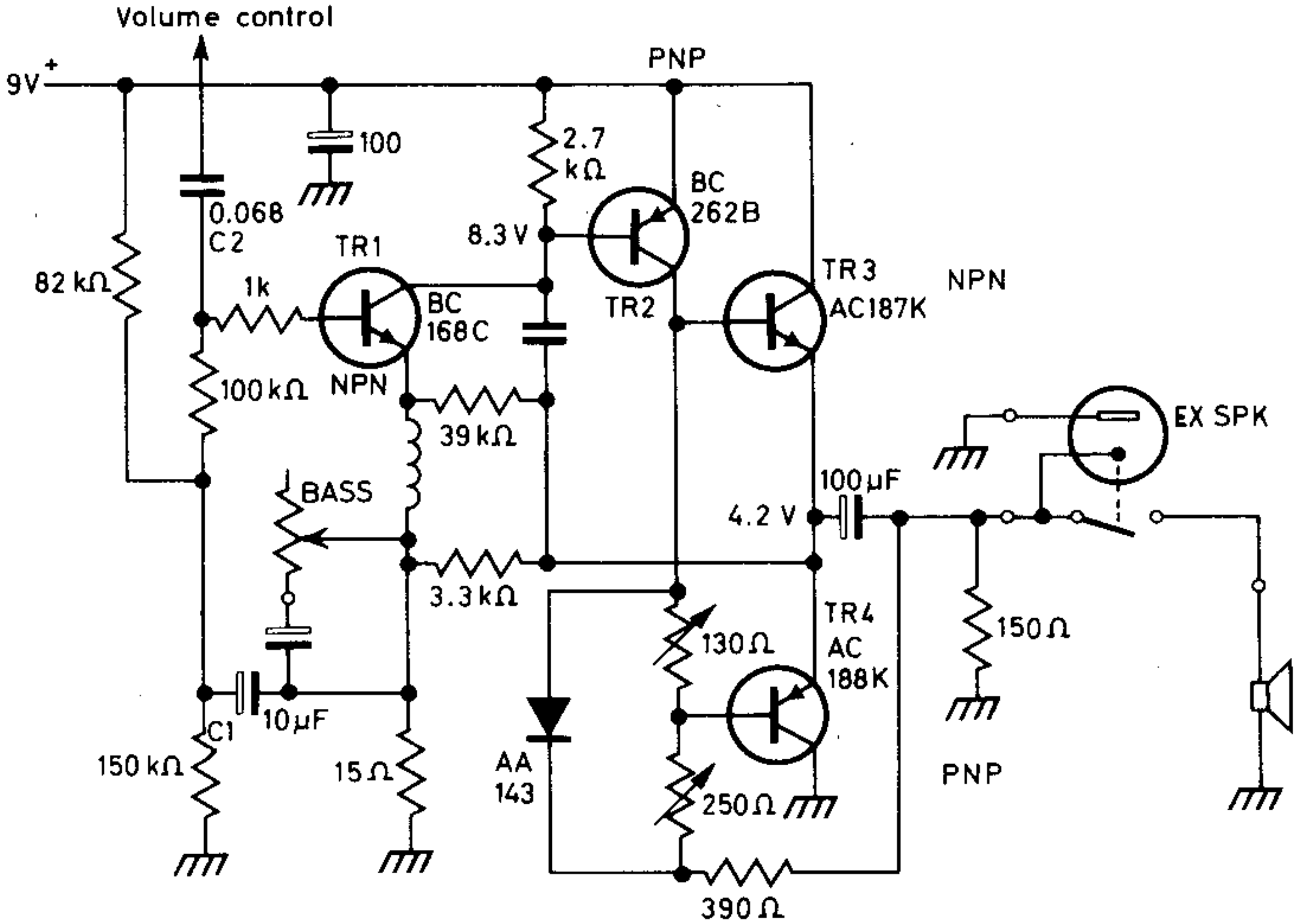



*Fig. 9. An example of a d.c. coupled audio circuit. A fault in the Tr1 base-emitter circuit, such as a leak through C1 or C2 would stop Tr1 conducting. This would shut off Tr2 and the whole output circuit leaving only the collectors of Tr1 and Tr3 plus the emitter of Tr2 showing a voltage reading. Tr1 itself would be a primary suspect (base-emitter leak)*

This can be very tedious and time consuming but it is methodical, instructive and well worth the effort, as one difficult and involved fault tracing exercise teaches more than any amount of reading on the subject. If reliance is placed on hit or miss methods very little is learned and the day of reckoning is only put off. It has to come sooner or later to either boost or deflate confidence.

### *When is fault-finding particularly difficult?*

When the printed circuit is completely unmarked and the transistors carry no identification at all. This means that each transistor connection has to be separately identified and its purpose understood. The only help here is to remember that an npn transistor collector is positive with respect to the base and emitter and a pnp emitter and base are positive with respect to the collector. The confusion is hardly helped by the different configurations of different types of transistor. As far as audio transistors of the lower power types are concerned, we could once rely on the base being in the centre with the emitter here and the collector there. However, if the device is unmarked (so that it cannot be checked with the book), one has to pause and consider the meaning of the voltage readings and the cold ohms test.

### *When is fault-finding relatively easy?*

When the circuit board is marked above and below with all the necessary information, circuit numbers, transistor configurations and perhaps even the expected voltages. This indeed is the hallmark of a considerate manufacturer and makes the difference between normal routine testing for expected figures and variations, and a potential nightmare. This means that two identical circuits (well, almost) can offer utterly different servicing conditions and marks the difference between theory and practice.

### *If the set is alive but the sound is distorted, are the tests of a different nature?*

Not really but it depends upon the nature of the distortion. Sounds are difficult to describe in words. In fact it doesn't take long to gain enough experience to be able to identify most causes, be they low power supply (check voltage), a rubbing loudspeaker coil (check cone for free movement) or incorrect operation of the audio or earlier stages.

It is extremely common for a transistor to become open-circuit, either internally or through a detached connection. The result of this depends upon the design and can vary from complete non-operation or very low and distorted output, to merely a slight drop of efficiency.

If there is doubt as to the cause of the distortion it is necessary to start from the loudspeaker and work back, as previously described. Having checked the supply voltage, plug in an earphone or otherwise check voltages throughout if a visual examination fails to show an obvious cause.

### *What if the voltages are reasonably correct, the transistors and loudspeaker are in order, but there is still no output?*

Look for small electrolytic capacitors which couple one stage to another and check these, either by shunting an equivalent value across the contacts or by disconnecting one end and testing with an ohmmeter switched to the high range.

An alternative or back-up test is to inject a test signal; the result should be roughly the same on both sides of the suspect. Distortion could well be due to leakage through such a capacitor although this is more likely to upset the voltage readings thus calling attention to it. Disconnection would restore normal voltage readings and a back-up test with the ohmmeter will probably show a constant reading. In other words, an electrolytic capacitor usually suffers from one of two faults. It either loses its capacity to charge and discharge, in which case another can be shunted across it to prove the point, or it becomes leaky or completely shorts, thus upsetting the d.c. conditions which necessitates its removal for test purposes.

### *What audio checks should be made?*

Having checked the supply source, whether it is suspect or not, switch the set on and advance the volume control. This alone can prove several things but if there is doubt, apply an audio test signal to the centre tag of the control, preferably with a signal injector but even a screwdriver blade held in the hand will give audible clicks or a hum if the succeeding stages are in order. If there is no response, check the loudspeaker and earphone socket and inject signals working from the output towards the input, checking voltages as previously outlined to see if these depart from what should reasonably be expected.

# 3

# I.F. AND DETECTOR STAGES

***Assuming the audio stage has been proved, how are the i.f. and detector stages tested?***

It is best to look at the design to see if any short cuts present themselves.

For example, if the receiver has v.h.f. reception facilities, the i.f. stages will terminate in separate detector or demodulator circuits. There will usually be two diodes for f.m. detection and one for a.m. and the output of each will be taken to a selector switch which ultimately connects to the volume control or some other part of the audio circuit. The signal injector can again be used here and should give a clear tone from one side of the detector diode(s). Failure to get a response will direct attention to the switching arrangements, tape socket, p.u. input or whatever frills are provided in the design. The detector diode itself should not escape attention and can be checked with the ohmmeter in much the same way as silicon diodes except that the forward resistance will be higher. Whereas a silicon diode will read about 30 Ω forward, a germanium diode will read somewhat higher at say 200 Ω, a reverse reading taking into consideration the circuit resistance which could be 3000–5000 Ω. If switching to v.h.f. produces some noise but the a.m. remains silent, the a.m. detector diode may well be at fault and close inspection may show it to be cracked.

*Do all sets have a detector diode?*

All sets have a detector but not necessarily a diode. A transistor can be used, sometimes with the volume control as its load resistor. Otherwise a transistor can often be found with two of its leads twisted together so that it acts as a diode. Whatever the device, it will be found near the final i.f. coil can. The exceptions are in later sets using i.c.s and earlier ones which employed modules encasing the i.f. stages and the detector(s).

*What can be done where an i.c. is found?*

Having ensured that a test signal applied to the output of the device produces a good response but there is little when the test signals are applied to the input, the supply to the device should be proved after examination of the circuit diagram. If the supplies are in order the i.c. may fairly be suspected and a replacement fitted.

Confirmation can often be made by spraying the i.c. with a freezer coolant aerosol which may bring the circuit back to life for a brief period.

*Since an i.c. may have many closely spaced pins, how can it be removed without damage to the print?*

Once all traces of solder have been removed from each connection using the small iron and a solder sucker or desoldering braid, removal is quite easy. Trouble comes when a heavy iron is used and repeated efforts are made to clear the pins.

*What if the pins are hidden under a dial drive drum with complicated drive cord?*

Secure the nylon in place with Sellotape on the drum and at the rollers. On paper, draw the position of the drum, the direction of the stringing and the number of turns on spindles in case of accidents. Then remove the drum and keep the nylon well away from the heat of the iron. Remove any wax from the print and then proceed as above.

### *What if the whole i.f. strip and detector is in a module?*

The unit can either be replaced as a whole, or the suspect can be repaired. The module usually consists of a rectangular metal box with a number of lead outs at either end. Having released the soldered contacts and removed the unit, more soldering is usually necessary to remove the covers. Once this is done, the individual components can be seen.

### *What are the usual defects of modules?*

Units used in the majority of UK produced sets of a few years ago employed transistors of the AF115, AF116 and AF117 types. These are pnp transistors having a screen contact in

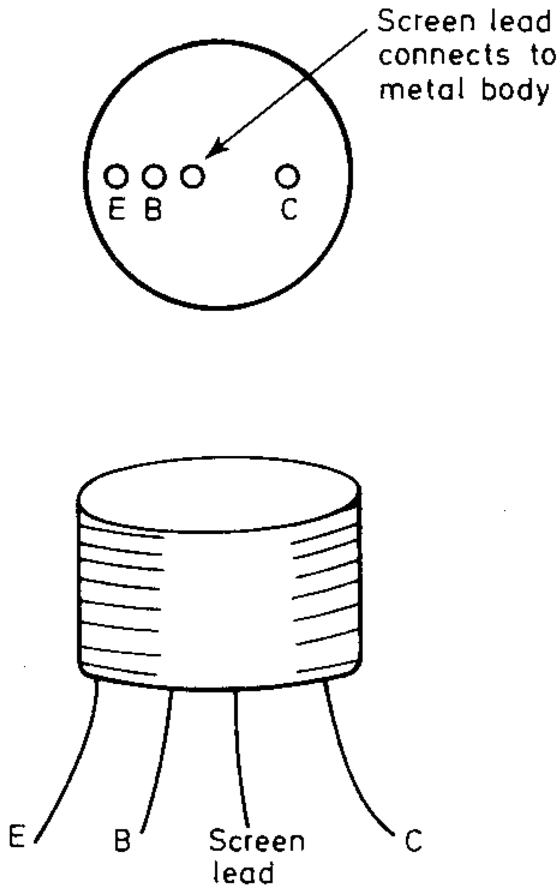



*Fig. 10. A transistor of the AF117 type. Normal reception can often be restored by cutting the screen lead*

addition to the base, emitter and collector. The screen lead is that located in approximately the centre with a gap between it and the collector (Fig. 10). The basic defect is for the screen to short internally to the collector. Therefore it is quite possible to locate the defect and rectify it without coupling it back to the circuit purely by checking for shorts between the collector and screen of each transistor. The screen can be disconnected from the print or of course the transistor replaced to prove the point. This is not to say that other faults do not occur. They do, but not very often.

### *Are there short cuts?*

Yes; there are many sets using conventional circuits which can be restored to working order merely by clipping the screen connection to the print. A very large number of UK produced sets used transistors of the AF115/6/7 type and where these are found and the audio stages are in order, nine times out of ten the fault is due to a screen to collector short in one of these transistors. In the majority of cases, divorcing the screen connection from the circuit has no detrimental effect.

### *What sets used AF115, AF116 and AF117 type transistors?*

Many receivers were produced in the middle and late sixties and include such popular models as the Bush TR130, TR146 etc. Thorn group receivers such as the Ferguson 3152, Marconiphone 4142, Ultra 6146, HMV 2140 etc. including radiograms. Dynatron TP36, Radiomobile and Motorola car radios; models in the Pye, Ekco, Ferranti ranges, the list is very extensive, and only a few are quoted here as examples. It is of course necessary to identify the correct lead out and clip only this. Also, whilst the i.f. stages will be hardly affected, it is possible that the tuning may be altered when the transistor is used as a mixer-oscillator and in this case it is better that the defective transistor be replaced. The whole point is that the culprit has been identified by a very simple test and this can save a lot of time.

### *If the detector seems fault-free, what is checked next?*

The testing now depends upon whether the receiver has f.m. facilities as well as a.m., the switching involved, stereo decoder etc. It is impossible to be explicit on these points as there is so much variation. Therefore some assumptions must be made. We have to assume that the switching is in order, as proved by signal injection and if necessary, checks with the ohmmeter. Next, we have to assume that both the f.m. and the a.m. sections are affected and are not functioning. This will normally direct attention to the i.f. stages and the one nearest the detector should be proved first, i.e. the final i.f. stage. While there is normally only one transistor involved, there may be separate coil cans for the a.m. and f.m. and as the size of these coils becomes smaller with more modern designs, so the troubles seem to increase.

### *What are the major problems with small i.f. coils?*

The difficulty of soldering the fine wire to the lead out posts gives rise to various symptoms ranging from complete stoppage when the joint is entirely open circuit, to noisy and intermittent operation as the connection varies. Since we have not yet considered noisy operation in the audio stages, we will not consider it here in any depth. Suffice to say it can be very annoying and a time consuming exercise to locate and overcome the cause.

