THE RESTORATION OF VALVED HIGH FREQUENCY COMMUNICATIONS RECEIVERS

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  This issue: 23rd July 2005

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1. Foreword and Acknowledgements

This book is the distillation of well over 20 years work, both in a professional capacity and as an enthusiastic collector and restorer. I hope you find it interesting and useful. If you find any errors in it, or if you want to bend my ear about any of my opinions I have stated or any of the techniques I have advocated, then please feel free to contact me:

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My grateful thanks go to:

Simon Buxton VK2UA, who provided great encouragement to get this book published, and kindly offered the use of his **www.vk2bv.org/radio/** server to host it free of charge for the good of the radio community at large.

Ian O'Toole VK2ZIO, whose kind invitation to his impressive museum at Kurrajong in NSW, Australia helped catalyse the publication of this book.

Andrew Sinclair G0AMS, for his ongoing support and encouragement over many years, and for his specific contribution to the work of restoring the R1155A and BRT400K receivers described here.

2. Scope

This book covers the restoration of valved HF receivers developed for sale into military, amateur or industrial markets. It does not contain rebuild or repair information relating to cabinets, front panels or antennas. Domestic broadcast receivers are of little interest to this writer and are not covered as a specific topic, though much of the book would be found useful if working on such equipment.

3. Abbreviations

ABS	Acrylonitrile Butadiene Styrene
AGC	Automatic Gain Control
AFC	Automatic Frequency Control
AM	Amplitude Modulation
AME	Ateliers des Montages Electriques
ANL	Automatic Noise Limiter
BFO	Beat Frequency Oscillator
CAD	Computer Aided Design
CENELEC	European Committee for Electro-technical Standardization
CNR	Combat Net Radio
CW	Continuous Wave
DMM	Digital Multi-Meter
EAC	Electronic Assistance Corporation
EKCO	E K Cole Ltd
EMF	Electro-Motive Force
ETSI	European Telecommunications Standards Institute
FM	Frequency Modulation
FSD	Full Scale Deflection
GDO	Grid Dip Oscillator
GEC	The General Electric Company Ltd (≠ General Electric USA)
GPO	(British) General Post Office
HF	High Frequency

HMP	High Melting Point
HT	High Tension
IF	Intermediate Frequency
IFT	Intermediate Frequency Transformer
IPA	iso-Propyl Alcohol
ISB	Independent SideBand
ITU-R	International Telecommunications Union - Radio
JAN	Joint Army and Navy (USA)
LMP	Low Melting Point
LO	Local Oscillator
MARS	Military Affiliate Radio System
MFP	Moisture and Fungus Proofing
MTB	Motor Torpedo Boat
MUF	Maximum Usable Frequency, especially in the summer daylight hours during high sunspot activity.
NOS	New, but Old Stock
NTC	Negative Temperature Coefficient
o/b/o	on behalf of
p-p	Peak-to-Peak
PAT	Portable Appliance Tester
PBT	PassBand Tuning
PCB	Printed Circuit Board or Poly Chloro Benzene (hazardous material) (context sensitive)
PD	Potential Difference
PSEI	Peto Scott Electrical Instruments
PSU	Power Supply Unit
PTFE	Poly Tetra-Fluoro Ethylene
PTO	Permeability Tuned Oscillator
PVC	Poly Vinyl Chloride
QPP	Quiescent Push-Pull
RAF	(UK) Royal Air Force
RCA	Radio Corporation of America
RCL	Resistance, Capacitance, Inductance
RF	Radio Frequency
RIS	Radio Interference Suppression
RIT	Receive Independent of Transmit
RME	Radio Manufacturing Engineers
RMS	Root of the Mean of Squares
RN	(UK) Royal Navy
SAE	(USA) Society of Automobile Engineers
SMPU	Switch-Mode Power supply Unit
SNR	Signal to Noise Ratio
SRE	Ship's Received Entertainment
SSB	Single SideBand
Topband	1.8MHz to 2.0MHz
TRF	Tuned Radio Frequency
TSC	Teledyne Systems Corporation
UHF	Ultra-High Frequency
UNC	Unified National Coarse
VFO	Variable Frequency Oscillator
VHF	Very High Frequency
μ-metal	Magnetically soft Iron

4. Objectives

The view of this writer is that what should primarily be restored is the original electrical and mechanical performance. If possible, this should coincide with an exact physical restoration of the chassis. Where this is not possible, then the changes made to the physical construction of the receiver should be kept to the absolute minimum. There is an argument that this approach may show future generations more of how the unit was restored than how it was originally built.

This viewpoint is entirely accepted. However, at least it will be possible to see how the designer intended the unit to function.

It is advocated that in some cases, mains arrangements should be upgraded to reflect modern day practice. This is to ensure the continued safe operation of the product, well into the future. Again, it is accepted that this may cause some loss of originality.

5. The Restoration Process

The work should proceed in four stages, in the following order.

1. Renovation of chassis and mechanical assemblies.

2. Repairs to wound components and wiring.

3. Replacement of valves and other components.

4. Faultfinding and realignment.

It should be noted that this sequence is the direct reverse of what would normally be attempted in the way of repairs to an equipment of recent manufacture. This implies that major chassis components and inductors will usually be found in original condition, even on the older equipments. Valves and sundry minor components will be found to have been replaced many years ago, perhaps two or even three times over the years. A variable number of past repairs will ordinarily be found, many of which will have been botched.

This book describes the techniques which I use in my own workshop. They work OK for me. There may be alternative methodologies which would work even better for you.

The restoration materials indicated here are types available in the UK. Recognising the international readership of this book, a glossary is included in an attempt to define the materials so that locally available substitutes can be identified if necessary.

6. Supporting Information

It is ideal to have <u>exactly</u> the correct technical information to hand. This may prove unexpectedly difficult to find, or even to identify. It is also highly advisable to obtain details of the various production or service modifications applicable to your unit. Then, before the commencement of any work, the unit should be surveyed to identify its build standard, and to identify any authorised or unauthorised modifications that may have been implemented, whether correctly or incorrectly.

The error rate in original documentation will be found far higher than would be considered acceptable nowadays. Problems and uncertainties due to this cause are best resolved by reference to a "gold standard" example of the model in question if you can find one near where you live, and if the owner is sympathetic enough to let you examine it in detail.

The overall difficulty of restoration can sometimes be compounded by the publication of spurious magazine articles, some of which have been elevated to the status of folk lore since the 1960s when so many of them first appeared. These articles are usually more or less loosely based on original manufacturer's information. Almost the worst case possible, is when you try to restore a chassis that some previous owner has repaired well (ie almost invisibly) using a recent magazine article based on one of the earlier ones. The opportunity for error has then increased greatly compared with what was in the manufacturer's original production drawing package.

Because each radio design had its own set of stock faults when in service, a lot of time can be saved by getting wise to these sooner rather than later. Magazine articles can be invaluable as a source of informed material, as can old hands who used to work on these sets prior to retirement. Sometimes the list of stock faults can be surprisingly specific. For instance, the mains transformer on the B40 is unreliable… but only on the original production variant. Some B40s mistrack… but this problem will usually be found only on those examples of the later "D" variant that somehow escaped one particular authorised service modification package.

7. Chassis & Mechanics

7.1 Chassis Cleaning

Stand the chassis in a convenient position, noting that some chasses cannot safely be inverted or angled far from the vertical without severe risk of mechanical damage to IFTs etc. The Hallicrafters SX28 and Marconi CR100/B28 are two examples of this inconvenient design.

If faced with this problem, make a pair of handling frames right now at the start of the job, one fitted to the left skirt of the chassis apron and one to the right. Chipboard usually works fine for this job. Wooden chocks can be screwed into position, to tilt the chassis slightly backwards at a convenient angle for working on the bench. By making the chipboard sideplates a little higher than the tallest component on the chassis, this technique would allow full inversion of the radio on the bench without damage.

Wherever possible, dry clean using a vacuum cleaner nozzle and paintbrush. Where essential, wet clean the product by painting/scrubbing methylated spirit onto it using a paintbrush or toothbrush, then using a vacuum cleaner nozzle to remove liquid and suspended debris. I have not yet exploded the vacuum cleaner doing this, but it might just prove possible, so do be careful. An alternative approach used with success by some other restorers, is to use household detergent mixed with water. Try to prevent any ingress of liquid into wound components, potentiometers, ceramic trimmer capacitors or wafer switches. Thoroughly wash out all grease, oil and congealed goo from accessible bearings, and from grounding springs fitted to rotating or sliding parts.

Petrol (gasoline) works well as a cleaning agent but does tend to dissolve wax coatings and remove resistor colour rings, so should be strictly reserved for the most difficult cases. Petrol works very well indeed for removing congealed grease. It is therefore particularly useful on gearboxes. However, Jizer of Gunk may be even more suitable. It is suggested that cleaning be performed with the chassis standing vertically so that the used fluid with its dissolved goo does not get a chance to run down onto the components under the apron. In particular, the RF coils and the bandchange switch need to be protected. This cleaning job is best done outdoors, not least to reduce any fire hazard. Do not use the vacuum cleaner drying technique here, just let the radio drip dry in the open air.

Plated pieceparts that have corroded, can usually be replated. The cost is not prohibitive. This applies to Cadmium plating (shiny orange surface over steel), Alochrom plating (matt yellow/gold surface over

Aluminium) and of course, Copper, Nickel and Chromium plating. A partial repair to Alochrom can be achieved by simply wiping over the damaged surface with a cotton wool pad of Alochrom dye. This is a cosmetic repair rather than a corrosion resistant repair, but has the advantage that it can be done in situ. Wash your hands afterwards.

A specific caution regarding Cadmium relates to the toxicity of the white oxide coating that forms in time on surfaces that have been stored in damp conditions. Care is definitely required in handling Cadmium plated parts that have developed an oxide coating.

Rusted steel chassis parts can be passivated by using Jenolite before proceeding further with the repair sequence.

Silver plating was used by Marconi and Eddystone amongst others, and tarnishes with age unless it was lacquered when new. Unlike other metals, the oxide of Silver is nearly as conductive as the metal itself, so there is little to be gained by polishing. Quite the reverse in fact. All polishing will achieve is a reduction in the depth of the highly conductive plating. If it is desired to shine-up an oxidised Silver surface, a quick wipe over with a cotton wool pad carrying a very little Silver Nitrate ($AgNO_3$) will be found more beneficial. This material is hazardous to health, however.

7.2 Earthing

WARNING: AC/DC sets must not have their chasses earthed, and not all radios fitted with mains transformers have an isolated chassis. Examples exist of radios with transformers which nevertheless have the chassis connected directly to one side of the mains. (This design type is most commonly found on broadcast receivers.)

Corrosion of grounding points is a common problem with steel and Aluminium chassis, and particularly so with pressed Dural types. The prime objective must be to restore correct earthing, appearance being an important, but purely secondary factor. Be sure to pay special attention to loose or rusty screwed or rivetted earth returns. Remake all of these at this stage as a matter of course, using brand new hardware which looks as similar as possible to the original.

Many radios were assembled with paxolin valve sockets. All too often, the securing screws were also used as grounding points. The paxolin tends to creep with age, leading to the securing screws becoming somewhat loose. The repair technique used by this author is to introduce externally serrated washers between the soldertag and the chassis. These washers have considerable in-built springiness and the sharp teeth do a good job of providing continuity.

7.3 Chassis Resoldering

Soldered chassis seams may be found cracked, so they all need to be checked carefully, especially where the seam performs a structural as well as an electrical function. Resoldering must be done fearlessly, using an electric paint stripping gun to preheat the chassis, followed by rapid soldering using an extremely big, very hot iron. If access is impossible, sort this out first by performing a localised stripdown. Use an aggressive grease flux such as Fluxite, together with 60% Tin, 40% Lead alloy cored solder. After cooling, remove all traces of flux residue using methylated spirit and the vacuum cleaner. Then perform local rework, making repairs as necessary. Pay particular attention to the integrity of the insulation of wax capacitors and wiring, if they have been at all close to the heat gun or the iron.

7.4 Grommets

Very often rubber grommets are used to support variable capacitors, RF subchassis or anti-microphonic valve sockets. These must all be replaced at this stage with brand new items. Don't bother trying to make the originals last. They probably won't go on for very much longer, and the development of related faults can be very insidious. Tuning backlash, creeping paralysis of the dialdrive mechanism and slowly developing crackles due to intermittent waveband connections, are all phenomena that this writer has positively tracked down to failing rubber bushes at various times over the years.

7.5 Gearboxes With Metal Gears

Gearboxes need checking for bent gearwheels, correct split gear spring preloading, tooth wear, and bearing maladjustment. Start by verifying that the gearbox sideplate securing screws are good and tight, and that the gearbox frame is firmly attached to the RF unit subchassis or whatever else it is bolted to in your radio.

The correct endfloat for all gearbox shafts is zero, with very slight endthrust. Note that on the average gearbox, over-tightening any one shaft will spring the sideplates apart slightly, reducing the endthrust on adjacent bearings. Any adjustment should therefore be made only a little at a time.

Check the input shaft for truth. It is permissible to bend it very slightly to get it exactly right. Be careful, because it will probably be made of hard steel which will break without warning if it is strained excessively whilst the material is cold. When the input shaft is running true, disconnect the input and output couplings and wind the gearbox back and forth through its entire motion. The feel should be consistent throughout. Do this with the gearbox in an entirely dry state, to avoid lubricant masking any problems that may be present.

All split gears should run true and have a full compliment of tensioning springs. B40 owners should note this particularly. The amount of tension should ideally be equal to about 1½ teeth. Check that the two halves of each sprung gearwheel are free to move with respect to each other within the limits imposed by the mesh of the gears, and that the two split faces have not become corroded together, or separated too far because of wear in the hub. With the gearbox dry but uncoupled, the spring loading should be sufficient to accommodate all effects of friction and stiction in the geartrain.

Some split gears are very large in diameter, even as big as 3". With these sizes it is particularly important to check that the wheel rotates concentrically, and that the two halves are properly supported by the hub.

At the end of gearbox repairs or readjustments, relubricate all bearings very sparingly with synthetic car engine oil, and all teeth with a light household oil. An alternative lubricant to consider is spray-on chain grease, as sold for cycles.

7.6 Gearboxes With Plastic Gears

The plastic gears found on Drakes are sloppy at best, and can impart a very lumpy feel to the tuning, due to wear, grit or long term underlubrication.

Limited application of the special grease sold for use on the nylon gearboxes of model racing cars is a good first step. It will be best to avoid using any of the usual automotive greases.

7.7 String and Wire Dialdrives

String or wire runs are often fiddly to assemble, but do tend to be relatively trouble free. The only common irritations concern nylon pieceparts. Drive pulleys on Eddystones can swell due to moisture absorption. This causes pointer over-travel at extremities of the scale.

Most pointer dialdrive systems used an open fabric or nylon cord, and these rarely present insurmountable problems. If replacing a cord on a radio originally fitted with waxed string, be sure to clean the pulley grooves carefully as otherwise lumps of old wax residue may cause uneven travel of the new cord. Cord knots should be sealed with a bead of polystyrene cement. Replace rusted or stretched tension springs as necessary.

The most difficult type of repair on a string dialdrive is where the cord is positively located in the middle of its run, often being captivated to a large pulley, by means of a clamp or loop. Usually, each end of the run is individually sprung. The easiest procedure is to work from the point of captivation outwards, being careful to leave plenty of cord on each side.

Whenever the need arises to temporarily captivate a new cord whilst fitting it, use tags of PVC adhesive tape as necessary. This stuff is particularly good at holding turns in position on the drum, prior to knotting. Mark exactly where the knots need to be with a black marker pen on the cord. Use double knots every time. Special spring pusher kits are available to make handling of the tension springs easier, and less hazardous.

Some radios, such as the BRT400 and those of the Swiss manufacturer Paillard, used an open stranded steel wire which is terminated at each end by soldering, without the use of a separate tensioning spring. The writer is unaware of any source of this material, though modelmaking shops do stock plastic covered stranded aircraft locking wire that can be used instead. However, it is noticeably less flexible than the original. Care is needed on later models of BRT400 (suffix B and onwards) to grease the wire where it passes over the bronze guides. Early BRT400s, and most other sensible radios, used pulleys instead of guide sleeves and hence do not suffer this problem.

Collins used an open plastic insulated stranded steel wire from the beginning on their model range. In general there are no problems, but inside the KWM-2 PA cage it is necessary to make sure the wire ends do not touch anything to prevent any possibility of unwanted RF currents flowing along the steel core of the wire. The ability to control this problem was purportedly the reason why the factory selected the plastic covered wire in preference to the (then) more common uninsulated stuff.

Lubricant should be kept well away from cord or nylon dial strings, because it can rot the fabric in time. One useful modern lubricant that can find an application in old radios is the type sold for lubricating the carriages of computer printers. It contains PTFE in colloidal suspension, and has proved excellent for lubricating pointer slides.

7.8 Chain Drive

This technique was used by Murphy in their B40 design for the British Admiralty and in an HRO variant (a German copy?) which the writer saw 23 years ago at Aston University, and which he now wishes he had inspected rather more closely than he did. It was also used by Peto Scott in the Trophy-8.

A worn chain drive will always cause backlash, the only variable being the exact magnitude of the problem. Tightening the inevitable jockey wheel reduces the backlash, but introduces excessive friction due to bearing sidethrust. The solution used by this writer is lots of medium grade lubricant, with the tensioner set to only just take up all the slack.

Fitting a new chain will usually stop the backlash, but in the writer’s experience, the use of a new chain running on old sprockets is a recipe for stiffness and notchiness in the drive.

7.9 Friction Drive

Some highly ingenious friction drives have been designed. The key aspect for a restoration programme, is to ensure an absence of uneven wear on the friction surfaces. It is also important to make sure that the spring tensioners are functioning correctly, and that the lubrication conditions are correct.

Collins S-line, Hammarlund SP600 and Eddystone types should run perfectly dry, and all of these friction mechanisms should work perfectly. The cheaper National and Jackson balldrive designs are very prone to develop slop and lumpiness. Little can be done about this except to repack the ball cage assembly with Kilopoise 0868S, and to make sure the input and output shafts are perfectly aligned. Certain Jackson balldrives are still available, but no source of National ones is known to this writer.

Even the smallest trace of ordinary mineral oil can quickly ruin a friction drive. Do not therefore, lubricate friction drive mechanisms other than as indicated above or better still, exactly as recommended in the manufacturer’s documentation.

7.10 Dialdrive Mechanics

Make sure the LF and HF endstops are correctly adjusted. This can prove extremely difficult, for some designs seem not to have been right even at the start. The National NC100 comes instantly to mind. The writer has had to file the endstop wedges on his example, and can see no way that it could ever have worked properly without this rather bespoke operation being performed.

You are cautioned not to experiment too enthusiastically with the endstops. It is true that some designs (mainly British) had very heavily engineered stops, and were provided with spring release over-torque clutches for dissipating excess energy from the flywheel (BRT400, B40, Atalanta etc). Over-torque clutches should be adjusted to only just pass normal operational drive without slipping.

Other designs were far less competent, with the result that severe damage may be caused by mishandling. The NC100 and HRO are examples. The first does have stops, but has no means of slowly unwinding the flywheel. The second has no endstops at all, relying on the torque absorption capabilities of the (admittedly beefy) gearbox and variable capacitor. The friction drive Eddystones and the SP600 can wear flats on the rim of their driven pieceparts if spun repeatedly against the endstop, causing lumpiness in normal operation.

For most dialdrive systems, the coupling to the variable capacitor is set so that with the drive mechanism against its LF endstop, the capacitor gang is just fully closed. In the case of bellows couplers on screwed (eg. Collins BFO) shafts, arrange for the coupler to be at its natural length in the centre of the allowed range of rotational motion.

Set Oldham couplers to have specified endfloat, and make sure the anti-backlash spring is present, and effective against the rotational stiction of the output shaft.

Dialdrive lubrication needs to be very sparing, the emphasis being on the use of the right stuff in the right places, rather than on the quantity applied.

7.11 Gang Capacitors and Mountings

Variable capacitors need careful cleaning. A good technique is the use of compressed air followed by gentle brushing with a strong solvent. Avoid bending the plates. The correct rotor endfloat is zero, with a very slight preloaded endthrust. Rotor vanes should be central with respect to those of the stator.

Rotor grounding springs need to be correctly tensioned and lightly lubricated. They must be connected properly to the chassis, or wherever else they are supposed to be wired to on the chassis under repair.

Ceramic or fibreglass insulators need to be very clean if the Q values of the connected coils are not to drop unduly.

On most good quality receivers the tuning gang has a cover, to keep out dust and draughts. Notable exceptions include the KW equipments such as KW202, certain Eddystones such as the 940, and certain Hallicrafters receivers such as the SX62. For these equipments, consideration should be given to fitting a plastic cover, ideally of polystyrene or ABS material. A good place to start is the plastic potting boxes available from RS and Maplin. These things come in a range of sizes, and are devoid of the corner fixings found on boxes designed to accept lids. They can be held in position with Evostik or silicone rubber.

Tuning backlash is often due to perished rubber mountings on the tuning gang. In the event of this problem occurring, look carefully at the movement of the capacitor frame over the complete motion of the tuning mechanism. The movement should be zero except at the endstops, where visible distortion does occur with some poor designs.

Some receivers, such as the Murphy B40 and the Hammarlund SP600JX use variable capacitors which have ceramic shafts. These are very fragile, and can sometimes be found fractured, especially if the radio has been dropped. In the event of unexpected tuning backlash in a newly acquired receiver, this point is worth checking. It is usually possible to effect repairs by using Araldite.

7.12 Scale Plates

If your translucent scale plate or meter plate is already darkened by age, do not attempt to compensate for this by fitting a huge bulb immediately behind it. It has proved possible to replicate a blackened cursor disc for a Collins 75A-3, by using 0.05" translucent white modelmaking plastic sheet cut exactly to size, with a quite separate, newly manufactured scale mounted directly in front of it. The scale was generated at 1:1 size on a professional CAD system. It was plotted in colour ink onto conventional plastic acetate (Mylar) drafting film, then cut to size with scissors. The new scale was lightly tacked to the plastic support disc at a few places around the edge with Bostik, which is fairly transparent when dry. The end result was quite indistinguishable from the real thing when viewed through the front panel window.

