

Collecting and Restoring Vintage Radios



By Paul Stenning

OVER the last few years, collecting and restoring vintage radio and other electronic equipment has become much more popular. I think this has been helped and encouraged by the growing popularity of the Internet as a means of communication.

Vintage radio collecting is not yet popular enough for mainstream publishers to produce magazines for general newsagent distribution (although, of course, *EPE*'s sister publication *Radio Bygones*, which is available on subscription – details later – covers this fascinating subject). At present the Internet fills that gap by allowing collectors around the world to communicate on their own terms. The time is now right to reintroduce the subject to the newsagent's shelves, via this special supplement to *EPE* magazine.

WHAT TO COLLECT

Some collectors specialise on sets from certain manufacturers, specific eras or design features. You may wish to collect a representative selection of models across the whole vintage radio era. Alternatively, you may prefer to collect whatever becomes available, that you like and can afford.

You are not limited to just broadcast receivers. Professional, military and ham radio equipment is very popular. Some people collect early television and video equipment, record players, tape recorders,

car radios, hi-fi equipment, telephones, computers etc. Displays can be supplemented with valves, valve boxes, books, publicity material and other related items.

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My Favourite
Dinosaur –
The Majestic 90

The ZC1 of New Zealand – Part 1
Restoring an Ekco PB505
Talking to Mosquitoes – WW2 OSS Covert Communications

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Radio Bygones magazine, a sister publication to EPE – see page 15 for details.

In this article I will concentrate on valve broadcast receivers. More specifically, I will discuss post-war circuit techniques. Post-war sets (in particular 1950's sets) are more readily available at reasonable prices, and are ideal for those new to valve radio repair. Circuit design tended to be more standardised as manufacturers tried to reuse chassis and sub-assemblies across a number of models. This means that you will be more likely to find suitable spare parts in scrap sets. However, much of the information in this article can also be applied to earlier sets and to other vintage electronic equipment.

BUYING RADIOS LOCALLY

You could scour the local car boot sales, antique dealers, junk shops, auctions and newspaper adverts. It is possible to find decent sets at reasonable prices by this means, but you are more likely to find lots of overpriced junk.

Try placing a "wanted" advert in the local newspaper. This will bring lots of enquiries, but you could waste a lot of time and petrol, viewing sets that turn out to be nothing like the descriptions.

Some collectors have had success at the local recycling centre. Speak to the person who runs the place. They may already have standing arrangements with local traders, but you could be lucky.

VINTAGE RADIO DEALERS

There are several specialised valve radio dealers, who have a stock of sets available. Most dealers will sell by mail order, although the carriage charges can add significantly to the cost.

Past Times Radio and Wireless Works offer a good range of reasonably priced sets, both restored and as-found, while On The Air specialise more at the top end of the market. I have had good dealings with these three suppliers and am happy to recommend them. They have websites, which show their current stock.

Note: Full contact details for all the companies mentioned in this supplement are given on pages 15 and 16.

SWAPMEETS, FAIRS AND AUCTIONS

The Radiophile and the British Vintage Wireless Society organise swapmeets and auctions of sets and related items. The prices paid at these events are generally fair, and it is possible to pick up some bargains, particularly later sets that need restoration. Many of the sets in my collection were purchased at these events.

Many dealers and private sellers attend the twice-yearly *National Vintage Communications Fair* (NVCF) at the NEC in Birmingham. This is the largest such event in the UK, so prices tend to be fairly high, but tatty unrestored sets can still be obtained for fair prices, particularly later in the day. (The next Fair is on September 15th 2002.)

INTERNET

Online auction sites, such as eBay, are a relatively recent way of buying vintage radios. A lot of items seem to sell for excessively high prices compared to swapmeets etc. I have seen sets sold at auctions that then appear on eBay within a few days and sell for a lot more. You are relying on the honesty of the vendor's description of the goods. The best advice I can give is to be wary, and also to remember that the carriage has to be paid separately.

Look for sales and wanted adverts on vintage radio websites. Malcolm Bennett's Vintage Radios has a section containing dozens of adverts. I have bought a couple of items through this route successfully.

There are also a couple of online discussion lists – such as the *Radio Bygones* message board – which sometimes have adverts from private collectors selling or even giving away sets. *Radio Bygones* also carries a Free Readers' Adverts page in each issue.

ASSESSING THE OVERALL CONDITION

Look at the general condition of the set, in particular the tuning scale, speaker fabric, knobs, cabinet, trim and back. If some of these are damaged or missing, you may have problems finding replacements or satisfactory alternatives.

In general, you should consider the appearance of the set above the electrical condition. Electrical problems can normally be overcome or worked around, whereas some cosmetic problems can be very difficult, or impossible, to resolve.

You may wish to remove the back and look inside. Always ask the seller or auction organiser first.

Remember that the set is between 40 and 80 years old, so do not expect it to look like new. Always consider the asking price when examining a set. You won't get a first-class set for a fiver (or ten dollars!). At auction viewings, decide how much you would pay, note it down and try not to get carried away when bidding.

SCRAP SETS

Do not disregard sets that are not worth repairing since they can be good as a source of spare parts. These can often be picked up for a couple of pounds in auctions (perhaps with badly damaged cabinets) which is less than you would pay for one of the valves or a couple of knobs. At swapmeets and fairs look under the tables – that's where the junk tends to be!

REPLACEMENT VALVES

Many valves are still available. There are still a lot of New-Old-Stock (NOS) valves appearing from old workshops and local TV and radio shops that are closing down. These tend to be available through specialist valve dealers like Wilson Valves or Valve and Tube Supplies.

Most of the new valves from such dealers will be NOS, although some genuinely new valves are still manufactured (mainly in the former Soviet Union by companies such as Svetlana, for the hi-fi market). New and NOS valves are normally guaranteed for three months, but this guarantee is void if the valve is damaged by a set fault.

If a new replacement valve is not available or is too expensive for your budget, many dealers sell used-tested valves. Wilson Valves and Valve and Tube Supplies each have a vast range, with many costing less than five pounds.

Do not assume that all valves are available. Some earlier valves can be more difficult to come by – which will be a problem if your interest is sets from the 20s and early 30s. However, most replacements for 40s and 50s sets should not present any problems.

OTHER COMPONENTS AND PARTS

Generally, the main problem areas are items of cabinet trim, speaker fabric, tuning scales and knobs. Sid Chaplin supplies a selection of modern replacement fabrics as well as Rexene, brass clips and hinges, handles etc.

There are often boxes of knobs at swapmeets, with a typical price of around 50p per knob. As mentioned above, scrap sets are a good source of components. Obviously, you need to be selective and to choose scrap that is similar to the sets you collect.

SERVICE INFORMATION

Unless the work required is minimal, it is worth obtaining a copy of the relevant Service Sheet. I have produced three *Vintage Radio Service Data* CD-ROMs (containing information on approximately 3,000 different receivers), which may be of interest to those who repair sets regularly. These are available through the *Radio Bygones* (RB) Bookshelf. For more occasional or one-off jobs I also offer a low cost Service Data by email facility via my website.

There are a number of suppliers of photocopied service data. Savoy Hill

Publications claim to have the largest collection of service manuals in the UK, and will supply a comprehensive service data pack for around £12. Other suppliers are listed at the end of this article.

The Newnes *Radio and Television Servicing* books, published annually from 1953, contain circuit diagrams and basic service information for many sets produced in the year of publication. These are often available at swapmeets and fairs for a few pounds each, and may still be available at your local library.

If you cannot find the exact data for your set, look for data on similar models from the same manufacturer. Often the circuit design did not vary greatly from one year to another.

Some manufacturers produced sets under more than one brand name, especially in later years as companies merged. For example, Philips made sets under the Mullard and Cossor brands.

VALVE DATA

A valve data book is useful, particularly if you do not have the service sheet for a set. *Radio Bygones* offer reprints of Bernard's Valve Data books for very reasonable prices. It is also worth looking out for original data books – particularly Mullard and Brimar publications.

I have also produced a Valve Data CD-ROM, which contains scanned copies of a number of useful publications, including Mullard, Mazda and Brimar valve data books, together with manuals and data charts for several valve testers, again available through the *RB Bookshelf*.



Data CD-ROMs available from the RB Bookshelf.

There are also a few websites offering valve data on-line. Duncan Amplification has a useful database program for Windows (giving basic characteristics and pinouts) available for free download. A wide range of original valve data is available for download at Nostalgia Air.

TOOLS AND TEST EQUIPMENT

Many readers of this magazine will probably already have a good electronics toolkit, containing a soldering iron, desoldering tool, screwdrivers, cutters, pliers, adjustable spanner, etc. You will probably want to add nut spinners to suit 2BA, 4BA and 6BA nuts. You may also need to buy a more substantial soldering iron, rated at around 40 or 50 watts for working on large tagstrips etc.

The only item of test equipment I would regard as essential is a multimeter. A basic



DESIGN, AVAILABILITY AND PRICES

Up to about **1926**, radios look like scientific equipment and have wooden boxes, ebonite panels, and valves sticking out, exposed to danger. These sets are very desirable and a crystal set will usually cost over £100, with the early valve stuff being between £50 (home-made) and a couple of grand (commercial, rare, and very tidy).



A Marconiphone V2A set from 1922/23 (left) and a Ethophone Junior Crystal Set Mk II from 1923. (Courtesy Radio Bygones)

From about **1926** to **1932**, they look like boxes with things inside, often under lift-up lids. Home made here £20 to £100, and commercial probably £20 to £1000 depending on how scrumptious. There is almost nothing available from this era – only what comes from the dispersal of a deceased collector's hoard.

From **1932**, there was a sea change in styling, and the sets become styled as radios, because all of a sudden, a radio is important enough and confident enough to make its own style. It's an Art Deco box with guts inside and a few well-chosen controls made available to the punter who bought it. It's becoming furniture that talks rather than scientific instruments. Until 1934 you find small dials, wild Deco cabinets, TRF circuits, great rarity and desirability, and £50 to £500 should be the bracket.



A Philips 'Superconductance' Model 634A from 1933 (left) and the Murphy AD94 from 1940. (Courtesy Radio Bygones)

After **1934** things began to settle down to a superhet circuit in a cabinet with a big, clear, back-lit dial, and slightly less Deco styling to the cabinets. Some TRFs (Tuned Radio Frequency sets) left, and these always a little more desirable (more fun to fix) and slightly higher price, but 1934 to 1937 sets sell for £50 to £250 normally. The major exception being the round Ekcos (AD55 – 1934, AD36 – 1935, AD76 – 1935, AD75 – 1940, AD22 – 1945) which now fetch very high prices – or mental prices if they are the original (beware of fakes) in special colours.