### *What sort of tests can be carried out on i.f. stages?*

It depends upon the equipment available. While faults can be located by voltage checks backed up by ohms readings, it should be realised that coils have to be tuned to a particular frequency, normally about 470 kHz in the case of a.m. f.m. coils and usually 10.7 MHz in the case of f.m. It is possible that the coils may have had their cores tampered with and there is always the possibility of a small tuning capacitor inside the coil can becoming defective.

However, putting these possibilities aside for a moment, the most probable trouble spot is the transistor concerned or the supply to it. The first check is to establish the operating voltages. Once again the design will dictate the sort of voltages to be expected. The circuit diagram will usually give these figures but if this is not available, the transistor type should be identified (if possible) so that the obtained voltages make sense. Normally an npn type will be operated with its collector supplies through the i.f. coil can(s) from a positive supply line; there will be a small positive voltage on the base and a smaller voltage on the emitter if this is returned to the negative line via a resistor. In this case, the voltage drop across the resistor gives an indication that the transistor is passing current and is a convenient check although not a conclusive one. It does not take long to establish the mode of operation of the i.f. amplifiers and to ascertain which are functioning and which is the odd man out by comparing the readings. If the readings are apparently right, signal injection to the bases, working from the final i.f. back to the mixer, should establish where the signals are being lost.

### *Is there a short cut in checking i.f. stages?*

With certain reservations, yes. Operating the wavechange switches or buttons will give an indication whether the i.f. stages are operating. Healthy clicks will normally indicate that the stages are in order and that the fault is probably in the mixer-oscillator section. In addition there will probably be a degree of background hiss. If these conditions are present, time spent checking the i.f. stages will probably be wasted and could be better spent investigating the aerial input and oscillator sections.

### *What sort of troubles afflict the mixer-oscillator stage(s)?*

While some circuits employ a separate oscillator, the output of which is fed to the mixer in order to produce the required i.f., it is more common to combine the two and employ one transistor to do both jobs. Receivers with v.h.f. facilities use a separate circuit because the frequencies involved are much higher. A typical receiver would employ two transistors in the v.h.f. tuning stage (say a BF195 r.f. amp and a BF195 osc-mixer) and one for the long, medium and short a.m. input (say a BF194). Thus it is possible for the set to function perfectly on one system but with no results on the other.

The most common fault to develop is that the oscillator ceases to function, this occurring more on a.m. (long, medium, short) than on f.m. (v.h.f.). Most often, the transistor itself is at fault, perfectly willing to function as an amplifier perhaps, but steadfastly refusing to work as an oscillator.

Since the mixer-oscillator transistor is normally situated near the tuning gang, it may be necessary to remove the dial drum in order to gain access to the print contacts. There are times however when the transistor is not at fault. It is then necessary to try to pinpoint the faulty component.

### *Are there any prime suspects?*

Look for polystyrene capacitors: those of the silver 'see through' type. These are by far the most likely to be found either shorted or open circuited. Depending upon their function, they can be responsible for the conditions of no results at all or the common 'medium wave O.K., long wave not functioning'. Also look for studs or pins from the wavechange switches not contacting the print, cracks in the tracks and fine wires on the oscillator coils broken away from the posts.

There are of course many possibilities but these are the sort of run of the mill defects which have been found to be mainly responsible for this part of the circuit not functioning.

One component often overlooked also is the smaller type of electrolytic capacitor used to decouple the supply to this end of the circuit. If a capacitor in this position dries up it will often cause the oscillator to stop working. In other positions at this end of the circuit they can cause a number of defects ranging from very poor signal gain, oscillation (not of the wanted kind, but audible whistles and screams) and generally poor reception.

*What does an electrolytic capacitor do when it 'dries up'?*

Nothing. In other words it fails to charge up on a rising voltage and discharge as the voltage falls. If this rise and fall is the result of signal voltages of one kind only, the result will be loss of gain. If more than one kind of signal voltage is present at this point, the result will be interaction and probably oscillation. It is an easy matter therefore to insert a test capacitor across the suspect as a quick check, at the same time realising that the suspect may also have a distinct leak which can rob the circuit of some of its supply. If in doubt, remove it and fit a known good one.

*Are some types of capacitor more suspect than others?*

Yes, and it doesn't take long to learn which are the ones liable to give trouble. The writer's pet hate centres upon the black ones with silver writing but this is probably due to his experience in other fields and shouldn't be taken too seriously.

*What is the result of the oscillator working at the wrong frequency?*

The effect is to shift the tuning along the dial and since the aerial or r.f. tuning is still at the correct point the result is a drastic drop in sensitivity.

*What could cause the oscillator to change frequency?*

Apart from the possibility of eager little hands having twiddled with the trimmers and coil cores, the trouble is usually experienced on a.m. medium and long waves and here again capacitors are the prime suspects. Polystyrene types are the ones more likely to give trouble (silver see through types) these being commonly used as trimmers across a tuned circuit, or padders in series with it. Note which bands are affected and if possible look up the circuit to see which are switched in and which are permanently in. A little logical thinking armed with this information will usually enable the culprit to be identified without too much trouble.

### *Surely other types of capacitor give trouble?*

Not often in tuned circuits but there is always the possibility that silver mica (flat) types are mounted on the print under stress and that over a period these can pull apart internally although the external coating may hide the defect.

### *What should be looked for before checking capacitors?*

While most receivers use variable capacitors in a gang for tuning, many employ slug-tuned coils where the dust iron slugs for the aerial, r.f. and oscillator coils are inserted or withdrawn

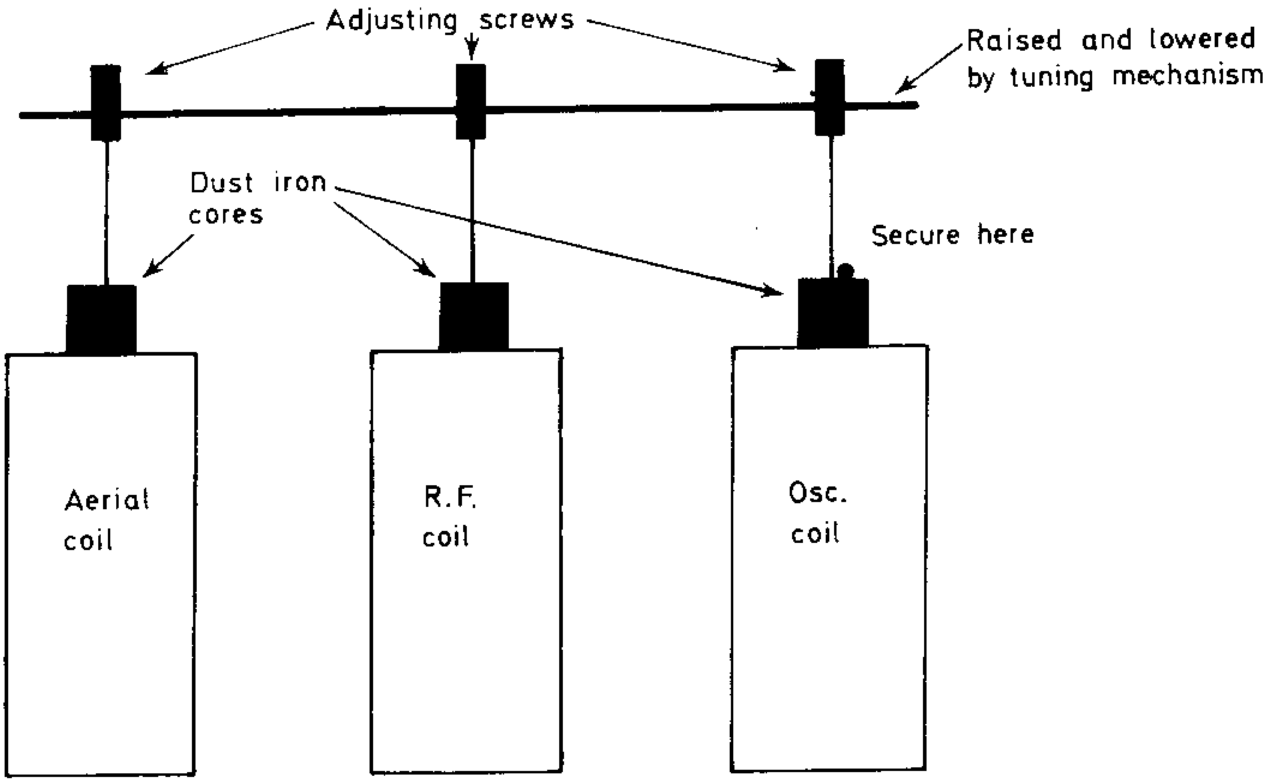



*Fig. 11. An example of slug-tuned coils in a permeability tuned receiver front end. Poor sensitivity and selectivity result if the aerial or r.f. cores are not secure. Inaccurate tuning will result if the oscillator coil slug is loose. To realign slugs: (1) Tune to known station around 500 m (600 kHz) and adjust slug. Secure the slug with adhesive. (2) Reset aerial and r.f. trimmers at around 200 m (1500 kHz) if necessary*

simultaneously (Fig. 11). A gantry is operated by the tuning knob with screws or wires to each dust iron core. The core is, or should be, secured to the wire or thread by glue or cement or sometimes merely a kink in the wire. Obviously therefore a slug can become loose and wander about causing havoc to the tuning.

### *How are tuning slugs realigned?*

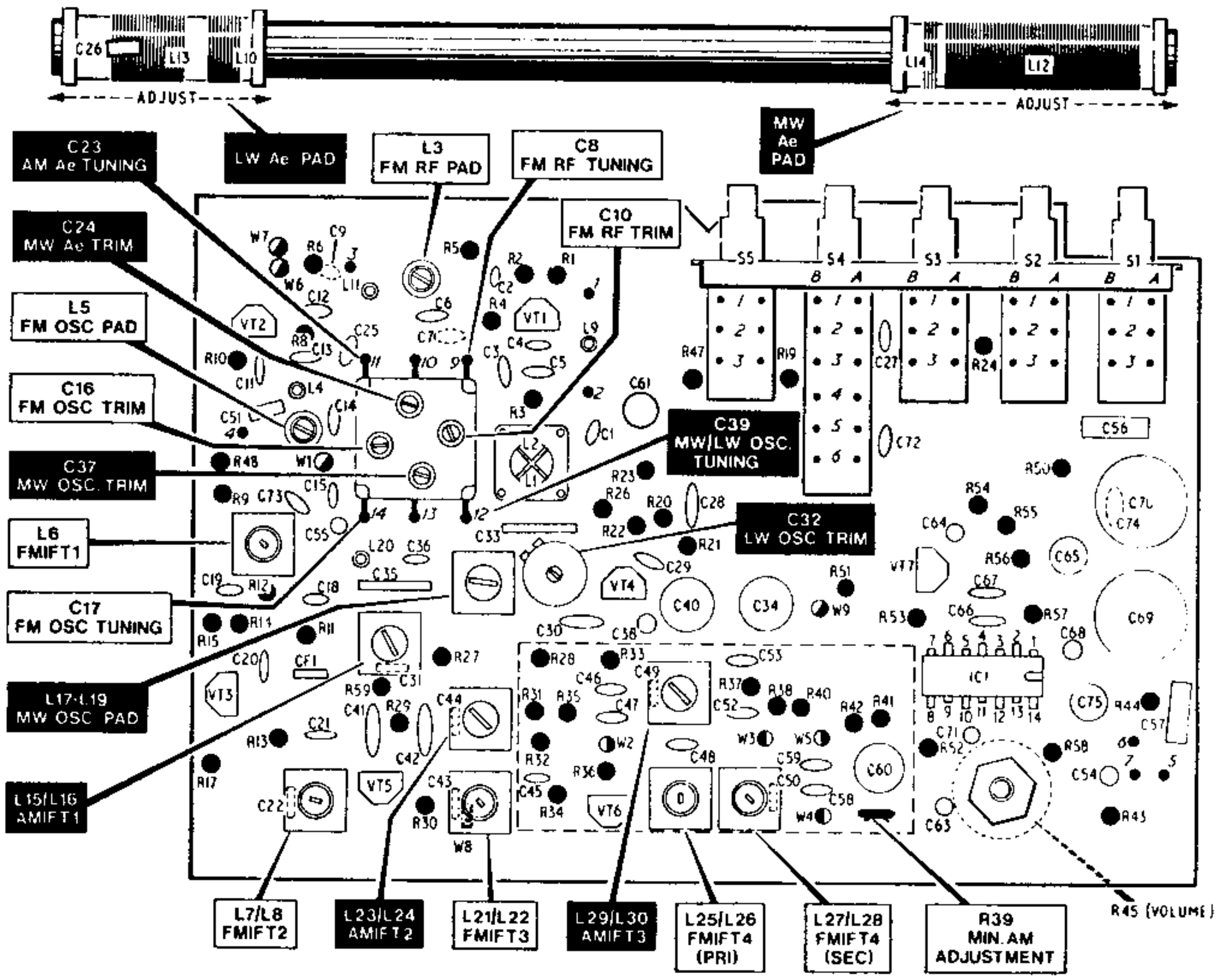
While the mechanical fixing should present no problem, the actual realignment should be carried out at the low frequency (high metres) end of the dial.

Set the dial pointer to a well known station at say 500 metres (600 kHz) on the medium wave, reset the slugs to tune in the station and fix them at this setting. The tuning should then hold good over the rest of the dial if the trimmers have not been disturbed.

### *What is the difference between a trimmer and a padder?*

A trimmer is used to bring the aerial, r.f. (if used) and oscillator frequencies into line at the high frequency end of the scale (medium wave, say 1.6 MHz or 187 metres) whilst a padder is used to align them at the low frequency end. Padding may be carried out by adjusting the slugs in the cores of the oscillator and r.f. coils, and the position of the aerial coils on the ferrite rod (Fig. 12), or (usually in older sets) by adjusting a variable capacitor in series with the coils.

This takes into consideration the different effect a tuning capacitor has at different frequencies and can be largely offset by the design of the assembly where the shape of the tuning vanes can be made different for the aerial and oscillator so that they track together through the whole (near enough) tuning range. The maker's alignment instructions specify which adjustments are required at which frequency and once this has been carried out a few times on different sets there is very little difficulty. The golden rule is not to disturb a trimmer until its precise function is known.




Printed circuit board, viewed from components side, showing alignment adjustments.