7.13 Optical Projection Systems and Filmstrip Scales

German and Russian equipment made widespread use of projection techniques. This technique was also seen on some Eddystone and RCA radios.

It is important to use the correct type of bulb, which sometimes has a non-standard filament orientation, or a very precise mechanical construction.

The projection may be of images marked onto a glass drum or disc, and is usually presented on a ground glass strip or plate. Some very ingenious arrangements were made, many of which gave a quasi-linear presentation of markings originally made in a circular format. The technique is efficient in the use of space and very reliable in service.

Filmstrip scales were immortalised by the RA17, and copied (usually with less success) by a host of imitators. Provided the filmstrip is clean and undamaged, little usually goes wrong provided the sprocketry is serviceable, and provided the spring tensioning arrangements are properly adjusted.

It is absolutely essential to have properly functioning endstops with filmstrip scales, and this has been responsible for more design and service failures than any other feature.

7.14 Screening & Insulation Structures

Screening covers over RF sections are frequently located by a large number of 3/48UNC, 6BA or similar setscrews, all of which must be present and correct during alignment. On some radios, the AR8516L being an example, very weak fastenings were used to hold the radio together, and to hold the covers in position. Any highly stressed small brass screws could usefully be replaced by stainless hardware.

Any insulating blocks or earthing straps connecting adjacent parts of the structure, must be present and properly fitted.

Insulation plates and tagstrips in thermally hot areas of the chassis are distinctly prone to decompose. Usually the first sign is delamination of the material, local dark brown colouration, or wrinkling of the surface. Replace as necessary, preferably with a new structure built from epoxy-fibreglass FR4 laminate. Examples of insulation plates usually found burned up, include the BRT400 mains transformer cover, the R-390 heatshield insulators near the 6082 HT regulator valves, and the AR88D bias resistor tagboard.

7.15 Cooling

Cooling arrangements need to be checked very carefully. In particular, the cabinet feet all need to be present and of at least the same height as the originals. This is to promote airflow under the chassis which will maintain long term reliability and minimise local oscillator drift.

In the case of radios such as the Murphy B40, which are fitted with metal rollers or skids underneath, proper feet will have to be fitted anyway. This is to avoid severe damage to the surface upon which the radio is to rest. When fitting feet to these radios, consideration needs to be given to the height of the feet, and to the weight of the radio. When in service, the B40 had lots of air available due to the design of its anti-vibration mounting cradle. So a standoff height of at least 1/2” would seem reasonable.

Fans fitted to radio receivers are normally found only on high performance equipments such as those with nuvistor front-ends, or on radios designed for continuous service under tropical conditions. Fans have a limited life and should be replaced when necessary. Many types had lubrication cups or wicks which need to be kept properly lubricated. Given a choice, sleeve bearing types are generally quieter than ball bearing ones when the time comes for a replacement to be fitted.

7.16 Control Knobs

These are often found missing or damaged.

Removal can on occasions be incredibly difficult. The problems usually stem from one of three causes: damaged grubscrews, seizure of the knob onto the shaft, or severe scoring of the shaft.

Grubscrews can sometimes be drilled out, but this is often only practical where the knob is very close to the edge of the panel. Where the problem is a sheared segment on a flat headed grubscrew, this approach cannot be used unless the opposing segment is also removed, to give an approximately flat surface for the twistdrill to bite into.

Damaged Allen and Bristol pattern grubscrews are self centring for the drill bit, but they can sometimes be removed more easily with a reverse threaded stud remover. American grubscrews always seem to be made of much harder material than the usual flat headed British ones.

Occasionally the knob will be found stuck fast, even after removal of its captivating screws. The obvious solution is to remove the shaft as well, so that repairs can be performed away from the radio. Very often though, this is impossible. On these occasions it is necessary to decide up front, the extent to which brute force is to be used. Various techniques are available. It may be best to drive the knob further onto the shaft prior to any attempt at pulling it off, but be extremely careful in the case of collet knobs. It is generally inadvisable to lever against the panel, because of the near certainty of causing cosmetic damage. In desperation, this writer once used a miniature butane torch on the knob, with a fibreglass mat being used to protect the panel. The knob was quickly ruined, but at least it came off easily. The panel was unscathed, and the control shaft quickly cleaned up with some emery paper, ready for the fitment of a new knob which had been obtained for this purpose beforehand.

On radios with badly designed over-travel stops, the tuning knob may have slipped round in service, especially if it has unusually large inertia, as on the Marconi Atalanta. Sometimes the wavechange detent is so strong that the selector knob suffers the same fate. The result can be that the shaft gets so severely scored that the knob cannot be removed after removal of its securing screws, even though it can spin freely on its shaft. This is because either the shaft or the bore of the knob bush, or most likely both have become severely burred. Because of the size of the tuning knob, a hefty puller can sometimes be used. If mishandled, this can damage the over-travel clutch and the mechanism, causing even more work. If the knob can be replaced or repaired, it may be worth drilling the centre of the knob to allow the jackshaft of the puller to bear directly on the end of the shaft. When the set is rebuilt, make sure the shaft has no burrs, and tighten the grubscrew(s) hard. Then take care in the future.

Knobs which are taper seated, or which tighten down onto a wedge, are best assembled onto the shaft with a trace of grease so that they will come off more easily next time. Do not over-tighten the securing screw.

Black bakelite knobs often have engraved arrows, letters or lines which were colour filled, often in white. The original colouring often wears off over the years, leaving the engraving unfilled. The original appearance may be restored quickly and easily by the use of a Kwikfyl crayon pencil. The various available colours can be useful for restoring the engraved panel legends, labels and warning signs. Completely remove all old colouring material from the engraved character with a pin. Then refill the engraving with new Kwikfyl, applied with a candle. Remove surplus material immediately, with a clean rag.

The alternative is to use a white enamel paint such as Humbrol. This is best applied by dropping it into the engraved characters from the end of a small scriber. After doing a complete letter or number group, wipe the surface clean with kitchen tissue. Then when the panel is completely dry, thoroughly clean its entire surface with a brass cleaning polish. This will remove any light smearing and leave the panel looking as good as it will get. It should be noted that in this application, enamel paint proves no more or less durable than Kwikfyl.

7.17 Printed Circuit Boards

Towards the end of the valve era, these came into widespread use. Unfortunately, the substrate materials then available were very poor as regards mechanical strength, water absorption, dielectric strength, RF loss, dimensional stability, thermal survivability and track/substrate adhesion. Taken all in all, this is a rather damning list, and indicative of the problems nowadays found in restoration.

Methylated spirit can dissolve the silk screen component placement markings, and the water content can cause hidden tracking and arcing problems inside the PCB material if the unit is not dried for ages after the PCB assembly has been washed. Surgical spirit seems to cause fewer problems.

Many PCB etch patterns were lacquered on the print side, after soldering. This coating can, and usually does partially wash off during the cleaning process. After repairs have been completed you may wish to consider brushing (do not spray) a thin coat of clear gloss exterior grade polyurethane varnish over the print. The good points of this technique include preservation of the PCB appearance, the avoidance of Copper oxidation, and the extra support - albeit slight - given to the Copper print. Bad points include difficulty in the event that rework is found necessary, or in the event that repairs have to be made in the future.

At first sight it may seem that the first generation radial ended components used in these equipments would cause few problems, but unfortunately this tends not to be the case. Heavy components like the bigger polyester capacitors in moulded cases, often relied on being physically supported by the PCB, rather than being captivated by a P-clip as on earlier equipments. Modern components tend to be much smaller, with a reduced pitch spacing of the leadout wires. When using today’s components as replacements for period types, the inevitable wire doglegs look bad, and the body of the components are usually left at some distance from the PCB surface, standing proud by perhaps 5mm or so. This can place too much strain on the print doughnuts in the longer term, often resulting in the appearance of an intermittent fault. This writer would advise a small bead of Araldite beneath each incorrectly sized replacement component, to save the fragile print from having to take all the strain.

Nowadays it is recognised that for PCBs having print on only one side, it is good practice to cross-hatch all large solid areas. This avoids undue stress on the track/substrate bond, which prevents buckling of the PCB at temperature extremes. In the days of valve radios this problem was not recognised or if it was, then it was not addressed. Many intermittent faults stem from long term thermal cycling of these early PCB structures, resulting in cracked Copper tracks. Beware in particular, of large PCBs with output stages or rectifiers in the middle. Be even more suspicious if the PCB is horizontally mounted directly above the valves.

Rather than carry out extensive repair of a first generation PCB assembly with much loose track, several missing doughnuts and some burned areas, this writer would advise the creation of a new PCB on FR4 epoxy-fibreglass substrate. Do not be tempted to waste your time with an etch-resistant pen. This would not yield a solution of sufficient quality for fitment to a professional class vintage receiver.

Production of a proper drawing package in the form of a Gerber file designed on a PC program, is perfectly straightforward in the domestic environment, and manufacture of a batch of boards is not as expensive as most people seem to think. Perhaps your owner's club can be persuaded to commission a minimum size batch, thus reducing the cost per board and helping fellow owners of your model. The only serious cost threat that this writer would identify, concerns through-plated holes and multilayer boards. However, these are extremely unlikely to be encountered in the types of equipment covered by this book.

The new PCB could be a straightforward mimic of the original, but this writer would advise that the print be roller tinned, that all large groundplane areas be cross-hatched, and that pitch spacings should suit currently available components. Put a component silk screen onto the board, even if there was not one on the original. All resistors, capacitors and valve sockets would normally be renewed as a matter of course. Ceramic or PTFE sockets would be used for the RF, oscillator and hot-running valves. All wound components including any RF chokes, would be the originals transferred from the existing board.

The lower RF losses of FR4 laminate & modern valve sockets at VHF, could lead to parasitic oscillation not found with the original PCB assembly. Be on the lookout for this phenomenon, and have 10Ω resistors or ferrite beads at the ready.

The different dielectric constant of the new substrate, any changes in track width, length or thickness, and/or any difference in substrate thickness will affect track inductance and stray capacitance. However, these effects have not been found to matter in practice, at least as regards HF receivers. This is because the components themselves really do determine the operation of the circuit. That is not the case at VHF, where component sizes, exact positions and interconnection arrangements are all significant. For this reason, much greater care is required when working on VHF receivers.

7.18 Valve Sockets

On the chassis, check all valve sockets for contacts that do not grip the valve pin snugly. Be particularly wary of the side contact family (CT8, type E). These suffer a variety of problems. A slightly tight fitting socket often causes the Copper rivets on the valvebase to loosen, causing intermittent contact. On the other hand, a slightly loose fitting socket can also be a source of actual or latent intermittent faults. In the middle there may be a happy medium… but not usually, with this awful family of valves. Each individual contact comprises a hairpin spring leaf, the ends of which are supposed to be free to move with respect to each other, not firmly connected together by a lump of solder. This is a point worth checking carefully. Because little of the CT8 valvebase stands proud of the socket when the valve is seated, it can be difficult to remove the valve except by pulling on its glass envelope. This is an unsafe practice, and of course there is every possibility of the bulb becoming loose in its base. Perhaps more commonly on removing CT8 valves from their sockets, the bottom edge of the metalizing becomes detached from the bakelite base, leaving the valve looking ragged edged. It certainly pays to make sure there are no bits of debris or loose metalizing, lying in the well of the bakelite moulding. The sockets for this family usually seem to have a marking pip at pin 7, which seems unusual considering the valve carries eight pins. Another peculiarity of CT8 valves is that the pin numbering advances anticlockwise as viewed from underneath the valve, which is the reverse of every other popular valve family.

Check also for contacts that have become a loose fit inside the overall socket insulation moulding. This problem tends to be specific to certain families, especially those B7G, B8A and B9A moulded composition sockets where each individual female contact comprises a piecepart resembling a miniature tuning fork. If your radio has these items fitted, it is definitely not a good idea to power the set without its valves because sometimes the individual contacts can be so free to move, that adjacent connections touch each other. When reworking one of these sockets, be sure not to rigidify the wiring more than originally. This is to ensure the valve pins have the same amount of freedom in the valve socket as previously. Failure to do this can result in microphony, especially in sets with an integral loudspeaker. Or broken valve pins, of course.

Some sets are fitted with special sockets which positively locate the valve. This may be done to get the heat away, or to guarantee local oscillator performance under operational conditions. The Eddystone 770R for example, uses standard McMurdo valve sockets in its RF unit but they are modified to suit the application. Certain contacts for the EF95s are replaced by special turned pieceparts.

Inspect the sockets of hot running valves and all barretters and output valves for signs of decomposition or dry joints. Rectifier sockets should additionally be inspected for evidence of flashovers or tracking paths leading from the anode pin to chassis, or more often between the anodes in the case of full wave rectifiers.

Be especially careful with any valve sockets mounted directly on printed circuit boards. If replacement is necessary, always try to use ceramic or PTFE ones in these applications, especially for RF, oscillator, rectifier and power output stages. Having said this, it is wise to be a little careful when replacing the valvebases of frame-grid valves. Replacement of the socket by a modern low-loss type can cause unexpected VHF instabilities to occur.

The acorn family (954, 955, 956) of valves are usually seated in large ceramic bases which have strongly-sprung gripper contacts. Because of the fragility of the radial seals on these valves, it is important that the contacts mate correctly. For this reason, it is advisable to lightly oil each radial pin before insertion of the valve into its socket, then remove all traces with methylated spirit to avoid problems later on.

7.19 Repair of Damaged Castings and Threads

Radios based on castings include many Eddystones, the Murphy B40 and much German and Russian equipment, as well as a lot of CNR sets. The castings may be of brass, Aluminium, or a Zinc alloy such as mazak. They may be further subdivided into sand castings, gravity diecastings, pressure diecastings and investment (lost wax method) castings, in ascending order of quality.

This writer believes that slightly bent castings are best left well alone unless of brass, which can stand a certain amount of resetting without much likelihood of cracking. In the event of a casting becoming cracked as a result of being dropped, or because of a failed attempt at straightening it, there are several optional ways ahead.

Be sure to remove fragile major components such as variable capacitors and valves before attempting any form of repair. The easiest method is to use Araldite to mechanically fill the crack, after drilling through the ends of it to relieve any stresses. This will prevent propagation of the fracture. To be fully effective in the longer term and to provide proper ground continuity, a repair like this may need to be backed up by fishplates which may be put into position first or afterwards, whichever is most practical.

In the event of cracked cast cabinet handles, whether repaired or not, it is sensible to affix a warning label indicating the exact state of affairs. This way, other people can make up their own mind about what is safe and what is not, when their time comes to lift the radio.

If you are determined to attempt to straighten a bent casting, it is wise to remove all components and wiring, and strip the casting down to the bare assembly first. Take all the paint off with a chemical stripper. Then measure the casting on a surface plate to assess the extent of the deformity. Heat it gently and evenly with a blowtorch. Be sure not to melt the material. Keep the heat applied whilst somebody else has a go at straightening it. Both of you should wear eye protection. Go a very little at a time, and stop periodically for the casting to cool, so that it can be checked for truth. Be prepared to spend ages. If necessary, anneal the casting from time to time, to prevent cracking. Note that annealing brass is quite difficult as the colour changes only slightly before the material melts.

The measurement technique depends on the accuracy required, which in turn depends on whether the casting carries a precision subchassis or a big variable capacitor. Do not strive for perfection, unless you are very brave. When you are satisfied, the external surfaces can be filled and stopped, then repainted. Do not coat any areas where metal-to-metal contact is necessary for proper grounding.

You are advised not to attempt to close up the inevitable small gaps when the major components are offered up to the repaired casting. Tinplate or brass shims should be constructed to fit the major components perfectly into position without appreciable distortion.

Damaged threads in castings can be Helicoiled down to the original size. Alternatively, an over-size thread can be cut directly into the material with a plug tap. Whatever happens, be sure to get all the swarf out. For female casting threads that carry a stud insert, it may be possible to open out the casting thread and make up a special stepped stud to give an invisible repair.

Many RF covers are retained to bulkheads with screws which pick up on threaded nutserts or rivnuts. These are supposed to be captive to the bulkhead. Very often, one or more of them is found to be missing when the RF cover is removed. In this case, be sure to conduct a thorough search inside the screened compartment to make sure that the insert has not simply fallen out and lying loose somewhere inside, waiting to cause problems in the future.

Given the availability of the right tool, new thread inserts are easy enough to fit, though most are metric types nowadays. If you wish to retain the original BA or UNC securing screws, a matching hexagonal nut may be secured in position on the bulkhead using Araldite. Unfortunately, tapping a BA/UNC thread into a metric insert is impractical because the material is far too hard.

7.20 Fully Sealed Radios

Some receivers were fully sealed against water and dust ingress. At least, they were when they were new. Many of these designs were intended for tactical use by the armed forces. Good examples include the British R209 and the American Collins R-392 HF receivers. Because most such sets were fitted to tanks, Landrovers, halftracks or Jeeps, the construction had to be rugged in the extreme.

Army CNR sets were capable of operation over wide temperature ranges. For operational reasons, they were designed for use by an operator wearing arctic mittens and so chunky knobs were generally fitted. Many radios were installed in their host vehicles in positions which deliberately encouraged their use as toe holds. Therefore the front panels, knobs and windows had to be “boot proof”. Nevertheless many surviving CNR sets are found in badly damaged condition. Be on the lookout in particular, for CNR sets which rattle or which have huge dents or broken castings. Such sets have probably been dropped. The internal damage will probably be far worse than you at first imagine.

Other waterproof sets were intended for marine use, and these include commercial types as well as Naval. Here, the standard of construction is better than normally found in other classes of equipment, but less robust than the military CNR types. The marine sets tended to be well looked after by the users, and by the maintainers as well.

In general, sealed radios with valves in run very hot because of the obvious lack of ventilation louvers, and most have led a very hard life indeed. At least no dust or grit will have got in! The extent of the required overhaul will depend on whether the seal has failed, allowing internal corrosion to develop. If it has, then most of the work will usually stem from this cause. Especially on marine equipments.

The intricate mechanical design of sealed CNR sets will provide many challenges caused by interlocking structures and high component densities. Some of the better sets were modular. This makes them easier to repair if all the necessary connectors and umbilical patch cables are to hand. The unfortunate corollary is that sets designed this way often prove harder to repair than a straight chassis layout if no service harnesses are available. One thing to be on the look out for with all modular CNR sets is intermittent connectors caused by all the maintenance that had to be done over the years, to keep these sets fully operational when in service.

Very much on the plus side for sealed equipments is the joy of opening one which has had intact sealing throughout its working life. The interior gleams like new and the chassis requires no cleaning at all. It must be said though, that the smell which escapes when the seal is first broken is often very unpleasant, especially if MFP doping has ever been sprayed on!

The seal itself is often in the form of one or two O-rings. These are commercially available in different sizes of round and a variety of rectangular cross-sections. A ring made from Viton material of about

60 Shore “A” durometer hardness would be a good starting point for most radios. Note however, that this material produces Hydrofluoric acid which is extremely corrosive, if grossly overheated. Therefore do not touch a Viton seal with a soldering iron. If necessary, sections of O-rings can be joined together, and proprietary kits are available to make this job reasonably easy. Clean the groove in the casting, and then lightly coat the new ring with MS4 silicone grease before fitting it.

Sets with silica gel desiccator cartridges should have this component present and thoroughly dried-out before resealing the case. Unless all the control shaft O-rings are also renewed, it may be expected that the overall sealing of the radio will not be perfect. Therefore, drying of the desiccator will need to be an occasional preventative maintenance chore.

If the intention is to fit a restored set into a period Landrover, Jeep or wireless truck, then it needs to be borne in mind that the reason these sets were so robustly constructed in the first place, is that this is exactly what is needed for survival in such vehicles. For the radio to give full satisfaction, all restoration work must be of the highest possible standard. Proper military valve types should be fitted, and there must be no bits of debris floating around loose inside the cabinet. If the set was designed to be supported on an anti-vibration mounting, then this component should be viewed as essential wear. It should be correctly fitted to the radio and to the host vehicle, if it is to be properly effective. Any extra waterproofing arrangements and sunshades should also be present and correct. All mating connectors should be the right types, and be soundly fitted to the cable, with all glands and waterproofing gaskets in place and functional.

7.21 Bowden Cables

In the context of old radios, Bowden Cables refer to mechanical coaxial cable assemblies used to transmit motion from one part of a chassis to another. Many continental radios used these devices to transmit linear motion to slide switches, and/or rotary motion to variable capacitors. The Philips company was a noted exponent of this technique, as may perhaps be expected.

The flexibility inherent in Bowden cables made for an easy way to transfer mechanical motion to a sprung subassembly such as a tuner head mounted on rubber grommets.

The type of mechanism used to transmit linear motion often contained bellcranks and rods as well as the Bowden cable. Usually the assembly was spring loaded under tension. Excessive friction or congealed grease can cause the mechanism to jam, or fail to actuate over the full intended operating stroke. A weak spring can cause similar effects.

Rotational Bowden cables often work in push-pull mode, which avoids the need for a strong tension spring. Philips used this type of arrangement to operate the tuning gangs on some of their radios, for example model 643A. In practice it all worked better than may be expected, with minimal backlash and no need for the tuning gang to be strongly located on its chassis mountings.

Philips fitted their chasses into a wide variety of different cabinets. Some had long horizontal tuning scales. Others had short ones. Maybe the tuning scale was vertical instead of horizontal. Perhaps it was rotary. The clever 2-stage drive system used by Philips ensured that as a complete chassis assembly, the gang was permanently connected to the tuning spindle by a Bowden cable. Final test could be performed in a consistent way irrespective of the destination cabinet. Then by fitting an appropriately sized pointer drive pulley and bracketry to suit the pointer mechanics, the job of chassis/cabinet final assembly would have been greatly simplified.

Repair of Bowden cable assemblies depends on the extent of damage, rust and missing parts. There are no special rules except to ensure correct lubrication after cleaning and reassembly. Synthetic car engine oil is a good choice for stranded wire cabling. This writer prefers to run textile Bowden drive cords completely free of lubricant where these are found instead of the metal type. Textile cords are usually on tuning gangs, where it is important to use an insulating material to avoid circulating RF earth currents and frequency instability. Molybdenum Disulphide grease is a good choice for bellcrank bearings and slides.