1938 was an exceptional year. Huge sets with loads of valves, push-pull, press-buttons, magic eyes, lovely veneered cabinets, maybe even motor tuning. In my opinion, we never made better sets, before or since – the pinnacle of achievement in the field of AM domestic sets. Motor tuners and sophisticated sets £100 upwards.

Most of the good stuff has been found, and snapped up into collections. Most of the really rough stuff has been thrown away or broken up for scrap. Some nice things are still turning up, but mostly it's just fairly run-of-the-mill things.

1939, back to earth with a bump. Some push-buttons, but not many, and almost no motor tuners. Some adventurous souls going to European Side Contact valves (i.e. Pye, Ekco), much simpler circuits and far fewer valves. 1940 more of same. 1941 almost nothing made. Radios from this period are hard to find. Prices start at £70, with very few seriously expensive, except Murphy AD94 (few hundred pounds).

No sets until about **1944**, when we get the Wartime Civilian Set. These are £20 to £150 depending on how well it's been looked after and/or restored. Some of the late Civvies made in **1945** had three knobs and LW coverage added, which can add a few pounds to the value.

The sets made in the war were not made in big numbers and are not common but they are still turning up from time to time, and not always just from collectors who have passed away.



A Wartime Civilian set (left) and the Ekco A22 from 1945.

1945 to **1949**. Sets of post-war vintage in general vastly improved in terms of ease of servicing. They had quite austere square woody cabinets in general, because of shortage of materials and labour. Some 1945 sets are literally the same tooling as the 1939 sets, pressed back into production as quick as possible, with new sets in 1946. Some of this stuff is getting harder to find, but in general there is enough to go round. Pay £10 to £150 in general, but for the Ekco A22 a lot more!

1950 to **1954**. Smaller valves. Even the table models which are quite large are not so deep front to back and will stand on a shelf, not a big table. All are buyable at £10 to £100, no need to go mad, although the classic Bakelites are harder to find and to pay for. Some of this stuff looks older than it is, passing for a 1930s set easily enough, though some of it is ultra-modern for its day and looks 1960s. We had lighter woods, outlandish Bakelite shapes and colours for the ultra-modern types, and dark wooden cabinets for the more traditional customers.

1954 onwards, FM comes along. FM sets more useful to the general punter, but harder to fix for the amateur, so no particular upward pressure on prices, as users want FM, restorers want it older or AM only in general, so each to his own. All are still available; there is no need to spend mental money.

1960s valve sets are quite scarce, as most sets used transistors, and these might get pricey in the end, like the 1940 sets, due to lack of numbers. Plenty of this sort of age around still. You can get given these if you're lucky. There is a school of thought that says that 1960s valve radios are rarer than 1930s valve radios, but a lot cheaper, and therefore well worth collecting.

Transistor sets are finding a ready market because a lot of younger collectors have never been taught how a valve works, even if we are graduates in Electronic Engineering, so it's easy to collect the trannies and not bother with the valves. They are smaller as well, so the house takes longer to fill up!

An excellent book which carries hundreds of photos plus details of sets is *Radio! Radio!* by Jonathan Hill. This book will aid the identification and dating of sets from the 1920s through to the 1960s, plus listing of nearly 3,000 different transistor models. It has become the bible of UK vintage radio.

digital type is ideal, and has the advantage of a high impedance input. Some repairers hate digital meters, and swear by analogue types. If you want to go for analogue, choose a model with a large, clear scale. A small cluttered scale will put you off analogue meters for life!

Period service data often quotes measured voltages assuming a fairly low input impedance analogue meter. A digital meter may give higher readings for some measurements because it loads the circuit less, and you will need to make allowances for this.

A loudspeaker in a wooden cabinet is useful when testing a chassis that has been removed from the cabinet. This allows you to get the radio cabinet off the bench and out of the way.

Eventually you will need to realign the RF and IF circuits of a set, and for this you need an RF signal generator, covering the range 150kHz to 100MHz, with an option to amplitude-modulate the output with an audio tone. I have a Heathkit unit which cost me about five pounds in an auction. After a couple of basic repairs it works fine.

If you already own an oscilloscope you will find it useful occasionally, but it is not really worth buying one for valve radio work alone.

Another optional item is a valve tester. These are available from the same auctions and swapmeets as radios, and sell for between £50 and £100 typically. Note that valve testers will sometimes condemn valves that actually work fine in a set.

DISASSEMBLY

Often the first stage of any repair and restoration is to remove the chassis. With some sets, reasonable access can be obtained without disassembly (via an access plate in the bottom of the cabinet), but if you are planning to do anything more than a basic repair the chassis will have to come out anyway, so you might as well do it before you start.

Disassembly should be carried out with care, so as not to cause further damage. It is worth sorting the various screws and small parts into separate containers, and making notes or sketches so that you can remember how it all goes back together. Photographs from a digital camera are also useful if you have one.

REMOVING THE KNOBS

It will often be necessary to remove the knobs before the chassis can be withdrawn. This is usually easy, but a little corrosion in the wrong place can cause real problems.

The most common fixing method is grub screws, accessible through small holes in the side of the knobs. Sometimes the screw passes through a hole in the shaft, so complete removal is needed. The grub screw hole in the knob may be filled with wax or a second plastic grub screw. **This is a safety precaution on live chassis sets and it is imperative to replace the filling when the set is reassembled.**

If the grub screw will not shift relatively easily, squirt a *small amount* of WD40 into the hole and leave it for half an hour. Often this will penetrate sufficiently to allow the screw to be removed.

If the grub screw still refuses to budge, or the screwdriver slot is damaged, you may have no choice but to drill it

SAFETY

It is essential to realise that vintage sets do not comply with the latest electrical safety regulations and also often work at very high voltages – 350V DC for the high tension line is not unusual. Such sets can also have live chassis and hence can be very dangerous to work on – beware, a shock from such a set can kill you.

An *essential* safety item is a Residual Current Device (RCD) or Earth Leakage Circuit Breaker. These are available as adapters for use with power tools etc. Plug this into a wall socket, and power the set you are working on *plus* the test equipment from it, via a four-way extension lead.

For improved safety, I would strongly recommend the use of an isolating transformer. A 100VA type is adequate for most domestic sets. An isolation transformer is *essential* if you need to connect earthed test equipment to an AC/DC radio.

Neither an RCD nor a transformer will provide protection against a shock from a charged capacitor, so sensible precautions must always be taken.

When working on live equipment, always use one hand only (put your

other hand in your pocket) to prevent shock current from passing through your body and across your heart. Ensure the chassis is supported steadily, so you don't need to steady it with your other hand while working on it. When checking voltages, always clip the negative terminal of your meter to the chassis so voltages can be measured using only one hand.

Switch off the supply and allow the capacitors to discharge before connecting or disconnecting anything, and before handling the chassis.

Many sets were of the live chassis type, where the chassis is connected to one side of the mains. Before operating these, ensure that the chassis is connected to the neutral side of the mains, as this is generally within a few volts of earth potential. Some sets have a single pole mains switch, and this does not always break the live mains lead – rewire it if necessary.

Another danger is the high temperatures of the valves and high power resistors. Rectifier and output valves, in particular, can become hot enough to cause nasty burns.

Be careful

out. This is a last resort however, because of the risk of damage to the knob. Flexible drill chuck extensions are available which can help. Use a low speed battery drill and take it steadily.

If there is no grub screw hole, the knob is either a push-on type or is retained by an internal screw, accessible either from inside the cabinet or through holes in the base.

Push-on knobs can be difficult to remove. If you cannot pull it off with your fingers, lay the set so that the knobs are uppermost. Wrap a length of strong cord or fabric strip around the base of the knob two or three times to form a loop and gently pull the knob off. *Never* use a screwdriver to lever the knobs off, you will damage the case or break the knob.

In some cases, the control knobs will be on the glass tuning scale. If so, loosen the chassis mounting screws and move the chassis slightly. If the tuning glass moves too, it is attached to the chassis so it is not necessary to remove the knobs at this stage.

REMOVING THE CHASSIS

In most wooden and heavier Bakelite cased sets, four screws or bolts on the underside of the cabinet retain the chassis. The cabinet feet may cover the screw heads. On some lighter sets, particularly AC/DC sets, the chassis fixing screws may be internal.

You may have to disconnect the leads from the loudspeaker or output transformer before you can remove the chassis, and possibly remove the dial lamps. Before disconnecting any wires, note their positions carefully. Sometimes the leads are fitted with plugs or terminals to enable easy disconnection, but more usually, they will be soldered.

TESTING AN UNKNOWN SET

Don't just plug in the set and see what happens! Several things could happen, and most of them are not desirable. Some systematic checking will pinpoint many problems before any harm is caused, and a cautious approach when you do show it some power will reduce the risk of anything you've missed causing serious harm.

Examine the chassis carefully. Look for signs of previous repairs or "bodging". Check anything that is not original manufacture against the service sheet. Tidy and correct anything that is wrong or badly done.

Look for signs of trouble. Burnt-out resistors, swelling ends on electrolytic capacitors, wax-paper capacitors that are dribbling wax or have blown themselves apart, Hunts capacitors that are falling apart, and anything else that just doesn't seem right. If you read the later sections of this supplement detailing the circuit operation, you will have a good idea of what you are looking for.

In AC/DC sets, if there is a capacitor connected directly across the mains input and it hasn't already blown itself apart, remove it. It is very likely to go off with a bang when you apply power, particularly if the set hasn't been used for some time. You can fit a replacement later.

I normally disconnect the output valve grid coupling capacitor and connect a temporary replacement at this stage.

Check the primaries and secondaries of the mains and output transformers with a meter. The service sheet gives the actual resistances, but you can be generally happy if they are not open-circuit. On AC/DC sets, check the dropper resistor.

Measure the resistance across the HT line. It will probably start low and climb as the



smoothing capacitor charges. If it stays low (below about 10kΩ), something is probably wrong and should be investigated. A leaky smoothing capacitor is a likely suspect.

On sets that do not have an isolating transformer, make sure the chassis is connected to the neutral side of the mains.

Check the valves are the right types in the correct sockets. If any of the valves have what looks like a milky white deposit

on the inside of the glass, the vacuum has been lost and the valve must be replaced.

Check the dial lamps (if fitted) and replace if necessary. Refit the knobs so that you don't have to touch the metalwork with the set powered. Reconnect the speaker, output transformer and anything else you disconnected previously. If the set does not have an internal aerial, connect a few feet of wire to the aerial socket.