*Fig. 12. Layout of the printed circuit board, components side, showing adjustments (Ferguson 3182)*

## *How do the coils on the ferrite rod differ?*

Some multiband radios have more than one ferrite rod. For example, the long and medium wave aerial coils may be wound on one rod and various short wave coils on another, each selected by the wavechange switch. However, the majority of sets encountered will have one rod only and the various coils will be found on this. The larger multilayer winding at one end is the long wave aerial coil, the single layer coil at the other is the medium. Between may be the widely spaced short wave coil or the external aerial coupling coil connected to a separate aerial socket. Since these coils are usually secured to the rod by wax or some other means, their position is fixed and if they have been moved the original position can immediately be seen. Provided the rod is undamaged the coils should be returned to this position and secured there. If this impairs reception, the dial should be set for a known station at the low frequency end (high metres) and the oscillator coil slug adjusted to bring in this station. If the correct position for the coils on the rod is not known, tune the dial as above and slide the relevant coil on the rod for best reception and secure in this position.

### *What if the rod is broken?*

If it is broken in the centre it can usually be cemented or joined without a serious loss of inductance as alteration of the coil positions will show. Quite often however it is necessary for a new rod to be fitted and these are generally available from component stockists. If the exact replacement is not available, choose the next size down and secure the coils on the new rod with wax, having ascertained their best revised position, say for Radio 4 on the long wave (200 kHz) and Radio 2 on the medium wave (693 kHz) or some station between 630 and 600 kHz (470 and 500 metres).

### *How does one tackle a broken dial cord?*

With caution. Although some dial cords are extremely simple to restring, usually where a large drum is fitted, others are very difficult to say the least. First examine the existing cord to see how it is threaded round the main and secondary pulleys, making a drawing showing the number of turns and their direction (Fig. 13). The broken cord will usually retain some of its original shape to enable one to get an idea of the direction of the turns.

Most service sheets or manuals give explicit instructions regarding the length of cord, the start and finish, number of turns etc. and these should be followed faithfully. Nothing is more frustrating than to tediously restring a dial drive only to find that the pointer travels in the reverse direction when assembled.

Note the movement of the cord in relation to the print on the dial and the movement of the tuning capacitor gang or the tuning slugs. As the gang opens or the slugs withdraw, the cord (which will carry the pointer) should travel to the high frequency end of the scale, i.e. 1600 kHz (about 187 metres) medium, 300 kHz (1000 metres) long and say 108 MHz v.h.f.

One end of the cord can be temporarily tied off to a convenient point or weighted while the other is threaded and

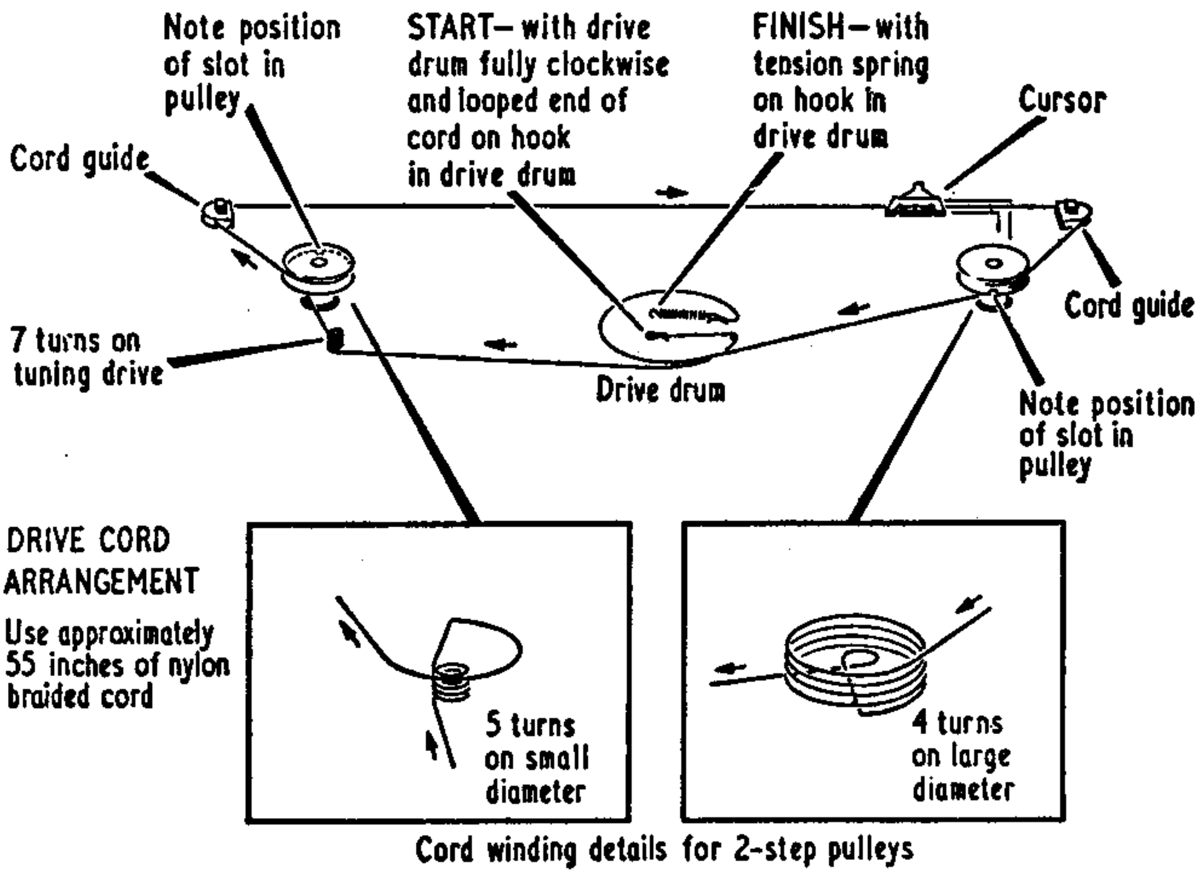



*Fig. 13. Dial cord stringing for the Ferguson 3182*

then secured to the spring or bollard as the case may be. When the final knots are tied they should be secured with a dab of adhesive. When a soldering iron is being used anywhere near the cord, move it well out of the way or cover it, say with a large crocodile clip.

Also bear in mind the fact that some dial pointers are intended to remain on the dial when the panel or chassis carrying the drive is removed. Look for an opening where the cord can be unhooked from the pointer, usually at one end or in the centre and mark the cord at this point.

# 4

# CAR RADIOS

### *How do car radios differ from those already considered?*

From a servicing point of view there are several things to consider. It is difficult to service a car radio actually in the car and once it is removed it is minus its power supply and aerial and often its loudspeaker as well. Therefore one needs a bench supply preferably switched from 6 V to say 15 V (approximate to the car charging voltage) at about 1 A. There should also be some sort of current limiter to reduce a possible short circuit overload, say in the form of a wirewound resistor of one or two ohms.

### *Why is a current limiter desirable?*

The supply unit will probably have fairly long leads with crocodile clips and although these will hopefully be insulated, they could at some time come into contact with each other. They could also be connected by mistake incorrectly to the radio if the polarity is not known or accidentally in other cases. In addition, there could be a dead short in the radio and the fuse may have been left in the car (albeit blown), or in the course of testing a short circuit could suddenly be presented. If the bench supply unit has a more elaborate specification this may not be necessary since a cut-out may be provided but this is not always the case.

*What sort of test loudspeaker should be used?*

A small 4 Ω unit will suffice for most but some later models may require 8 Ω. If in doubt use the 8 Ω unit.

*Can any piece of wire be used for an aerial?*

As a rough test, yes, but this will not match the tuning of the set. The aerial trimmer should be left as set and the test aerial should be either a car aerial or a similar length of wire at the end of say two metres of coaxial cable terminated in the correct type of plug.

*What are the first steps in checking a car radio?*

Ascertain whether the set has been in use in the same car before it failed. It is possible that an attempt has been made to fit it in a car with a different battery polarity.

Whilst there are some car radios which incorporate a bridge rectifier which automatically selects the correct polarity for the set proper, the majority have to be switched or adjusted in some way to ensure correct working. There are others which are permanently wired for either negative or positive earth only and cannot be altered. A refinement is the addition of a diode which conducts only when the polarity selection is correct, thus the receiver will appear 'dead' when the polarity is incorrect.

This may be confused with an alternative whereby a diode is connected across the supply so that it blows the fuse if the polarity is wrongly set. The snag here is that in passing the current necessary to blow the fuse, the diode may become permanently shorted.

*What are the things to look for?*

Since most car radios have a dial or indicator lamp, the fact that this lights when a supply is connected means at least that the supply is reaching the on/off switch. If it doesn't, either the lamp is faulty (as it often is), the on/off switch is defective (as it often is) or there is a break between the supply input and the switch which could be due to an open circuit filter coil or choke, a burned up track due to excessive fuse rating or perhaps a poor contact on the polarity selector. A quick check is to take the supply direct to the on/off switch, having ensured correct polarity and the supply is protected (fused).

***If the lamp lights, but the set is inoperative, what is the next step?***

First make sure the loudspeaker is properly connected and then look for visual signs of damage in the output stage. It is extremely common for output transistors to short and to burn out their associated resistors. This is often compounded by the rating of the supply fuse being far in excess of the correct 1 A or so. If there is no sign of damaged components to indicate the probable cause, proceed exactly as outlined previously, checking the supply to the output transistor(s). If the supply is present, remove the supply and check with the ohmmeter for forward conduction from base to collector and emitter and for direct shorts.

Since the supply source is probably operated from the mains, if the output stage is working at all there will probably be a degree of hum from the loudspeaker so this is some sort of aid. Once again, the type of output stage determines the results to be expected. Transformer coupling enables the stages to be separately checked whereas d.c. coupling can result in a defective early stage switching off the output. The usual short cuts apply. Listen for the effect of the on/off switch. Apply test signals (or a screwdriver blade) to the volume control. Check transistors and coupling capacitors in particular.

***What usually causes the supply to be overloaded (blown fuses)?***

A defect in the output stage is by far the most common cause. The cheaper type of radio may employ output transistors of the AC128 type (2SB prefix for Japanese transistors, the actual numbers varying enormously) which tend to develop a collector to emitter short as soon as the car charging voltage rises a little. Others may use the more substantial AC161-162 matched pair (Fig. 14) but these also are inclined to short with monotonous regularity. Larger types such as the AD149 are

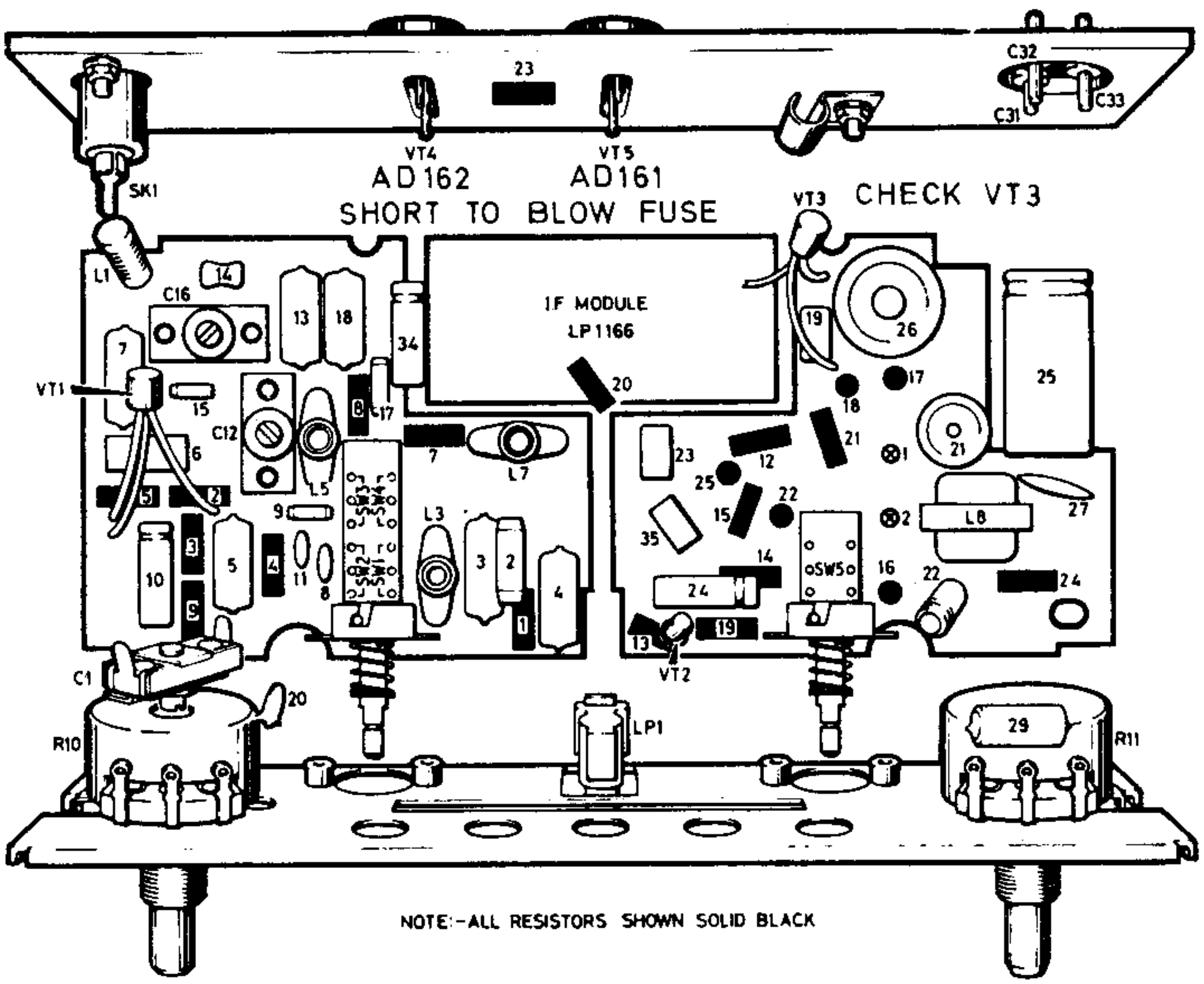



*Fig. 14. Layout of a typical car radio (Ekco CR939, 1967) showing component locations. The output transistors are mounted on the rear panel of the case, which forms a large heatsink*

more reliable. Experience so far with sets using i.c.s is that these tend to go open-circuit rather than cause overloading by shorting internally, but this must become more common as time goes by. Shorted electrolytic capacitors is a far less frequent cause. The general rule is to check the output transistors first, tidy up any mess such as burned out emitter transistors and then check for contributory causes if any d.c. coupled circuits are involved.

### *If the output stage is in order, is the audio suspect?*

Suspect yes, but in fact it will rarely be found at fault. In any case, it is a matter of moments to apply a check to the volume control which in the case of a car radio, is more definite as more power is provided than in say a small radio with a few milliwatts output. If there is little response from the volume control, it doesn't take long to apply signals either side of the coupling capacitor (trace from centre slider of control) and through the audio transistor(s).