8. Switches, Turrets and Coilpacks

8.1 Rotary Wavechange Switches

Rotary switches often give trouble, especially oscillator range switching wafers made of paxolin. Check all contacts for correct operation. Be very careful indeed, if attempting to reset the tension or position of any of the spring contact fingers. All shaft grounding springs need to be correctly tensioned and lubricated.

On wafers that appear to have problems, it is a good idea to examine very carefully the rotor contact clipped to the hub of the wafer. If this does not rotate concentrically, the mating contact spring fingers will have difficulty following the rotor disc. This is a frequent cause of contacts weakening and springing apart slightly, causing intermittent faults. The rule is, get the rotor to run concentrically before resetting any of the contacts.

It is important to check that the rotary motion is carried in full, to the switch bank furthest from the detent mechanism. Too much friction halfway along the shaft can cause it to wind up, leading to lack of rotary motion towards the rear. The source of friction may be in the wafers themselves, or in misaligned or underlubricated bushes or grounding springs. If the shaft appears twisted along its length, it is permissible to judiciously reset it, using a pair of miniature adjustable spanners at the front and rear of the shaft.

RCA used a particularly poor type of double-articulated tongue & groove shaft coupler in their AR8516L model. This was intended to accommodate slight positional errors without loss of rotary motion. Being made entirely of a plastic material, electrical insulation of the input and output shafts was assured. But the design seems to have huge backlash, at least in old age. These couplers and others of this general design, should be checked very carefully for unwanted slop. Repairs or substitutions may or may not prove possible.

The bellows type of coupler is excellent, provided the brass corrugations are not cracked. One of these can be used as a replacement for inferior original types, provided its diameter and length can be accommodated, and electrical insulation between input and output shafts is not a requirement.

Spider couplings are usually not well suited to wavechange switches, because of the inability of the smaller ones to transmit large amounts of torque. Big spider couplings can be excellent though, if you have room for their large overall diameter. All of these types of coupler should be inspected for unexpected cracks in both the hub and the coupling diaphragm.

The detent mechanism used on wafer switches is usually found at the very front of the shaft, very close to the operating knob. Little can be done to overcome weakness of the springs due to ageing, other than to lubricate the undulating track and its rollers or balls with EP90 oil. This part of the waveswitch was usually not intended to be dismantled. That does not stop them falling to pieces sometimes though, when the factory staking fails! Repairs can usually be effected, but there is no standard technique.

If the decision is taken to replace a wafer switch with a modern component which is physically different from the original (usually somewhat smaller and of less lossy material), experience shows it is best to remove the original assembly as a complete unit, unwiring only those connections necessary for this stage of dismantling. Then the new wafer switch assembly is pre-wired on the bench alongside the original, which is used as a model. Do not throw away the original switch bank until the new one is installed and working properly. You may be surprised how many screening plates and rotor grounding springs will be found necessary, so buy plenty beforehand. It is better to have a few unwanted parts in your junk drawer than an oscillating front end in your radio.

8.2 Rotary IF Switches

Wafer switches used to control IF bandwidth are broadly similar to bandchange switches, but there are a few points unique to this application. All contacts should be surveyed visually, in order to verify their integrity. This is because unlike waveband switches, a contact malfunction can be extremely non-obvious, and many subtle IF faults can be “adjusted out” by accident.

For similar reasons, it is worth paying extra special attention to the shaft grounding springs, as any problems here can lead to skewing of the IF response nose, which may not be immediately noticeable without access to a reference receiver or an IF wobbulator.

Neutralisation may also need adjustment if a switch assembly has been replaced by a replacement modern low-loss unit, especially in the case of high gain, high frequency IF stages.

It is recommended that all IFT canister securing screws be checked for tightness, as problems here can lead to unsatisfactory stopband performance, as well as intermittency over the temperature range. Check especially, any screws that carry solder tags wired to the IF wafer switch.

8.3 Turrets

Turret tuning mechanisms are to be seen in the B40, SP600, DST100 and 51S-1. Although generally trouble free, it is important to get the rotor contacts to mate centrally with the stator contacts. This means that the axial position of the drum needs to be correct, with zero endfloat. Usually, one end of the drum is supported by an adjustable bush bearing, while the other is spring loaded by a wavy washer. Wherever turret grounding springs are supposed to be fitted, they should all be present, correctly tensioned and properly lubricated.

The drum detent arrangement needs to be checked, and reset as necessary, to ensure that the drum infallibly comes to rest with the contacts at the centre of their wipe. On some radios it is possible to vary the rotational position of the drum with respect to its detent mechanism. This can be useful in aligning the wipe of the contacts, and in extreme cases, to avoid engaging the rotor contact with a burned area on the mating stator contact.

Some radios were designed to have their turret turned in one direction only. If working on one of these, do not remove the interlock/detent mechanism without being very careful.

It is generally necessary to ensure the assembly is between ranges prior to removal of the drum. Thus usually requires removal of the detenting spring first.

Quite often the sprung contact leaves are found to be broken. New contacts can be fabricated from thin phosphor bronze sheet, and held in position with a brass collar prior to soldering. After the solder has cooled fully, the contact can be bent gently into exactly the right shape, or at least near enough to do the job. On most turret designs, access to the mating contacts is quite good, the SP600 being a noteworthy exception to this rule.

8.4 Interchangeable Coil Assemblies and Coilpacks

A range of interchangeable coilpacks was used by National in their HRO, and by Eddystone in their 358X/B34 and earlier models. In general, this approach is straightforward and the coilpacks are trouble-free to overhaul, provided each coilpack has a properly matching set of biscuits, and is not a hybrid made up from pieces of coiplacks from a selection of similar (but not identical) donor radios. HRO owners in particular, should be careful. There are subtle differences between MX and 5T coilpacks, for example, which can cause unexpected tracking problems if not identified prior to alignment.

Eddystones seem to suffer from dirty contacts. HROs suffer from broken rivets securing the spring finger contacts to the insulator blocks under the tuning gangs. This fault can be quite hard to repair in situ, although it is definitely possible without removal of the tuning gang.

An interesting engineering variant, the non-interchangeable rack mounted coilpack, was used by National in their NC100 range. This is best imagined as a form of linearly “developed” turret mechanism, and represented a dead end development path. It had problems all of its own, such as the inability to access all of the chassis at once which made powersupply distribution faults particularly hard to find; intermittent operation on some ranges because the stator leaf springs were expected to do the detenting as well as the contacting; and severe headroom limitations for the components mounted on the main chassis underside. Access to the bandchange contacts is not too bad on this set, as individual biscuits can be removed from the rack after separating the two halves of the casting assembly. The dial pointer was designed to vary in length as the carriage moved from side to side in order to change ranges. The arrangement for doing this was bizarre and distinctly hard to adjust.

As with turrets, it is necessary to ensure that the carriage is between bands prior to removal from the chassis. Broken contacts may be dealt with in the same way as for turrets, but because of the invisibility of the parts after reassembly it is necessary to use a dental mirror to inspect the mating of the contacts as the carriage is moved. This is quite fiddly.

8.5 Slide Switches

Slide switches have changed footprint quite a bit over the years. Sometimes, exact replacements for early types are impossible to find.

Whilst this is rarely a problem for panel mounted slide switches, there can be severe headaches in the case of PCB mounted ones. Often, the best way ahead is to salvage the baseplate from the original switch, and use it as a header for a new component mounted piggyback, with its legs trimmed as short as possible or splayed apart, then soldered to the header. Deft work is required. If the new switch is slightly smaller than the old one, the overall dimensions of the new hybrid will be approximately the same as the original component.

In the event that the original switch has become loose on the board, or stiff in its operation, the connecting print doughnuts may have ripped. In this case, strengthening is necessary. Start by gluing the switch baseplate to the top surface of the PCB substrate, prior to soldering. This task is often made difficult by the residue of lubricant which will have been applied over the years.

8.6 Toggle Switches

Switches carrying signals at low voltage and zero current need gold contacts to avoid developing high contact resistances. On wartime radios where this is a recurring problem because the switch contacts were of cheap material, it may be possible to introduce a bit of bleed current through the original switch (say 2mA or so) to keep it clean.

Certain open frame switches used on military equipment eg B40s, need frequent lubrication of the mechanism in order to ensure reliable opening and closing. This problem also occurs on some American equipment where a reliable break of the mains switch can sometimes not be guaranteed, a problem made potentially dangerous if the mains switching is single pole.

The slotted type of toggle switch often found mounted on a bracket on the BFO capacitor, and which is used to switch HT to the BFO can sometimes go open circuit due to burned contacts. Sometimes these can be renovated by immersion in paraffin, or worst case by stripping and cleaning. On other occasions it is worth trying to mount the original slotted dolly onto a new switch body. The author has successfully transplanted the slotted dolly from an SPST HRO Arrow wartime switch into an Arrow DPDT switch body from the 1970s, thereby creating a BFO/AGC switch suitable for a DST100.

8.7 Potentiometer Switches

This section deals with the switches mounted piggyback on potentiometers. The only problems of note are seen on American sets which use switches comprising a rotating paxolin disc which carries studs. The pivots get stiff or the springs get weak, with the result that the mechanism seizes up or the contacts fail to engage properly.

On one SX28, the switch on the noise limiter would click convincingly but not actually make or break reliably, even after careful lubrication. This same fault was also seen on an original replacement switch which was then fitted as a swap for the first one! In the end, a modern replacement had to be used, a great shame since this component is at the top of the chassis and extremely visible from above.

Avoid the common mistake of automatically assuming these switches are all normally closed circuit, changing to open circuit when set to the anticlockwise click position. In the KWM-2 will be found a perfectly ordinary looking potentiometer-mounted switch that does the exact opposite.

9. Wound Components and Wiring

9.1 Initial Inspection

Where they appear undamaged and have reasonable conductivity, wound components and wiring may be presumed innocent until proven guilty. Pay particular attention towards the top of the chassis, where temperatures are highest. This is where insulation decay starts first. Look for gooey, hardened or fried wiring, cracked wax coatings, and wax drips due to overheating.

Pay extra attention to IFT bobbins carrying an over-winding which forms part of a switched selectivity arrangement. Often on the BRT400, the insulation between the two windings can flash-over as the set warms up, destroying the next IF valve. This problem occurs most often when receiving a good signal with the RF and IF gain wound right up, and the AGC switched off.

9.2 Screw Cores

Iron cores come in two basic types with a range of grades to cover different applications. They have a wide range of relative permeability.

True ferrites are shiny, and coloured either charcoal or black. They have a high to exceptionally high value of relative permeability, and are best suited to LF and MF work.

Powdered Iron cores are usually matt grey. These have a lower but still positive value of relative permeability, and are well suited to HF and VHF applications. For both ferrite and powdered Iron types, the coil resonant frequency will drop as the core is inserted.

Brass and Aluminium cores are sometimes found in VHF/UHF equipment. The resonant frequency rises as the core is inserted into the coil.

It is important to ensure that each coil has the correct type of core, and that the length of the core is as originally specified by the manufacturer. Usually, coil assemblies that look untouched need not be investigated further. Coils that look to have been the source of past problems, should be surveyed to see if the right type of core is fitted. This can be difficult without reference to a gold standard radio.

As a first step in sorting out the wound RF/IF components on your radio, move all screwed cores very slightly to prove that they do in fact rotate, and that the coilformers remain fixed in position while this is performed. Then carefully reset the cores to their original positions. It is often a good idea to record the depth to which each core is recessed into its former, using a vernier calliper.

Cores that do not move as they should, can cause major headaches. Before attempting anything potentially hazardous to the health of the former or its windings, some basic measurements need to be made so that if the need arises, the coil assembly can be replicated. The complete coil assembly should be removed from the chassis. Disconnect any capacitors, and measure each winding in turn with all other windings disconnected, to determine their individual inductances. Note the wire gauge, wire type and the relative sense of all the windings. Then if possible, measure the mutual inductance. Note whether the windings are lap wound, wave wound, pile wound. Or indeed, a mixture of these. Finally, be sure to measure the length and diameter of each bobbin, and record the physical distance between the windings.

The most troublesome cores are those which have a hollow hexagonal bore. These cores look very robust but actually, they are very prone to shearing longitudinally. Removal techniques for jammed or broken cores include eating away at the material with a small drill, or creating a new screwdriver slot by scraping the surface with a scriber. In the case of hex cores it is sometimes possible to drift one of the broken flutes down and out of the coilformer, after which the others can usually be removed very easily by careful use of a hatpin.

Cores that are loose in their formers may be held in position by a length of elastic filament, or if extremely loose they can be wound with PTFE plumbing tape before insertion into the former.

9.3 Mains Arrangements

Routinely check the integrity of all mains wiring and insulation using a proper Megger or other high voltage insulation tester. Do not try this test using a DMM, as the results may indicate the equipment to be safe when in fact it is not. If in doubt, take the radio to somewhere equipped with a calibrated PAT machine. You could try your local tool hire shop.

If a single pole mains switch is fitted to a 230V-only equipment and you are not going to use an outboard isolating transformer all of the time, then you are advised to change the switch to a properly rated double pole type even if this destroys originality. Review the voltage rating of any mains input filter capacitors that may be found, especially on American radios.

Some designs of mains switch cannot be relied upon to break cleanly. The B40 and R-390 are both distinctly prone to this fault. For this reason, the writer likes to switch power externally on all old radios, rather than rely on the front panel control.

Always fit a new mains cable conforming to current electrical practice and renew all fuses, even if they appear undamaged. Mains fuses would ordinarily have a value typically three times the steady-state RMS current drain when operating at maximum HF and IF gain under no signal conditions. Use the correct value, where this is known.

American radios are often supported by handbooks written only for the home market, where the transformer had a single 117V primary. The export sets were often referred to as the “universal” models. (Warning: in the UK this would often mean an AC/DC variant). When operating American universal sets from 234V, the mains fuse should normally be halved in value compared with the figure in the book.

In the case of universal American radios fitted with a simple unshuttered slide voltage selector switch, and a single pole mains switch, this writer would recommend operating the set on 115V via an autotransformer. This avoids excessive stress on the transformer and wiring insulation, and on the mains filter where fitted. It is often an easier route towards modern safety standards than changing the mains switch. This policy also avoids disaster in the event of the selector slide switch accidentally being moved during restoration or servicing. If an isolating transformer is available, then so much the better. Confusion with 230V supplies is easily avoided by using a deliberately different family of connectors for your 115V radios. There must be absolutely no possibility of these low voltage radios being plugged directly into the household 230V mains, of course.

Change cable grommets where they have hardened, even if this is highly inconvenient to do.

Many awful types of mains chassis connectors have been used over the years. Strip out anything suspicious and fit modern components, even if this further worsens originality. What's at stake is worth far more than mere cosmetics.

Make sure the main chassis of the radio is earthed, even if originally it was not designed to be. For AC/DC sets, or other live chassis designs referred to in the UK as “universal” radios, it is prudent to use an outboard isolation transformer to achieve this objective.

This writer advises that in all cases, the mains tap be set to 10V above the prevailing mains line voltage.

When the set is first running, keep an eye on the mains transformer temperature. These things can run warm, or on some American radios, hot. They should never smell or smoke, or have core temperatures exceeding +90°C. The large thermal mass means that the transformer core temperature may take several hours to stabilise.

In the case of so-called “line cord” radios, which were mostly cheap American midget domestic or enthusiast sets, measure the mains cord resistance carefully, examine the condition of the insulation and take the right decision about its future. The original length of line cord cannot be shortened, of course. Do not simply replace the line cord with ordinary mains cable, and be especially careful with the mains plug connections of these sets. Some had two wires to be connected to the Live pin, one to the Neutral and none to the Earth. All too often, the chassis of the radio went live as the set was switched off, a thoroughly nasty characteristic. This writer is inclined to condemn line cord radios on sight, but fully acknowledges their collectability.

In the writer’s own collection, all pre-war mains radios are routinely modified to have an over-voltage varistor wired directly across the power input. Most such radios then have a Brimar CZ3 or similar negative temperature coefficient thermistor fitted in series from there on into the radio. This arrangement will hopefully protect the old and fragile mains transformer from grossly excessive mains transients, and allow a slightly easier warm-up for the bulbs and filaments every time the radio is switched on from cold.

9.4 HT Insulation

On American radios, especially SP600s, measure the insulation resistance of all HT smoothing chokes. These will sometimes be found to have excessive leakage to frame, on occasions less than 20kΩ. This disease is progressive, and not curable by inaction. It is curable by replacement/rewinding, or by insulating the choke frame from chassis using stepped plastic bushes. If using the latter technique, record it on a prominent label tied to the choke frame, to avoid a later owner finding the unwanted side effect of your chosen solution unexpectedly, whilst working on the chassis.

9.5 Re-impregnation

Re-impregnation of wound components is sometimes needed. IF and RF transformers having wax insulation may have progressively lost unloaded Q over the years, due to increases in the dielectric losses caused by water absorption. AR88Ds often suffer from this problem, which causes an asymmetrical IF response which cannot be wholly compensated for by adjustment. In this case, the component must be baked dry before resealing with a suitable impervious paraffin wax. Not all waxes are suitable, and period literature indicates big differences between the types then available. This writer is unable to offer meaningful advice, except that the correct stuff is definitely a type of paraffin wax, and not any other kind despite claims from time to time in the press that beeswax is satisfactory.

1950s mains transformers, smoothing chokes and AF output transformers were often sealed with bitumen. This stuff tends to fall off and make a mess. There are two alternative methods of repair. Either the component can be resealed in a boiling tar bucket (be sure to leave it in the goo for at least a quarter of an hour), or else all the loose bits can be prised off and the bald patches then painted with a bitumen based sealer paint. The former method is to be preferred, but may be rather less convenient. Fumes from boiling tar buckets may not be welcomed in your domestic environment, unless there are roofing repairs to be done as well.

9.6 Wiring and Looms

Rubber wiring may be found brittle or the exact opposite, gooey. In general the rubber will be in worst condition at the top of the chassis, where the temperatures are highest. So look at the wiring to dial lamps and high mounted switches/potentiometers first.

In the case of radios using rubber or canvas coax to feed the LO gridcap, it is strongly recommended that this cable be replaced by one having a PTFE dielectric such as RG316/U. This is often an easy way to improve the frequency thermal stability because of a greatly improved temperature coefficient of capacitance, which is especially important in this application because such coaxes run right to the top of the hot valve envelope. By similar logic, changing the coaxes feeding the RF amplifier valve gridcaps can give increased image rejection on the HF ranges because of reduced dielectric losses.

An alternative to changing the entire coax, is to run the original insulated inner out of its jacket braid, and then thread in a replacement insulated wire. Again, PTFE is to be preferred, but even PVC insulated cable will be a huge improvement over a rubber original. Repairing the cable this way has the benefit of retaining the original external appearance.

This technique can also be used to mend coaxes which have developed short circuits between the inner and outer conductors. This is especially likely to happen at the connectors to valve top caps.

Plastic wiring sometimes goes brittle with age, especially where it has been heavily doped with an MFP compound. Sometimes shorts develop between different PVC insulated conductors in the loom, if it had been laced too tightly when new. This is because PVC is a plastic material which creeps out of the way in time, leaving the conductors exposed.

PTFE will only occasionally be found on radios of the valve era, but the comments regarding creep are even more relevant to this material. PTFE has the added problem of being very easily nicked by the knife whilst being prepared for tinning, or by sharp pieceparts whilst the loom is being positioned in the chassis.

Varnished canvas and fibreglass insulated wire rarely if ever gives any trouble at all.

In the case of transformers and chokes that have doubtful looking insulated wires emerging through an unbushed hole in the metal screening cover, it is a good idea to varnish the wires at the point of entry. This can keep the component in service when otherwise it may eventually need rewinding or at the very least, internally re-terminating in a few years time.

If your chassis needs rewiring, first make an assessment of the extent of the repair necessary. Prod the insulation of individual wires along the length of the looms, using a small screwdriver. The insulation should move, then spring back. If it does not move, the insulation is too hard, and possibly brittle. If it does not spring back, it has probably gone too soft.

If an entire loom has to be replaced, clip each wire at its termination, release all the P-clips and lift the loom gently out as a complete assembly. Draw it carefully at 1:1 scale on a big piece of stiff card. Don't take the loom to pieces to do this! Replicate the loom on the bench using suitable modern wire, with all branch lengths and directions correct. Be sure to leave each wire end 15mm longer than originally. This is partly to make good the shortfall in end lengths caused by the cableform being cut off rather than unsoldered, and partly to allow each wire to me re-made one more time if necessary, without the pigtail becoming too short.

Still on the bench, bundle the new loom initially with tywraps, then lace it properly with new braided nylon cord or string. Start at one end, and remove each tywrap as you go along. This work is not difficult, but will be time consuming if you have never done it before. Be patient, and work carefully. Aim for perfection. This is one job where you <u>can</u> achieve it, given time. Each loop should be independently knotted. Do not use tywraps or spiralwrap anywhere on the final loom. These things look awful inside an old radio, and are very eyecatching.

Do not be tempted to re-route the loom somewhere easier to fit. It was designed to go exactly where you found it, very possibly as a result of parasitic instability found by the design team when the loom was put in the more obvious position.

Remove all solder and old wire ends from the various connecting lugs on the chassis. Then strip and tin the cable ends of the new loom, and offer it up into position on the chassis. If you have done your work properly, the new loom will fit perfectly. Reuse the original P-clips if you can.

If only partial rewiring is needed, snip each loop of the lacing cord back as far as you need to go, and carefully feed out the old rotten or burnt wiring complete with its lacing. It is best to remove complete wires if you can. Then fit new wires into the loom. Where joins are essential in mid-loom, use a Hellermann sleeve to cover each solder joint. Everything has to be done in situ, which is why the use of heatshrink sleeving cannot be recommended. End by re-lacing the loom using the original positions for each loop of the cord. Partial repair of a loom like this very often takes longer than fabrication and installation of an entire new loom assembly, and never looks half as good. Except in the case of very localised damage, this writer recommends complete replacement of damaged looms, every time.

Suitable wire for most radios will be PVC covered 16/0.2mm for signal and HT circuits, 24/0.2mm for runs feeding up to 3 filaments, and 63/0.2mm for high current runs to the filament transformer of a big receiver. Umbilical power cables for the 358X, HRO etc should use 63/0.2mm for the filament, and 24/0.2mm for HT+ and HT return. The colour brown looks unobtrusive in most radios.