APPLYING POWER FOR THE FIRST TIME

For the initial tests, the set should be powered with a 100W lamp in series with the live mains connection. If the set is consuming the right amount of current, the lamp will scarcely glow and the set will receive close to the full supply voltage. If there is a problem that causes it to draw



A 1960 Roberts R200 transistor portable. Roberts now produce various similar "Revival" models.



The Bush MB60, a mains/battery valve portable from 1957. Various transistor models such as the popular TR82 also used this case and it is now available new as a re-creation of the original set.



A Loewe Opta good quality valve set from the 1960s.



The Bush DAC10 four-valve AC/DC set from 1950.



Bush VHF61 AM/VHF set from 1956 sporting a magic-eye tuning indicator.



The Pye P131MBQ "Jewel Case Portable", a four-valve AC mains and battery set from the late 50s.

HOW DO VALVES WORK?

To those of us who have been brought up with transistors, valves (called tubes in the USA) can seem unnecessarily complex. I will attempt to explain the workings of the valve in a clear simple manner – without the atomic theory and the maths!

A BRIEF HISTORY LESSON

In 1883, Thomas Edison was experimenting with electric lamps. In his early experiments, the glass bulb was becoming dull, and he wondered if this was due to particles being given off by the filament. He fitted a metal plate inside the bulb to attract these particles, and found that if the plate were at a positive potential a current would flow from the filament.

Later Professor Flemming found that current only flowed when the plate was positive, and that the arrangement could be used to rectify an alternating voltage. He patented this in 1904.

Lee de Forest discovered that, by placing a wire between the filament and plate, the current could be controlled. Thus, he invented the triode (or Audion as he called it) – the first electrical amplifying device.

THERMIONIC EMISSION

When a metal is heated to a sufficiently high temperature in a vacuum, it will give off electrons. These will be attracted to any electrode that is at a more positive potential.

Most metals will melt by the time they are hot enough to emit a significant amount of electrons. Tungsten is an exception, which gives good emission at 2300 to 2500 degrees Centigrade, and melts at 3380 degrees Centigrade. This would glow almost as bright as an electric lamp, which was a characteristic of early "Bright Emitter" valves.

In later valves, the tungsten was coated with an oxide (such as barium or strontium), which gives good emission at around 700 degrees Centigrade.

In most valves, the emitting conductor is a separate component to the heating filament. The emitting conductor is known as the cathode, and is normally in the form of a thin tube. The heater passes inside the cathode and is electrically insulated from it. This is known as an indirectly heated cathode. However, most early valves, and those intended for battery operated radios, have directly heated cathodes, where the heater and cathode are the same component.

ELECTRON FLOW VS. CONVENTIONAL CURRENT FLOW

We are now used to thinking of current flowing from positive to negative. However, current is actually a flow of electrons in the opposite direction. This anomaly is the result of an incorrect assumption by early scientists, which has become established – hence we have the separate terms Electron Flow and Conventional Current Flow.

To avoid confusion (hopefully!), think in terms of electron flow when considering the actual workings of the valve, and conventional current flow when thinking about the circuit.

THE DIODE

The electron collecting plate is known as the anode. It normally consists of a cylinder or rectangular box of metal around the cathode, a few millimetres away.

When the anode is positive, the (negative) electrons emitted by the cathode are attracted to the anode and hence there is a current flow.

However, when the anode is negative the electrons are repelled from the anodes and hence no current flows. This is useful for detection and rectification, but is obviously incapable of amplification.

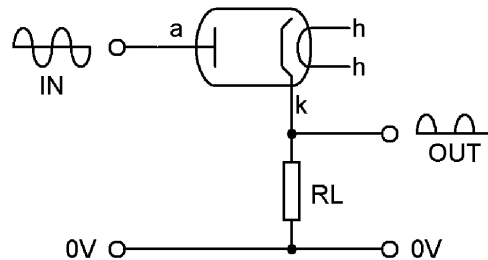


Fig. 1. Basic valve rectifier circuit.

A rectifier valve has larger, more substantial electrodes than a detector diode, to cope with the much greater currents involved. Fig. 1 shows a rectifier valve circuit with an AC input and a half-wave rectified DC output.

A smoothing capacitor would normally be connected across the load (RL) to give a relatively steady DC supply. The load would normally be the remainder of the circuit rather than a single resistor.

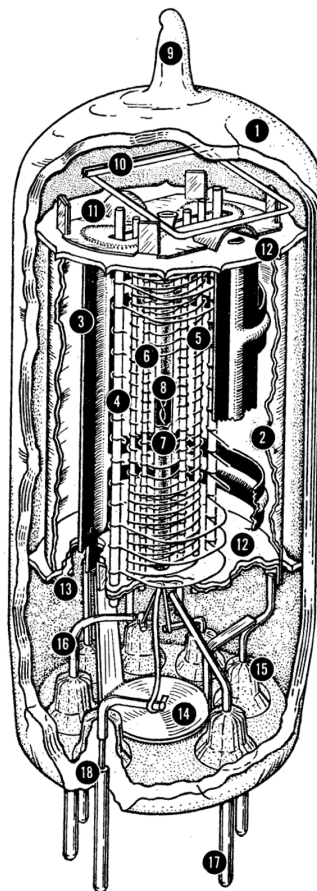
The valve electrodes are indicated by the normal abbreviations – a for anode, k for cathode and h for the heater connections. A heater supply is not shown in the diagram for simplicity.

THE TRIODE

By adding a spiral of wire or a wire mesh between the cathode and the anode, it is possible to control the current flowing between them. This additional electrode is known as the control grid.

Referring to Fig. 2, if a varying signal is applied to the control grid (g1) via C1, the anode current will vary in sympathy. By placing a resistor (RA) between the anode and the positive supply, the varying current will be converted to a varying voltage on the anode.

In normal use the control grid will not be at a positive potential relative to the cathode, otherwise it will act as another anode and draw current (known as grid current). It is normally biased a few volts negative. In very early radio sets, a separate grid bias battery was used, often having several tappings to give different bias levels – but this was quickly superseded.



Structure of a Miniature Valve

1 - Glass Envelope. 2 - Internal Shield. 3 - Anode. 4 - Grid No. 3 (Suppressor Grid). 5 - Grid No. 2 (Screen Grid). 6 - Grid No. 1 (Control Grid). 7 - Cathode. 8 - Heater. 9 - Exhaust Tip. 10 - Getter. 11 - Spacer Shield Header. 12 - Insulating Spacer. 13 - Spacer Shield. 14 - Inter-Pin Shield. 15 - Glass button-Stem Seal. 16 - Lead Wire. 17 - Base Pin. 18 - Glass-to-Metal Seal.

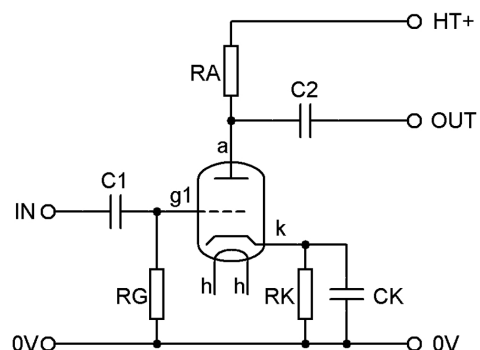


Fig. 2. Basic triode valve amplifier circuit.

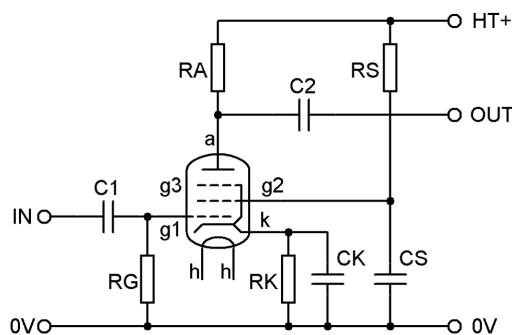


Fig.3. Basic pentode amplifier stage.

Usually cathode biasing will be used. Instead of connecting the cathode directly to ground (0V), it is connected via a low value resistor (RK). This will drop a few volts, so the cathode will be a few volts positive. The control grid is at high impedance and draws virtually no current. It is normally connected to ground via a high resistance (RG), and the signal is coupled via a capacitor (C1).

If CK is omitted, the voltage at the cathode will vary with the anode current. This causes negative feedback, which gives a reduction in gain (and also reduces distortion). CK is fitted to obtain the maximum gain from the stage, and has a low impedance over the signal frequency range.

Triode valves are mainly used for low-level audio amplification. Their use is limited at radio frequencies because of the capacitance between the control grid and the anode. Although this is only a few pF, the "effective capacitance" is approximately equal to this value multiplied by the stage gain. This effective capacitance becomes the input capacitance of the stage, and has a drastic shunting and detuning effect on a radio frequency signal.

THE TETRODE

The tetrode was a development of the triode, designed to overcome the effective capacitance problem. A second grid is placed between the control grid and the anode. It is known as the screen grid, and acts as an electrostatic screen, the purpose being to minimise the capacitance between the control grid and anode.

For this to work it must be connected to ground at signal frequencies. If it were connected directly to 0V it would act as another control grid and greatly reduce the anode current. It is therefore often connected to the HT rail via a resistor to drop some voltage, and decoupled to 0V with a suitable capacitor.

The tetrode solves the capacitance problem allowing operation at high frequencies, and also gives greater gain. However, it introduces another problem – limited output voltage swing if distortion is to be avoided. This is caused by secondary emission, which is too involved to describe in this brief article. Consequently the use of the tetrode is generally confined to 20s and early 30s sets, but it is included here because it is an important stage in the development of a better solution.

THE PENTODE

As its name implies, the pentode has five electrodes. Four of them are the same as those in the tetrode, namely the cathode, control grid, screen grid and anode.

To suppress the secondary emission a further grid, known as the suppressor grid, is added. This is normally connected to the cathode, sometimes internally within the valve envelope, otherwise a separate connection is provided.

The result is a valve that retains the advantages of the tetrode – high gain and operation at high frequencies – without the distortion. Pentodes are commonly encountered in RF and IF amplifier stages, and in amplifier power output stages.

The circuit of Fig.3 shows a basic pentode amplifier stage. This is fairly similar to the triode circuit discussed previously, with the addition of the connections to the screen and suppressor grids (g2 and g3).