A point to bear in mind is that the full supply is applied to the output stage but the audio supply is via a decoupling resistor and that the associated electrolytic could be leaky, resulting in a drastic loss of voltage in all stages other than the output.

### *What is a Phantom Dabbler?*

This is the unmentioned person who unsuccessfully attempted to repair the set before it was handed to you. This is one of the factors which should be taken into account upon initial inspection. A prime example is transistors taken out and replaced either incorrectly or in the wrong position.

### *What faults does a Phantom Dabbler leave behind?*

One of the most common is where the set has failed for some reason, say having been fitted in a car with the wrong polarity, and the AD161 and AD162 transistors have been removed for test. They are then replaced in the set but in the wrong positions leaving much doubt in the mind of the repairer. If this is suspected, the first move is to check the transistor type and the voltages which will be applied to it. In the case of the pair mentioned, the AD161 is an npn type which should have its collector (body) connected to the positive line. An AD162 is a pnp which has its body returned to negative, i.e. the chassis in the case of a negative earth radio. Thus by simply checking the connection of the body of the transistors much time and confusion can be saved. If this is done with an ohmmeter, disconnect the dial lamp. Since this is wired directly across the supply, it can give misleading results when an ohmmeter is used. Look for obviously disturbed soldered connections and check that these are correct.

### *What are the most common causes of loss of signals in the i.f. and r.f. stages?*

Defective transistors are the most common cause, followed by defective capacitors.

### *How are these defects located?*

There are two methods. One is to use a signal injector and methodically move back through the i.f. strip from the detector to the aerial input until the faulty stage is found, the other is to take voltage readings at each stage to find where these vary from those expected. The latter method also acts as some sort of signal injection as there should be audible clicks as the meter is applied to the relevant bases and collectors. These checks are far easier to make in some sets than others or more accurately, far more difficult in some due to restricted space and unmarked print.

Once again, the widespread use of transistors of the AF117 type in many different makes offers the delightful possibility of a very quick repair by the simple expedient of clipping through the screen lead once this can be definitely identified. Other types of transistor fail more often due to base to emitter leakage or an open-circuit junction. An ohmmeter test will usually enable the culprit to be found once the print connections are identified. Here a strong concentrated light is of great help.

### *What hints can be given regarding faulty capacitors?*

Many well known makes of car radio use small polystyrene (silver) capacitors of some 400 pF to tune the i.f. coils. As these are inside the can they can present a problem. The effect is that the signal is lost or is severely attenuated at one stage although the transistor and its voltages are correct. This is often difficult to locate when the faulty capacitor is associated with the final i.f. transformer (before the detector) and is doubly difficult when the capacitor defect is intermittent, resulting in full strength signals at one moment and very little the next. Here there is no alternative to removal of the suspect can in order to gain access to the component; the capacitor can be clipped out and the replacement wired to the print underneath when the can has been reassembled (unless of course the replacement is of the exact size and can be accommodated in the correct position). If the fault is not intermittent, the can need not be stripped out, merely the replacement held across the relevant pins to see if this restores the signal strength. If a signal generator is to hand, the correct i.f. can be injected and the suspect identified as being that associated with the coil core which will not tune. Capacitors of this type are commonly used in mixer-oscillator stages and can when defective 'kill' the oscillator or shift the tuning as previously described.

It must not be assumed that only polystyrene capacitors give trouble. Tantalum capacitors (small bead types with high capacitance for their size) seem to leak or short thus upsetting the a.g.c. or supply circuit, usually around the r.f. stage. Small electrolytics have similar habits and are always suspect, usually upsetting the voltage readings of the stage concerned.

### *Do a.g.c. circuits give much trouble?*

Not usually, because of their relative simplicity. Usually the resistors can be ignored and the diode concerned can quickly be checked with the ohmmeter. The capacitors are more troublesome (on the rare occasions when the a.g.c. is at fault) usually due to leakage.

Depending upon the circuit, the effect can be one of no signals at all or excessive signals interfering with each other with various types of oscillation and whistles. The a.g.c. diode should be the first suspect, not only because it is likely to be the item at fault, but also because it is the easiest one to check. Its forward resistance would typically be around 200 ohms, very much higher when the leads are reversed.

***Which of the signal stages is most likely to be found defective?***

Usually the r.f. stage because being coupled to the aerial it is more subject to the accumulated static induced into this under normal conditions and particularly so in stormy weather (for the want of a more descriptive term). The peaky waveform voltages in this part of the circuit often cause the r.f. transistor to fail. Therefore if the audio stages are in order, it is prudent to inject signals direct into the mixer stage to see if this produces results. If so, the r.f. transistor and associated capacitors are suspect. This is why we direct attention to the capacitors in this part of the set in particular.

The voltages due to induced static are often surprisingly high and are responsible for the failure rate in transistors and capacitors with fairly low voltage ratings.

# 5

# NOISY OPERATION

### *What are the prime causes of noisy operation?*

It is first necessary to define what is meant by noise. The problem is that it is difficult to describe in words what is heard by the ears.

The effect of a dirty volume control is well known and easily dealt with (usually) by a deft squirt (not too much) of switch cleaner of the type which does not attack plastics. Even this is not as simple as it sounds, however, because the noise created by an apparent poor contact in a control is often the result of a leaky capacitor which is allowing d.c. to pass to the track of the control and no amount of cleaning is likely to effect a cure. The clue is that a noisy control is noisy more often when it is being rotated whereas a leaky capacitor will not only worsen this effect but will give rise to intermittent rustling and varying output. If in doubt, the voltmeter set to a low range will detect a variation due to a leaky capacitor or a constant reading where there should not be one at all.

The volume control is also a convenient point to discover in which part of the circuit the noise is being generated. If the noise remains when the control is turned down, the fault is likely to be in an audio stage following the control.

### *How is the actual source located?*

First look at the type of circuit which is being used. The job is far easier if there are transformers or at least capacitors separating each stage, since the d.c. operating conditions of one stage can be tampered with without the succeeding stages being affected. For example, in the circuit shown in Fig. 5 it will be seen that the preamplifier takes its base signal from the volume control via a 4.7 μF electrolytic. The amplified signal voltage appearing across the 2.2 kΩ collector resistor is coupled to the driver by a further 4.7 μF, so that the base and emitter of the preamp can be shorted to 'kill' this stage without the driver and output pair being affected.

Thus a suspect preamp can be eliminated from a noise point of view merely by shorting base to emitter. If the noise continues it must be in the collector 4.7 μF or in the driver and succeeding output. Again, the driver can be similarly checked.

By this means, the source of the fault can be rapidly narrowed. This cannot be done in d.c. coupled circuits such as that in Fig. 9. Shorting the base to emitter of TR1 upsets the working of TR2 and shuts off the output pair and produces no conclusive result. Therefore other means have to be used.

### *How can a noise source be located in a d.c. coupled circuit?*

The most elegant method would be to use a pair of high impedance headphones with one side on the earth line and the other connected via a capacitor to each suspect point in turn, starting from the volume control. If no noise is heard here, connect to the base of TR1, then the collector, base of TR2 and so on until the noise is heard. In fact this is not a good example due to the feedback path but it serves to illustrate the general idea.

An alternative is to employ a capacitor to short the signal and hopefully the noise to earth whilst leaving the d.c. conditions unchanged after the initial charging current of the capacitor has had its effect. This works up to a point but the capacitor must be discharged to earth after each check so as to preclude the possibility of it discharging through the base emitter junction of a transistor and thereby destroying it. Another way is to use the voltmeter to record the fluctuations and work back to the early stage to find where the variations stop. If none of these methods work or the results are confusing, use a hair dryer to heat up particular components and then rapidly cool them with an aerosol freezer. Noisy transistors are often heat sensitive and this method seems to work a surprising number of times. It is also invaluable when dealing with suspect integrated circuits which seem to be sensitive to the slightest temperature rise.

### *What happens when the noise reduces as the volume is turned down?*

One then has to determine at what stage the noise is being introduced. A strong possibility is the wavechange switching and a squirt of switch cleaner on the switch contacts can often clear the trouble but really this is rather an obvious source since operating the switches should tell you whether or not these are at fault. A more methodical approach is to work from the detector stages back along the i.f. strip (if this is made up of discrete components and not 'canned') shorting in turn the base emitter junctions to render them inoperative until the stage is reached where the noise remains. The stage is then identified and the few components involved can be checked out.

### *What items are likely to cause noise?*

To a certain extent it depends upon the set. For example, several Grundig models suffer from dry joints in the i.f. transformer coil connections and it is rather tedious to remove the complete can, strip it down and locate the poorly soldered connection. Since these items are very small, it calls for very delicate handling to dismantle and reassemble them. It is better to obtain and fit a new unit. However, it is often possible to overcome the trouble without dismantling simply by applying a hot iron to each soldering post with the object of resoldering the internal connection. This can succeed in a large number of cases.

Transistors and capacitors are however responsible far more often and provided there is reasonable access, there should be little difficulty in replacing the one or two items involved. The real difficulty arises when the entire i.f. strip is contained in a module. If a replacement module can be obtained, no more need be said; if it cannot, the casing will have to be removed, having first removed the module from the circuit, and the supply and output connections extended for reconnection to the board. This is by no means easy in some receivers in others it is downright difficult, certain Roberts models being shining examples of inaccessibility.

### *Are there other aspects to the noise problem?*

Unfortunately there are many. Among the more frustrating is the fact that the noise may apparently be cleared only to reappear when the receiver is cased up. The reasons for this may be many and varied. Sometimes only a pulse is needed to temporarily seal up a poor contact in a component, be it a capacitor or a transistor, or perhaps a dry joint on a coil. This pulse may come from the equipment (or some other nearby) being switched on or off, the application of test probes or perhaps of a soldering iron. The fact that the noise stops is by no means the end of it. Unless some valid reason has been found for the disturbance therefore it must not be assumed that the trouble is over merely because it stops.

### *Are resistors above suspicion as sources of noise?*

Indeed no. Although they cause less trouble than other components, they must still remain on the list of suspects. Some however are more suspect than others. Resistors may be perfectly made but when inserted into a board may be subject to stress. Over a period and perhaps after added strain, the end clips lose positive contact with the carbon and one then has a classic dry joint, this time without solder, the intermittent contact giving rise to noisy or varying results depending upon the circuit and the resistance at the poor connection. Gentle probing with a light insulated tool, say part of a plastic knitting needle which, with a shaped end, also acts as a trimming tool, will often identify the culprit.

### *What other likely sources of noise are common?*

Connectors are the first items which should be checked. These may take the form of single clips or multi-way strip connectors. Check the goodness of all contacts and examine the print underneath where undue pressure when inserting a strip or plug may have damaged the print or solder under the socket. A similar condition occurs when sub-panels (i.f. transformers etc.) have edge connectors and these are soldered to the main panel. A poor connection can be difficult to locate under these conditions and it is advisable to resolder each connector carefully so that a very small amount of solder runs onto the internal copper connection.

### *Can the power supply be a source of noise?*

Quite frequently, and it is often overlooked. The best check is to provide an alternative source if this is practical. Failing this, if the receiver is battery operated only, check the cells, the spring contacts and the soldering to them.

If a mains unit is involved, it is not difficult to unhook this and substitute a battery. If this cures the noise, examine the power unit, suspecting poor contact on the secondary winding (thicker wires) supply to the rectifier(s), intermittent diodes, defective smoothing electrolytic capacitors etc. This is also essential if the noise is in the form of a hum.

### *With mains units becoming more common, can more be said about hum?*

A low degree of hum must be expected but if the level is obtrusive, the type of supply should first be understood before steps are taken to remedy it. A transformer is the first item in the circuit. Whilst the primary winding poses no problem (other than its habit of becoming open-circuit and bringing the whole thing to a very quiet end), the secondary may be simply one winding with the ends brought out to feed a half-wave rectifier (one diode) or a bridge rectifier (four diodes). An alternative is two secondary windings with a common centre tap, the two free ends supplying separate diodes in a full wave circuit. In the latter case, although the windings themselves rarely become open-circuit, it is not uncommon for one end to be poorly soldered leaving only one diode conducting. Thus one has half-wave conditions in a circuit which is designed to cope with full wave, i.e. 50 Hz instead of 100 Hz. This gives rise to the same conditions which would obtain if one rectifier diode was to become open-circuit. These points are easily checked with an ohmmeter. The rule here therefore is to check the secondary windings and the back to front conduction of the diodes.

The voltage output of the rectifier is heavily rippled and must be smoothed by electrolytic capacitors or by an electronic circuit acting as a regulator. Therefore electrolytic capacitors are the chief suspects if the hum level is obtrusive. Sometimes bridging the suspect with a known good capacitor of similar value will verify the fact but this is not really a conclusive test since it may well be that the added capacitance is helping matters but this is not the answer. There are several points to consider. A circuit which draws excessive current will require extra smoothing to achieve the same hum level. If in doubt therefore, check the current drawn compared to what it should draw. If the current is not excessive, the cause could be an open circuit rectifier diode or a transformer defect. Normally however, the smoothing capacitor will be found faulty and a replacement will restore normal working.

### *What is the electronic smoothing circuit?*

A stabilised voltage supply obviously has many advantages and many radios incorporate a regulator circuit, albeit a simple one. Since its function is to conduct more as the supply tends to fall, and less as it rises, it will be seen that it also acts as a smoothing circuit and therefore high value electrolytic capacitors are unnecessary. However, lower value capacitors are used in this circuit and if these lose capacitance, the efficiency of the regulator is impaired and therefore the smoothing effect.

### *What action should be taken if hum is present?*

If the hum is loud and raw, the cause is likely to be an open circuit electrolytic capacitor. Bridge the suspect and replace it if this action is completely effective. If the hum is more subdued, check both diodes in a full-wave circuit and all four in a bridge (if the bridge is formed by separate diodes; replace the block otherwise).

If the diodes are in order, check the electrolytics which could be drying up. Check the transformer secondary if in two sections. Check the current drawn by the receiver to see if this is excessive. If a voltage regulator is employed, check the control transistor and associated capacitors, also the regulator transistor if necessary. Normally a defective regulator would give more definite signs of defect with the voltage either being high or low.

### *What does 'bridging suspects' mean?*

This is a common term meaning that a known good component, such as a capacitor, is connected across a suspect which could be open circuit or could have become low in value. It is a quick check and is conclusive only when the suspect is disconnected from the circuit.

Resistors suspected of being open circuit or high in value are often checked in this way but again the check is not conclusive in all cases and should be employed with caution.

Electrolytic capacitors must be of similar or higher voltage rating than the suspect with approximately the same capacitance. Connection from a polarity point of view is vital since they present a virtual short circuit when incorrectly connected.