One curious feature of Collins and Marconi radios is that they used screened cables that had no insulating sleeve over the braid. It is necessary to take particular care not to let the braiding fray, or lie against any live metalwork.

9.7 Motors

These are principally found driving the auto-tune mechanisms in military radios, and AFC mechanisms in SSB adaptors.

Most motors can easily be rebuilt to re-seat or replace seized or worn brushes. With a little ingenuity, helped by a press and a good modelmaking lathe, the bearings can usually be renewed too.

Most problems occur not with the motor itself, but with the driven mechanism. As a rule of thumb, a worn motor will indicate a much more severely worn geartrain. Indeed, before purchase of a motor tuned radio it is well worth a good search for metal filings near the driven gears. You can form your own conclusions, if any are found.

Electrical noise is usually due to brush wear, failure of the suppressor component(s), or failure of one diode in the driver rectifier bridge. The result can be extreme deafness of the radio during tuning, something which can be puzzling when first encountered, especially if the radio has a squelch system.

9.8 IFTs

The primary of the first IFT may have a higher impedance than the other IF windings in the set. This is especially likely with radios using a 6K8 or Mazda/Ediswan 6C9 mixer, and was considered necessary to give the best conversion gain with these types.

In contrast, the windings of the final IFT may have lower than usual impedances, in order to efficiently drive the usual AGC and signal detector diodes, which present low impedance loads.

For the reasons given above, it is necessary to exercise care when fitting IFTs taken from another radio, especially if the donor set is a different type from the one being repaired.

9.9 Battery Wiring

On battery sets of American origin, wiring may be found labelled "A" (heater), "B" (HT) and "C" (grid bias). Various voltages were in common use and it will be necessary to identify which voltages go where on the chassis.

Whatever country of origin applies to your radio, the battery connections will be by special connectors which are often found badly corroded. The cabinet or battery case will often also need attention.

9.10 Audio Transformers

Inter-stage transformers were sometimes excited by a parallel feed (often called parafeed) arrangement which used RC coupling to keep DC out of the primary. This enabled a smaller and cheaper Iron core to be used in the transformer.

In battery sets, QPP output stages would normally use a step-up driver transformer to feed drive voltage into the high impedance control grids of the output pentodes. In contrast, class B sets would use a step-down type to drive positive grid current into the zero bias triodes. Both of the transformers here will ordinarily be of the unbalanced to balanced type.

Output transformers are distinctly prone to flashovers across the primary, and from primary to frame. More dangerous are flashovers between primary and secondary, especially in those cases where the output winding is left floating or only lightly connected into a negative feedback circuit. To reduce the risk of flashovers, output transformers should never be run without a load. Short circuit loads are generally safe, but open circuits are generally not.

Many transformers are protected by a shunt resistor or capacitor, or by a Zobel network. The capacitors need to be able to tolerate high AC voltages; and if the cold end is grounded, they must withstand the applied HT voltage too.

10. Thermionic and Other Active Components

10.1 Criteria for Selection of Valves

On grounds of reliability, longevity and consistency/accuracy of characteristics, this writer would advise that you use valves made in UK, Canada, Germany, France, Sweden, USA or Japan. Valves made in the former soviet block, India, China and Spain generally deserve suspicion because they are often of very inferior quality.

For VFOs, and hot running applications such as output valves or rectifiers, you may be well advised to consider the use of high reliability types even where not originally specified for your radio. Military examples such as USA four digit types (5749 etc), UK CV4000 series, or commercial uprated types (M8136 etc) are to be considered very desirable in these applications.

In general, the American military suffix-W valves are better than the average commercial grade, though they are not necessarily any more reliable. In this respect they are similar to the CV100 series used in the UK.

The WA, WB suffix American military valves will each safely replace lesser suffices, but the converse is not true. For instance, a 6AU6WC will replace a 6AU6, 6AU6WA or 6AU6WB in all applications, but a 6AU6WA will only replace a 6AU6 and should never be used to replace a 6AU6WB or 6AU6WC. Some of the suffix upgrades affected secondary parameters such as warmup time, heater/cathode insulation withstanding voltage, or the mechanical resonant frequency of the electrode structure.

Warm-up time, mutual conductance, gas current and heater/cathode insulation may all be valid selection criteria. The application will determine their order of importance. The one thing that ought not to be allowed to matter too much is the external appearance of the valve.

Sometimes a valve may be encountered with Gold plated pins. This is a very visible and obvious sign of constructional quality. A popular example in the radio world is the E180F, used as mixers in the Racal RA17/117 series. However, a word of caution is in order. Taking the example of the E88CC, many specimens from the cheaper manufacturers are found to be lacking the Gold plating. This is because they are actually the commercial ECC88 type branded as E88CC, and not the real thing at all.

Frame grid valves have an extremely small spacing between the cathode and the innermost grid, which is usually the control grid. This was necessary to obtain higher mutual conductance than was otherwise obtainable. An unwanted side effect of this construction is that these valves are far more sensitive to mishandling or electrical damage than non frame grid types, and they seem noticeably more prone to develop intermittent faults. Valves of the frame grid type and certain others such as the 6SG7 and 7H7 are rather prone to developing control grid emission, especially if the heater voltage is too high. This problem can cause very poor AGC action if the affected valve is somewhere in the RF or IF amplifier chain.

With side contact valves (CT8, type E), it is important to make sure the valvebase has no loose contact rivets.

Occasionally it will be found that a suffix Y octal valve is called up in American equipment. This signifies a type with a low loss base, usually of made of a woodflour loaded phenolic material, coloured brown. Sometimes ceramic bases were fitted.

Valves fitted to receiver RF units should be thoroughly tested to ensure the absence of any inter-electrode shorts prior to their fitment in the chassis, because of the invariable difficulty of access to this area of the chassis.

Caution is advised with the GT (glass tubular) family of valves. Some of these had moulded bases of larger diameter than the standard G (shouldered glass) type, and may not fit into all skirted octal sockets. The confusion was removed by the eventual introduction of the GT/G suffix. This denoted a variant which could replace both the G and the GT in all applications. The same comment about not fitting into skirted sockets also applies to metal valves of course, with the added problem of ensuring the metal envelope is properly grounded for safety and to ensure proper electrostatic screening.

In Europe, and especially France, the MG series of octal valves was developed and sold by manufacturers such as Adzam. These valves are the same height as the -G types but are tubular, and clad in an integral close fitting Aluminium jacket. Confusingly, the French also fitted a metal jacket to their –GT valves. Thus both the 6Q7MG and the 6Q7GT are tubular and metal clad, the only difference being the height.

When ordering replacement valves, it is wise to be aware that many valves were made in different envelopes without any change in type number. For example, the RCA 80 rectifier and the Mullard EBC33 dual diode triode were both available in shouldered and tubular glass styles. The Mullard ECH35 was available in two different sizes of shouldered glass envelope. The smaller had a 200mA heater rating and the larger, 300mA. (This appears to have been the reason for the existence of the CCH35, which was made only in the larger envelope.) Some military ECH35s came in a tubular envelope, just to complicate the situation further. If paying good money for a new valve, it is worth checking that it will at the very least fit properly in the available space.

10.2 Valve Repair and Remanufacture

Bearing in mind that so many of the older valve types were basically common bulb/electrode assemblies mounted onto a family of alternative bases, it may be possible to “make” a new valve, if you have a source of donor pieceparts. This writer has successfully grafted the bulb/electrode assembly from a new spare octal Brimar 6F6G onto the UX base from a defunct RCA 43, to create a 42; and converted an octal AZ31 into a side contact AZ1 using the base from a dud ECH3. The work is rather fiddly, and you must perform a comprehensive set of tests to verify that there are no inter-electrode shorts before you put the “new” valve into service. The best way to remove the bulb from an octal base is to start by loosening it rotationally, wearing gloves and goggles and with all parts of the valve held inside a big rag in case of breakage. Then one by one, gently bend each pin in the bakelite moulding back and forth until it snaps at the root, making sure each wire remains attached to its pin. Then melt the solder at the end of each snapped pin and pull it off the wire. The next step is to paint the end of each wire in a distinctive way so that it can be uniquely identified later on. After doing this 8 times or as necessary, the old bakelite base should pull straight off. Then the bottom of the bulb can be cleaned up, and all wires extended and sleeved as necessary ready for insertion into the new base. Araldite works fine for the bond, but do be careful in the case of magic eyes to align the bulb onto the base in the correct angular position. A quick check on a valve tester will confirm that you have connected the wires to the new valvebase pins in the right order.

Cathode rejuvenation works a few times on valves with thoriated Tungsten filaments, which of course are mainly transmitting types. Some success may be obtained with oxide coated cathodes at the risk of deterioration of the heater/cathode insulation, a worsening of the gas level, and/or the possibility of the filament becoming open circuit. Three minutes at double the normal filament voltage is worth trying as a first step, with no other voltages applied to the valve.

Several proprietary rejuvenators are available, though these are mainly intended to work with cathode ray display tubes. Their use with receiving valves is strictly in the experimental category, though some success may be expected, particularly with poisoned calibrator valves and VHF front-end valves such as ECC85s on receivers that have rarely been used in this mode of operation.

Be careful when attempting to rejuvenate frame grid valves. The very close grid-cathode spacing on these types makes them intolerant of even small changes in cathode geometry caused by structural warping due to excess heat.

In the case of those valves that are no longer obtainable from anywhere at any price, or where cathode rejuvenation is inappropriate, repair of the original valve is the only logical alternative to the manufacture of a new one, unless rewiring of the socket for a slightly different type is considered acceptable. Many faults, such as a broken cathode connecting strap, or a heater wire that has snapped at its weld to the pinch leadout wire, would appear to be very simple to repair given the necessary trepanning, welding, pumping and gettering equipment. The writer would very much welcome contact with anyone with experience of this type of work. It is noted that unlike large transmitting tubes, the valves used in receivers were never designed to be rebuilt after a period of service. Hence the envelope glass may well be a type fundamentally unsuited to repair.

10.3 Loose Top Caps and Valvebases

Loose top caps are best unsoldered and removed. Clean the cement surface, but do not attempt to dig it out unless it is loose, in which case be sure to remove all unattached pieces. Then apply a bead of Araldite to the pip without disturbing the lie of the wire, which is quite fragile. Immediately refit the cap, push it home and quickly solder it. Do not disturb the assembly for a day or so.

The term “valvebase” is easily the least confusing of the various names used for the bakelite base forming the bottom part of many older style valves, and which carries the male connecting pins or protruding side contact lugs. They are found on standard glass octal, tubular octal, UX, British, CT8 etc valves.

The best way to fix a loose base is to invert the valve, squirt some solvent based contact adhesive through one of the spare holes in the bakelite, then try to swill it round a bit. Finally, store the valve upside down with an elastic band squeezing the bulb into its base for a couple of days. Any adhesive that dribbles through the gap between envelope and valvebase, can be trimmed off with a scalpel after it has set.

A slightly more unsightly repair, for use mainly when the valve has no spare pin holes, is to run a fillet of Evostik between the bulb and the valvebase. Then apply the elastic band and store the valve the right way up for a day or so. If using this technique, you are recommended not to attempt trimming of surplus adhesive, because it will leave a mess and weaken the joint.

10.4 Metalized Coatings

Metalized valves must have a complete coating, so far as it originally went. Some types, for instance the Mazda 6P25, had a metalized coating extending only part of the way up the bulb. Any patches of metalizing found loosely adhering to the glass should be wirebrushed off. Then repaint the entire area that should be coated, covering any original coating that remains, using a suitable conducting paint such as the Nickel screening spray sold by Maplin Electronics. Make sure you coat the wire ring or spring clip that connects to the shield pin in the valvebase.

In general, the early grey coatings are very prone to peeling off. To make things worse, this type of coating can get so dirty as to completely obscure the markings of a VP41, AC/VP1 etc. The later gold, black and red coatings were much better in both respects.

The metalized coating should be well grounded. Even a few ohms can cause incipient or actual instability in RF and IF stages.

Because the metalizing is very brittle and because the earth contact wire or clip is captive to the valvebase, it is obviously necessary to make sure the bulb is not at all loose in its base. If it is, fix this problem before attempting to restore the connection from the valvebase shield pin to the metalized coating.

If your chassis uses an entire family of metalized valves that look much the same (ECH35min, EF39, EBC33 etc), then mark each valve in some way so it can infallibly be fitted in the correct socket. This is best done by scribing the underside of the valvebase, where the marking cannot be seen. Do not use a pencil! It may cause tracking.

Wherever metalized valves were originally specified, they should be fitted. However, beware of using metal or metalized variants where they were not originally installed. The shield pin on the valve socket may sometimes have been used by the factory as an HT anchoring lug. British manufacturers in particular, were inclined to do this rather than fit a separate insulated tag. The Peto Scott H52 domestic receiver was designed to use an unmetalized Marconi DH63 double-diode triode. It so happens that this type of valve was available with and without metalizing under exactly the same part number. If a metalized specimen is plugged in, the outer coating is at HT and thus potentially dangerous to the service engineer.

10.5 Valve Cans and Retainers

On most old radios, valve cans are usually fitted somewhere or other. They are all there for a purpose, therefore they should all be fitted - except in some American equipments, where certain specified cans should be removed for static rack mounted service. Check which valves should have cans fitted, for your particular type of installation.

Do not assume that cans should always be fitted wherever a skirted valve socket is to be found. This is not always so. The 12BY7A transmitter driver in the Yaesu FT101 family is a good example.

The ordinary shiny Aluminium or Nickel plated brass valvecan is not at all friendly to the valve. Blackened cans are much better, giving a far lower plate temperature under adverse conditions of operation. You might wish to consider an upgrade to blackened cans for ethical reasons, especially if you intend to use your radio a lot and it uses rare or fragile valves. Cans were made in brass and Aliminium. The brass ones are much heavier and of higher quality.

Red cans are often of heavy μ-metal material. They were sometimes fitted to valves operating at high audio sensitivity such as the EF86 to reduce hum, or valves which are susceptible to AC magnetic hum fields such as the 7360 mixer, where the objective was to reduce hum modulation of the signal. Another application was on battery-powered radios fitted with integral loudspeakers. The static magnetic leakage field from the magnet could damage certain of the more fragile B7G 1.4V filament types.

The Hammarlund SP600 uses a special can for its 6C4 first local oscillator. This has a special lug which must be screwed down onto a support pillar, to provide proper mechanical support and to guarantee efficient grounding of the can. The objective was to improve frequency stability and possibly also, to reduce local oscillator radiation.

The best cans for B7G and B9A valves are the contact-cooled types made by IERC such as the TRNC6000 family, which was licence manufactured by Garrard in the UK. These can sometimes be fitted as an upgrade, in place of the standard type. Avoid fitting contact-cooled cans to barretters or neons, though. Marconi were quite fond of using an elaborate fully screened can which contained wire wool to get the heat away. These cans screwed down onto a special threaded ring which surrounded the valve socket. These things cannot be used as replacements for ordinary valve cans. One side effect of all these cans is to feed heat from the bulb to the skirt of the valve socket, and hence down onto the chassis. This is generally not a problem. However, care is needed with VFOs, which may drift more with a heatsink can than they do without because of increased component heating near the valve socket. Another relevant fact is that for valves without an internal shield around the anode cylinder, heatsink cans increase the anode capacitance to ground more than ordinary types.

Certain American radios used spring fingerstock inside B7G and B9A valve socket skirts, presumably to support the valve and promote cooling. If originally fitted, all such hardware should be present and correct. Make sure none of the spring fingers has become detached and fallen on to the top of the valve socket insulator or got jammed alongside one of the socket contacts. This problem is frequently encountered.

Some radios by Philips and Heathkit and perhaps others, used push-on cans which connected to a grounded metal finger running up alongside the valve envelope. Sometimes the finger was intended to be trapped between the valve and its can, and sometimes it pressed onto the can from the outside. In either case, it is important to make sure the can is properly grounded, so that it acts as an effective RF shield.

Spring valve retainers generally give little trouble if made entirely of metal. Some of the types intended for balloon top valves have a woven basket at the top of long side springs. These do not go wrong either. In contrast, retainers using a pair of helical springs and simple knotted fibreglass or cotton string are a source of constant pain. It must be possible to repair these things when the string breaks, but this writer has never succeeded in doing so.

The Marconi B8G '80 series (like loctals) and B9B (EF50) valves used all-metal valve retainers which often need new side springs, but little else ever seems to go wrong with this pattern.

10.6 RF Amplifiers

RF amplifier valves need to be selected primarily for high mutual conductance. A valve tester is fine for this job. Use the gainiest valve you have as the first RF amplifier. Be wary of using a later design of valve to get more HF sensitivity. In the main, any benefit achieved will be small, but the risk of VHF parasitic oscillation will be large. Similarly, be careful of using a semi-remote cutoff valve in a design originally based around a wide grid base variable-μ valve. There may be slightly more ultimate HF sensitivity to be had, but this time it will probably be achieved at the expense of strong signal handling.

The worst option of all would be the use of a straight frame grid valve such as an EF95 to replace a big old variable slope standard type such as a KTW61. The difference in capacitances and mutual conductances between these two families is so great that correct tuning would be difficult to achieve on the HF bands, at least with adequate stability. Even if this condition were found to be obtainable, the AGC performance would now be poor because the front end would be trying to perform almost the whole of the variable gain function on its own whilst lacking the intrinsic linearity to cope properly under strong signal conditions.

Having said all of this, some radios certainly do benefit from a modest upgrade. For example, the SP600 gives 10dB NF on 6m with a 6DC6, compared with 12dB with the original 6BA6. No circuit changes are needed, the stage is totally stable under any conditions of source impedance, and the two-signal performance is only slightly worsened.

In designs that use high gain or frame grid construction front ends such as 6CB6, 6DC6 and 6BZ6, the valve will often be found distinctly flat, giving poor HF sensitivity and worsened intermodulation performance. These high performance valves also seem more prone to inter-electrode shorts than lower gain types with larger electrode separations, especially when the valve envelope is mounted horizontally in a way which allows sagging of the electrode structure.

American wartime radios which are supposed to be fitted with suffix Y octal valves having biscuit coloured low loss woodflour-loaded phenolic bases, should always have this type fitted in order to avoid deafness at the higher frequencies.

10.7 Acorns and Nuvistors

Acorns and nuvistors had a period of vogue in American professional radios, mainly HF/VHF and UHF types made by the likes of Hallicrafters, Watkins Johnson and Nems-Clark. The good news is that these devices are very reliable indeed and give a long service life.

Most types of acorn are generally still available.

The main problem with acorns is fractured radial seals, caused by excessively forceful attempts at insertion into the socket. The best way to avoid this risk is to oil each radial pin before insertion, then wash it off with methylated spirit after the valve has seated home.

Nuvistors generally come at extremely high prices, because so many still remain in active service. If all the nuvistors in your radio are present and serviceable, then sit tight and hope for the best. In the meantime do not disturb them, but start trying laying in a cautious stock of spares.

If any nuvistors are missing, and direct replacements are not traceable or affordable, you may wish to consider the use of an available miniature wire ended glass type such as a 5840/EF732 with legs bent to fit into the original socket. The new valve will be taller than the original, so support it at the top of the envelope using a grommet. Keep the wires very short, but do not bend them within 1.5mm of the glass seal. Be particularly careful not to damage the valve socket, otherwise you may have problems fitting a new nuvistor, if you ever manage to get one later. It may prove possible to open the old broken nuvistor and use its bottom end to anchor the new component.

Some nuvistor front ends were blower cooled. In such cases it is important that the blower works properly and that all airflow ducting plates, gaskets etc are present and correct. If fitted, the airflow intake filter should be inspected and cleaned if necessary.

At the risk of being branded a heretic, this writer would point out that it may be possible to use something like a TO92 packaged N-channel JFET to replace acorns or nuvistors in certain situations, especially where the operating potentials are low. For a little while, Fairchild and possibly other manufacturers too, produced pin compatible non-thermionic replacements for certain nuvistors. These devices were called "Fetrons". The list of available types was small, but did include the ubiquitous 6CW4.

10.8 Compactrons

These were used in some American radios but not for long, and their production life seems to have been quite short.

Compactrons were really three or more valve sections in one large tubular glass envelope fitted with 12 little pins. The supply situation seems to be very variable, so the writer recommends owners of radios using these things to build up a good stock of spares. The multiple electrode structures can cause gas problems. It is wise to be on the look out for this problem in compactrons containing hot running sections used as output stages, when another section in the same envelope is used for a negative voltage high impedance application such as AGC detection or VOX amplification.

10.9 Mixers

The key to healthy mixer operation is to use the right valve - not a near equivalent - and feed it with the right amount of local oscillator injection. Too much causes whistles. Too little causes a lack of conversion gain, and hence low sensitivity. Although multielectrode mixers have rather complicated surrounding circuitry, surprisingly little usually goes wrong with them. most types remain widely available. In general, it is acknowledged that the octal 6A8, 6K8, 6J8, ECH35, 6TH8G, 6E8, X61M, X65 & X66 types are all broadly interchangeable despite various differences in electrode constructions. Care is needed with the 6TH8G as it is physically huge, and draws a large heater current. The 6SA7 and 6L7 types are deliberately not included in this list, since the mechanism of their operation is very different from the valves on the list - and from each other. In addition, these two valves are not pin compatible.

In the loctal family, the 7S7, 7J7 & X81 are all broadly interchangeable.

The Mazda/Ediswan 6C9 and the far more common ECH42 are also broadly interchangeable, though these types have very different filament current ratings. Some adjustment may need to be made to the triode grid resistor value if this substitution is made. Note that the American 6C9 is an entirely different valve from the British Mazda/Ediswan, the latter being constructed as a sort of miniaturised 6K8.

Check the screen grid feed arrangements carefully. This electrode is usually connected to the tap of a potentiometer across the HT line. The top resistor often goes high in value.

Many American/Brimar 6K8 circuits have a big electrolytic decoupler on the screen, in parallel with an RF bypass capacitor. These circuits may have a single dropper resistor of value 22kΩ or thereabouts giving typically 100V on the screen grid, with the dame DC voltage being fed to the triode anode. Where used, check this dropper component carefully because the screen voltage is critical on the 6K8 type of mixer. In addition, the maintenance of good screen grid voltage and decoupling conditions may also be important for correct AGC response, and/or the prevention of motor-boating effects. The 6K8 used very clever construction, and was very resistant to pulling when its triode section was used as the oscillator. An unusually high impedance 1st IFT primary winding was usually used with this type of valve, to the benefit of both gain and selectivity. The 6K8 was a difficult valve to manufacture and was expensive when new, though it is one of the more commonly available octal types nowadays.