VARI-MU VALVES

It is often necessary to be able to control the amplification (gain) of a valve either manually or automatically. This is

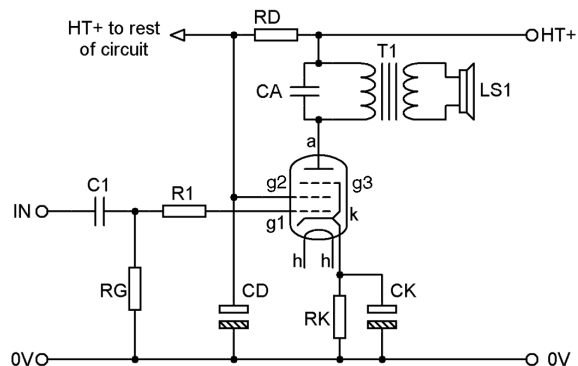


Fig.4. A typical Class-A pentode valve output stage.

commonly required in the AGC (Automatic Gain Control) circuits in radio receivers.

To achieve this the spacing of the wires that make up the control grid are varied, being closer together at the centre and wider apart at the ends. By varying the negative voltage on this grid, the gain can be adjusted.

PENTODE POWER AMPLIFICATION

The circuit in Fig.4 shows a typical Class-A pentode output stage. The anode load resistor is replaced with the primary of the output transformer (T1), which drives the loudspeaker (LS1). The purpose of the transformer is to convert the relatively high anode impedance of the valve to the low impedance of the speaker.

Since the output transformer is inductive, its impedance varies with frequency giving an uneven frequency response. A capacitor (CA) is often connected in parallel with the transformer primary, which corrects this to a great extent (this is sometimes referred to as tone correction). In some cases more than one capacitor is used, together with series resistors to give correction that is more accurate.

The screen grid (g2) is shown connected to the HT supply after a decoupling resistor (RD). This is a common arrangement in valve radio receivers.

A resistor, referred to as the "grid-stopper", may be placed in series with the control grid (g1). This works in conjunction with the input capacitance of the valve to attenuate the high frequencies (above the audio range) to ensure stability.

Many hi-fi amplifiers and some more expensive valve receivers use a Class-B push-pull output stage. This is an involved subject in its own right and will not be covered in this brief article. A higher quality output transformer is normally used in conjunction with negative feedback, which makes impedance correction capacitors (such as CA) unnecessary.

OTHER VALVE TYPES

A number of special-purpose valves have been produced with a greater number of electrodes. For example, hexodes, heptodes and octodes (containing six, seven and eight electrodes respectively) are sometimes used in mixer-oscillator stages. The operation of these valves is rather complex and I will not attempt to describe them here!

COMBINED VALVES

Often more than one valve section is contained in a single glass envelope. These sections normally share the same heater connections and are sometimes interconnected.

The mixer-oscillator valve in radio receivers often consists of a hexode (or similar) and triode sections in the same envelope. The triode is used as the oscillator section and the hexode acts as the mixer and amplifier. The two sections may be connected internally within the valve, or externally.

The first AF stages generally use valves containing several diodes plus a triode in one glass envelope.

FURTHER READING

Those requiring a more detailed discussion of valve operation are advised to refer to the book by Chas E. Miller entitled *Valve Radio & Audio Repair Handbook* (see page 16).

excess current, the bulb will glow brighter and the voltage applied to the set will be reduced. It gives a degree of protection to the set, and a warning that all is not well to you. Once you are happy that nothing is seriously wrong the lamp should be removed from the circuit.

Arrange a safe mains connection, with the lamp in series, positioned so that you can switch it off quickly if necessary, without leaning over the chassis. Connect a test meter on an appropriate DC voltage range across the HT (if in doubt set it to 1000V DC).

Switch the power on. After several seconds, all the valve heaters will start to glow, and the dial lamps should illuminate. The valve heater is in the centre of most valves and can usually be viewed from the top. Note that the valves in a battery set will probably not glow visibly. The same situation will also occur if battery type valves are used in a mains or mains/battery set. Some valves are coated or have metal cases such that the innards cannot be seen.

If nothing happens, the power switch may not be switching reliably. Operating the switch a few times with the power applied will often burn through the tarnishing and get the switch working.

If the heaters seem OK, leave the set on for a little longer and watch the HT voltage reading closely. After maybe ten to thirty seconds the HT should start to rise, and will reach a maximum of perhaps 220V to 350V after a further five to fifteen seconds. The voltage will then begin to drop again, by between ten and fifty volts, as the output valve warms up.

VOLTAGE CHECKS

Check the service information for the correct voltage on the cathode of the rectifier valve. The actual voltage can vary by about 10%, but any greater discrepancies should be investigated. If you are running the set through a series lamp, all the voltages will be a bit low.

If you have a digital meter with a high impedance input, measure the voltage directly across the control grid resistor of the output valve. It should be virtually zero or slightly negative. If there is a positive voltage here (more than about half a volt), the coupling capacitor is probably leaky, or the valve may be faulty.

In AC/DC sets, you may see a gentle wisp of smoke from the dropper resistor as the dirt burns off. This may continue for several minutes. As long as it remains just a gentle wisp, don't worry about it.

After a few minutes, carefully feel the case of the smoothing capacitor can (*switch off first*). It should be cold. Any warmth suggests that the capacitor is leaky.

If you are really lucky you may hear something from the speaker – but do not worry too much if you cannot. If you can tune in stations and the sound quality is OK, there probably is not too much wrong!

The series lamp should be scarcely glowing. Normally the filament will be glowing a gentle orange only. If it is brighter than this, there may be a fault that is causing the set to draw excessive current. Once you are happy that nothing dramatic is going to happen, switch the lamp out of the circuit so that the set is working from the full supply voltage. Some sets will not work correctly from the reduced voltage supply via the lamp. However, the purpose of the lamp is to help us confirm there are no major problems in the power supply and output stage. Once this is done, it is no longer needed.

QUICK CHECKS

If the set does not work properly, a few simple tests and observations may help to narrow down the faulty section.

If you get a loud humming noise from the speaker, or the stations sound like they are broadcasting from under water, one of the main electrolytic smoothing capacitors has probably failed.

If the set seems dead, listen closely to the speaker for signs of life. If you can hear some sort of hum or noise, albeit faintly, then the power supply and amplifier are probably doing something. If it is completely silent, check the connections between the output transformer and speaker. The primary of the output transformer may be open-circuit.

Turn the volume right up and touch a screwdriver blade on the centre tag of the volume control potentiometer. If the amplifier is working you should hear a buzzing from the speaker. This would confirm that the amplifier and power supply are alive.

If there is background hum but no buzzing when the volume control tag is touched, the fault may be in the audio pre-amplifier stage. The anode load resistor for this will sometimes be found to be open-circuit.

With the volume turned up, operate the wavechange switch. If there are healthy crackles from the speaker, the IF and detector sections are probably alive. Confirm that the set is definitely dead on all wavebands. If some wavebands are working, the fault is narrowed down to those components or circuits that are used only on the faulty bands.

On VHF sets, the VHF band will often be dead while MW and LW work OK. The usual cause is low emission valves on the VHF tuner assembly.

If the IF seems OK, try connecting an aerial or a length of wire to the control grid of the mixer-oscillator valve. If this produces some sort of noise or even stations, the connections and coupling between the valve and the aerial socket or ferrite rod aerial may be suspect.

If noise is heard which alters in note and volume as the set is tuned across the band, this may indicate that the local oscillator is not working.

CIRCUIT OPERATION

In this section, I will give a brief overview of the circuit operation of AM and FM valve radios, highlighting common fault areas. Due to space restrictions, this will be limited to the more common circuit arrangements. This subject is covered in much greater detail on my website and in some of the recommended books – see later for details.

POWER SUPPLY CIRCUITS

There are two basic power supply arrangements, depending on whether the set is designed for use on both AC and DC mains or on AC mains only.

AC only sets use a transformer to power the valve heaters and the full-wave HT rectifier (Fig.5). The valve heaters and dial lamps are connected in parallel and powered by a low voltage winding, often 6.3V. The rectifier heater may be powered from a separate winding and may be a different voltage. The transformer normally provides isolation from the mains, allowing the chassis to be earthed for safety if required.

In AC/DC sets, the valve heaters are connected in series and powered via a high power dropper resistor directly from the mains input (Fig.6). The heater current is 100mA in many later sets. The dropper resistor often has to drop around 100V and runs fairly hot, and thus failure is not uncommon. This component often

contains several resistance sections for voltage selection etc. The normal repair is to bridge the faulty section with a wire-wound resistor of suitable resistance and power rating.

Dial lamps (where fitted) are connected either in the heater chain or in the neutral connection to the whole set, and are

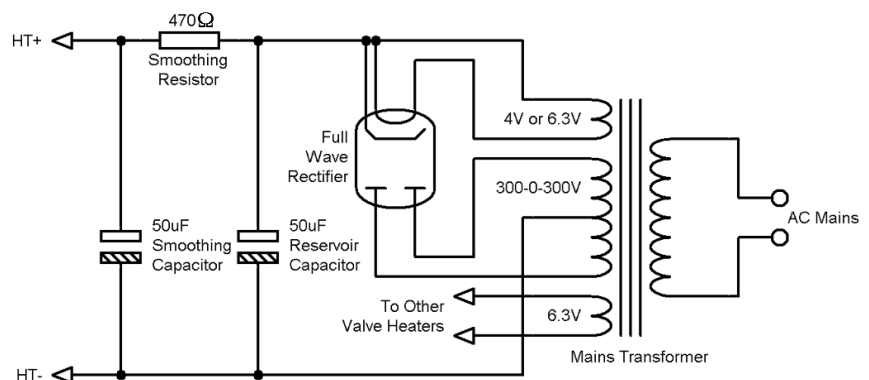


Fig.5. Power supply of a typical AC set.

triode. It is normally self-biased and has a very high grid bias resistor (10M Ω). This is coupled to the wiper of the volume control potentiometer via a capacitor. In most sets, the triode is combined with two detector and AGC diodes in a single envelope. In some later sets it is combined with the output pentode, and the diodes are combined with the IF amplifier valve.

This stage is generally reliable. The anode load resistor (around 220k Ω) occasionally goes high or open-circuit, resulting in no audio. A few sets built on p.c.b.s suffer from leakage in this area of the board due to the heat build-up. This normally shows as excessive hum. The only solution is to isolate the valve holder pin from the p.c.b., remove the tracking, and then rewire the connections from the volume control in a point-to-point manner.

Sets without this stage of amplification are known as "short superhets". The output valve is generally a high-slope (high gain) type to partly compensate for the missing amplifier. This type of set was sold for use on more local and powerful transmissions and can perform very well with a reasonable aerial.