### *What other items are likely to cause hum?*

If the radio is giving normal results there are very few instances where hum will be troublesome. There are a few high impedance circuits which require screening in the average set and disconnected screening can give rise to hum in audio stages which are otherwise working properly. When this sort of trouble is experienced, the leads to and from the volume control are those which should receive attention, in the rare cases where the screening is separate from the circuit proper. This type of problem is far more likely to be met in amplifiers and valved radios.

Hum can also be the result of output transistors drawing too much current, but this condition would be accompanied by distortion which would draw attention to the source of the trouble.

### *What hints can be given on noise causes and their location?*

The most common type of noise is that caused by dry joints and the like, in other words, improper connections inside components or between components and soldered connections. Noisy controls and switches being fairly obvious need not be considered. If the source is after the volume control the cause is likely to be a transistor in the first a.f. stage. Less likely are coupling capacitors and less likely still (but still to be considered) the higher value capacitors in the supply line.

If the noise occurs before the volume control, i.e. the noise fades with the rotation of the control, progressively work back through the stages, shorting base to emitter until the noise continues and then examine the offending small part of the circuit left. To clarify this, if shorting out the final i.f. transistor stops the noise but it continues when the second i.f. is 'killed', the trouble is either the final i.f. transistor itself (as the noise stopped when it was rendered inoperative) or an associated component or coil between the two stages. As already mentioned, a dry joint in one of the i.f. coil lead outs is a very strong possibility if the transistor is not at fault.

### *What causes poor reception and background noises?*

This is usually due to a poor aerial installation, inaccurate tuning or a defective r.f. stage as far as v.h.f. is concerned (or car radios in some cases) and depends upon the situation to a large extent. If there is doubt about the r.f. stage, aerial signals can be applied direct to the mixer, which will further upset the tuning, but at least the point has been proved, i.e. that there is a fault in the r.f. stage which is giving rise to loss of gain. This type of trouble is far more common in car radios than the average type of domestic radio.

# 6

# SERVICING VALVED RADIOS

### *Are many valved radios still working?*

Yes, there is a surprising number of sets still in daily use as table models, radiograms and communications receivers. It is not easy to purchase valved replacement sets and they often have a sentimental value. Even sets 40 years old are still capable of good results. They also present a challenge as well as a change to the repairer.

### *What are the basic power requirements?*

Apart from a few odd car radios using valves in the signal stages which operate from a 12 V line, a smoothed h.t. line of something like 200–300 V is required, ignoring small battery operated portables which work between 75 V and 90 V, and some imported 110 V equipment. In addition to this h.t. supply, valves require to be heated either by a 6.3 V transformer winding feeding the heaters in parallel (Fig. 15) or in a series chain (Fig. 16) which can be derived directly from the mains via a suitable dropping resistor. In a parallel feed, all heaters have the same voltage rating with different current drawn for the power valves, whilst a series chain demands the same current rating (typically 100 mA), with differing voltage ratings.

The low-voltage heater winding(s) on a suitable transformer are usually accompanied by a centre-tapped h.t. winding to provide full-wave rectification while receivers using series

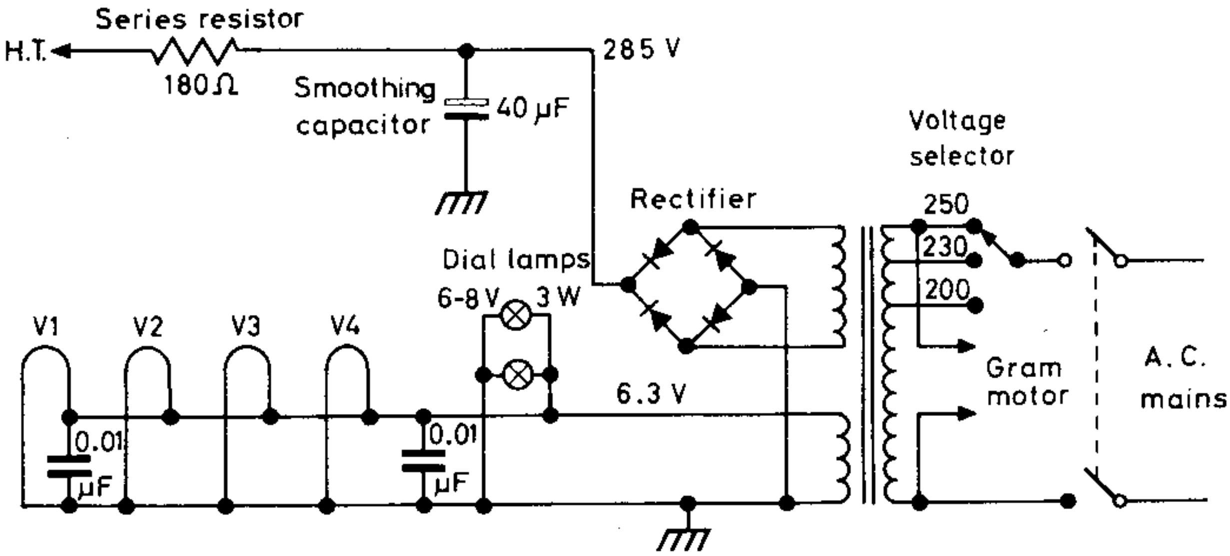



*Fig. 15. An example of a 1962 radiogram chassis with a mains transformer (Ekco SRG 412)*

heaters derive h.t. from a half-wave rectifier, the anode of which is fed from a tapping on the mains dropper resistor. There are variations of course as can be seen from the illustrations.

### *What are the advantages of using a transformer?*

Apart from the receiver being isolated from the mains (although this is not always so) the h.t. voltage can be higher if necessary and the valve heaters can be at a low potential with respect to their cathodes which reduces stress and the possibility of induced hum, particularly in the output stages. The rectifier may have a separate heater winding on some receivers, again to decrease the heater-cathode stress as the cathode provides the h.t. line voltage.

### *What are the advantages of a series chain of heaters?*

The main advantage is that the bulky and expensive transformer can be dispensed with and the design simplified (Fig. 16). The fact that the circuit could also be made to work from a d.c. supply is a secondary consideration.

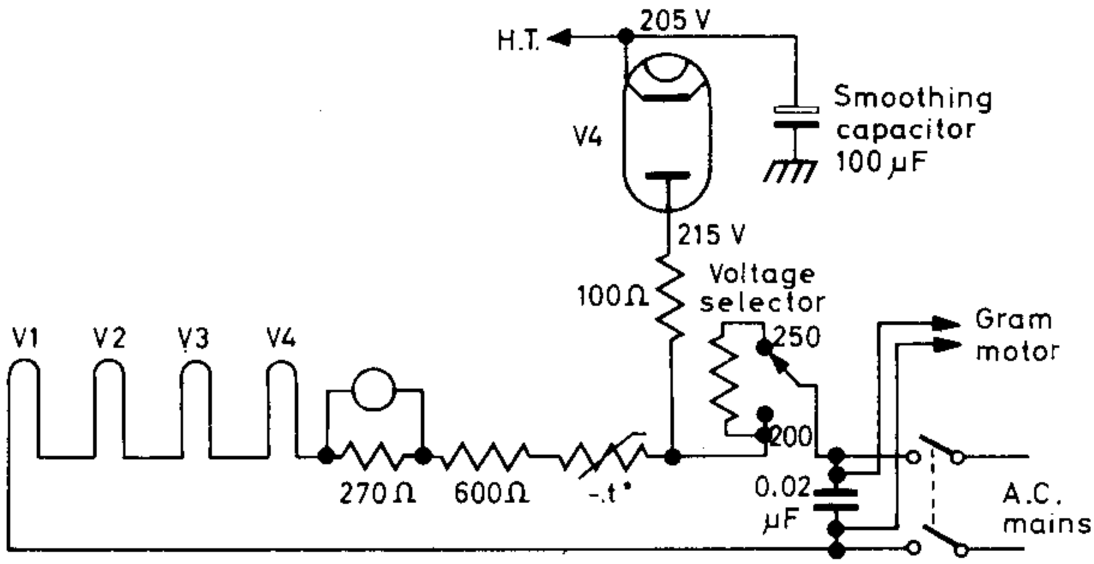



*Fig. 16. An example of series heaters (Philips F4G31A, 1964)*

### *Are valved radios more difficult to service?*

No. In some respects they are much easier and the relevant test points more accessible.

### *What extra test gear is required for valve radios?*

Provided the multimeter used has a fast cut-out, little more is required except perhaps a mains testing screwdriver.

### *What if the meter does not have a cut-out to protect it?*

More care needs to be taken to ensure that the selector(s) are set for a higher range than is likely to be present. If the h.t. line is say 250 V, the meter should be set for this range or higher if there is the slightest doubt before any tests are made.

### *What are the points to look for in valved sets?*

Obviously the heaters must glow for the valves to work and except in the case of small battery operated valves, this glow can immediately be seen. In addition there will probably be dial lamps although the failure rate of these is pretty high and

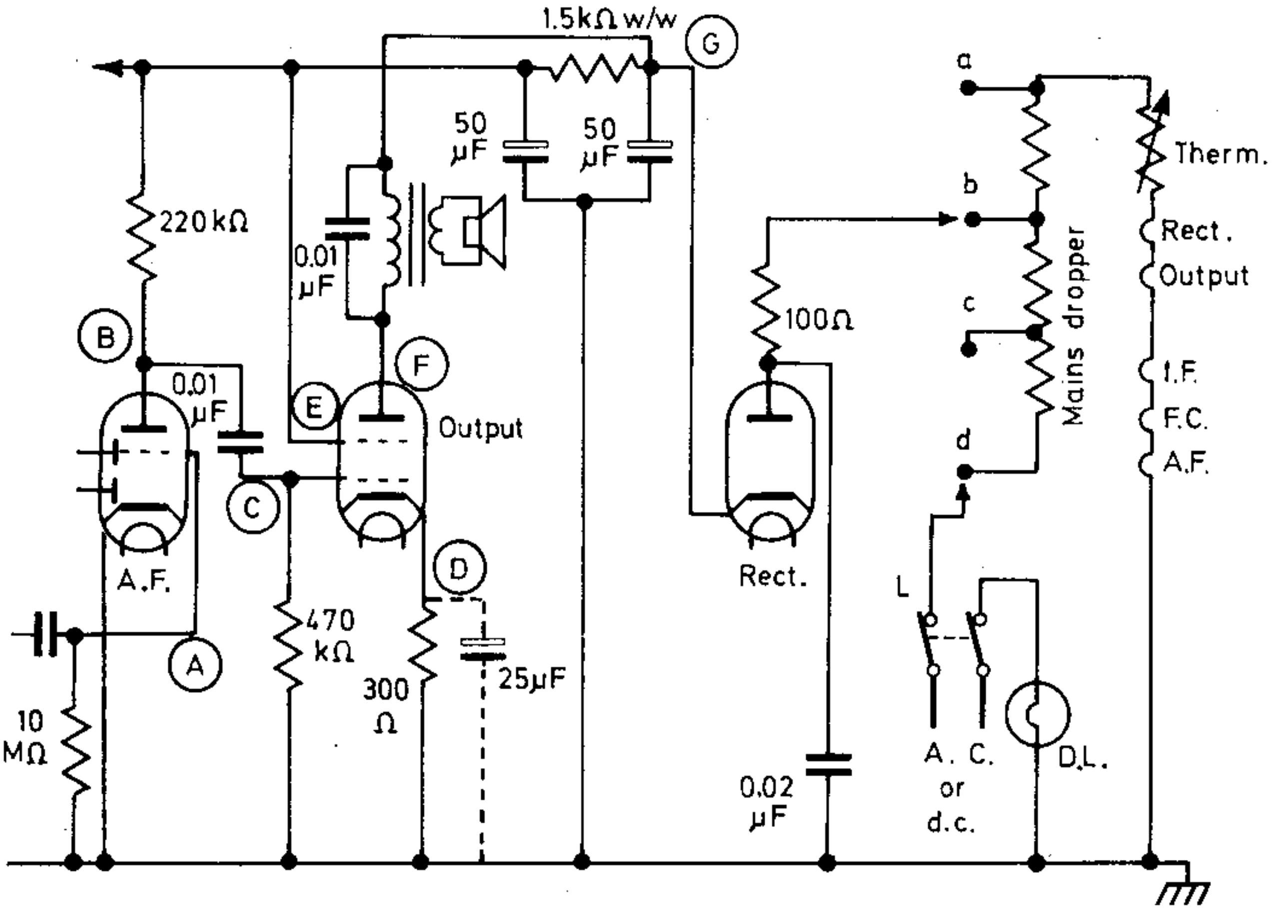



*Fig. 17. Another, less common, a.c./d.c. circuit of the mid-1950s using series heaters. If the valves were of the 0.15 A type (not usual) the L mains lead could connect to 'a' for use on 110 V mains. The dial lamp carries total receiver current and must be rated accordingly. The fact that it is not shunted by a resistor means that it also functions as a fuse. If no valves light, check lamp or fuse and dropper resistances before suspecting valves*

**Check points**

A Should be negative with normal signal input.
B Should be around 20–50 V.
C Must not be positive. A positive reading would indicate a faulty output valve or leaky 0.01 μF coupling capacitor.
D Should record positive voltage depending upon current drawn. If much higher than 12V for 40mA, check for positive volts at C.
E Should be 100V or more depending on supply voltage. If absent there will be no voltage at D.
F Should be full h.t. less the small drop across the transformer primary. If absent, check at G. Primary winding could be open-circuit.
G Output of rectifier. If absent check 100Ω anode supply resistor. If this is low and the receiver hums loudly, check 50μF electrolytics.

the fact that they are not lighting is no positive indication that they are not supplied.

If the valves are in a series chain, the fact that one heater is not glowing will probably indicate that this valve is cracked (the heater does not glow if the vacuum is impaired). If the heater were open circuit, the series chain would be broken and no valves could light up.

If the valves are parallel fed from a transformer, any one could fail without the others being affected.

If the heaters are glowing, but there is not other sign of life, the h.t. supply is probably at fault.

***An initial loudspeaker check was advised when dealing with transistor radios. Do larger loudspeakers have the same failure rate?***

No. It is very rare to find an older type loudspeaker speech coil open circuit. Rare, but of course not unknown. However, there is often provision for an external loudspeaker with a muting switch or plug ( or screw) to disconnect the internal one and this can give rise to trouble (poor contact etc.).