The 6E8, ECH35, X61M & X81 types of mixer are unusual in that the mixer section is a hexode rather than a heptode. In this respect, these devices are similar to the 6K8, though of more conventional construction. All of these valves rely on a large anode-screen spacing to prevent secondary emission distorting the Vg1/Ia transfer characteristic.

Triode mixers are altogether much more critical in their operating conditions than are multielectrode mixers. Here, it is often necessary to be very careful in the choice of valve specimen. With the 6C4 for instance, there were many different basic types of electrode construction in widespread use. Some work well in the R390A, others do not. The handbook specifically cautions against the use of type 6C4W in this application. The writer has a KWM-2A which uses a 6BN8 triode section as a receiver mixer. The difference in conversion gain between new examples from different manufacturers is reliably as much as 10dB.

The use of a general purpose triode as a mixer depends on secondary performance parameters that vary greatly between different electrode structure designs. Usually the injection will be at a level of between 3V and 7V RMS for correct performance. The triode may be biased such that the injection lowers the anode current (anode bend operation) or raises it (leaky grid operation). In practice there is little to choose between these two modes of operation, except for the severity of the side effects in the event that the oscillator should ever stop running.

Selection of a new specimen of exactly the original type used by the radio manufacturer is definitely the safest way ahead with triode mixers. If possible, choose from a boxfull of new triodes by various manufacturers, looking at spurious levels and third order intercept point. Certainly this is tedious work. But the on air results are likely to be far better than relying only on selection by valve tester results.

Beam deflection tubes are generally available, but the 7360 in particular commands extremely high prices. There is usually no alternative to replacement by the correct part if the original valve is damaged or (more often) missing. If a good example is fitted, look after it carefully. Japanese and American designs of 7360 differ slightly in their characteristics. Use the right type or organise a swap, in the event of problems.

The 6JH8 and 6ME8 beam deflection have an extra grid compared with the 7360 and work rather better as receiver mixers. They are cheaper, too. With all types of beam deflection mixer, the local oscillator injection needs to be at a very high level, perhaps 10V RMS or even more according to design. Stage gain is proportional to excitation over an extremely wide range. The local oscillator injection may be applied to the deflection plates differentially, or in single ended mode. Balance of the DC current paths within the valve itself is necessary, and this is invariably achieved by slight differential adjustment of the deflection plate DC voltages. The IF output from the mixer stage may be taken from the anodes differentially, or in single ended mode.

Beam deflection valves are easily hum modulated by strong magnetic fields so if a μ-metal can was originally specified, make sure it is present and correct. Such cans were often painted red and tended to be rather heavier than the ordinary types.

The ubiquitous triode-hexode or triode-heptode mixers are best evaluated in the radio. If restoration is underway and all that can be done is to use a valve tester, then the most useful single test is triode mutual conductance. Anything better then 60% of the book value should be regarded as a "pass" result, and probably indicative of adequate installed performance. The real test though, is performance in circuit over all wavebands, and with a close eye on whistle levels.

10.10 Local Oscillators

VFO valves sometimes had a different part number from other valves of the same type used elsewhere in the set. As an example, the 6BA6s used in the VFO of the 75A-4 were allocated Collins part numbers different from the 6BA6s used in the IF strip. This may indicate that these components were pre-aged, had unusually low heater/cathode leakage, or were in some way selected to be especially suitable for the job. Perhaps they were sourced from a different manufacturer.

If a VFO valve has heater/cathode leakage problems, appreciable filament electron emission, or is a type sensitive to magnetic hum fields radiated from the filament structure or from an adjacent mains transformer, then the effect is usually seen as unwanted AM or FM hum on the oscillator output. The problem is usually worst at the HF end of coverage of the VFO. This may or may not correspond to the HF end of coverage of the radio's RF range, depending on the mixing scheme employed. Because of the multiplicity of causal mechanisms for modulation hum, local oscillator tubes often require selection for lowest residual levels of impressed AM or FM.

In general it may be said that ruggedised valves are very desirable in VFOs, but try to avoid brand new ones. It is a good idea to age your chosen valve in the oscillator for 100 hours or thereabouts before final adjustment. The radio will then hold its dial calibration longer.

The slightly different characteristics of valves with the same part number made by various manufacturers, can be useful if there is a selection to choose from.

Where a multielectrode octal mixer valve from the long list in paragraph 10.9 also operates as the first LO, it may be found that it fails to oscillate correctly at the LF end of the highest frequency band. This is where the L:C ratio is least favourable. Under these circumstances, it may be necessary to fit a 6K8 or other type having a higher triode transconductance than the type being replaced.

Try to avoid using an extremely high gain specimen of local oscillator valve. In HF receivers, this precaution will reduce the probability of whistles and other unwanted effects caused by excessive oscillation levels or parasitic oscillation in the VHF region. This phenomenon can cause oscillator inefficiency and/or inexplicably high noise levels in the receiver. As an example of problems that can occur in VHF receivers, the writer has a Hallicrafters S36 which suffers severe LO squegging on Broadcast Band II if an overly good 955 LO valve is fitted.

By way of contrast, a weak oscillator valve will cause low drive to the mixer leading to insensitivity of the receiver. Alternatively, the oscillator may drop out or fail to start correctly, somewhere in the coverage range. Weak LO valves also tend to cause seemingly endless frequency drift.

Wartime American radios supposed to have a suffix Y valve fitted to the local oscillator should have this type correctly in place. The suffix Y indicates the use of a ceramic or woodflour-loaded low loss phenolic base.

10.11 Automatic Frequency Control

In the context of HF receivers, AFC is normally used for SSB/ISB frequency drift compensation, or to maintain frequency accuracy in radiotelex applications.

Reactance valves are used for small frequency changes. These have variable DC voltage drive, and are typically strapped across a local oscillator tuned circuit.

Motorised AFC gives greater variability in terms of frequency range, and was used for the correction of gross system drift in products like the CV-157 ISB adaptor for the R390 or R390A.

10.12 Calibrators

Calibrator valves are often found to be flat, due to cathode poisoning brought on by lack of use. This situation is not recoverable unless you’re lucky with the rejuvenator. Replacement with a fair but used example of the same type of valve is usually the best policy. The use of a brand new valve just for a calibrator, is rather hard to justify in these days of rising costs.

10.13 IF Stages

IF strips often use several examples of the same type of valve. The final IF amplifier has to develop the most signal power. It often gets little AGC, in order to suppress unwanted modulation rise. Therefore it is wise to fit the best specimen you have in this position. A weak valve here may cause an unacceptable amount of distortion on strong AM signals.

A curious feature of 6BA6s and 6SG7s is the frequency with which they are found to be very flat indeed, even though the radio itself may have been working fine with them fitted.

Some types of valve are rather prone to developing control grid emission. In particular, this applies to valves with unusually close spacing between the cathode and the control grid. Types 6SG7 and 7H7 are frequent offenders. Grid emission can cause serious problems in AGC systems, due to the high grid feed resistances usually used. Apart from trying another specimen of valve, it is worth raising the mains tap setting to reduce the cathode temperature slightly. Gassy IF valves are less commonly encountered, but this problem also causes poor AGC action.

10.14 Detectors & AGC

Multisection valves need a bit of care when an amplifier triode, or, much worse, an output pentode is combined with one or more signal diodes. Gas problems (see output valves section) can cause serious malfunction of the detector or AGC rectifier, if the power amplifier valve in the same envelope has been thrashed or was poorly degassed at the factory.

Where the detector diode is in the same envelope as an audio triode, there may be a problem due to play-through at the minimum setting of the volume control. This is often due to internal capacitive coupling within the valve, in which case it may be reduced by fitment of a different specimen. Diode pentodes are much better in this respect, where the pentode was used as an IF section.

Beware the Mullard EBC33. For unknown reasons, this type is very prone to problems with its diodes. Inter-diode shorts are known, as are anode-to-cathode shorts. The problem seems not to be found on EBC33s from other manufacturers. For instance, the wartime military black metalized EBC33s from Rogers in Canada seem almost indestructible.

Paired diodes which are used as FM demodulators should be specifically selected for good balance, if there are any doubts about the match. The EABC80 type is often found to have two (out of its total of three) weak diodes after long service, causing suspicions about the VHF IF alignment. Replacement of the EABC80 with a new or known good specimen is often a good idea before spending too long readjusting the IF strip or ratio detector.

AM detector valves, and product detector valves may need to have low heater/cathode leakage to avoid hum problems. This is particularly true in the case of receivers with series-connected heater chains.

Some pre-war battery sets used indirectly heated double diodes such as types 2D2 or 220DD. These are now believed to be completely unobtainable. The best answer in event of problems would appear to be to use a semiconductor diode or two, leaving the original valve in position for the sake of appearances.

Product detectors based on the 7360 valve, may be susceptible to hum introduced by the stray magnetic field from the mains transformer.

In some cases, μ-metal cans were fitted to the detector and/or the noise limiter. These were often painted red for easy identification. These cans are heavier than the usual type and have the necessary soft magnetic characteristic.

Sets using delayed AGC may suffer from “differential distortion” of the audio as the AGC diode drops into and out of conduction on a weak signal subject to fading. Quite a lot was made of this phenomenon years ago, and some very clever circuits were devised to compensate for the problem. The cleverest approach was to provide a level of forward bias for the detector diode which was proportional to the strength of the received signal. In the opinion of this writer these complicated circuits are of esoteric interest only, since most detectors work perfectly well enough for communications purposes when correctly restored to original specification.

Radios having double AGC systems obviously have about twice as much AGC generation hardware to restore as the usual variety. There are no special pitfalls to avoid during restoration. The Hallicrafters SX28 Super Skyrider has a complicated dual AGC system, operating at different bandwidths. Despite the grand claims in the promotional material relating to this receiver, there seems little practical benefit to the user. Each AGC system works so well that the writer’s example works fine with only one (either will do!) AGC loop being connected - a useful test of performance.

The infinite impedance detector is a rarity. It uses a triode biased almost to cutoff. This design has something of a bad press as regards distortion. In the opinion of this writer, this type of detector is perfectly suitable for use in a CW communications receiver. It gives extra selectivity for free, and works particularly well if the high value cathode resistor is decoupled to IF only, and not also to AF. This gives lower ultimate detector gain than could be obtained by totally effective decoupling, but the distortion at high levels of modulation is vastly reduced. The McMurdo DST100 has a particularly well engineered infinite impedance detector based on the 6J5G, which is used on all but the widest IF setting. This circuit design gives excellent results on CW. It is even passable on SSB.

Anode bend detectors have some similarities to the infinite impedance type, but are rather more common. The GEC BRT400 uses an EF91 as its AGC detector in a rather complicated circuit which has its own negative HT rail, produced from a dedicated rectifier/reservoir arrangement. The overall result is excellent. This set can generate such large amounts of AGC for its W81 (later variants used 6BA6) RF and IF valves, that it can accommodate 100dB of input signal range without overload.

10.15 Magic Eyes

The main design problem with magic eyes is the loading they put on the signal detector, in the many circuits where the magic eye is fed from this stage to avoid the effect of AGC voltage delay. Little can be done about the resulting AM distortion, except to use a large grid series resistor (in comparison with the diode load), together with a low leakage decoupling capacitor on the control grid of the eye amplifier triode section. To avoid the AC loading problem, some of the more expensive sets used an entirely separate detector to feed the magic eye without any voltage delay. Some of these radios put the main magic eye on the signal detector to help tuning on weak signals and had a second, reduced sensitivity, magic eye running on AGC for use on very strong signals.

Special mention needs to be made of the pre-war Philips magic eye type EFM1, which was a combined AF pentode and magic eye used in sets like their 735A. The EFM1 was also made by Tungsram, and by French manufacturers. This valve required its pentode section to be connected to the signal detector for DC as well as AC purposes, which meant it automatically introduced feed-forward AGC. This in turn, meant that the audio amplifier needed heavy feedback to reduce the curvature distortion to acceptable levels. Some good news with the EFM1 is that there were no problems with AC loading of the signal detector caused by the magic eye section. Nowadays, the main problem with type EFM1 is one of finding supplies. Though produced by Philips in large numbers, this type is now very rare and correspondingly expensive. One perfectly good reason for this scarcity is the lack of light output resulting from heavy inking inside the viewing end of the valve, at least on early production examples. Frequent replacement would have been necessary. Post-war EFM1 production had an ordinary clear viewing window, and these later devices are a lot brighter. In the event of non-availability, the best approach would be to change the socket to suit an ordinary octal magic eye such as the 6U5G, and then to mount a wire-ended variable slope pentode such as a 5899 directly on the socket tags. Alternatively, it should be possible to rewire the base to suit an EF9, and completely do away with the magic eye functionality altogether. The EFM1 was also made on the German octal base. This valve was called type EFM11. It is just as rare as the EFM1.

To obtain the correct shadow pattern at zero signal input, the cathode of the magic eye was often tied slightly above chassis potential, typically to a point part of the way up the cathode string feeding the receiver audio amplifier or output stage. In the event that an incorrect shadow pattern is found, look at this area of circuitry first, and only then move onto the anode and grid supplies.

The main restoration problem with magic eyes of all types, is lack of light output. This has led to a distinct shortage of certain types due to the need for frequent replacement in the past, combined with modern-day collectability. The problem usually seems to be caused by phosphor burnout rather than lack of cathode emission. This is shown by the fact that many weak magic eyes still glow brightly from the part of the phosphor that is only illuminated under extraordinarily high levels of input signal. Interestingly, many older magic eyes took a lot of target current - for example the Mullard type TV4. Sometimes the current drain was very variable between samples. This can lead to significant differences in light output even between new and unused valves of the same type.

One clever receiver once owned by this writer was made by the Swiss manufacturer Paillard, being their model 59. This only energised the target electrode of its UX6-based 6E5 magic eye to full HT when the maximum selectivity position of the IF strip was selected. In the other positions, the valve received rather less than 200V and glowed only dimly. The original magic eye had remained in service for 57 years, and was still in very good condition. This intelligent piece of design has not been seen on any other receiver known to this writer.

Many magic eyes were available with either fixed-mu or variable-mu triode sections, examples of the latter being much harder to find nowadays. The fixed-mu types such as EM81 & UM81, were usually found in measuring instruments such as RCL bridges of grid dip oscillators. The variable-mu types such as EM80 & UM80 were usually found in radio receivers. There is currently a despicable trade in re-marking ordinary EM81s and the Russian 6E1П valves as EM80s, and re-marking UM81s as UM80s by carefully scraping off the original chalk Mullard markings. These practices are deliberate attempts to catch the unwary, or to lighten the wallets of those who cannot recognise inappropriate behaviour of the shadow pattern in their radio. I invite you to mount one of these impostor magic eyes on a valve tester, whereupon its shadow may be found to close at less than 6V of grid bias. This amount of grid swing is simply not enough to allow the eye to indicate the full range of AGC voltage on the average receiver. A genuine EM80/UM80 does not close its shadow at less than 15V of grid bias.

Much confusion surrounds tubular octal types EM34 and 6AF7. Both are European magic eyes of dual sensitivity, the EM34 being directly equivalent to American type 6CD7. The 6AF7 is a French type. Despite its number, this is not an American valve. The military CV394 is supposed to be equivalent to commercial type EM34. Now consider this: the writer has three new & boxed Amperex (a USA brand owned by Philips) valves which are actually type 6AF7 even though they are marked EM34/6CD7. The Soviet bloc never seems to have made copies of the genuine EM34. So: what are the differences? They can be summarised as follows:

> EM34: constant diameter over both bulb and bakelite base; 200mA heater.
>
> 6AF7: bakelite base of larger diameter than the bulb; 300mA heater; electrode structure may be (but not always is) offset by some 15° compared with the EM34.

How much these differences mean in your radio, may well depend on whether the heaters are wired in series or parallel, and whether any provision exists for rotating the magic eye relative to the cabinet. Some sets that were designed for a genuine EM34 cannot mount a 6AF7 due to their inability to accommodate the larger bakelite base.

Further confusion exists surrounding tubular octal types 6U5G (not 6U5GT - no such type exists) and EM35. The genuine Telefunken EM35 has a Maltese Cross shadow pattern of dual sensitivity, and this device was adopted as type 6M2 by Ediswan/Mazda. In contrast, the 6U5G is a very ordinary American magic eye of single sensitivity, also available as type Y63/VI103 in a shouldered glass envelope. In the UK, type 6U5G was made by Brimar who erroneously listed the EM35 as a direct equivalent to it in their early databooks, and even made many valves marked “6U5G/EM35”. The trade has seized on this error with the result that nowadays several dealers try to pass off ordinary 6U5Gs as EM35s, even though these two types are not functionally interchangeable. In practice however, the EM35 is replaceable by type EM34. The only difference is the layout of the shadow pattern. So this swap can be made easily, safely and without any loss of functionality.

10.16 Noise Limiters

Noise limiters are very often troublesome. Most benefit from selection of the limiter valve for minimum hum. Exceptions are found in some Collins equipments (eg. 75A-4) and some AR88Ds, which operate the noise limiter valve under current-starved heater conditions, and some Eddystones (eg. S880/2), which apply positive bias to the centre tap of a separate noise limiter heater supply rail.

One problem with the Eddystone approach is that because the limiter has a dedicated filament winding, it gets full voltage at the moment of applying mains power. This can cause the cold filament to flash brightly, with the result that open circuit filaments are commonly found.

It is worth noting that one easy way of current-starving the filament of the limiter to reduce hum in an AR88D, is to fit a 12H6 in place of the original 6H6. This is much easier than going underneath and adding the series resistor network, if the necessary valve is readily to hand. Takes ages to warm up, though!

10.17 Audio Stages

Audio output valves run hot in normal operation. They get even hotter if the grid coupling capacitor goes a bit leaky. To check a grid coupling capacitor, briefly short the anode of the audio driver valve to earth with a screwdriver, whilst measuring the cathode voltage of the final stage. There should be no change in reading greater than 100mV. This test only applies to output valves having automatic bias.

Gas problems are cumulative, and must never be ignored. Excessive heat causes gas that was previously trapped in the metalwork of the electrode structure, to be released into the vacuum inside the envelope of the valve. This gas then ionises with a positive charge and the gas ions wander towards the most negative electrode, which is the control grid - pulled there by electrostatic attraction. On collision, this causes grid current to flow. If the grid leak is much over 470kΩ, the negative grid bias can reduce appreciably because of ion bombardment. The anode current then rises, so that even more heat is generated in the plate and screen grid. This process can happen cumulatively during the first few minutes of operation, causing a steadily rising HT current. Even more gas then gets liberated. The valve soon goes "soft". The situation escalates until the HT fuse, valve, output transformer, HT choke, rectifier or mains transformer fails. Some of the gas ions may collide with the cathode instead. If severe, this can lead to the mechanical fragmentation of the oxide coating.

The vicious spiral can appear in American sets with fixed grid bias lines, but is seen at its worst in British sets using high gain output stages operating with little bias. The problem is relatively common in AR88Ds using the 6K6GT output valve, and is endemic in AC/DC Eddystones using the high gain UL41.

A good telltale for grossly excessive current in the output stage is a regulator neon that doesn't glow, because there is insufficient HT inside the radio to strike it.

Certain types of output valve are now widely recognised as being unreliable. The ECL83, 6K6 and 6AK6 are all distinctly prone to inter-electrode shorts. The valves most prone to gas problems are the E/UL41 and the E/UL84. There are big variations from manufacturer to manufacturer for the same type of valve, depending on the quality of materials used, and the efficiency with which degassing and gettering operations were performed at the time of construction.

Gas ionisation can be seen as a pale mauve glow inside the metalwork of the electrode structure. It must not be confused with fluorescence, which is a sign of unusually good vacuum. This is seen as a dark blue glow just inside the glass wall of the envelope. Sometimes the inside of the glass is sprayed with graphite to stop this secondary emission from the bulb - or at least, to prevent it from being visible! Osram and Brimar were very inclined to use a graphite coating. Mullard and Mazda were not.

Push-pull audio was used by Hallicrafters and Eddystone, amongst others. The valves are best chosen from the same manufacturing batch. Genuine push-pull arrangements give far less trouble than the self-feeding paraphase arrangement. With all designs, be sure to check with an oscilloscope that the grid and anode AC voltages are equal, and anti-phase to within 10%.

The DC voltage drop across each half of the output transformer primary should be within 10% at no signal. Note that because of the way it is constructed, the DC resistances of each winding will often not be identical, even though they have the same number of turns.

Check that in actual service, both output valves get equally hot and if not, investigate. One of the valves may be flat, or oscillating at VHF. Be particularly suspicious of any crackling distortion from the loudspeaker, sounding for all the world as if the speaker voice coil is rubbing on the polepiece. This is often an audible symptom of unwanted RF oscillation in the output stage.

One problem unique to push-pull, and the reason this writer dislikes the use of this technique in communications receivers, is the variation in HT current with signal at medium and high volume levels that occurs unless the stage is operated in true class A mode. As the valves start to draw extra current on peaks, he HT voltage then becomes modulated by the bass content of the audio. On the higher RF frequencies particularly, this can cause the local oscillator to suffer severe pulling or fluttering. This is especially true if no neon regulator is fitted, and when listening to SSB transmissions. Bias problems can cause HT current variations greater than intended, and a careful check of grid and cathode voltages is an essential early step in the overhaul of any push-pull output stage.

Battery sets often had intricate QPP or class B output stages. The QPP type used a pair of pentodes biased almost to cutoff, with grid excitation usually coming from a step-up voltage transformer. Class B designs used a pair of zero bias triodes which were driven into conduction by feeding their grids from a step-down voltage transformer which was capable of providing significant AC drive current.

The testing of output valves is generally straightforward except in the case of class B valves, whose only satisfactory examination is by measuring the actual developed output power under conditions of representative positive grid current.

10.18 HT Regulators

Neon regulator tubes are usually trouble free, but not invariably so. Quite often, especially with S130 and 85A2 types, the operating voltage will be found too high. There is no alternative to replacement of the valve. Fortunately, most types of neon are still cheap and plentiful. AF oscillation of the regulated line is sometimes seen, typically causing unwanted sidebands on the local oscillator. This is usually caused by excessive capacitive decoupling of the regulated rail. Make sure a previous owner has not inserted an electrolytic across the neon in a misguided attempt to improve performance.