The tone control in most sets is a simple top-cut arrangement (treble control). This consists of a pot and capacitor in series, between the audio signal and chassis.

Noisy volume and tone controls can often be fixed with a shot of contact cleaner (*do NOT use WD40 as this damages the resistive track*). If this is not successful, the control can be removed, dismantled and carefully cleaned with contact cleaner and cotton buds. Increasing the tension on the moving contacts often helps too. Alternatively, a replacement control can be fitted. If the replacement is 1M Ω and the original was 500k Ω , fit a 1M Ω resistor in parallel.

AM (MW AND LW), RF AND IF STAGES

The MW, LW and SW dials of virtually all British valve radios will be marked in wavelengths (metres) rather than frequencies. To convert from one to the other, divide 300,000 by the known figure (this conversion works both ways).

MW/LW superhet sets from the later 1950s generally use a ferrite rod aerial. Some sets from the mid 1940s onwards use an internal frame aerial, but many sets rely on an external wire aerial. The aerial circuit is tuned by one section of the variable tuning capacitor, before being coupled to the control grid of the mixer section of the mixer-oscillator valve.

The other section of this valve oscillates at a set frequency above (or occasionally below) the tuned frequency. The frequency is controlled by the other section of the variable tuning capacitor. The mixer stage combines the received signal with the oscillator signal. The result is a difference signal, which consists of a carrier at the difference between the oscillator and received frequencies, modulated by the received audio. Since the frequency of the difference is constant, it can be amplified by a fixed tuned amplifier circuit.

This difference frequency is known as the Intermediate Frequency (IF), and is generally 465kHz in later British sets. Other frequencies such as 455kHz and 470kHz may be encountered in

post-war sets, while pre-war sets often have a lower IF around 110kHz to 130kHz. The actual figure is given on the service data, and is only of importance if you need to realign the set.

The advantage of superhet circuits of this type over earlier TRF arrangements is that the signal passes through several stages of sharp tuning, which gives good selectivity and sensitivity. Since the IF is at a fixed frequency, the IF tuning is fixed. This is much more straightforward and reliable than attempting to keep several variable tuning stages in line with each other across the waveband.

Most sets have a single IF amplifier stage and two tuned IF transformers (one before and one after the IF amplifier). Some later Bush sets had an additional amplifier stage and transformer, although it is questionable whether this makes much difference.

The IF stage is followed by the detector, which extracts the audio signals from the IF. Since MW and LW transmissions are amplitude-modulated (AM), detection can be achieved with a single diode to remove one polarity of the signal, together with filtering to remove the IF, leaving just the required audio. This passes to the volume control and on to the audio amplifier already described.

AUTOMATIC GAIN CONTROL

The strength of the received signals can vary widely, with local or powerful stations blasting through and possibly overloading the receiver. The automatic gain control (AGC) circuit brings about some order to this situation.

As well as producing the required audio signal, the detector output can be passed through a low-pass filter to give a DC voltage proportional to the received signal strength. The types of valve used for the mixer-oscillator and IF amplifier stages are "vari-mu", which means their gain can be controlled by altering the DC biasing on their control grids. The DC level from the detector, known as the AGC signal, is used to reduce the gain of the valves when stronger signals are received.

The arrangement just described is simple AGC, as used in many cheaper sets. The drawback with this is that even a weak received signal will produce an AGC voltage and reduce the gain of the set. Better sets use delayed AGC, whereby the AGC does not come into play until the received signal is above a set level. Thus, weaker signals have the benefit of the full gain of the receiver, while larger signals are kept under control. A separate diode is used to derive the AGC voltage in sets having delayed AGC.

The AGC line is at high impedance, and is normally decoupled by one or two capacitors of around 0.05 μ F or 0.1 μ F. Any leakage in these capacitors can prevent the AGC from working properly, resulting in distortion on stronger signals. If this occurs, the relevant capacitors should be replaced and the associated resistors checked.

The screen-grids of the mixer-oscillator and IF amplifier valves are normally connected to HT via resistors and decoupled to chassis by capacitors. The cathodes are also decoupled to chassis by capacitors. Failure of these decoupling capacitors can result in whistles and instability or low gain.

FM (VHF) RF AND IF STAGES

Because of the much higher frequencies in VHF sets, the tuner and mixer-oscillator sections of a VHF receiver are normally contained in a separate screened case. The signal from the aerial first passes through a stage of RF amplification. As well as providing some gain, this prevents the local oscillator signals from getting back onto the aerial.

The mixer-oscillator works in a similar manner to that already described, however the whole operation is achieved with a single triode or pentode valve. The IF is normally 10.7MHz, although higher IFs were used on a few early VHF sets.

In many VHF sets, the RF amplifier and mixer-oscillator are a single dual-triode valve, often an ECC85 or UCC85. Some sets use two RF pentodes such as EF80 or UF80, or individual triodes.

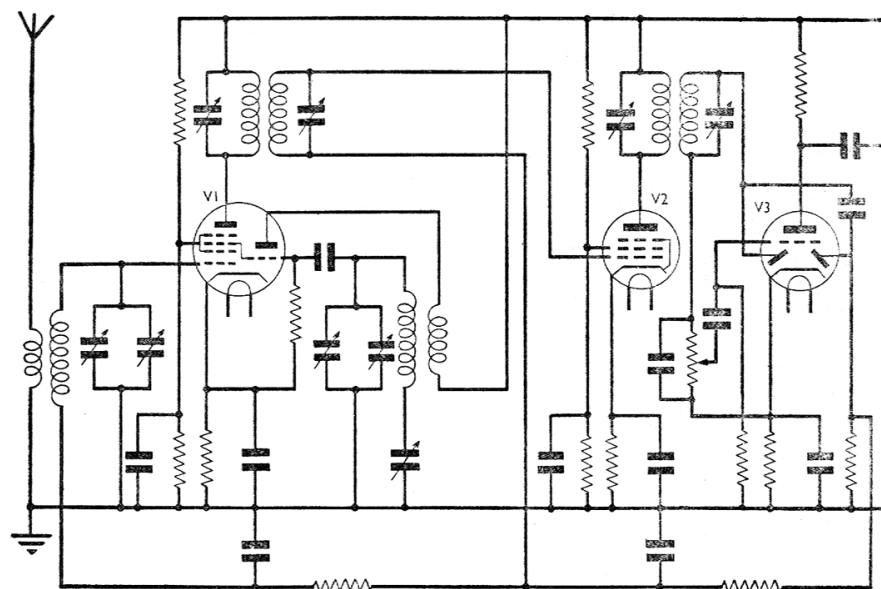


Fig.8. RF, IF and AGC stages of a typical superhet receiver.

In AM/FM sets, the mixer section of the AM mixer-oscillator valve is used as the first IF amplifier on FM. The oscillator triode is normally disabled, although in a few sets it is used as an additional audio amplifier on FM. The AM IF amplifier becomes the second IF amplifier on FM. FM-only sets will have two stages of IF amplification.

Because VHF transmissions are frequency-modulated (FM), the bandwidth of the IF amplifiers needs to be broader than for AM. Such amplifiers cannot have as much gain as tightly tuned AM IF stages, so an additional stage is needed to get the same amount of overall gain.

In AM/FM sets, there will be two IF transformers in parallel between each stage, one for AM and one for FM. The waveband switching sometimes bypasses the unwanted transformer, particularly in the earlier stages.

The FM detector is rather more complex than that for AM. The type of circuit used is known as a "ratio detector" and uses two diodes from a centre-tapped IF transformer secondary. The audio is extracted from the centre-tap, and the two diodes are coupled by a small electrolytic capacitor across which the AGC voltage is developed.

The diodes are often contained in a triple-diode-triode valve such as the EABC80 or UABC80, which also contains the AM detector and audio amplifier. If these diodes are low-emission VHF reception may be distorted. Incorrect adjustment of the final IF transformer will also cause severe distortion.

The AGC requirements for FM receivers are simpler than for AM sets. It is the variation in frequency not the variation in amplitude that matters. It is actually advantageous to drive the final IF stage into limiting, so that there are no amplitude variations on the detector input to cause distortion. The AGC therefore only needs to control this such that earlier stages are not overloaded and the limiting is not excessive.

The condition of decoupling capacitors is even more important on FM than on AM. It is not uncommon to have a set that works fine on AM but is distorted and unstable on FM. Replacement capacitors will often be all that is required.

Some sets feature a "magic-eye" tuning indicator. The control signal to this is derived from the AGC line.

ALIGNMENT

Alignment is the process of adjusting the IF and RF circuits for best reception (sensitivity, selectivity and absence of whistles) and accurate indication of the frequency/wavelength on the tuning scale. The set will have been properly aligned when it was manufactured but could require realignment either due to component ageing and drift or because somebody has been fiddling with the adjustments previously.

Before considering realignment, make sure there are no other causes of the poor reception. In particular, faulty decoupling capacitors in the IF and RF stages (as mentioned above) can give symptoms that might be confused with poor alignment, such as instability or low gain.

To align a set properly you need an RF signal generator, some means of monitoring

the output level, appropriate tools for altering the adjustments, and some patience! If the alignment is only slightly out, it is possible to make some minor adjustments on stations, but this should be done with great care to avoid making the situation worse. No harm will be caused to the set if the alignment is out, although the set may not be performing as well as it could. If in doubt, *leave it alone!*

The adjustment procedure varies with different makes and models of set. The best advice I can give here is to obtain the service sheet and follow the instructions carefully. Some alignment instructions call for specialist equipment. If you do not have the right equipment, some adaptation of the instructions may be necessary.

For more detailed information on alignment, the book by Chas E. Miller entitled *The How and Why of Alignment* is recommended.

CAPACITORS

If you have read the sections above, you will already realise that faulty capacitors can account for a lot of faults with valve radios. The main culprits are those with values between $0.001\mu\text{F}$ and $0.5\mu\text{F}$. Some repairers replace all the capacitors in this range in sets regardless. Others prefer to change only those capacitors that they have diagnosed to be the cause of the faults encountered. You need to make your own decisions, based on the initial state of the set, the number of capacitors, and the time you have available. There are various types of capacitor used, and some are worse than others.

Probably the most common and the most troublesome are the wax coated paper types. These are tubular components, with a distinctive sticky yellow coloured wax coating (usually turned brown with age and dirt). Most of these capacitors will be found to be leaky, and I usually replace them all.