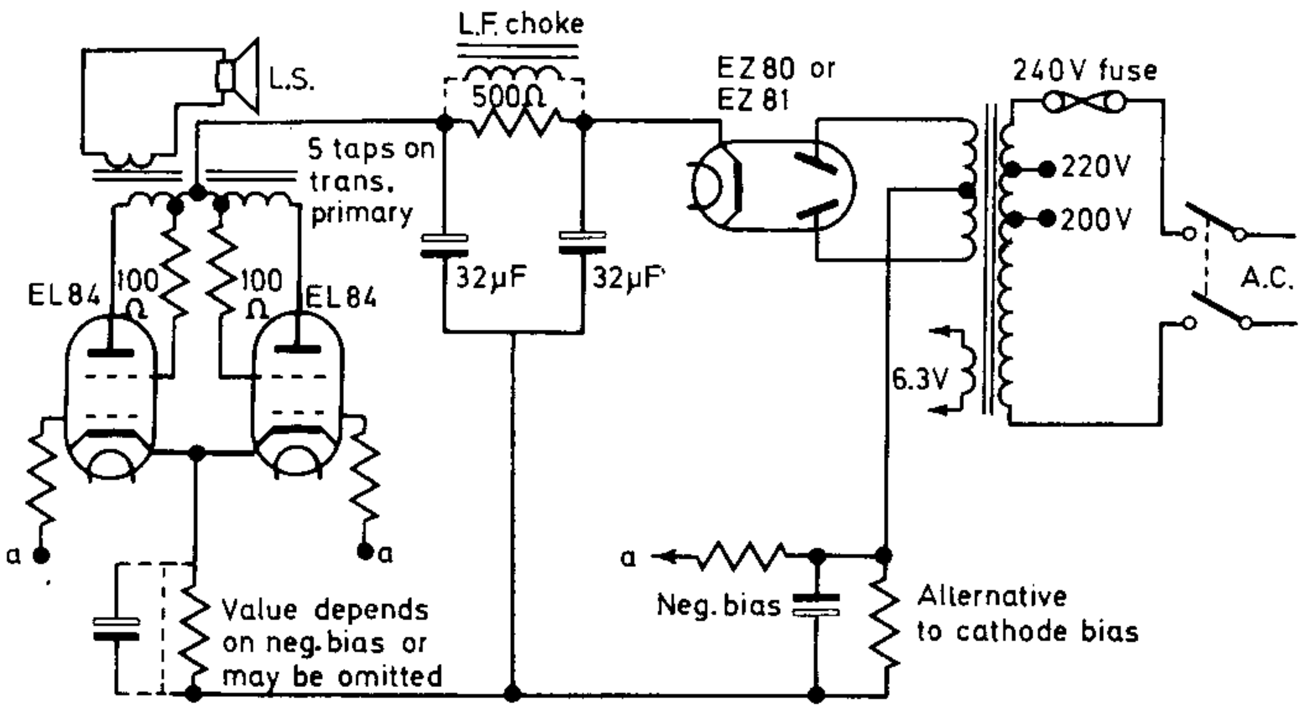



*Fig. 18. A push-pull output stage and power supply (bare essentials only)*

Therefore it is prudent to check any such selector before proceeding further.

The 'high risk' item is in fact the output transformer which will often be found with an open circuit primary winding. This supplies the loudspeaker via the secondary winding, so the result is a lifeless loudspeaker but a very lively h.t. supply line to other parts of the receiver, including the g2 electrode of the output valve (Fig. 18). Since the anode of the output valve is fed from the transformer primary, this can no longer draw current and the screen or g2 electrode is left collecting far more current than normal and may present a red hot spiral of wire appearance inside the valve thus proclaiming (a) that it is overheated, (b) that there is h.t. present and (c) that the anode is not drawing current. All this can be seen at a glance and is helpful to put one on the right track.

### *Do output transformers vary in appearance?*

Yes, considerably. They may be small, bolted or rivetted to the loudspeaker with a pair of leads to the loudspeaker and a pair from the primary leading back to the output valve. Also there could be a further tapping on the primary to provide a measure of smoothing for the rest of the set (other than the output anode). This arrangement will normally be found on receivers using a printed panel. Older sets with a metal chassis usually have the transformer on the chassis near the output valve. These usually have tags which provide a convenient test point. Tone compensating components usually consisting of a capacitor, or a resistor and capacitor in series, may be found wired across the primary tags. In some cases the transformer may be fairly large and may have many tappings, several primary tappings to provide push-pull output for two output valves with perhaps added tappings for the g2 electrodes in order to improve the output response.

A few transformers have an additional winding for negative feedback to the audio stage (again to improve the quality) but in general such feedback is taken from the loudspeaker secondary winding.

*All this sounds confusing. Is it in practice?*

No. If there are two output valves they will normally be of the same type (e.g. EL84, ECL86 etc.) and this immediately indicates that there must be a minimum of three primary contacts (one h.t. supply and one for each anode) with perhaps two more tappings for the screens (g2). If there is only one output valve there will be only one primary winding with perhaps a tap for smoothing to make three tags which should carry h.t.

*Using an ohmmeter, what are typical resistance readings of the windings?*

First identify the secondary winding which feeds the loudspeaker; a meter applied across these tags will show a very low reading and will produce an audible click in the loudspeaker. If there are only two tags on the primary the reading of this will depend upon the ratio of the transformer (to suit the particular type of valve used) but typically a figure of about 500 Ω will be recorded. A much lower value could indicate shorted turns and could account for low output when all other items have been checked. If there is an h.t. tap for part smoothing there will be a much lower reading from this to the h.t. supply tag but the 500 Ω or so to the output anode is the important factor. A push-pull transformer will have two high resistance windings (one to each anode) with the other taps being less likely to suffer breakdown.

*What other troubles are likely to affect the output stage?*

Usually the valve itself is the chief offender. If the heater is glowing, there will usually be some output, albeit weak or distorted or both. A new valve will often put things right but voltage checks should be made to ensure that these are correct.

*Why are voltage checks necessary?*

There are two reasons. The first is to ensure that there was no contributory cause of the valve failure such as leakage through the grid coupling capacitor which would cause excessive current to be drawn. The second is to ensure that the old valve had not damaged the circuit components such as the cathode bias resistor. Excessive current through this resistor can cause it to change value (usually downward) resulting in insufficient bias and having much the same effect as slight leakage through the grid coupling capacitor.

*Would these conditions result in audible distortion?*

Not necessarily. A coupling capacitor may have only a slight leak or the bias resistor may have lost value by say half. Either will cause rapid deterioration in the new valve but this may not be immediately apparent.

*What defects other than a leaky coupling capacitor could cause an unwanted positive voltage on the control grid?*

The valve itself is most often defective and if removing it also removes the positive voltage it is reasonably safe to conclude that the valve alone is responsible and only the cathode bias resistor need be checked to ensure that this has not changed value. If removing the valve results in an increase of positive potential at the control grid connection, either the capacitor is leaky or there is some other leakage path. Removal of the capacitor is fairly easy in the majority of cases and if the voltage remains it is possible that the receiver uses a printed panel and that this has become conductive in an area very near the valve base.

*What can be done about deterioration of the panel?*

Since the leakage is probably confined to only a small area, the panel can be cut away at this point and if necessary, leads fitted to complete the circuit.

## *Is panel deterioration likely to be found elsewhere than around the output stage?*

The reason for leakage is the effect of heat over a long period. Since there is more heat dissipated in the output stage this is most likely to be affected. Other areas such as around resistors which normally run fairly warm in the power supply circuitry could be also leaky. However, such deterioration is not so serious since the panel leakage resistance will still be high compared to that of the circuit. When breakdown does occur there is little doubt about the cause and remedy.

## *If there is no voltage supply to the output stage, how is the power supply checked and what precautions should be taken?*

While it is quite likely that the h.t. is absent at the rectifier, this must not be assumed. Indeed, it should be assumed that the rectifier is functioning and that the reservoir capacitor is fully charged. It should therefore be treated with respect until the voltmeter proves that there is no voltage present. If there is doubt, identify the main electrolytic capacitors and shunt a low value resistor from each tag to chassis to discharge any residual voltage when the set has been disconnected from the mains.

The action to be taken depends upon the type of supply. If a transformer is used, it would be unusual for voltage to be absent from the rectifier and it would be far more likely for the smoothing resistor to be open circuit. If there is no transformer, and a half-wave rectifier is employed, it is far more likely that the surge resistor feeding the anode is open circuit. Figs. 15 to 18 show the relevant components and check points.

The last generation of valved receivers tended to use fairly small wirewound resistors as surge limiters and smoothing resistors and it is very common indeed to find these open circuited. It was also common to feed the anode of the output valve from the reservoir capacitor via the output primary so it is quite common to find h.t. on the output transformer and output anode, the set being inoperative due to there being no supply to the g2 of the valve and to other parts of the set. Again, the diagrams make this clearer.

### *What are the advantages of using valve rectifiers?*

A valve rectifier does not become conductive until its cathode reaches emitting temperature, by which time the other valves also become operative, therefore the h.t. builds up and remains fairly constant. Solid state rectifiers, either as separate diodes or in bridge formation, conduct immediately and as there is no current demand from the slowly warming valves, the h.t. voltage rises to a high level unless there is some device to prevent this switch-on surge.

### *What device is used to limit switch-on surge?*

A thermistor which has a high resistance when cold and a much lower resistance when hot. As it depends upon the current drawn by the valves to heat it up, there is a much slower build up. This is termed a negative coefficient thermistor.

Positive coefficient thermistors have a low resistance when cold and high resistance when hot and can therefore be used as shunts across items which tend to have a heavy switch-on surge.

### *What type of power supply is likely to be encountered?*

Most sets of European origin likely to be worth restoring to working order, e.g. Grundig, Telefunken etc. will be found to use a bridge rectifier fed from a large transformer, neither of which is likely to give trouble. It is the smoothing and feed resistors which are likely to be found open circuit. Sets of UK origin and the smaller Philips for example used series heaters with no transformer and the most common valve line-up was the 'U' series (100 mA heater current) with a UY85 as the rectifier. This is where the anode surge limiting resistor as well as the smoothing resistor are likely to be found open circuit. Earlier sets of UK origin used a metal chassis and a more substantial mains dropper which had a longer life expectancy or used a transformer with parallel fed heaters and 'E' series valves (6.3 V). There were many variations of course but this was the general pattern.

### *What typical valve line-ups are likely to be encountered?*

Fashions changed over the years of course. At one time the five valve set was the most common. This could well have used an ECH81 frequency changer or mixer-oscillator, EF89 i.f. amplifier, EABC80 f.m. and a.m. detector plus triode a.f. amplifier, EL84 output and EZ80 rectifier.

Receivers without v.h.f. facilities often used an economy line-up with an ECH81, EBF89 double diode for detection and a.g.c. with a pentode i.f. amplifier, an ECL82 audio amplifier triode with pentode output and an EZ80.

A typical transformerless design could be UCH81, UF89, UABC80, UL84 and UY85. A large number of cheap radio-grams, still likely to be encountered, used the UCH81, UBF89, UCL82, UY85 format.

### *What were and are the likely trouble spots?*

The output valve, particularly the UCL82 type, is likely to draw grid current resulting in low and distorted output with probable damage to its cathode bias resistor (around 400 Ω).

A triode a.f. amplifier will probably have an anode load resistor of some 220 kΩ. This is likely to go high and again result in low output with a typical clipped type of distortion.

The i.f. stage is usually trouble free but the same cannot be said for the multi-electrode frequency changer (typically E or UCH81). This can become noisy or stop oscillating altogether (sometimes restored temporarily by a sharp tap). It can also give rise to varying types of hum.

### *Name some other causes of non-operation*

Other commonly encountered causes of non-operation include shorted decoupling capacitors taking feed resistors to earth instead of the valve electrodes they are intended to supply, sometimes resulting in the demise of the resistor.

Other capacitors likely to short include the mains filter capacitor commonly connected from the on/off switch to earth. Depending upon the value of the supply fuse, this can stop the set working altogether or simply blow the end off the capacitor with the probable result of modulation buzz being experienced on stronger signals.

Noisy controls and poorly contacting wavechange switching are among the easier faults to deal with but h.t. tracking across the wavechange wafers can be a problem not so easily resolved.

### *What does 'h.t. tracking' mean?*

Sometimes the wavechange switch may have a 'Gram' position in which case it may be used to switch off the h.t. to the earlier stages. If one does not require the pick-up input facility, this problem is easily solved by removing the h.t. connections from the switch and permanently connecting them as required. However, the switch is often used to supply the a.m. or v.h.f. tuning sections and here the problem is not so easily dealt with. In rare cases the switch assembly may include a totally unused section and the leads from the leaky section can be transferred to this but most often the difficulty can only be overcome by fitting a new wafer (no easy job) or providing a separate switch.

The trouble usually starts by very small leakage across the switch insulation giving rise to an intermittent rustling noise much like a poorly soldered connection. However, this rapidly develops into a loud continuous crackling and rustling which completely blots out normal reception. In some cases, the offending wafer can be seen sparking between contacts.

### *How do sets incorporating v.h.f. differ from the 'standard' line-up?*

Apart from the extra i.f. coil cans, there is usually a separate tuner section containing the mixer-oscillator and r.f. tuning components, with perhaps one ECC85 (or UCC85) or two separate valves (say two EF80). The tuning may be carried out by additional (smaller) vanes on the main tuning gang capacitor or by ganged slugs inside the unit much the same as some car radio tuning arrangements.

Apart from the mechanical means of accurately moving the slugs, the only commonly encountered cause of failure is the valve(s) or the h.t. supply to the unit (less likely). In addition, the commonly used method of f.m. demodulation is by ratio detection employing two diodes.

In valved sets it is common practice to employ a valve containing three diodes (one for a.m.) in the same envelope as a triode a.f. amplifier. This is usually an EABC80 or UABC80 identified by its three heaters.

### *Do valves require bias for efficient operation in the same way as transistors?*

Indeed they do. The control grid must be negative with respect to the cathode and if the cathode is returned to chassis it is evident that the control grid must be held negative by some means.

In the case of the mixer and the i.f. amplifier the negative voltage is obtained from the a.g.c. line (which is negative by virtue of the demodulated signals). In the case of the a.f. amplifier the control grid is held negative by virtue of the very high value grid leak resistor (some 10 MΩ) keeping the coupling capacitor charged.

It is therefore obvious that any leakage through the a.g.c. decoupling (smoothing) capacitors or the a.f. coupling capacitor will remove this bias. In the former case the reception will become unstable (whistles and oscillation) and in the latter the reproduction will be weak and distorted closely resembling the effect of a high value anode load resistor.

### *Are there any receivers using a mixture of valves and transistors?*

Only a few, in fact too few to consider at any length. It is however interesting to note that in the case of some early car radios the signal stages employed valves working from a 12 V supply while the output stage used a power transistor. In the case of a few mains radios, the signal stages employed transistors whilst the output used a valve to deliver the required power. These hybrid designs were few and the notes already given should be sufficient to enable them to be serviced should the occasion arise.