One S130/S130P of GEC manufacture, has been seen to give an orange glow, rather than the usual mauve. This is indicative of being filled with a gas other than Neon. This valve gave really superb regulation. Unfortunately, the extraordinarily low dynamic resistance of this specimen caused oscillation of the regulated HT line in a BRT400D, when operated at certain mains voltages. This is indicative of an overall negative circuit resistance. The problem has not been found with any other specimen tried. The oscillation resulted in a Christmas tree of local oscillator sidebands on the highest range of coverage. This was a wholly unacceptable side effect of a valve that in other respects was far better than the average. The problem could no doubt have been fixed by the addition of a suitable Zobel network across the neon, or by fitting a small resistor in series with the neon. But either of these options would have needlessly destroyed originality.

The successful operation of a neon voltage regulator depends on the circulation of gas inside its glass envelope. Fitting contact-cooled cans where not originally specified, is definitely unwise. Frequently it will be found that the neon was originally supported by a can of fluted, mainly open construction; or maybe no can of any type was fitted. The best advice is to leave everything as originally built.

A final caution for neon regulators concerns the suffix WA (US military ruggedised) variants of OA2 and OB2. These contain a radioactive isotope, which was intended to promote ionisation, and hence lower the striking voltage. The activity level and half life of this isotope is not known to the writer.

Rather than use inert gas voltage stabilisers, some German designs used a solid state rare earth regulator. These are normally reliable, which is just as well since these devices are nowadays very difficult to obtain.

Some valve radios used a Zener HT regulator diode for the VFO. The RA117E is one example. These early devices were unreliable and should be checked very carefully. Replacements can be difficult to find, especially as the stud needs to be the anode (negative) pole of the device. A quick catalogue search revealed that a 150V 5W Zener, with its anode connected to the stud is not available nowadays. An OA2 may have to be fitted instead.

10.19 Thermionic Rectifiers

Rectifier valves should always be checked for the presence of any bits of oxide cathode coating floating around loose inside the envelope. This is usually due to a past flashover caused by an HT short or an extraordinary mains transient. Some loose oxide is OK but a lot of it, or a big bald patch on the cathode, would condemn the valve.

Rectifiers can stand a lot of gas before they malfunction, but in extreme cases the valve can flash-over from this cause.

Some rectifiers take ages to warm up, especially Mullard type CY1. This is not necessarily indicative of a fault. Thickwall cathode tubing may have been used, to make sure the rest of the valves in the radio all get a chance to warm up properly before the HT appears.

If the rectifier is a multisection affair like a U801, make sure all of the heaters warm up, and that all of the individual internal cathode and anode connecting straps are intact, where they go to the leadout wires on the pinch.

One fact about rectifiers that puzzles this writer, is the great difference in HT voltage developed by different samples of the same type. Some radios such as the Hallicrafters S36, are generally short of HT and would benefit from a really low loss rectifier. Others like the Eddystone S940C, produce excessive transformer secondary voltages and are at their best with a low output rectifier. In the case of these radios, special care to select an appropriate rectifier is a very good idea.

Some rectifiers proved notoriously unreliable in service. Your attention is drawn to American type 26Z5W in this regard, which was used in the R-390/R-390A family of receivers. The problem was exacerbated by the fact that not all of these complex receivers had an HT fuse. In the R-390, the rectifiers are really thrashed even when no faults exist. If your radio was not originally fitted with an HT fuse, it may be wise to consider a modification to fit one at this stage. It should be a quick blow type rated at about three times the normal running current.

Do not be tempted to use a directly heated rectifier where not originally specified. The cold start over-voltage problems are as for Silicon rectifiers, though less severe. The higher losses of direct rectifiers compared with indirect types, can cause insufficient running voltage, oscillators to cease functioning, and neons to go out as the set warms up, for the same reason.

Similarly, do not be tempted to use an indirectly heated rectifier where not originally specified. The main problems here concern hot restart flashovers, excessive running voltages, and audio hum caused by inadequate HT series resistance.

10.20 Transistor Stages

In the context of valve radios, transistors are found in the final generation performed mostly secondary functions such as heater voltage regulation, meter driving and low level audio amplification. Most are Germanium PNP types from the 0Cxx, 2Gxxx and NKTxxx families. On American equipment, early Silicon NPN types from the 2Sxxx and even 2Nxxx series will usually be encountered.

In general, Silicon devices have stood the test of time well but Germanium types have not. Modern hazards include intermittency developed as a result of metal migration on the surface of the chip, noisiness (usually with pronounced leakiness as well) due to inadequately clean conditions during manufacture, and short circuits developing between the electrode structure and the outer casing. In particular, members of the Mullard AF10x and AF11x series of RF/IF Germanium alloy transistor nowadays often suffer from low gain, and/or shorts from collector to case.

With the 0Cxy family of small signal transistors mounted in little shut-ended black painted glass tubes, the devices can become photosensitive if the paint film is damaged. This is especially true of early manufacture, when a clear jelly was used inside the device, instead of the white stuff that was used later on. This can be the cause of significant hum when the radio is out of the cabinet on the bench, illuminated by a fluorescent inspection lamp.

Most early devices are still available very cheaply in 2005. For low level audio applications, you may need to try a selection to get an acceptable noise level. Unlike valves, just because these early semiconductors have not been used does not stop long term problems from developing. Remember to use a heat shunt when soldering Germanium devices, because these things are thermally fragile.

If an alternative type has to be selected to replace an unobtainable original device, it is a good idea to use a Germanium type to replace a Germanium original, and likewise to always replace Silicon with Silicon. Otherwise re-biasing will be needed to reflect the differing Vbe voltages, which are approximately 200mV and 600mV respectively.

When rebuilding heatsink assemblies, it is important to replicate the original arrangements as closely as possible and in particular, to ensure the correct seating of all metal pieceparts. Heatsink grease should be used when necessary, remembering not to over-tighten the transistor securing screws. Excess force can buckle the baseplate of the device which causes lack of thermal contact right under the chip, which is exactly where it is most needed.

Transistor cooling arrangements sometimes use heat-conducting washers that are electrically insulating. A popular material for this job was and remains, Beryllium Oxide. This material is very hard. It is white with a slight pink or blue tinge, and its dust is toxic. For this reason, special safety precautions should be adhered to with regard to handling, storage and disposal. Alternative materials that might be found include Aluminium Oxide (alumina) and Boron Nitride. Neither of these is particularly hazardous. Both are dead white in colour. Both are thermally inferior to Beryllium Oxide.

11. Other Components

11.1 Wire Ended Component Replacement: General

Use HMP alloy solder to connect to the wires and lugs of hot running dissipative components like wirewound resistors and heater thermistors. The iron should be a medium/large type with a tip temperature of +450°C or thereabouts.

Use LMP alloy solder to attach the leadout wires of new components to their termination soldertags, using a medium/small iron running at about +350°C. This will avoid excessive reflowing of the original soldering material.

It may be possible to locate a source of new components with Copper leadout wires, rather than the usual (nowadays) steel. This makes the job of repair very much easier, as the Copper is so much more ductile than steel.

Most radios were originally constructed with each joint being wrapped before soldering. However some receivers, especially Eddystones, used laid-on joints that were not wrapped. They seem none the worse for it. This really does open up the question of whether it is worth the bother of unwrapping and rewrapping the solder joints during repair of all the other makes. It must be accepted that ideally however, the repair should use the same technique as was employed in the original manufacturing process.

Wick seems to work better than a plunger sucker for removing old solder, but there is great variability in the quality of the wicks on offer. Don't keep too much in stock for long periods, as this stuff loses efficiency quickly when the braid starts to oxidise.

Leadout wires of glass encapsulated devices such as valves, bead thermistors, crystals and diodes should not be bent within 1.5mm of the envelope, or soldered within 5mm of it.

11.2 Resistors

Check in particular, the values of all cathode & screen resistors, and all carbon HT dropper resistors. If more than 20% away from the nominal value, replace the component. Where sufficient space exists, use the next power rating up from that originally specified, to stop the problem happening again in the future.

Do not be tempted to bridge drifted high-value resistors in situ, to try to restore the design ohmic value. Drifting resistors will generally remain unstable with time, so the new combination could not be relied on to stay within tolerance.

Similarly, open circuit resistors cannot be relied upon to stay open circuit over future years. So always clip them out of circuit. American metal clad "Candohm" wirewounds cannot be relied upon either to stay open circuit from end to end, or to remain insulated from chassis, once the element has broken and fried the impregnated cardboard insulation somewhere along the length of the component.

Many of the better quality radios have low wattage series resistors fitted in the HT feed to each stage, typically 2.2kΩ/¼W. These all need to be checked carefully. If darkened, burned out, or incorrect in value, first find out why. Then replace the component with the same value <u>and wattage</u> as originally. These resistors are intended to act as telltale fuses to identify problems downstream in the circuit diagram. They will not do this job properly, if you uprate their power dissipation capability.

Replace all wirewound resistors that have cracked or missing insulation, even if they measure OK at the time of overhaul.

Be generally suspicious of potential divider arrangements providing negative grid bias on American sets, or positive bias to the top grid of double-triode cascode stages on British ones. In these circuits, resistor problems are very much the rule rather than the exception.

Dubilier grey and brown power resistors with fibrous bodies should be condemned on sight. These components are extremely prone to going high in value, and they can get very noisy in old age, too.

A quick check for noisy resistors is to squeeze them gently with pliers. This will often dramatically change their noise output.

11.3 Non-electrolytic Capacitors

HT smoothing capacitors in cubic grey painted cases with ceramic pillar terminals had a period of vogue in the days before electrolytics became fully trustworthy. In general, if such capacitors look undamaged and are not weeping oil, they probably are perfectly serviceable and not worthy of special investigation. If replacement is needed it will be in order to use modern components of suitable ripple current rating except in the case of vibrator power supplies, where non-electrolytic devices should be used because of the square waveform of the ripple current.

This writer recommends the routine replacement of all inter-stage coupling, screen grid, noise limiter and AGC tubular capacitors.

In HT and screen feed systems, waxed paper/cardboard tubular capacitors that ooze wax or which have obviously done this at some time in the past, must certainly be replaced. In these cases, the physical leakage of sealant is due to overheating caused by progressive insulation failure. The problem seems to be cumulative, and is often accompanied by a rise in the value of the associated HT feed resistor.

A different version of the same problem is often seen with lozenge shaped encased mica capacitors. Sometimes these ooze a kind of froth out from where the leadout wires leave the case. This is evidence of chemical activity going on inside, again due to insulation breakdown. On any particular chassis, this problem always seems worse on capacitors with DC voltages across them than on ones without. The El Menco red ones often seem problematic, whereas Centralab components which look very similar, are usually found to be trouble free.

Check that the AGC circuit resistance exceeds 100MΩ when all shunt resistors are disconnected, but with all of the AGC capacitors left in circuit. This is a good opportunity to measure each of the shunt resistors individually, while they are temporarily disconnected from the rest of the circuit.

The grid coupling capacitor(s) to the output stage must be absolutely beyond reproach. Otherwise extensive long term damage may be caused to the output valve(s), rectifier(s), output transformer, HT smoothing choke and/or mains transformer. The writer trusts good quality ceramic capacitors in this application, but replaces all other types as a matter of routine during overhaul.

On British radios, change on sight all brown or black Hunts moulded tubular capacitors, and all bitumen GEC paper capacitors. These types are all prone to crack their insulation casings and go very leaky indeed.

On American radios, change on sight all Sprague black tubular paper capacitors that have colour coded rings, because this type crack their casings and go very leaky. SP600s are full of them. Be equally suspicious of red El Menco micas, which go leaky and lower the Q of the circuits they are in, causing oscillators not to start and other bothers. Collins A-line equipments have plenty of these to go wrong.

A quick check if you are suspicious that a tubular capacitor is intermittent, is to squeeze the body of the component gently, with insulated pliers. This can often introduce the fault decisively and sometimes permanently. So be prepared to switch off quickly!

Bathtub capacitors are frequently encountered in American radios. These give neither more nor less trouble than the average equivalent wire ended components. Any goo oozing out around the terminal seals indicates the need for replacement. For an invisible repair, the casing may be unsoldered with a blowlamp. Do this job outside in the fresh air, standing upwind of the component. Drill some small holes in the rear plate first, to avoid risk of an explosion due to pressure buildup! After gutting the interior, and cleaning the case inside and out, fit new epoxy cased radial leaded capacitors inside. Solder one lead from each component to the inside of the metal case. Use grommets with metal spacers inside, and soldertags at each end of each spacer, to replace the original sealed insulated terminals. No not bother to refit the rear plate, because it is no longer needed for its original purpose. In any case it is invisible in situ. Your attention is drawn to the fumes given off during the repair process. The original liquid content may be a PCB type and should therefore be regarded as hazardous to health.

If you are concerned to preserve the original appearance of the underside of your chassis apron, it may be possible to fit modern tubular polyester components inside the shell of old wax and metal cased tubular paper capacitors.

11.4 Electrolytic Capacitors

This writer recommends that you change all electrolytic capacitors more than 25 years old. Be especially diligent with red and yellow plastic cased wire-ended Plessey types, and all others that show signs of bulging or cracking of the rubber endcap or where there are signs of electrolyte leakage. American radios were inclined to use octal plug-in reservoir and smoothing capacitors. These components are usually of excellent quality, and need not routinely be replaced. The only problem associated with these things occurs when the base or socket contacts get a bit tarnished. This can cause mysterious hum and/or low rectified HT voltage.

Do not be tempted to increase the capacitance of the HT reservoir. This could strip the rectifier cathode of its oxide coating during a hot restart. In addition, the reduced conduction angle will cause increased Copper loss in the transformer windings, making this component run hotter than originally.

Do not use a cheap little etched foil reservoir in place of a larger, rarer and more expensive, high ripple current replacement. Overheating due to AC dissipation can cause inadequate capacitors to run so hot they explode - especially in transmitters.

This writer recommends that you avoid the use of NOS electrolytics. If you really must use one of these things, you are advised to reform the internal insulation of the component first by a slow, progressive buildup of voltage, fed through a high value current limiting resistor to prevent excessive gas pressure buildup.

Do not automatically assume that the negative poles of the HT reservoirs and smoothing capacitors are grounded. They sometimes are not. This is especially true of American radios with centralised negative bias lines, an arrangement called "back bias". The capacitor cathode may be at up to -100V with respect to chassis, as for instance on the National NC100. When using modern replacement smoothing capacitors, it is often a good plan to insulate the outside of the can from the securing clamp using Kapton® polyimide film, or paper masking tape. Do not use PVC or PTFE tape because these materials are inclined to creep with time, leaving your radio with a shorted bias line and/or a loose capacitor.

It is sometimes possible to fit a new component inside the shell of the original. In the case of electrolytic capacitors, this usually involves the deft use of a lathe to spin off the swaged lip that retains the rubber endcap. The new component is best potted into position, but do be careful to allow fresh air to access the blowout plug or over-pressure vent. This is usually fitted into the rubber endcap, identifiable as a little round dimple.

11.5 Barretters and Urdox Regulators

Barretters (ballast tubes) are very fragile. They must not be subjected to any mechanical shocks, and must not be mounted in strong magnetic fields. They also tend to be very rare, though some Amperite types (for instance, 3TF7) are still available ex-stock from the manufacturers at the time of writing. Whether currently available or otherwise, all barretters are becoming increasingly expensive to replace. If the correct barretter is unavailable, it is possible to use a resistor of suitable value and rating instead.

Because a barretter comprises a glowing Iron filament in a Hydrogen atmosphere, there is the possibility of an explosion if the envelope has developed a very slight leak to atmosphere. When running up an unknown barretter for the first time, it is very wise to make sure all the radio covers are in position. This writer has only ever had one barretter burst, but it was a huge Osram 302. There was a most impressive bang, and glass went absolutely everywhere inside a Peto-Scott HU52 domestic receiver.

In the event of non-availability of the correct barretter for your chassis, the use of an over-current type is sometimes a viable way ahead. In this case, shunt the regulated heater(s) with a resistor drawing current equal to the difference between the current ratings of the correct barretter, and the one that is actually fitted. Over-current barretters need to have a voltage regulation window at least equal to the original component.

It is also permissible to use an undercurrent barretter shunted by a ballasting resistor. The regulation worsens according to the fraction of the load current passing through the two components. Thus in order to maintain reasonable current regulation, this technique should be used only when 10% or less of the load current has to be sourced from the ballasting resistor.

There is occasional talk in the press of using series rectifiers or series paper capacitors to replace, or partly replace broken barretters. If attempting such an approach, be sure to use a true RMS meter to measure the voltages and currents that result from your modification, before putting the radio back into service.

Note that all barretters run hot. Some of them run very hot indeed. This is intentional. The regulating action depends on the thermal behaviour of the gas and the filament inside the envelope. For this reason, it is most unwise to use a contact-cooled valvecan where not originally specified. To do so may well mean that the filament heats up more then normal, to compensate for the excessively low gas temperature surrounding it.

German and Russian equipment running from AC/DC mains supplies tended for some years to be fitted with an Urdox (Uranium Dioxide) filament current regulator. This device comprised a conventional Iron/Hydrogen filament barretter section, in series with which and inside the same glass envelope lived an NTC thermistor made out of Urdox material. This should in principle have prevented the usual switch-on flare of the iron filament, thus prolonging the life of the barretter section. A clever detail is that the thermistor element was located immediately above the Iron filament, acting to ensure a very low running resistance for the solid state element.

11.6 Bulbs

Bulbs require a lot more care than might at first be expected. Part of the problem is finding the things on the right base, in the right voltage/current combination, with the right envelope style, in a quantity sufficient for your chassis - plus a few spares.

Some bulbs perform crucial secondary functions such as controlling LT current distribution throughout the chassis heater chain, in which case the bulb ratings must be exactly as given in the handbook. The glass envelope style and size can also be critical, in some applications.

For the sake of appearance and longevity, it is often best to fit bulbs rated at 12V, to radios having filament systems running at 6.3V, in order to avoid excessive illumination. For series connected bulb chains, this is very good practice, otherwise manufacturing tolerances may mean that one or more of the bulbs could fail prematurely due to voltage hogging. Keep an eye on the voltage distribution if you use this trick on AC/DC sets.

Bulbs mounted immediately behind translucent cursor discs or meter scaleplates need to be run particularly gently, to avoid discolouration due to heating effects.

Look very hard at bulb wiring, as a matter of routine. It is often found in fried condition due to past short circuits.

11.7 Trimmer Capacitors

Before any attempt at adjustment, it is recommended that you sketch or mark the position of all trimmer capacitors. Then move them all very slightly to prove that they do, in fact, rotate. Then put them all back to their original positions, pending proper alignment.

Beehive airspace trimmer capacitors are inclined to suffer open circuit intermittency unless their threads are clean. This type can also suffer short circuit intermittency unless the rotor and stator plates are truly concentric, and completely free of swarf.

Ceramic trimmer capacitors tend to develop intermittent open circuits unless the compression spring is clean and correctly tensioned. They can also go noisy. This type can develop hard to find tracking/arcing paths across, or even through, the dielectric, especially when used in crystal oscillator circuits giving a high level of combined DC+RF peak voltage to the component.

11.8 Potentiometers

Rotary potentiometers quite often give trouble. Slider types nearly always do. Check the end-to-end resistance of every single variable or preset fitted to the chassis. Some potentiometers used in American radios appear to have very thin resistive tracks, and can greatly increase in value if they have been used a lot.

Use Cermet or wirewound replacements for any components that carry DC, as in all BFO and VFO fine tune arrangements and some squelch and volume controls. Suitable replacements can often be quite difficult to find, especially potentiometers having reverse log (antilog) tapers, or taps along the track for tone compensation.

RF and IF gain potentiometers are often arranged as variable cathode resistances in the appropriate amplifier chain. This means they pass maximum current towards the clockwise end of their travel. For this reason, antilog potentiometers are generally considered ideal. In contrast, logarithmic potentiometers often over-dissipate per unit track length towards the high gain end. This type will often give trouble if fitted in error by a previous owner.

Many types of potentiometer can be dismantled for cleaning. This often entails the temporary removal of an SRBP rear cover plate. If there is no easy way to get inside, it may be necessary to drill a 1/16" hole in the body of the component. This need not be a problem, if done carefully in the right place and if the swarf is carefully removed.

Contact cleaner can often provide a truly permanent cure to noisy operation of resistive controls, and is definitely not a bodge if applied properly. To make sure the stuff doesn't go everywhere, avoid the use of aerosols if you can.

11.9 Crystals and Crystal Filters

Crystals are very critically sensitive to the cleanliness of the quartz slice and its mountings. For 100% glass encased crystals, not much can go wrong, since this type of packaging is truly hermetic.

Crystals in solder sealed cans are to be regarded as cheap types with a finite life, especially if the leadout wires were sealed with epoxy resin adhesive rather than glass. Crystals of this construction will normally drift LF with age, as the quartz slice gains mass due to progressive surface contamination from the flux residue inside the can. Ordinarily, provided the ambient temperature does not change too much, the rate of LF drift should diminish with time. Cold weld sealed crystals in metal cases will drift LF much more slowly, and can be regarded as being almost as excellent as the all glass types.

Any crystal of any construction drifting slowly HF with time, is to be regarded as seriously defective. The problem may be due to inadequate cleaning of the quartz slice after grinding. In all cases, it is due to poor manufacture.

Most crystals encountered in post-war receivers are of the synthetic quartz AT cut type. These have a zero frequency/temperature inflexion point at around the ambient temperature expected in normal service. For crystals intended to go in ovens, the inflexion point may be at +70°C, whereas filter crystals would typically have the point at +30°C. It is thus important when missing crystals are encountered in a radio chassis, to identify the complete original specification before searching for a replacement.

Oven crystals that have previously been cooked because of a jammed thermostat, are usually fit only for the bin. This is because renewed or accelerated LF drift in later life is nearly certain, even when the crystal is rehoused in a properly functioning oven.