Many later sets use small Hunts capacitors. These are small brown or black tubular plastic components, although a few have white paper labels around them. They are typically about 15mm long and 6mm in diameter. They are very unreliable. If the case is cracked or fractured it must be replaced, otherwise it may be OK but many restorers replace these on sight.

Many Philips sets use black capacitors coated in a substance that looks like tar. They are similar in size to the waxed paper variety. From my experience these capacitors in a set are usually either all OK or all

faulty. The value marking on these is sometimes difficult to decode, in which case the service sheet is especially useful.

There are a few modern types of capacitor that will be good replacements. My favourites, and the most expensive, are the yellow LCR metalised polypropylene axial types. These are rated at 1000V DC, and are similar sizes to the wax-coated paper types. They are available from most major component suppliers.

A good general-purpose replacement is the yellow polyester axial capacitors made by Vishay-Roderstein. These are available in 63V, 250V and 400V DC ranges, the 250V and 400V types being the most suitable for our needs. They are fairly small so ideal for replacing the small Hunts capacitors. These are stocked by RS Components.

The cheapest option is p.c.b. mounting dipped polyester capacitors. The 250V DC and 400V DC types are suitable electrically, but the leads will often need to be extended. They are cheap and work OK, but are fiddly to use and look untidy. I use these for "cheap" jobs, such as low cost sets with rough cabinets that are never going to be brilliant but that I want to work. Most major component suppliers stock the BC Components (formerly Philips) 368



Troublesome wax coated paper capacitors.



Hunts plastic capacitors – many restorers replace these on sight.

series. Some suppliers also stock a cheaper version made by Samwah.

For any position where a capacitor is connected across the mains or is subjected to similar AC voltages, Class X or X2 suppressor capacitors must be used.

The replacement capacitors may not be available in exactly the same capacitance values as the original components. Fit the closest available. For example, a new 0.047 μ F component could be used to replace a faulty 0.04 μ F or 0.05 μ F capacitor.

Some restorers like to fit the modern replacement capacitor inside the case of the old one, which leaves the underside of the chassis looking original. I have never attempted this because I feel it is really not worth the effort. It is only practical when the original is fairly large and in good external condition.

REPLACING RESISTORS AND CAPACITORS

Any replacement components must follow, as closely as possible, the path and position of the originals. In particular, this applies to those close to the chassis and those in the RF stages. The original layout would have been planned and optimised to avoid instability, so it is best not to deviate from this. Any component lead that is close to another component or the chassis should be sleeved with PVC sleeving to avoid any risk of short circuits.

There is always a risk of damage by applying heat for a long time while trying to desolder the component lead and unwrap it from around the terminal. To avoid this, I normally cut the old component leads close to the relevant tags. I then fit the new component by wrapping the leads around the tags and soldering. If there is a lot of solder on the tag, it is worth removing some with a desoldering tool (or solder wick) first.

Another option is to cut the leads close to the faulty component, then solder the new component onto the old leads.

VALVEHOLDER FAULTS

A fairly common problem, particularly on cheaper sets, is poor contact between the valve and the valve holder. This could occur anywhere in the set, although it tends to occur more often with rectifier and output valves.

Try applying some contact cleaner, then plugging and unplugging the valve a few times. This is often sufficient to clean the contacts. If the contacts in the holder have lost some of their spring tension, they can often be tightened by carefully pushing a small jeweller's screwdriver between the contact and the body of the valveholder to close the contact.

Sometimes the contacts will be found to be broken, or will break when you try to tension them. Don't panic! There is an easier solution than replacing the holder, particularly if only a couple of contacts are damaged.

With some types of valve holder it is possible to remove individual contacts once they are unsoldered and the tag straightened. If you have a similar valveholder in a scrap set, you can use contacts from this for replacement. If not,

you might be able to use a couple of unused contacts from other valveholders in the set. If you are concerned about causing damage when you unsolder all the connections, just cut the tag from the old holder and remove the contact. Insert the new contact, and solder the original tag, complete with all the connections, onto it. It's a bit messy, but it works.

MAINS WIRING

If the mains cable is not double insulated PVC flex with the modern colour code, it should be replaced. The only exception to this is if the cable contains ballast resistance, i.e. the lead itself drops the voltage to the set (beyond the scope of this article).

If one side of the mains flex connects (directly or indirectly) to the chassis, use two-core 3A cable, making sure the neutral (blue wire) connects to the chassis. If the set is an AC only model with an isolating transformer and neither side of the mains connected to the chassis then I prefer to use three core 3A mains flex and earth the chassis.

The cable must use the current colour code of brown (live), blue (neutral) and green/yellow (earth). The mains plug should be fitted with a 1A fuse. If the set only has a single pole mains switch, make sure it breaks the live connection. If it has a double pole switch, it should break both live and neutral.

Make sure the mains cable is securely fixed to the chassis so that there is no strain on the connections if it is pulled or twisted. In many sets, the original cable passes through a grommet and then has a knot tied in it to stop it from pulling out. If possible, do something better (maybe using cable ties or a P-clip), you should never tie a knot as it may damage the cable. Replace the grommet if it is not in good condition.

Check the voltage selector. If it is accessible externally for safety reasons, you will either have to relocate it or disconnect it. It is often easier to disconnect it and wire the set permanently to the appropriate voltage setting.

TUNING DRIVE CORD

The tuning drive cord often breaks or becomes weakened. Replacement cord used to be available from component suppliers, but is now difficult to obtain. Try linen cord or fishing yarn.

Normally the broken cord will retain some of its shape, and this should be carefully noted before disturbing it. On many sets, the drive cord arrangement is fairly simple, but a few can be more complex. If you cannot work it out, obtain the service sheet for the set.

The tuning pointer can be repainted if necessary. Enamel paint intended for plastic construction sets (such as Airfix or Humbrol paint) is ideal for this. You may also wish to repaint the plate behind the tuning scale using spray paint.

TUNING SCALE

The printing on the tuning scale glass is usually very soft and can easily be removed if the wrong cleaning product is used. The best approach is not to clean the printed side at all unless it is really necessary and you are sure the printing is sound. Even then, you should only use a dry

duster or possibly a tissue slightly dampened with water. Be very careful, as a replacement tuning scale will be almost impossible to obtain.

If the printing is flaking off, spray it with a clear lacquer to hold the printing that remains in place. Try a small amount in a corner first to make sure it does not soften the printing.

If some of the printing is missing, and you are reasonably artistic, you may like to repaint it. Remember that you are working backwards, and that the first layer of paint is the one that will be seen.

You may be able to scan the remaining pattern into a computer and recreate the missing parts in a photo-editing program. This could then be printed onto transparent film using an inkjet printer, and fitted behind the original glass.

The outside of the scale can be cleaned with a household or car glass-cleaning product. Make sure this does not get onto the printed side.

LOUDSPEAKER

If the cone of the loudspeaker itself is damaged or coming away from the frame, it can be repaired with a contact adhesive that dries to a rubbery consistency, such as EvoStick. If the speaker is badly damaged you will probably need a replacement.

If the cone is distorted, so that the speech coil is scraping against the magnet, you may be able to cobble a "repair" by lodging a wad of tissue paper between the cone and the frame at a suitable point. This is hardly an ideal solution but it may be the best option if a suitable replacement speaker is not available, or as a temporary measure while you are waiting for a replacement to arrive.

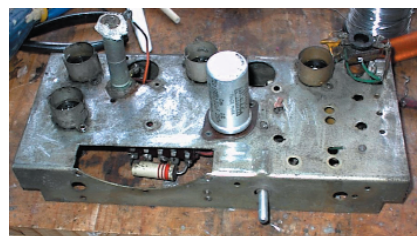
SPEAKER FABRIC

It is difficult or near impossible to clean dirty speaker fabric. One option is to wash it in cold water, using fairly strong detergent (such as Woolite). The water must be cold to reduce the risk of shrinking. While it is still wet, stretch it back to the right size and clamp it in place while it dries. You could also experiment with car upholstery cleaning products.

You are very unlikely to be able to obtain an exact replacement fabric since it is no longer manufactured. Sid Chaplin carries stocks of modern fabrics and reproductions that will act as reasonable replacements in some cases. Other suppliers (often from the USA) sometimes attend the NVCF.

CLEANING THE CHASSIS

Remove the valves, and carefully clean the glass envelopes with a dry tissue (such as kitchen towels). Breathing on the



A chassis during restoration. (Courtesy Radio Bygones)

glass – as though you were cleaning spectacles – may help. *Take great care not to remove the markings, which are often very soft.*

Over the years, the chassis will accumulate a layer of dust and grime, which needs to be removed without damaging the components. Foam Cleanser is good for this, but it should be sprayed onto the cloth and *not* the chassis. A toothbrush or cotton buds are useful for getting into the awkward gaps.

PRINTED CIRCUIT BOARDS

P.C.B.s are more of a problem to clean, because the cleaning products can cause damage to the components. Initially try using a dry toothbrush to remove the dust and grime. Patches of wax can be carefully scraped away with a small screwdriver, but if it is not doing any harm, you could just leave it there!

If the p.c.b. is particularly filthy, you can try using Electrolube Ultrasolve or a similar p.c.b. cleaning solvent. Take care to avoid rubbing the components, since it may remove the markings from some resistors. Cotton buds are useful for this.

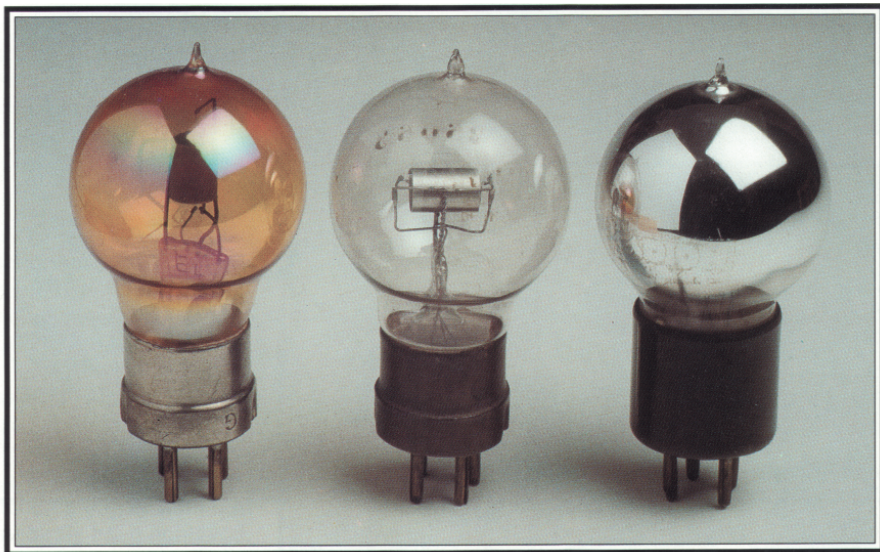
REPLACEMENT BACKS

If the original back to the set is missing you should arrange an alternative. This is essential if the set is to be used, to prevent little fingers finding their way onto live terminals. If you have a supply of scrap sets, you may have a back that can be modified to suit.