# 7

# UNIT AUDIO EQUIPMENT

As soon as the servicing of radio receivers is taken on the repairer is immediately expected to service other home entertainment items containing radio receiving facilities.

The mechanical aspects of cartridge and cassette players cannot be considered in this small book and on this subject the only advice which can be offered is: keep it clean and free to move. The majority of these devices received for service only require the heads to be cleaned and pieces of tape removed from the transport mechanism, all parts of which should move freely when they are supposed to move.

As far as turntables are concerned, remove any hard grease from the centre spindle and oil lightly. Apply a couple of drops of oil to the top bearing of the motor and if necessary gently rough up the rubber surface of the idler wheel with a very fine grade of glass paper.

### *What is likely to be faulty if the radio (particularly stereo) produces sound from both channels but discs reproduce through one channel only?*

The cartridge is most likely, but the fault could be elsewhere. First check the degree of hum produced by touching the two live leads at the rear of the cartridge, usually red and white. if equal hum is produced from each and the connections were right in the first place, the cartridge should be replaced. If only one lead produces a hum trace through the other to ensure it is intact, particularly checking any phono plugs which may be used for connecting purposes as these are notorious for producing shorts between the inner core and outer braiding. If there is no short and still no response from the connecting points it is likely that the p.u. input employs a separate preamplifier transistor and that this stage is defective. Normal test procedures can be employed, including voltage and resistance tests.

### *What tests should be made if discs play in stereo but the radio plays through only one channel on stereo but both on mono?*

The fact that one channel functions means that the radio up to the detected output is functioning. The fact that both channels are working on mono radio and disc stereo means that the audio stages are working and therefore this only leaves the decoder to be checked. If this employs an i.c., carefully check the maker's voltage figures at each pin. If the voltages are wrong at some pins but the supply line pins are right, the i.c. is probably defective and replacement will almost certainly restore normal conditions. If discrete components are used, particularly check diodes and small polystyrene capacitors if normal transistor checks (depending upon circuit) show no obvious fault. However, decoders are fairly reliable, working as they do on low voltage and apart from the occasional i.c. replacement little other difficulty should be experienced.

### *Where are the real trouble spots in the average unit audio?*

In the smaller units there is absolutely no doubt that the most troublesome part is the audio output i.c. either one or both failing for no apparent reason. If no i.c.s are used it is usually the output stages with shorted output transistors and burned up resistors (previously mentioned) (Fig. 19).

### *What is a typical example of audio i.c. failure?*

One of the most popular of the lower priced units is the Fidelity UA3. This and its relatives without radio use a pair of

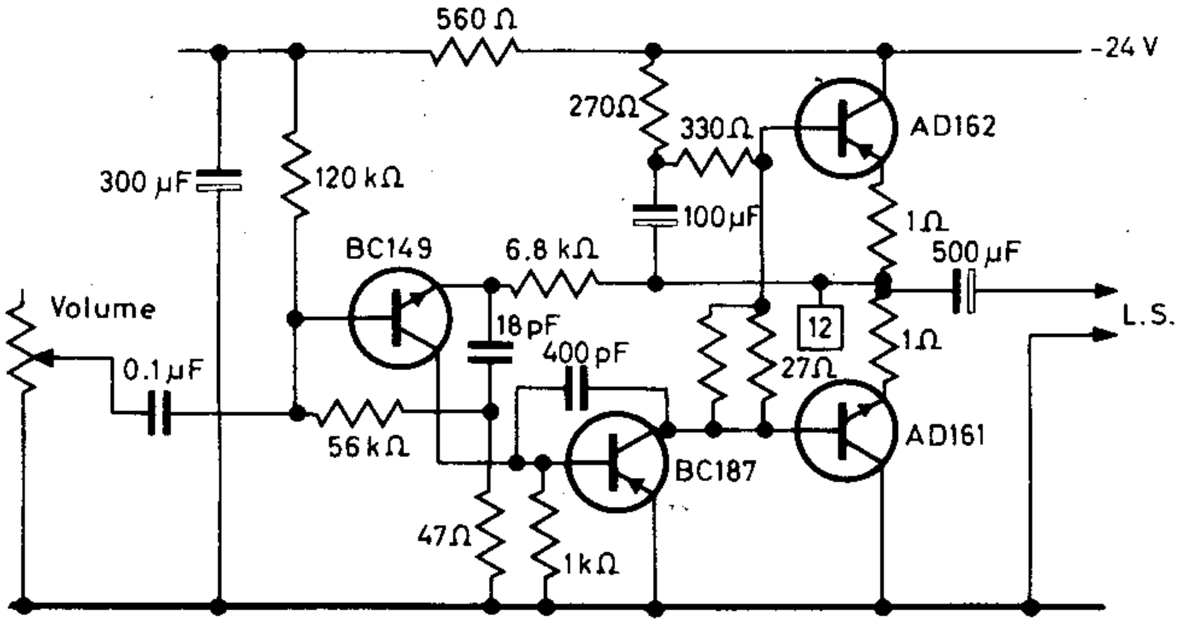



*Fig. 19. One audio output stage of the Fidelity UA1. The usual casualties are the AD161–162 output pair and their 1Ω emitter resistors*

i.c.s in the audio stages, usually SN76003, 76013 or 76023. Whilst the 003 and the 013 can be interchanged, the 023 uses a slightly different circuit. The supply is not regulated so that if one i.c. fails in a manner which merely stops it drawing current, the load is reduced and the supply voltage rises. All too often, the equipment is used in this condition with only one side functioning until the extra voltage proves too much for the remaining i.c. and this shorts and blows the supply fuse.

Whilst the failure of one i.c. is obvious due to the short across the supply line, it is not immediately apparent that the other i.c. is also in need of replacement and therefore confusion can arise if one is not accustomed to this state of affairs.

### *In addition to replacing the faulty items, what other checks should be made?*

Failure in the sound output stages is often caused by the use of unsuitable loudspeakers or faulty wiring to them. These items must also be checked before the equipment is put back into service. Frequently the original loudspeakers have been changed for units with a lower impedance (to produce more volume) or even shunted by another loudspeaker, thus demanding excessive current from the amplifier. Transistors do not like this and i.c.s like it even less. One may also find leads extended in an improper manner so that they can intermittently short with disastrous results in the amplifier. These are points well worth bearing in mind when failure has occurred in the output stages of audio equipment.

## *If both channels are inoperative does this mean that both amplifiers are defective?*

Not necessarily. Several designs cause the non-operation of one i.c. to switch off the other. As far as the previously mentioned i.c.s are concerned, the one with pin 2 connected

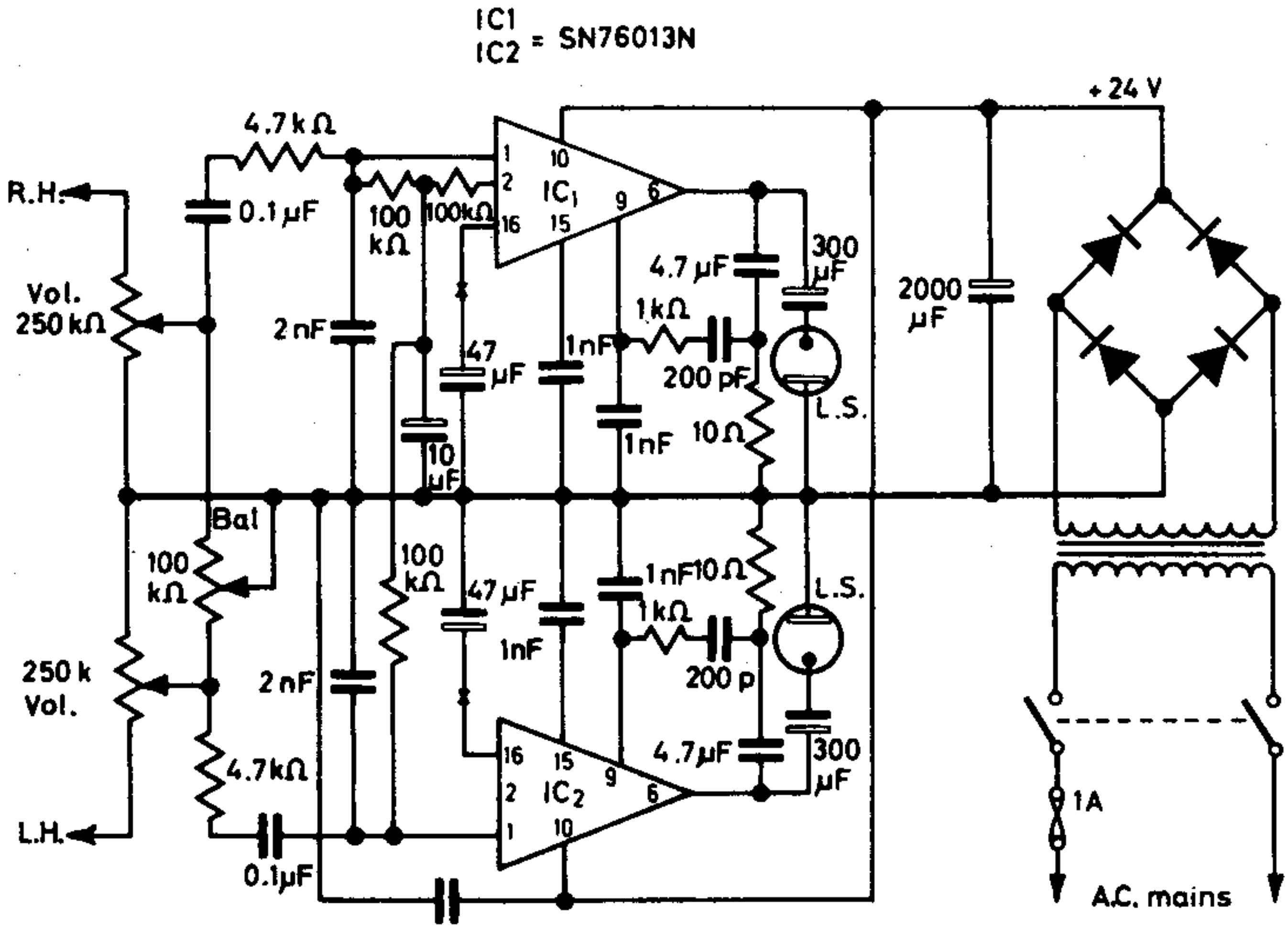



*Fig. 20. The amplifier circuitry of the Fidelity UA4 (the UA3 is similar) showing how the bias at pin 2 of IC 1 is applied to pin 1 of BOTH i.c.s to bias them on*

switches on the one with pin 2 unconnected (Fig. 20). Therefore, if there is no doubt, replace the i.c. which has a connection to pin 2 before replacing the other.

***When transistors are used, and the output pair are found defective, what precautions should be taken before replacement?***

First remove the defective transistors and any burned out resistors, noting their type, position and rating. This removal makes effective checking of other components easier. The driver and amplifier transistors should then be carefully checked to ensure that none are shorted or open circuit as this could have been the reason for the failure in the first place and a repeat performance is hardly desirable. This of course is the same point that was mentioned earlier on the subject of d.c. coupled audio stages in radios. Replacement transistors should also be checked to ensure that they are in order and are in fact what their marking proclaims them to be. The writer still has bitter memories of a batch of TIS91 transistors (so marked) which in fact turned out to be TIS90. When it is appreciated that one is a pnp and the other an npn, the trouble this caused can be imagined.

***What other trouble spots occur in unit audios?***

Mainly in the power supply circuits. The most common complaint is blown fuses either in the mains supply to or from the on/off switch of in the l.t. feed to the amplifier. It should be appreciated that there is a difference between a fuse failing (old age) and a fuse blowing. If examination of the fuse shows that the internal wire is broken with no sign of a large gap or discoloration, there is a good chance that a new fuse is all that is required. Although this is often the case, the circuit should still be checked for shorts or excessive current demand. Since the main supply fuse is usually quite light (typically 315 mA) the meter can be switched to the 1 A a.c. range and applied across the fuse holder. After the initial switch-on pulse, the needle should drop back to a fairly low reading depending upon the power of the equipment, say 100–200 mA in small units. If this is obtained, a new fuse can be fitted. If the fuse is in the l.t. line the current drawn will be much higher, again depending upon the equipment and the power it is required to deliver. A typical figure would be 2 A, but this would not appear on the d.c. meter until the amplifier is fully driven by a fairly strong signal.

When the fuse is found to be blackened or the wire has disintegrated, there is little hope of a new fuse restoring normal working. If the mains fuse is so affected there is an even chance that the fault is in the power supply circuit. If there is doubt, remove the l.t. fuse if one is fitted or disconnect the supply to the amplifier. If no short can be recorded in the power unit when this is done, the chances are that the fault is on the amplifier but it is also prudent to check the dial lights as clumsy handling can cause a tag to be in direct contact with the metalwork. This is a point often overlooked. Most often however the trouble is due to a short in the power unit, the rectifier diodes or bridge rectifier being mostly responsible. If separate diodes are used, check the back to front resistance of each to see if one records a direct short. If a bridge is used, the only short will be across the two a.c. input contacts, this being the low reading of the transformer secondary winding; reading; readings taken from the positive or negative to a.c. should not be below say 30 Ω and higher when the prods are reversed (Fig. 21). If necessary, remove the suspect from the circuit for a more conclusive test. Readings from positive to negative otherwise cannot be conclusive unless the supply is completely disconnected from the amplifier and scale or indicator lamps. Shorted electrolytic capacitors are a possibility which must be kept in mind but this is a less frequent occurrence.