For crystals in openable holders such as style J or FT243 packages used in filters, poor phasing notch depth indicates the need for cleaning. If used in oscillators, the telltale signs indicating the need for cleaning are a reluctance to start oscillating, low output from the stage, and/or a steady drift downwards in frequency. Use de-ionised or distilled water for rinsing. Tap water is not nearly pure enough. Do not use abrasives to clean the quartz slice, and do not re-use decomposing rubber gaskets on reassembly. Do not be tempted to get by without a gasket. Always make a new one.

Avoid the use of cheap silicone rubber sealant instead of a proper gasket. The acetic acid liberated during the curing process will not be welcomed by the surfaces of the quartz crystal mounting plates. Some of the more expensive silicone rubber sealants do not liberate acetic acid, and may thus be suitable.

Later radios tended to use block crystal filters. As the radio is tuned very slowly through the passband there should be no ripple worse than 3dB. If there is, it is likely that the filter circuitry has become defective. This may be confirmed if the LSB/USB switching causes drastic imbalance in the audio noise response, with the carrier crystals running at the right frequency. Unfortunately in most cases the problem will be internal to the filter, though there is the possibility that it is only the external matching that requires attention.

11.10 Mechanical Filters

Mechanical filters often give trouble, especially the round emblem Collins ones. 455kHz and 500kHz variants exist, most needing 130pF terminations at each port. Any filters that rattle, or appear to have loose innards should be viewed with very deep suspicion. Bitter experience shows that they probably have decomposing sponge foam element supports inside. The earlier winged emblem types used a less flexible method of element support inside the casing. In their youth, these would not have worked quite as well as the later types, but they certainly give far less trouble nowadays.

For all Collins types, both end coils should have the same DC resistance, often about 50Ω. The end windings should be insulated from each other, and also from the outer casing. Collins mechanical filters can go slightly lossy and develop passband ripple, but this can be difficult to diagnose without a gold standard available for use as a comparison. These components are not repairable, and can be extremely difficult and expensive to replace. Make sure that any capacitors responsible for keeping HT off the filter coils are the very best types you can find.

Collins appear to have been somewhat lax in specifying the bandwidth of their mechanical filters. Some R-390A filters labelled as 8kHz BW have been found to be little narrower than others marked as 16kHz.

An alternative supplier to the US military was the Dittmore Freimuth Corp of Milwaukee, Wisconsin, whose filters have blue labels instead of red. Their filters appear generally trouble free in service.

Collins used a standardised range of filter stacks inside a wide range of external casing styles. This opens the possibility of finding filters that are electrically suitable but which would require the chassis to be modified in order to fit them. Unfortunately some types, especially the B9A plug-in style used in the 75A-4 are now extremely rare and expensive, so that this approach may offer the only practical way to fit a CW filter.

Kokusai used piezoelectric driver units to excite the disc stack, instead of solenoid coils. These devices were used by KW and other manufacturers. Their performance when new was excellent, but the long term reliability is again prejudiced by the use of a foam material to support the filter element.

Marconi developed and used their own design of 85kHz magnetostrictive resonator for the Atalanta. These devices are inferior in performance to the multipole types covered above, but at least seem trouble free in service. They look like an ordinary IFT, but with a wire loop sticking out of the top adjustment hole.

11.11 Thermistors

Thermistors are often used in series heater chains, to avoid the flaring of some filaments immediately after switchon, and/or to accommodate failure of one or more of the dial lamps. Thermistors used in this way are designed to run extremely hot. They should therefore be positioned well away from other components. Do not change them just because they look mouldy. Measure them first, after the set has been running for about 15 minutes. Generally they will be found to be satisfactory, which is just as well, because power thermistors are getting distinctly rare nowadays. Wrap the leadout wires well around the anchoring tags and use HMP solder, if the component ever does have to be replaced. Leave a good length of lead, to prevent the thermistor from heating its mounting tags unnecessarily.

11.12 Non-thermionic Power Rectifiers

Do not leave in place Silicon rectifiers, where these are found bridged across thermionic types by a previous owner. The voltage developed during the first ten seconds can be high enough to damage the insulation of wound components. The subsequent high running voltage can over-stress the output stage and output transformer.

HT metal rectifiers are very unreliable indeed. Each should be replaced by a high voltage Silicon rectifier in series with a wirewound resistor of between 30Ω/5W and 150Ω/10W, depending on the desired HT voltage. Do not underestimate the PIV requirement of the rectifier. A BY127 is always a safer choice than a 1N4007, if in any doubt about what to keep in stock.

LT metal rectifiers are also highly unreliable. Each should be replaced by a high current Silicon rectifier in series with a suitable power resistor. The value and rating of LT rectifiers and series resistors needs individual selection for each application. Make sure the cooling arrangements for the new components are satisfactory. Each individual diode should be shunted by a 47nF disc capacitor, to reduce switching noise.

The 0Z4 fullwave gas filled rectifier had a period of vogue in radios powered by asychronous vibrators. This type of component is electrically fragile. It is intolerant of incorrect reservoir capacitance (it should be 8uF or thereabouts), and this rectifier will not survive open circuits or short circuits for long. The 0Z4 requires a minimum of 330V peak starting voltage per anode, and must deliver between 30mA and 110mA to the load, otherwise service life will be very short. Thus if your radio has been running with a defective vibrator, or is a low current design that has operated for some time with slightly flat valves, you may expect to find the rectifier in poor condition. Despite not having a filament or heater, these devices do take some time to get going from cold. This is not in any way indicative of a faulty device. In normal use, the cathode becomes incandescent as a result of ionic bombardment, and then emits electrons in the normal way. Type 0Z4 is considered to have ended its service life when its forward voltage drop exceeds 25V at +70°C ambient temperature.

11.13 HT Vibrators

Both synchronous and asynchronous types were used. Vibrators were very popular for low powered portable receivers running from batteries, where the current drain did not justify the use of a dynamotor, or where space or weight was limited.

Most vibrators were relatively unreliable components, though not perhaps when their mode of operation is considered.

Many types were sealed in cans where the guts were supported by sorbo rubber. Years of disuse will probably have caused severe tarnishing of the contacts because of the sulphurous emissions from the foam as it decomposed. Sometimes it is possible to revive an old vibrator by spinning the top off using a lathe, burnishing the contacts and then resealing by using the plastic top from an old aerosol canister.

The waveforms around vibrators tend to be very spikey. This writer would caution against the use of an AVO8 or similar for taking AC measurements, because the form factors encountered are likely to differ very greatly from the 1.11 value which forms the basis for the calibration of these multimeters for sinewave use. The best way of investigating vibrator circuits is with an oscilloscope, though the non-periodic waveforms can cause severe triggering difficulties. Use of a true RMS meter may be a good idea, but care needs to be taken with the HF limit of measurement, which may cause the meter to under-read.

Because of the current waveforms and because the operating frequency may exceed 100Hz, vibrators can place great demands on their reservoir capacitors. Be careful to select a generously rated component, if the reservoir is short circuit, has a bulging rubber base seal due to excess internal pressure, or has been weeping electrolyte through the blowoff vent.

In the case of a reservoir that is running warm and providing low HT from a synchronous vibrator, it may be that one of the HT commutating contacts has burned open or welded closed. Alternatively, the capacitor itself may have gone extremely leaky.

Although a possible heresy to some readers, it is worth pointing out that an intact but non-functional cylindrical vibrator may perhaps be fixed more easily (and certainly more permanently) with a pair of MOSFETs and a couple of 1N4007s rather than by filing the metal contacts. Both types of repair could me made to look completely invisible. If using the Silicon solution, do be sure to bias the circuit towards a defined state at turn-on, otherwise both halves of the multivibrator could perhaps ramp up together. If this happens, it could destroy the HT transformer primary winding.

11.14 Non-thermionic Signal Diodes

Germanium diodes using external solder seals to the glass envelope, such as early 1N60s and all GEX34s, are best changed for later Germanium types such as OA90 or OA91. Be careful not to use too much heat, and do not bend the leadout wires closer than 1.5mm to the glass envelope.

Diodes that are entirely glass encapsulated seem to be very reliable in service. Just occasionally, you will find one that has gone a bit leaky, and hence may be noisy. A Silicon signal diode should never be replaced by a Germanium type. The converse is also true.

Metal rectifiers were used for AGC and even signal detection in some valved sets, the Marconi Atalanta for instance. In general, these components are unreliable and should be replaced. This writer has always used small Silicon diodes such as the 1N914 or 1N4148 to replace these small metal signal rectifiers, and has had no problems.

11.15 Electromagnetic Relays

In receivers, these devices are mainly used for squelch, aerial switching and oven control. They are responsible for a lot of faults in the "really puzzling" category, and thus deserve particular care during chassis restoration.

The most troublesome relays by far, are open types that have no form of protective cover. The next most troublesome, are plug-in types with unsealed plastic covers which clip into position. Unfortunately, most receiver relays fall into one or other of these categories.

Repair of most faults is straightforward. Contact resetting is permissible, provided the original order of make/break sequencing is maintained. Fine glasspaper or better still, a magneto file is fine for cleaning the contacts, but always finish off with a cleaner such as methylated spirit. Never be tempted to use emery paper, even the really fine stuff. Carborundum is so hard that grit particles may become embedded into the contact surfaces. This can cause high resistance contacts, or even diode effects sometimes.

Relay coils give far less trouble than contacts, but they can occasionally go open circuit. This is firmly in the "bad luck" category of faults. Rewinding is generally possible. It is worthwhile pointing out that most of the 110VDC coil types of relay found in some Collins equipments are still manufactured, and available from component suppliers in the US.

Because of the vast number of relay types that were manufactured, it is sometimes possible to construct a suitable relay for your application by using a bobbin from one unused relay, a frame from another, and a contact set assembled from yet more scrap pieceparts. All that is generally needed is a big box of scrap relays, some ingenuity and hours of patience to provide a workable solution. Even really complicated contact configurations can be built up this way. This route also offers the opportunity to beef-up the ratings of contacts that lead a hard life. So this approach may be better than a brand new replacement relay in the very long term. The downside is that the "new" relay may not fit quite as neatly as the original one did.

Ideally, Gold contacts should be used for passing signals with no current. Alternatively, it may be possible to introduce a bleed current of some 2mA to keep standard (non Gold) contacts clean and reliable. Do not use Gold contacts in high current applications. The Gold is usually only a flashed finish, and quickly burns off. The low melting temperature of Gold sometimes means that Gold-plated contacts can fuse together if asked to switch high currents.

11.16 Thermal Time Delay Relays

These are octal or B9A glass devices found mainly in American radios, intended to delay the production of HT for typically 30s, 45s or 60s depending on the time delay value of the device. These components are little seen in British and European equipment because of the more widespread use of indirectly heated rectifiers, which did the same job a different way.

Thermal relays are generally reliable. This is just as well because they are now getting expensive to replace, though most types are still available at the time of writing. Delay relays were often made by Amperite, for instance their 6NO45T (6.3V filament, 45s delay time, normally open contacts, B9A glass envelope).

11.17 Meter Movements

Sealed types give less trouble than unsealed ones, which is only to be expected. Old sealed meters can be very difficult to enter though, in the event of problems. All too often the bakelite case can break, or bits of mastic become loose and jam the movement.

Many problems of stickiness or apparent stiffness, can be cured without dismantling. One good trick is to attach the meter to a 1Hz NE555 timer, to swing the movement back and forth over its entire range for a week or so. On several occasions, this has effected a lasting repair.

Corrosion problems can sometimes be overcome by slackening the bearings very slightly.

One difficulty that seems to afflict Ernest Turner (Marconi) meters more than most, is de-lamination of the varnish coating that covers the moving coil winding. Flakes tend to fall off and jam against the bore of the magnet pole pieces. Careful use of some 24swg tinned Copper wire can often rake out the loose bits, to restore free movement. Be very careful not to disturb the hairsprings.

Loose glass is best scraped with a razorblade, and then bedded back down into a <u>thin</u> fillet of Evostik around the edge.

Broken glass is best replaced with new glass, rather than plastic, which causes too many static problems. Cutting new glass to the right shape seems not to be too difficult for skilled glaziers. The best source of glass is from a junked meter rather larger than the one fitted to your radio, though it has to be annealed before cutting.

On some radios such as the Hallicrafters SX28, the meter case was drawn from sheet metal. They are often found cracked into sections splayed apart rather like flower petals. Presumably this was caused by stresses created during the manufacturing process. To bind the whole lot together and keep dirt out after overhaul, this writer advises that the casing be bound with masking tape and then secured with an automotive hose clip.

11.18 Headphone Sockets

Sockets which have switches to change over the output of the transformer from a dummy load and/or loudspeaker to the headphones when a jack is inserted, very often suffer from dirty contacts. The usual symptom is a lack of output, but rarely a total absence. Most of the time, all that is needed is for the contacts to be cleaned with methylated spirit.

Most headphone sockets are wired with respect to chassis, but not all of them are. For example, neither pole of the Hallicrafters S36 headphone socket is grounded.

11.19 Loudspeakers

The small types found in many communications receivers, especially marine ones, are a regular source of trouble. Repair is not generally practicable, and exact replacements are frequently not available. It is often best to fit a mylar cone type instead, since these seem to be more robust in service than the paper coned variety.

The ideal impedance of the replacement loudspeaker would be identical to the original. Failing this, a lower impedance will be satisfactory. It is generally unwise for the health of the output valve to use an 8Ω speaker to replace a 3Ω original, unless the new speaker is shunted with a 4.7Ω/2.5W wirewound resistor.

12. Faultfinding and Realignment

12.1 Checks on First Power-up

Before power-up, first check the integrity of the mains earth connection to chassis. Have a good look inside the plug top checking the security of all connections, the cable captivation, and the fuse value. Then check for HT shorts. If there is only a 2-core mains cord, apply a solid earth to the chassis at this time.

WARNING: AC/DC sets must not have their chasses earthed, and not all radios fitted with mains transformers have an isolated chassis. Examples exist of radios with transformers which nevertheless have the chassis connected directly to one side of the mains. (This design type is most commonly found on broadcast receivers.)

After these preliminary checks, apply mains power progressively with the rectifier unplugged, using a variac and preferably an isolating transformer as well. Check for correct LT distribution. Then plug the rectifier in, wind the variac right back to zero and bring the voltage up slowly once again. If the radio uses a thermionic rectifier, it may be worthwhile replacing it temporarily with Silicon diodes for this test. This would prevent any risk of stripping the cathode or filament coating in the event of a serious fault. Confirm the proper build up of HT voltage and bias. Meter the HT supply voltage and current very carefully, and keep checking it for a good while. Do not use an autoranging DMM where the decimal point position is not obvious at a glance.

If a neon HT shunt regulator is fitted, make sure it strikes, and then regulates at the right voltage.

Bulbholders may not be at or even safely near chassis potential, so check bulb operation early on, and make repairs as necessary.

12.2 Initial Running Checks

When fully powered-up, check all cathode and screen grid voltages under zero input signal conditions. Then check all anode voltages.

Check carefully for high temperatures and burning smells. Listen for crackling, frying or hissing noises.

12.3 Alignment Prerequisites

Alignment may not prove as easy as you expect. Do not attempt it yourself without the right equipment, the right tools, and enough previous experience to “feel” when something is not right.

Alignment data is one specific area where handbooks are often found to be incorrect. If your radio is known to be totally out of alignment, refer to the gold standard radio, and set all cores and trimmers to the same physical positions as on that one, to start with. Never arbitrarily twiddle anything. Always be systematic. Keep careful notes of what you are doing.

Marine radios which use 110VDC supplies such as the RCA AR8516L and also battery sets, will not give as much gain per stage as radios running on higher HT voltages. One piece of good news that results from this, is that these low voltage sets are very immune to RF and IF instability problems.

On unusual sets for which you have no information, and which refuse to tune up, be on the alert for possible use of harmonic mixing. The Atalanta is one radio that used this technique on the HF range of coverage, because the RF valves are mounted outside the coilbox to improve accessibility for servicing. Stray capacitances were such that the top range uses the second harmonic of the LO to track the signal circuits. Their earlier Marconi CR100 used the same mechanical design but did not suffer this problem, possibly due to the use of gridcap valves or because of the smaller number of ranges covered.

12.4 Coilformer Core Position Considerations

Cores often tune-up at two positions in the coilformer. Selection of the correct peak can be absolutely fundamental to proper operation of the stage. The tuning core should be fitted at the correct end of the former, as decided by the radio designer. This is especially important for two reasons:

a) When the coil is tapped near one end of its winding, the effective tap position depends on which end of the coil gets the extra inductance due to the core.

b) When two (usually IF) coils are coupled by proximity, the coupling constant again depends on which ends of the coils get the extra inductance due to the cores. If both of the coupled coils have adjustable tuning cores, there is only a 25% chance of getting the correct mutual inductance by random selecting from the four available peaks.

The following information is submitted as rule of thumb for use when you have no documentation, or where you do have it but believe it to be incorrect, and have no access to a gold standard radio.

RF/LO cores on brass leadscrews: use the peak which places the Iron core furthest from the leadscrew support nut, to give correct inductance temperature compensation (least positive value of dL/dt).

IFTs: the two cores are to be furthest apart in the former, to give the lowest mutual inductance between the two windings.

Exceptions to these guidelines do exist.

12.5 Double-tuned Transformers

Where alignment instructions specify that one side of an over-coupled double tuned transformer is to be resistively damped whilst the other side is adjusted, you will not get the correct response if you try adjusting the transformer any other way unless a network analyser is available, and you know how to use it properly.

12.6 Tracking the LO to the Dialplate

The scale tracking of the local oscillator may be found incorrect, even with a completely clean variable capacitor. If equally bad on all ranges and the errors are all in the same direction, you may consider bending the local oscillator plate vanes. This is an iterative process, which must be performed very carefully, especially if there is HT across the plates. It can take ages.

If the problem is unique to one range, check the local oscillator padder capacitor for that range straight away. Do not adjust the plates of the variable capacitor, in an attempt to cure this fault.

12.7 LO Frequency Jumping

Oscillator frequency jumping is a very common problem, and can be very difficult to fix. Sometimes a full cure is impossible.

If the problem occurs equally on all ranges, first check the BFO by listening to it on another radio. If the phenomenon occurs only on the higher frequency ranges of coverage of dual conversion radios, check the 2nd local oscillator the same way. Then check the following, for both the 1st LO <u>and</u> the 1st mixer.

1. Condition of supply, grid and cathode resistors and bypass capacitors.

2. Variable capacitor earthing straps/springs.

3. Waveswitch/turret contacts & grounding springs.

4. Security of RF/LO/mixer screening plates and bulkheads.

5. Local oscillator and mixer valve socket contacts.

6. Integrity of temperature compensation capacitors.

7. Integrity of low value mica and ceramic resonator capacitors.

The final possible cause is an excessive oscillation level, causing slight mode-changing due to parametric oscillations and overdrive. Try a slightly weaker local oscillator valve, or add slight loss into the oscillator circuit to reduce the loop gain by 3dB or so.

12.8 Aligning the RF Stages, Mixer Grid and IF Trap

Alignment of the RF stages ahead of the mixer should be performed first. This is usually straightforward. The only points worthy of particular attention are to ensure the correct RF sideband is selected rather than the image, and to be careful to use the correct source impedance connected to the antenna terminals.

Depending on whether the mixer valve is an inner grid local oscillator modulated (6A8, 6K8, 6SA7, 6BE6, Mazda/Ediswan 6C9) or an outer grid local oscillator modulated (6L7, 6J8, ECH35, ECH42, 6E8, X61M, X65, X66) design, the presence of the first mixer valve will increase or decrease respectively, the unloaded Q of its signal grid tuned circuit when the filament of the mixer is energised. This means that all else being equal, it is reasonable to assume that a radio with a 6SA7 first mixer will exhibit better image rejection than a similar radio designed around a 6A8.

In general, inner grid modulated mixers give worse local oscillator stability than outer grid modulated types. Bearing in mind the prevalence of the LO drift problem at HF, there is thus the possibility of swapping say, an original 6A8 for an ECH35 in an old radio that is regularly to be operated above 15MHz, even though there would be some slight loss of image protection.

Some mixer circuits are partially neutralised, even where the circuit diagram does not show it. The AR88D is one radio that has invisible neutralisation. This technique gives an improvement in the symmetry of the RF tuning response if the circuitry is correctly designed, and if the hardware and layout has not been butchered over the years.

All of the foregoing means that it is necessary to take much more care over the alignment of the mixer signal grid circuitry than would at first appear necessary. The best way is to align for a noise (not a signal) peak after first setting up the RF amplifiers, provided you can be sure to avoid selecting the image. Otherwise, keep rocking the tuning back and forth slightly during alignment, whilst listening to a weak wanted signal. Tune the mixer grid circuit for the peak response.

At the end of RF and mixer alignment, verify the tracking accuracy at both ends and the geometric mean of each band by offering up a ferrite/brass double ended tuning wand to each coil in turn. The ideal is for each end of the wand to reduce the gain as it approaches the coil. Errors greater than 3dB per stage should be investigated. Start by removal and measurement of the padder capacitor, especially if it is of mica construction. The values were usually special, and normally require replacement by a network of standard components, in order to get the value required.

Note that most tracking arrangements were intended to be correct at only three places in the band, and it may be that the central design frequency of your chassis does not coincide with the geometric mean. Furthermore, some radios had tracking errors built in from the day they were made. The B40 is one radio where a revision of tracking arrangements occurred during the production lifetime. Tracking accuracy can be regarded as very much a matter of design quality with these old radios, and rather variable from sample to sample of any one type.

A particular caution applies to the HRO family. In the event of tracking problems, first verify that the coilpack contains the correct mix of tuned circuits for your particular variant. Differences do exist between octal and UX styles of coilpack.

If fitted, the IF trap should be adjusted with nothing wired to the antenna terminals, but with the centre conductor of the signal generator output cable running at a high level held very close by. In this way, a very loose and undamped coupling is achieved to the radio antenna input tuned circuit. Under these conditions, the usual series resonant IF trap will give a very satisfying notch. If a single conversion radio, a good place to set its dial whilst performing this adjustment is a quiet frequency somewhere near 90% of the IF frequency. If multiple conversion, some experimentation may be needed. A good place to start setting the radio dial would 10% removed from the IF frequency in either direction.

12.9 IF Response Problems

IF adjustments are often complicated by unwanted Miller effects, to which some chassis designs seem more prone than others.