A suitable replacement back can be made from hardboard or thin plywood. Once it has been cut to size, drill or punch a large number of 1/4 inch (6mm) holes for ventilation. In particular, there should be holes near the output and rectifier valves, and any high power resistors. Drilling hardboard gives a rather tatty finish, which can be tidied somewhat with medium grade sandpaper. The back can then be sprayed with black aerosol paint if desired. Obviously it is much better if the set is complete with the original back when purchased.



Some collectors specialise in communications equipment like this Racal R17 receiver from the late 50s. (Courtesy Radio Bygones)



A selection of early valves from the collection of Bill Journeaux. (Courtesy Radio Bygones)

CABINET RESTORATION

Before embarking on the restoration of the cabinet and chassis, you should consider carefully what you are trying to achieve. This will vary with different sets, and everybody has their own preferences.

Many restorers do not try to make the set look like new, as this can appear artificial. The normal aim is to restore the set to the condition it would be in if it had been kept on a sideboard since it was new, and lovingly dusted occasionally. Small scratches and chips are signs of general wear and tear, and should generally be accepted as such.

Consider the value of the set, and the likely impact to this caused by any work you decide to do. If the set is worth next-to-nothing before you start, you really have nothing to lose, and could gain a nice-looking set! However, if the set is rare or valuable – say over £100 – you should take expert advice before doing anything that could affect the appearance and value.

DISMANTLING

Before attempting to clean and restore the cabinet, it should be dismantled as far as possible. Normally the speaker baffle board is a separate assembly and is held in place with screws or clips. Trim and manufacturers logos are often held in place with nuts, clips or bent-over pins on the inside, or possibly glued in place. The tuning scale glass is normally held with a few metal fixing plates, fitted with rubber pieces to protect the glass.

These items can usually be readily removed, and then cleaned and restored individually. Also, remove the speaker from the baffle board. Do not try to separate glued items unless it is absolutely necessary.

On many Bakelite sets, the baffle board and other components are held in place with spring clips pressed over pillars. Sometimes there is a flat side on the pillar,

in which case the clip can be removed by turning it so that one of the gripping sections is next to the flat. Otherwise, grip the sides of the clip with long nosed pliers and rotate it back and forth, as you pull it off – taking care not to break the pillar.

KNOBS AND TRIM

Plastic, Bakelite and metallic parts can initially be cleaned with warm water and washing-up liquid. The water should not be too hot, as very hot water can cause plastic parts to soften and distort. Leave the parts to soak for a few minutes. An old toothbrush is ideal for cleaning the parts and removing the grime from the finger-grips of the knobs. Once the parts are clean, rinse them in clean running water to remove the detergent, and leave them to dry.

Brass items can then be polished using Brasso or a similar product. You will often find that they have been coated

with a lacquer, which has become chipped and stained. Once you have a good polished brass surface, it should be protected with lacquer to prevent it becoming tarnished and dull.

Chrome plated items can be carefully polished with Brasso, taking care not to remove the plating. If the plating is already badly chipped and damaged, you may have to paint over it. Chrome paint is available, but generally looks fairly awful.

Plastic and Bakelite knobs can be wax polished in the same manner as for Bakelite cabinets (described later). If the knobs have printing that is lightly recessed, and some of this is missing, it can be replaced with suitable colour model paint. Any paint on the surface can be removed with Brasso once the paint is completely dry (24 hours).

CLEANING BAKELITE

The Bakelite or plastic cabinet can be washed with warm water and washing-up liquid. A washing-up brush and a toothbrush are useful for getting the muck out of the corners and recesses. When the cabinet is clean, rinse it in clean water and leave it to dry naturally.

The best finish can be obtained by using a specialist Bakelite polish. Bake-o-Bryte is available from The Radiophile for £2 plus 50p postage, and gives excellent results.

Alternatively, a good quality wax polish such as Colron Finishing Wax (available from DIY stores) can be used. If the surface is dull and cloudy, it can be improved with the gentle application of a slightly abrasive polish such as Brasso or T-cut.

REPAIRING BAKELITE

Clean cracks and breaks can be successfully (but not invisibly) repaired with a little superglue. The version with a small brush in the lid is recommended. Clean the broken edges carefully, then piece them together and secure with masking tape on the outside to hold them close. Apply the glue to the inside of the cabinet and let it work its way into the crack by capillary action. Once the glue is thoroughly dry (allow several hours), any excess on the outside can be gently removed with a razor blade or modelling knife.

Superglue is only suitable for repairing clean breaks, and is unable to fill gaps. If the broken parts do not fit cleanly together, you will need to use an adhesive that fills the void. An epoxy resin such as Araldite (the standard type, not the fast drying) is suitable. Any excess can be removed with a modelling knife once the glue has dried completely (at least 24 hours). More major rebuilding work can be carried out with two-part car body repair filler such as Davids Isopon P38.

The only problem with these repair techniques is that the epoxy or filler is not the same colour as the cabinet. You may be able to mix appropriate coloured Bakelite filings (removed from an old knob or scrap cabinet with a file) with the filler to disguise the repair. This will only work if the cabinet is a single colour, and it may be difficult to get an exact match.

PAINTING

The easier solution is to paint either the whole cabinet or just the repaired area with suitable colour car spray paint. If

you want a deep brown Bakelite colour, Vauxhall Brazil Brown is a good match. Car aerosol paint is also ideal for repainting the painted sections of cabinets. For off-white sections, Ford Sierra Beige or Lada Cream are often suitable. Bakelite should be primed first using the recommended colour primer for the paint being used.

Clean the cabinet thoroughly with white spirit or meths to remove any grease. Anything that should not be painted must be protected with newspaper and masking tape.

Spraying should be done outdoors on a dry still day. If you are working in a covered area such as a garage, leave the door fully open to let the fumes out.

Shake the can thoroughly before use. Spray painting needs practice to obtain good results. Each coat should be just thick enough that it has an even wet look. If it looks powdery, you need to spray it a little thicker, and if you are getting runs, it is too thick. With practice, and a bit of luck, you can sometimes do the job in one coat. If you need additional coats, they should be applied at about half-hour intervals.

Remove the masking tape and newspaper about half-an-hour after the final coat, then leave the cabinet to dry thoroughly for at least 24 hours. The paint finish will probably be fine as it is, but it can be polished with a household spray polish if necessary. Do not use car polish as it gives an artificially glossy finish. If the painted finish is too glossy, it can be dulled by gentle rubbing with fine steel wool.

RESTORING WOOD

This section details some of the more straightforward methods of repairing and restoring wooden cabinets. If you are feeling more ambitious it would be worth finding a good book, magazine or website about furniture restoration.

Some of the suggestions given here may result in a finish that does not look the same as the original. This could be a problem, particularly if you are restoring the set for someone else or intend to sell the restored set. This would also drastically affect the value of the set. If you are in any doubt, contact an experienced furniture restorer.

WOODWORM

If the cabinet shows any signs of woodworm, this must be treated before continuing. If you are not able to do this straight away, wrap the set in a plastic rubbish sack and leave it somewhere cool and away from other sets, furniture or timber structures. Any signs of woodworm must be taken very seriously.

Remove the chassis and any other removable parts if you have not already done so. Cuprinol Woodworm Killer is available in an aerosol can with a pointed nozzle for squirting into the woodworm holes. Treat the cabinet in accordance with the instructions and safety warnings on the can.

After treatment, wrap the cabinet in a plastic rubbish sack (do not seal the top of the sack) and leave it in a warm place for several days. If there is any further sign of woodworm activity, such as new holes or wood dust, treat it again. Wait at least a week for the woodworm killer to thoroughly dry out before carrying out any repair or restoration work on the cabinet.

CABINET REPAIRS

Wooden cabinets sometimes come apart at the joints, which are normally held together with glue alone. Apply a little Evostick Woodworking Adhesive to the gap, and use a scrap of cardboard to spread the glue well in. Hold the joint tightly closed with clamps or heavy items while the glue dries. Any glue that oozes out should be wiped off with a damp tissue.

If the layers of the plywood come apart, they can be repaired in a similar manner. The plywood should be clamped firmly between two solid boards while the glue is drying to ensure the result remains flat.

CLEANING

The build-up of dirt, household polish and nicotine on the surface of a wooden cabinet can often be removed with white spirit. If this does not work, try foam cleaner. Warm water and washing-up liquid is also effective, but *you should not submerge the cabinet and do not allow it to become too wet* – just use a dampened cloth and dry it off quickly. The aim is to remove the grime without disturbing the original finish. However, some dirt, particularly in corners etc., is a sign of age, which should not be disturbed.

STRIPPING

If the original polish or varnish is in a poor state, you may have no option but to strip it and start again. Do not rush into this, as it can be difficult to get a finish similar to the original.

If the cabinet has a wax polish finish you may be able to remove it with methylated spirits. Normally however you will need to use a varnish-stripping product such as NitroMors Varnish Remover. Use this with medium grade wire wool in accordance with the instructions and safety warnings on the tin. Once the varnish is removed, the cabinet should be thoroughly cleaned with methylated spirits or white spirit.

PREPARING

If the wood colour is too light, it can be darkened at this stage with Colron Wood Dye. The colour obtained is often slightly lighter than the shop display would suggest, so choose a fairly dark colour such as walnut. Any woodworm holes and other blemishes can be filled with plastic wood. This also dries lighter than expected.

The exposed wood should then be protected and sealed with Colron Wood Reviver. This is rubbed into the surface with a soft cloth and allowed to dry.

If the cabinet had a shiny lacquered finish, it may be sprayed with two or three coats of aerosol lacquer. The type sold in car accessory shops for use on metallic paint finishes is ideal. Do not use a brush-on product, as it is very difficult to get a smooth finish.

TOUCHING UP

If a polished finish is scratched or chipped, the blemishes can be masked to some extent with Colron Liquid Scratch Remover. This is supplied in a bottle with a small brush, and is applied to the scratch and allowed to dry before buffing.