The difficult one is where a direct short is found in say the rectifier which necessitates its replacement but in fact this is the result of faults elsewhere subjecting the supply to a severe overload, damaging the supply components before the fuse fails. Multiple defects can and do happen as the result of a chain reaction. As an example of this (Fig. 22), an amplifier

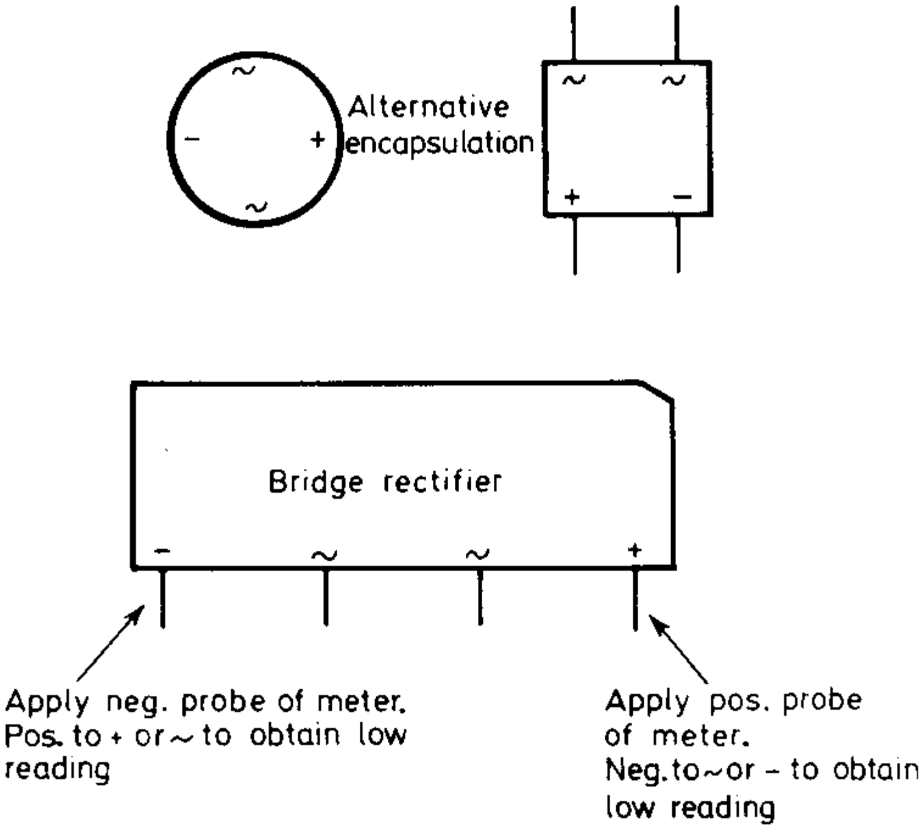



*Fig. 21. Checking a bridge rectifier. There should be no reading when the leads are reversed*

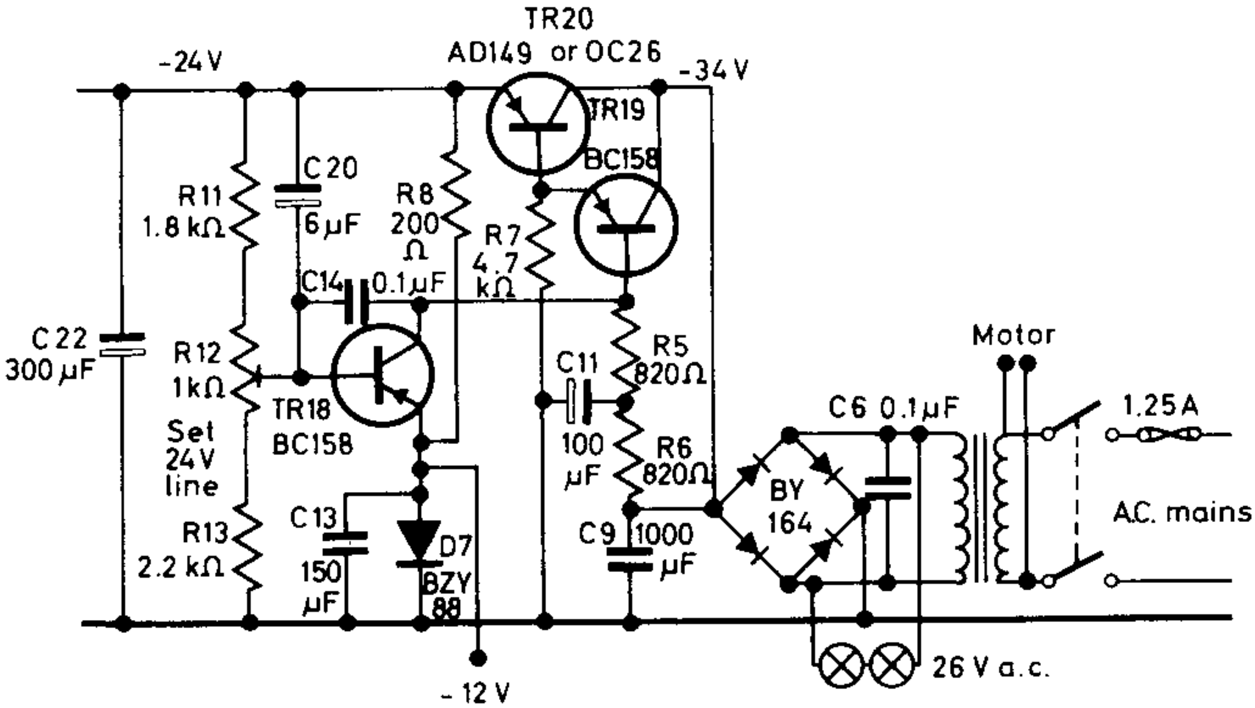



*Fig. 22. The power supply and voltage regulator of the Fidelity UA1. A chain reaction can occur if the regulator shorts, damaging the amplifier and the bridge rectifier. The dial lamps (12V 0.1A) may alternatively be connected across the 24V smoothed d.c. line*

may have a bridge rectifier feeding a voltage regulator which has the purpose of keeping the supply steady at say 30 V under varying current demand. For the regulator to function correctly and play its part as a smoothing circuit, the output of the bridge must be appreciably higher than 30 V. If the regulator transistor develops an emitter to collector short, the full output of the bridge will be applied to the amplifier and this could well cause the amplifier output transistors to short out also. The sudden surge of current could damage the bridge before the fuse fails and all this will have to be discovered and rectified before the unit can be restored to reliable operation. Such extensive damage is not general however, particularly if the correct fuse rating and type are adhered to.

### *What is meant by 'type' if the rating is the same?*

There are three basic types normally encountered (Fig. 23). The straight wire fuse is termed quick blow (or 'blo' as may be marked) and this type is intended to fail the moment the

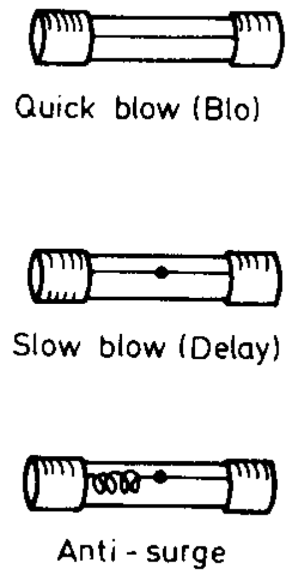



*Fig. 23. The three main types of fuse. There are others but these are the standard types commonly encountered*

current exceeds a certain figure thus saving damage to other components. There is a slow blow (slo blo) which appears as a straight wire with a blob of solder in the centre. This type will cope with an overload for say 20 milliseconds before failing and is intended for use where surges can occur which are not due to component failure. The third type is the anti-surge which appears to consist of one or two internal springs. This type will stand an overload for a longer period (say 60 milli-seconds) and is used in circuits where the switch-on surge is normally much higher than the normal operating current, for example to absorb the initial surge of current as the capacitors in a power pack charge up at switch-on. Different fuses have different functions and the original types must be adhered to. A quick blow fuse rated at 1 A should never be replaced with a 1 A anti-surge type. If necessary, it is better to slightly exceed the rating (say 1.25 A) than to change the type.

# 8

# GENERAL NOTES ON FAULT FINDING

### *What are the most difficult faults to overcome?*

It is generally conceded that intermittent faults are the most difficult to overcome and indeed some are enough to try the patience of the most placid. A close second must be the receiver with multiple faults, the existence of more than one being unknown or unreported to the repairer.

### *How does one tackle this type of defect?*

First by weighing up the known factors and the type of equipment involved. For example, the average type of small radio presents far fewer mechanical connections (plugs, sockets etc.) than a unit audio, music centre or items of 'in-car entertainment'. One should also bear in mind the probability of the fault being a far more likely one of an open circuit rather than a short circuit.

Thus in a radio set, intermittent results are likely to be due to incorrectly soldered joints, fractured print tracks or 'lands', inefficient switch contacts, earphone socket contacts, battery contacts and the like. These together with many others are examples of an open circuit condition or a partial open circuit.

The less likely short circuit condition could be components in close proximity which touch occasionally when the set (usually small) is handled, capacitors which leak when the voltage rises (new batteries) and transistors which draw excessive current when their temperature rises (particularly output).

The result of trying to locate an intermittent fault is often that another is created by disturbance tests, the probing of components, etc. This can well lead to a poor connection which was not previously present. This fault may be speedily located and rectified leading the repairer to conclude that the original fault has been cleared when, in fact, it is still waiting for the final reassembly to be completed. If the panel is again under stress, the original fault may show itself once more.

The problem is amplified when 'separates' are handled, necessitating the use of plugs and sockets. Whilst loudspeaker contacts and the like are obvious trouble spots, many music centres and unit audios use panels which are interconnected by edge strips or edge connectors which are often the source of intermittent results. These faults may not necessarily due to the contacts themselves but may possibly be caused by the leads being incorrectly soldered to the lugs and only kept in position by the plastic covering of the wire being captured.

Selector switches are a prime source of intermittent results. The fact that they are interlinked makes the identification of the faulty bank more difficult, i.e. faulty radio reception could be due to 'tape' switch which functions perfectly on tape.

### *What can be done to repair faulty switch banks?*

Whilst the injection of cleaning fluid may help matters it may not make the contact reliably positive. It is then necessary to strip out the moving member of the suspect section, where this is possible, so that the leaves can be cleaned and retensioned. This is often a very difficult process and other avenues should be first explored.

One way out of the difficulty is that in many cases the contact pins are round so that if the solder is removed from the print, the pins can be rotated to present a fresh surface.

### *What about the multiple fault condition?*

This is where one must keep a clear head and adopt an even more methodical approach than usual. This is particularly so in the case of a stereo unit as there may be one fault (or more) in each channel and to have both on at once all the time will only add to the confusion.

It is better to turn off one channel and concentrate on the working one (or non-working one as the case may be) and clear this first or, if this is not suitable for the particular conditions, space the test loudspeakers well apart. Carefully mark each loudspeaker and its channel and carry this through to the amplifier input and cartridge of the pick-up if there is no radio or tape for comparison.

Also, remember that the pick-up cartridge itself can play some confusing tricks, even new ones! If there is any doubt at all, a test record should be the final check and not the first check.

Having said this, we must also point out that too much reliance should not be placed upon a signal injector (or buzz testing with a screwdriver blade!). The application of such signals may temporarily seal up a dry joint and give the impression that a stage is working normally when in fact, under normal signal conditions, the poor connection would show up.

In addition, a heavy input signal may cause a stage to function (turn it on). Whereas under normal conditions a small signal will be insufficient to cause the stage to operate if the transistor bias is wrong.

Thus although test signals may enable one fault to be located and rectified, they may cover up a secondary fault which may only show up on final testing (or after reassembly).

***When dealing with stereo equipment under the 'multi-fault' heading which particular points should be remembered?***

It should be remembered that both channels share the same power source and probably the same earth returns. Therefore these must be of very low impedance in order to avoid interaction.

Whilst it is fairly obvious that electrolytic capacitors must be above reproach, the earthing points can easily be overlooked. In particular, earth tags which are rivetted to the metalwork without the rivet being well soldered (this also applying to some types of printed panel) and to thick earth leads which may not have been properly cleaned and tinned before soldering to the earth post. When the equipment is new, such connection may be making good electrical contact but as the months (or perhaps, years) go by surface resistance rises and presents a ripe source of instability or interaction.

Under these conditions some peculiar effects can manifest themselves in the shape of the balance control having little effect (or the reverse of that expected), the volume acting as a balance control and other confusing symptoms. This is particularly so if the common earth of the two loudspeakers (sockets) is not in good contact with true earth.

If in doubt, provide an alternative lead or pair of leads. In such cases checking with an ohmeter is useful but not conclusive.

***What does one do when the repair becomes a nightmare and apparently defeats all logic?***

Give it a rest. Get on with something else or go to bed.

If you have added up all the facts, the answer may well come when your personal computer has been freed to tackle the problem in its own time. Returning to the fray refreshed, a previously unconsidered factor may be apparent (why didn't I think of that before?).

The next time a similar problem is encountered the method of approach will be completely different and the job is done in a fraction of the time. It's called experience. . .

# APPENDIX:
# SPARE PARTS LIST

Keeping a large stock of spares can be an expensive business. On the other hand, one must have a certain number of spares to avoid irritating delay and to enable substitution checks to be made. The following short list of components most likely to be in demand should prove useful if repairs are to be carried out in any appreciable numbers.

**Transistors**

AC127, AC128, AC176/01, AC128/01, AD161, AD162, AD149
AF115, AF117, AF127
BC107–BC147, BC108–BC148, BC109–BC149, BC159
BC327, BC328
BD131, BD132, BD133, BD201, BD202
BF194, BF195, BF196, BF241

**Diodes**

IN4001, IN4005, BY164, BY179, OA90, OA91

**Valves, if visualised**

EF86, ECC83 (mainly amplifiers)
ECH81, UCH81, EABC80, UABC80, ECL82, UCL82, ECL86, EL84, UL84, UY85

**Integrated circuits**

The following ICs will enable most of the cheaper audio units to be serviced!

SN76110 (stereo decoder)

SN76003 (or SN76013 preferably suffixed N to denote finned heat sink)

SN76023 (again N) and TBA800

**Capacitors**

Component advertisers sometimes offer mixed packs at bargain prices. Two or three of these packs could well contain enough variation to provide a reasonable starting stock.

**Resistors**

Bulk purchase of mixed resistors is not advisable except from a long term point of view. The majority of values contained in such packs will hardly be of use to the occasional repairer of radios, unit audios, etc.

More likely essential items are low values such as 1 Ω, 2.2 Ω for use in output stages where these are often found burned up. A repairer will invariably collect several odd radios, unworthy of repair and these will contain most of the other values likely to be required on the odd occasion. It could be argued that this would also apply to capacitors but these would be more suspect through ageing, particularly electrolytic types.

It is a good practice to re-age all electrolytics before use. Since this involves not much more than straightforward checking it is not time wasting. Re-ageing is the application of a polarising voltage to the capacitor, and observing the voltage rating. For example, a small electrolytic rated at 6 V will hardly like 15 V applied to it from a meter switched to high ohms range, assuming the meter has such a battery fitted of course. In such a case one would apply the test leads with the meter switched to a lower (1.5 V powered) range.

The negative probe of the meter must be applied to the positive tag or lead of the capacitor as already outlined, and the positive probe to the other lead, tag or can as the case may be.

Whilst the test can be looked upon as routine to ensure the capacitor has the capacity it claims to have, and does not have severe leakage, it also serves to re-form the electrolytic action which is useful if the component is to be used in a low voltage signal circuit. With this reservation therefore, older capacitors can be used with some degree of confidence.

With the above short list of items, most of the smaller jobs can be tackled with some degree of confidence and it is only necessary to add such things as a test tape, cassette, cartridge and record which have sounds (and defects perhaps) well known to the user. Whilst good luck is 90% good planning we wish you all the best of the other 10%.

# INDEX