Scratches in lacquered cabinets can be repaired with car lacquer. Use the touch-up pot with a small brush in the lid. Several



layers may be needed to build up the depth. Test in a hidden corner first, to ensure that the lacquer does not affect the original finish.

REGULAR USE

Having repaired and restored your set, you should use it and enjoy it. Periodic use will keep the set in good order and dry out any damp. I would suggest that the set should be used for at least one hour every month. One hour or more allows the set to warm up properly, which is better for the valves than brief periods of operation.

ABOUT THE AUTHOR

I have been collecting and restoring valve and early transistor radios since the mid-80s. I prefer smaller Bakelite and plastic post-war sets, partly because they are much easier to accommodate than larger wooden cased models. I am also quite keen on early transistor sets, so a number of those are finding their way into my collection.

I have been running a website entitled Vintage Radio Repair and Restoration for

about five years. I have also produced several CD-ROMs of service data and valve data, which are now available through the *RB Bookshelf*.

ACKNOWLEDGEMENTS

The author would like to thank Rob Rusbridge at Wireless Works for his considerable assistance with the "Design Availability and Prices" section. He would also like to thank Jon Evans for checking and proofreading this supplement. □

CONTACT DETAILS

The following list contains a selection of suppliers of vintage radio sets, information and components. If you have Internet access, you can find a comprehensive directory of suppliers at <http://www.radiocraft.co.uk/directory/directory.htm>.

Please note that some of these businesses are run from the proprietor's homes, so please limit telephone calls to reasonable weekday business hours. In addition, some may not be open to callers, or may only be open by appointment so always check before travelling.

VINTAGE RADIOS

The Wireless Works (Rob Rusbridge), 40 Fore Street, Bugle, St Austell, Cornwall, PL26 8PE

Web – <http://www.wirelessworks.co.uk>

Email – rob@wirelessworks.co.uk

Phone/Fax – 01726 852284

Past Times Radio (Richard Booth), School House, Old School Lane, Wadworth, Doncaster, DN11 9BW

Web – <http://www.pasttimesradio.co.uk>

Email – richard@pasttimesradio.co.uk

Phone – 01302 858468

Mobile – 07971 701380

On the Air (Steve Harris), The Vintage Technology Centre, The Highway, Hawarden, Deeside, CH5 3DN

Web – <http://www.vintageradio.co.uk>

Email – info@vintageradio.co.uk

Phone/Fax – 01244 530300

Mobile – 07778 767734

Radiocraft (Steve Ostler), Main Street, Sedgeberrow, WR11 7UF, United Kingdom.

Web – <http://www.radiocraft.co.uk>

Email – steve@radiocraft.co.uk

Phone – 01386 882280

Mobile – 07876 296019

Radio Renaissance (Colin Boggis), Ruckholt Lodge, Ringwood Road, Bransgore, Christchurch BH23 8AE

Web – <http://www.radio-renaissance.co.uk>

Email – colin@radio-renaissance.co.uk

Phone/Fax – 01425 674925

Mobile – 07714 750918

Malcolm Bennett's Vintage Radios (Online Sales and Wanted adverts)

Web – <http://www.valve.demon.co.uk>

eBay (Online auction – look in "Collectables – Radio")

Web – <http://www.ebay.co.uk>

VALVE AND SERVICE DATA

Note: The service data and valve data CD-ROMs mentioned in this supplement are available from the *Radio Bygones Bookshelf* – see "Magazines And Organisations".

Savoy Hill Publications (Paul & Alex Ollivier), Fir View, 7 Rabys Row, Scorrier, Redruth, Cornwall, TR16 5AW

Email – paul.pollivier@virgin.net

Phone – 01209 820771

Chevet Supplies Ltd., 157 Dickson Road, Blackpool, FY1 2EU. Also sell books, reprinted manuals, hardware and components

Email – chevet@globalnet.co.uk

Phone – 01253 751858

Fax – 01253 302979

Mauritron Technical Services, 8 Cherry Tree Road, Chinnor, Oxfordshire, OX39 4QY

Email – enquiries@mauritron.co.uk

Web – <http://www.mauritron.co.uk>

Phone – 01844 351694

Fax – 01844 352554

Duncan Amplification (Online Valve Data)

Web – <http://www.duncanamps.com>

Nostalgia Air (Online American radio schematics – click the "Riders Online" link)

Web – <http://www.nostalgiaair.org>

Frank Nostalgia Air (Online Valve Data)

Web – <http://frank.nostalgiaair.org>

VALVES

Valve and Tube Supplies (Rod Burman), Woodlands Vale House, Calthorpe Road, Ryde, Isle of Wight, PO33 1PR

Web – <http://www.valves.uk.com>

Email – rod@valves.uk.com

Phone – 01983 811386

Fax – 01983 563730

Wilson Valves (Jim Fish), 28, Banks Avenue, Golcar, Huddersfield, Yorkshire, HD7 4LZ

Email – wilsonvalves@surflink.co.uk

Phone – 01484 654650

Fax – 01484 655699

Kenzen (Ken Bailey), Unit 9, 16-20 George Street, Balsall Heath, Birmingham, B12 9RG

Phone – 0121 446 4346

Fax – 0121 446 4245

COMPONENTS AND SPARES

Traditional Radio Grilles (Sid Chaplin), 43 Lime Avenue, Leigh on Sea, Essex, SS9 3PA

Email – sidney@tradradgrilles.free-serve.co.uk

Web – <http://www.vintage-radio.com/trg/>

Phone – 01702 473740

Sowter Transformers, The Boatyard, Cullingham Road, Ipswich, IP1 2EG

Web – <http://www.sowter.co.uk>

Email – techsupport@sowter.co.uk

Phone – 01962 620135

Fax – 0870 458 1700

Variable Voltage Technology Ltd., Unit 24R Samuels Whites Estate, Cowes, Isle of Wight, PO31 7LP.

All types of transformers for all types of circuits including specialist valve units and for restoration of vintage radios

Web – www.vvttransformers.co.uk

Email – rb@vvt-cowes.freemove.co.uk

Phone – 01983 280592

Fax – 01983 280593

RS Components – telephone or web site orders with a credit card only.

Web – <http://rswww.com>

Phone – 01536 444079

For general radio components and spares, the suppliers under "Vintage Radios" above will also be able to help.

MAGAZINES AND ORGANISATIONS

Radio Bygones, Wimborne Publishing Ltd., 408 Wimborne Road East, Ferndown, Dorset, BH22 9ND. Subscriptions – 1 year (six issues) UK £18.50; Europe £20.50 (airmail); Rest of the World £24.50 (airmail).

Web – <http://www.radiobygones.co.uk>

Online <http://www.radiobygones.com>

Email – radiobygones@wimborne.co.uk

Phone – 01202 873872

Fax – 01202 874562

British Vintage Wireless Society, c/o Vintage Wireless Museum, 23 Rosendale Road, West Dulwich, London, SE21 8DS

Web – <http://www.bvws.org.uk>

Email (membership enquiries – Graham Terry) – g.terry@virgin.net

Email (chairman – Mike Barker) – MurphyMad@aol.com

The Radiophile, Larkhill, Newport Road, Woodseaves, Staffs, ST20 0NP

Web – <http://www.radiophile.co.uk>

Phone/Fax – 01785 284696

National Vintage Communications Fair (Sunrise Press), Spice House, 13 Belmont Road, Exeter, Devon, EX1 2HF
 Web – <http://www.angelfire.com/tx/sunpress/index.html>
 Email – sunpress@eurobell.co.uk or sun.press@btinternet.com
 Tel – 01392 411565

Morsum Magnificat, The Poplars, Wistanswick, Market Drayton, Shropshire TF9 2BA
 Web – <http://www.morsemag.com>
 Email – subscribe@morsemag.com
 Phone – 01630 638306
 Fax – 01630 638051

RECOMMENDED WEBSITES

Vintage Radio Repair and Restoration (the author's website – includes repair and restoration information, repair stories and full details about the service data and valve data CD-ROMs)
<http://www.vintage-radio.com>

Radio Bygones (includes information about the magazine plus subscription ordering and a message board. Also links to the *EPE/RB* Online Shop where you can order a wide range of books/CD-ROMs/videos/back issues etc.)
www.radiobygones.co.uk

Radio Bygones Online (the web based version of the magazine. Log on, pay by

credit card (\$9.99 US for six issues) and download the magazine instantly – a free issue is also available, as are a number of back issues).

www.radiobygones.com

Jonz Valve Page (an interesting collection of radios, televisions and test gear, as well as some more technical information about valve workings etc)
<http://www.TheValvePage.com>

Allan's Virtual Radio Museum (radio collection, true stories, grumbles, "Radio and Television Servicing" radio index, IF frequencies etc.)
<http://www.thorneyhill.freemove.co.uk>

Vintage Radio World (lots of good repair and restoration information)
<http://www.burdaelclose.freemove.co.uk>

Wireless Works (good repair and restoration information in the "Information" section)
<http://www.wirelessworks.co.uk>

Alan Lord's Vintage Radio Collection (also offers a good discussion forum)
http://www.dundecoll.ac.uk/Sections/CS/Staff/al_radio/

Dave's Rust 'n' Dust Homepage (lots of info about Murphy radios)
<http://www.murphy-radio.co.uk>

Vintage Wireless Database (may help you identify that unknown radio)
<http://www.classaxe.com/wireless/data/>

Marconi Calling (online history of Guglielmo Marconi presented by Marconi PLC)
<http://www.marconicalling.com>

Old Telly's Website (lots of good vintage TV repair information)

<http://www.penders.cwc.net/otindex.html>

RECOMMENDED BOOKS

Vintage Radios (Collecting – Servicing – Restoring) by Tony Thompson, ISBN 0-9538218-0-3, £12.95.

Radio! Radio! by Jonathan Hill, ISBN 0 9511448 71, £39.95.

Comprehensive Radio Valve Guides (five books plus Master Index) £15.00.

Electronic Classics by Andrew Emmerson, ISBN 0-7506-3788-9, £21.75

Valve Radio and Audio Repair Handbook by Chas E. Miller, ISBN 0-7506-3995-4, £20.50

All the above are available by mail order, or via the shop on the web site, from *Radio Bygones* – address details on page 15. Prices correct at time of writing, they include UK post and packing, please enquire about overseas postage or order from the web site – www.radiobygones.co.uk.

Also: *Rapid Radio Repair – Standard Superhets* by Chas E Miller, £2.95. Available directly from The Radiophile – address details on page 15.

Rapid Radio Repair – The Why and How of Alignment by Chas E. Miller, £2.95. Available directly from The Radiophile – address details on page 15.

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