With an IF circuit that uses switchable or variable means of controlling mutual inductance in its IFTs, the passband can usually be made to achieve reasonable expansion symmetry as the bandwidth control is adjusted, at least under weak signal conditions. In general, the central trough in the passband response will remain on the same frequency as the coupling is varied. With strong signals, marked asymmetry is sometimes seen, with skewing of several kHz being fairly common on the widest bandwidths. This is due to Miller effect, transferring differing values of tuning capacity across the valve as the AGC varies the operating conditions of the stage.

Attention to IF strip decoupling often pays rewards, and it is wise to make sure all the IFT can grounding screws are good and tight. The addition of a small undecoupled cathode resistor in all but the final IF stage can prove a useful modification in extremis. Try 47Ω first. This negative feedback reduces the severity of the Miller effect.

IF designs using switchable or variable top capacitive coupling in order to vary the passband width are fundamentally incapable of symmetrical bandwidth expansion, so this technique was not often used except in the cheaper sets. If you are restoring one of these things, do not expect too much. The trough of the IF response will be found to vary in frequency as the coupling is changed and nothing much can be done to prevent it.

12.10 AGC Checks

When it is believed that the general alignment is correct and the set is operating properly, it is time to look hard at AGC operation. Meaningful voltage measurements require a measuring instrument with a very high input impedance. The usual DMM or scope x10 probe is not good enough for this job because they give only 10MΩ input resistance, which is inadequate for measuring an AGC system running at, say, 2MΩ impedance. If at all possible, you should use a proper VTVM such as a Marconi TF1041C instead. The 100MΩ impedance given by this class of measuring instrument gives negligible loading on even the highest impedance AGC systems, enabling accurate measurements to be taken.

Alternatively, a high voltage op-amp could be used as a voltage follower feeding an ordinary moving coil voltmeter. A 20kΩ/V type such as an AVO8 would work fine with an impedance converter such as this in front of it.

Look first at the AGC delay voltages, noting that delayed AGC was not always used - especially in American sets. When present, the delay voltages are usually produced from a valve cathode or from a potential divider fed from a high voltage point. Examine the way the set develops and distributes its AGC as the input drive signal voltage is progressively increased from zero. Make sure that every stage that should receive AGC gets it, in the right proportion, and in the right sequence of initiation as the input signal rises through the first few micro-Volts of aerial PD.

In the event of unexpected problems, one of the first things to check is whether the AGC detector is fed from an IF anode via a low value coupling capacitor. Any leakage in this component can cause extra voltage delay in the AGC operation, or conversely, can partially or wholly cancel the intended delay.

At the centre of coverage of the middle RF waverange, there should be a sharp knee to the RF i/p versus AF o/p voltage transfer characteristic of the radio. Use 30%AM at 400Hz for this test, on the narrowest non-crystal bandwidth position available on your chassis, with the BFO off and operating in AM mode. The sharpness of the knee is a good indicator of the general condition of RF and IF valves and the efficiency of the decoupling. A really sharp knee indicates a general absence of faults anywhere in the signal path.

In the case of radios which distort at high signal levels with large modulation on AM, the cause may be modulation rise in the final IF amplifier. Check that the right type of valve is fitted, and that the correct fraction of AGC is applied. This valve may be a straight type in comparison with the variable-μ specimens fitted elsewhere in the IF strip, and the correct amount of applied AGC may be zero. A good specimen is always needed in this position.

In the case of 2-stage AGC systems found, for instance in the Hallicrafters SX28, it will be necessary to verify that each circuit is operating with the correct characteristics, both as regards bandwidth and DC output voltage. On this particular design, the set should work perfectly satisfactorily with either system disabled.

12.11 Second Detector Issues

Second detector problems generally stem from the high impedance nature of the circuitry. This can cause difficulty in the event of even slight leakage in the circuit.

As with AGC systems, beware detectors fed via a small capacitor from a source of high combined AC+DC voltage such as the final IF anode. Any leakage in the coupling capacitor would cause detector distortion, or other more subtle problems such as unexpected squelch, as is sometimes found, especially in the RAF R1155.

12.12 Noise Limiter Problems

Because most noise limiter circuits operate at very high impedance, all the usual problems with high value resistors and leaky capacitors exist.

Many halfwave limiters are supposed to be “self following” as for instance in the BRT400. These are often referred to as ANL types. It is well worthwhile checking that they perform this function properly. A signal generator having simultaneously variable modulation depth and RF output level is most useful here, eg. the Marconi TF144H.

Full wave limiter designs are rarer. These provide symmetrical waveform clipping according to the setting of the front panel knob, as on the R-390A. Most of these types are not automatic (self-following) in their operation. Again, check by oscilloscope that all is well whilst driving the receiver over a range of RF input levels and modulation depths.

Hum problems are often due to heater to cathode leakage, lack of filament DC bias, or excessive filament voltage, dependent on the design. These causes all tend to result in the hum being at mains fundamental frequency. This fact is often most useful as an indicator of the source of hum.

12.13 Noise Blankers

Noise blankers are something of a rarity in receiving equipment of the valve generation. The only popular examples are the Lamb IF silencer found in the SX28, and the VHF TRF design sometimes found fitted as an (expensive) option to the Collins equipment, eg. the 136B-2 for the KWM-2 transceiver.

In general, these early noise blankers do all work provided their components are satisfactory, and provided that (in the case of the Collins design) a suitable externally mounted VHF lowband noise-collecting antenna is used. The use of loudspeaker wiring to do this job was suggested by Collins as a viable alternative. Unfortunately, in the computer infested domestic electromagnetic environment of today, this tends not to work too well. A properly sited and designed VHF noise collection antenna mounted outdoors would work far better. You could even beam it directly at the noise source for optimum rejection, something not possible with today's generation of HF receivers.

12.14 IF Notch Arrangements

An IF notch facility may be encountered. Other than the ordinary single crystal phasing filter, this function is generally provided by either a passive LCR network or a regenerative Q-multiplier operating around a triode valve or transistor. In general it may be said that the capacitors in all of these circuits need to be excellent.

Be sure to avoid the use of excessive Q-multiplier gain. Otherwise, the superb notch you obtain during alignment may well turn into oscillation at a slightly different ambient temperature or line voltage.

In general it is considered unwise to attempt to improve on the alignment procedure given in the handbook. One of the factory design engineers will have thought much longer and deeper about it than you yourself are ever likely to get the chance to, even if you have all of the necessary skill and access to suitable testgear.

12.15 Crystal Oscillators

Crystal oscillators give far more trouble than most people suppose.

Part of the problem, certainly with calibration oscillators, is that they are used so infrequently. A long period of zero anode current with the filament energised, causes progressive poisoning of the oscillator and/or harmonic generator valve due to gas ionic bombardment of the cathode surface. This causes the mutual conductance to drop far below what would be expected from the total active running time of the valve, to the extent that the circuit may become partially or even totally non-functional.

Eddystone was one manufacturer clever enough to spot this problem, and address it head-on. Their S880/2 model provides a very small cathode bleed current when the calibrator switch is in the OFF condition. This is sufficient to prevent poisoning, but not sufficient to cause oscillation or even noise output. All in all, this is a very elegant solution to the problem, and indicative of a receiver design that was better than average in several other respects too.

12.16 Ovens

Some receivers use ovens to control the temperature of crystals and even, in the case of certain American military receivers (eg. R-390) the entire VFO. This policy is fine so long as the thermostats do not jam in the closed position and cook all the circuitry.

In all cases known to this writer, VFO ovens can be switched off. This is recommended, unless the radio is to be operated continuously in areas having high diurnal temperature excursions.

12.17 BFO Injection

BFO injection is often at a very low level in old receivers. In fact, for quite a long time, this philosophy was distinctly fashionable in the industry. The plan was to avoid desensitising the receiver when the BFO was switched on, and to avoid pulling of the BFO frequency under strong signal conditions.

Where the injection coupling is capacitive, especially in the AR88D where it is by mere proximity, a great improvement in SSB reception capability may be made by the use of a parallel twisted wire capacitor. Use just enough C not to initiate AGC action under no signal conditions.

Sometimes, on sets with an inadequate level of BFO, extra injection can be had for free just by a change of valve, for instance by swapping the EF91 for an EL91 in the BRT400 family. Other sets had too much BFO injection, causing problems with the AGC. This may be cured several ways (eg fit a variable-µ valve or reduce the injection capacitor), or even ignored altogether as it is usually a very minor problem.

Much harder to deal with is the difficulty of restricted BFO tuning range as found for instance, in the HRO-MX. One cure is to increase the number of plates on the BFO variable capacitor, assuming a reasonable number of donor HRO chassis are available, of course. Three times the original number of stator and rotor plates may be fitted to the original frame using this technique. Coverage is then more than sufficient for CW, USB and LSB, without any adjustment of the coil being necessary.

Injection locking of the BFO is sometimes seen. Here, the BFO appears to suck-in towards the zero beat position under strong signal conditions. Having acquired lock, the BFO will not release back to its natural frequency unless the input signal is greatly reduced in amplitude, or moved to a frequency well outside the capture range. It is particularly annoying on SSB, where the effect is to impress severe syllabic rate FM on the demodulated audio.

The Eddystone S940C suffers badly from this problem, despite (or because of?) having a self oscillating 6BE6 product detector. A partial solution can be achieved by improving the decoupling arrangements. No total solution has yet been identified by this writer. The good news is that this phenomenon does have a practical application. Given some operator skill, the S940C can behave as a useful synchronous AM receiver giving better results on selectively fading 41m band signals than available from its envelope detector.

12.18 Intermittent Faults

This type of fault is not at all uncommon in old radios, and can be extremely hard to trace. Usually, the cure is easy and straightforward once the cause of the fault has been positively identified. The trick is to avoid inducing secondary faults along the way.

First try to isolate the fault to a particular area of the block diagram, by metering the radio extensively with a selection of scope probes and multimeters. Arrange temporary injection points in the IF and audio circuits, with coax tails coming from the radio. Be sure to monitor the local oscillator & BFO injection levels, which is often most easily done by measuring the grid current of the injected valve.

Suspect tubular capacitors and fibrous resistors should be squeezed gently with insulated pliers, to see if the fault can be made to appear on demand.

The use of a hairdrier can thermally stress areas of the chassis, or even individual large components. This can be a useful way of introducing faults that normally only appear with the cabinet in position, after the set has been running for an hour or two. Beware of using freezer aerosol or a paint stripping heatgun, these are much too vicious. It is easily possible to break old components this way, melt lots of wax, or introduce more intermittent faults.

In sets that used a soldered chassis frame which has cracked apart, it is often a good idea to resolder whole areas of metalwork en masse, in case the fault is due to a dry joint in an important RF ground path somewhere.

The final solution is for the desperate, and should only be used for thermal intermittent faults where all other avenues of analysis have already been explored. Be warned that this technique can cause secondary damage, but it usually does positively identify the original fault. Cover the radio with a fire blanket to block off all ventilation. Fit a thermometer or thermocouple probe in the airspace under the blanket at the top of the chassis. Run the set until the air temperature reaches about +75°C (use +65°C if your chassis uses waxed capacitors or coils, or was originally built with second grade components). Open the blanket slightly at the bottom, and try to stabilise the temperature at this figure. Stay with the radio, monitor it very carefully and leave it to run until something fails. Usually, what fails is the cause of your original intermittent fault, but normally the failure will now be permanent, and therefore traceable. You really must be present all throughout this test, and have a suitable fire extinguisher readily to hand.

12.19 Identifying and Curing Unwanted VHF Oscillation

The technique of using a spectrum analyser and coupling link as a diagnostic tool (see later) for investigating anomalous receiver performance, can often be helpful when chasing VHF instabilities. This problem has accounted for several instances of high noise levels, stage inefficiencies and strange intermodulation/spurious response phenomena in valved HF communications receivers seen by this writer.

VHF instability is particularly common in equipments that have been modified to incorporate hot front ends or mixers. The word “hot” can be used in the literal sense sometimes, if the oscillation is strong enough!

It may be possible to use a wavemeter or general coverage VHF receiver to detect the presence of unwanted VHF oscillation, instead of a spectrum analyser. The level of oscillation is usually extremely high, and often has a frequency between 90MHz and 200MHz in practice, so start searching this band first. Put the probe in the centre of the anode box of each stage in turn, and sweep the band for unexpected strong signals.

If you are convinced one of the stages in your radio is unstable, there are three alternative ways of proving the existence of parasitic oscillations when a spectrum analyser is unavailable, as follows.

Technique No 1: Replace each RF amplifier, mixer, and RF oscillator valve in turn with a specimen approximately 50% down on mutual conductance. Very often it will be found that the flat valve has inadequate VHF gain to oscillate, so if adding a flat valve magically improves the performance of your radio, then put the good valve back in and add grid and anode stoppers as described below.

Technique No 2: Add a small 47Ω resistor in the grid, and a small 10Ω resistor in the anode of each stage in turn, working from the 1st RF valve back through to the final mixer. Of course, this will identify the problem by curing it. The need to put the resistor directly on the valve socket contact does make this technique very fiddly to implement.

Technique No 3 (applicable only to high level oscillation): hold a small wire-ended neon in the anode compartment. Yellow glow indicates unwanted HF oscillation, purple/mauve glow indicates VHF. It is not necessary to connect the neon to anything, the neon is struck by voltage derived directly from the electromagnetic field radiated by the tank inductor of the unwanted oscillator. Note that this tank inductor may well be one of the wires in the anode structure, rather than a physical component such as a coil.

12.20 Post Alignment Tasks

Except where ventilation is critical, this writer would recommend covering all trimmer adjustment access holes with PVC tape after alignment has been completed. This advice extends especially to holes in the top of IFT cans, under which lie beehive capacitors. These devices are particularly prone to going dead short given the slightest encouragement from dust, swarf etc falling onto them from above through the access holes. Some IFTs of this design are incredibly hard to remove for repairs. The BRT400 comes immediately to mind.

13. Permeability Tuned Radios

This topic definitely deserves a section all of its own. Radios in this category are usually American, always multiple conversion, and tend to date from the 1950s and 1960s. In general, one or more RF stages are mechanically ganged to one or more tracking IFs and a VFO.

A permeability tuned VFO (often called a PTO in the original documentation) is invariably used on American models, whereas the British tended to use a tracked capacitor VFO, as for instance, in the Eddystone S880/2. Some American sets used a permeability tuned BFO (R-390/R-390A), others used a variable capacitor (eg Collins 75A-4).

Two basic mechanical systems were used. LF radios requiring large fractional frequency coverage used leadscrew techniques to raise and lower the slug racks, and this technique was also used in the S880/2 HF receiver. The Collins HF receivers used snailcam-operated cams and roller followers to control the slugracks, rather than leadscrews.

13.1 Module Interdependency

All of the Collins-designed receivers in this category seem to be modular in their construction, even the little R-392. Before contemplating any surgery or realignment, it will be essential to have a thorough understanding of how the various modules interact with each other electrically and mechanically, the latter being by far the most important.

On the American equipments, the screws that hold the modules onto the chassis are usually 6/32UNC with Phillips round heads, painted green. Do not be tempted to remove any red-painted screws without a thorough search through the handbook first. Red screws are rarely found, but normally indicate fastenings which ought not to be disturbed. In extreme cases, red screws could cause danger if removed, as a result of suddenly released turret springs or a dropped mains transformer.

The screws found elsewhere in American radios are mostly 3/48UNC or the larger 4/40UNC and 6/32UNC sizes. It is worth pointing out that Phillips heads are similar to Pozidriv, but without the extra guide flutes of the European system. It is therefore important to use the right screwdriver, especially on the tighter 6/32UNCs. Most Phillips drivers have red handles, whereas the Pozidriv ones tend to be blue. Unfortunately, UNC hardware is rather hard to come by in Britain, and most of the smaller stuff that is available has Pozidriv heads.

Some designs retain their mechanical integrity when disassembled into modules, while others do not. The R-390 is an example of the latter category. This chassis requires a tinplate idler gear to be fitted to the RF unit, before it is removed from the mainframe. This gearwheel must not be disturbed until the module is back in position. This little piecepart avoids the counter, which is mounted on the RF module, from getting out of alignment if the module's own kHz mechanism is rotated. The later R-390A maintains its integrity when dismantled into modules. The geartrain mechanics on any one of its modules are independent of all the rest. It would certainly be far easier to assemble a working R-390A from a random chassis frame and full set of working modules, than would be the case with the equivalent set of parts for an R-390.

13.2 Bristol Multiple Spline

The Collins radios, and others of their design made by manufacturers such as Motorola, EAC, Bendix etc all make liberal use of grubscrews of the Bristol Multiple Spline type, often erroneously called Bristo even in official documentation. These screw heads are NOT the same as the Allen pattern or the Torx pattern, and are not widely available in the UK.

You will need, at the very least, Xcellite tool number 99-66. If you or a previous owner has attempted to use an Allen key, it may be necessary to drill out the grubscrew. This is difficult since the material is very hard.

Some grubscrews were locked at the factory with Glyptol, which is a type of green varnish. To free a Glyptol-coated grubscrew, heat its core for 10s with a fine, very hot instrument soldering bit. Then quickly crack the joint with the Bristol key.

13.3 Tuning Slugs

It will be essential to start by having the right Iron cores in the right formers. The slugs are usually colour coded with a dot pattern visible from the top. Some designs of chassis use up to four deliberately different types of core. If one wrong core is used somewhere in a slug rack, that section of the receiver may not align at endpoints, and/or it may fail to track correctly.

Beware cores that have become detached from their leadout wires. Repairs are very simple once the loose core has been pulled free of its former.

Sometimes there were mid-production changes to the types of cores used in one or more of the slug racks. Very often, either the earlier type or the later type may be used without any changes, provided they are fitted as a complete set.

The slugs must move freely in their formers. These pieceparts must be truly coaxial in their alignment. Radial adjustment is usually provided for, often by means of movable supports for the slug support wire. It is permissible to use a trace of MS4 silicone grease on the outer diameter of the slugs, in the event of major binding problems.

13.4 Mechanical Alignment

Initial mechanical adjustments should be performed with the VFO declutched from its drive shaft. Set the dialdrive endstops to allow symmetrical over-travel at each end of the MHz and kHz ranges. Make sure the LF and HF MHz and kHz endstops work properly. You have four to check and adjust, in all. Repairs are often necessary, especially on early R-390 receivers.

Set the calibration clutch to the middle of its travel. Make sure this humble mechanism works properly. Repairs are often needed, and may as well be performed now, rather than later. Collins-derived radios seem to have fragile calibration clutches.

Check that all spring loaded split gears are properly preloaded. Then make sure the Geneva mechanism that drives the octave coil selection wafer switches is correctly adjusted, and properly ganged to the MHz readout cylinders.

The mechanical counter display needs to have fully functional "-" and "+" rollover display cylinders. These should appear when the kHz shaft is set to below 000kHz, or above 1000kHz on any MHz range, heading towards the adjacent mechanical endstops. Typical limits of travel will be indicated at "-966" and "+034" kHz as the endstops engage. Note the symmetry of the wrapround numbers.

Next, check that the MHz crystal oscillators, and any associated frequency multiplier coils, are properly selected by the drive shaft feeding from the bandchange mechanism. Dial up the “magic number” given in the handbook (this varies from model to model), and set all the cams to exactly the right positions. This should result in a properly aligned geartrain, onto which the VFO can now be tracked.

Finally, set the VFO to track the kHz mechanism, and then lock up the grubscrew. Be absolutely sure at the end of your work, that the main mechanism dialdrive endstops activate <u>before</u> the follower nut inside the VFO canister runs out of thread on its leadscrew.

The VFO Oldham coupler, and all others in the chassis, should have about 0.75mm endfloat. The anti-backlash spring should be present and functional.

13.5 VFO Alignment

VFO endpoint adjustments vary from model to model. They do all have an ability to be set to exactly the right frequency at the 000 and 1000kHz points or at least, they did when they were new. Typically the endpoint adjuster is hard to get at, sealed by a screw plug, and delicate. Not a nice combination. Frequency tracking across the range is set by internal adjustment, but should be within 1kHz (500Hz when new) anywhere between the 000 and 1000kHz endpoints. The error is allowed to worsen between either endpoint and its adjacent endstop.

The VFO tuning ranges of the R-390 and the R-390A can in fact be adjusted in the chassis, though the handbooks say otherwise. Target 2.455MHz to 3.455MHz from the VFO, over exactly ten turns of mechanical rotation. If this cannot be achieved within the adjustment range of the endpoint adjuster, the VFO will need internal surgery to remove some inductance from the small coil in series with the large main coil.

Messing with the tracking is probably best avoided, unless your pocket is deep enough to afford another VFO if things go wrong. The only American VFO type that seems to give incurable problems with tracking is the Cosmos, a late species of R-390A VFO. Most other types, including the Collins original, are generally there or thereabouts after half an hour of careful fiddling.

13.6 VFO Repairs

If your permeability tuned VFO is unpleasantly lumpy in its motion, or is known to be responsible for frequency jumps, it will be necessary to go inside and relubricate the mechanism. On supposedly sealed units, you must disregard all of the cautions on the labels outside of the can relating to sealing integrity.

Use heavy mineral grease on the corrector stack mechanism and its follower. Apply EP90 hypoid oil to the endthrust bearings. Sealing O-rings should be lubricated by MS4.

Do not bother to dry out the silica gel cartridge, if found. It is only there for show, the assembly never was truly hermetically sealed. If you do go to the trouble of drying it out, all that will happen is that you will have to reset the VFO endpoint adjustment in six months time, compared with two years if you leave it well alone. This is because during that first six months, the silica gel will dry out the coil, which then shrink slightly. After about six months, the moisture ingress past the seals will start to cause the coil to swell again, as the silica gel sack loses control of the humidity inside the canister. The endpoint adjuster will require tweaking with each change of dimensions of the VFO coil.

Inspect most carefully, the follower nut that runs on the leadscrew. On some designs, this nut is carried on a sprung cage, the fingers of which can break. This is one identified cause of backlash. Repairs generally prove possible, but it is important to retain some sort of spring loaded flexible mounting arrangement for the nut.

Lubricate the input shaft grounding spring after making sure it is bearing lightly on the shaft, as it should do.

After refitment to the chassis, always switch the VFO heater oven OFF if you have a choice on your radio.

13.7 VFO and BFO Operating Shafts

The shaft carrying the tuning knob is often supported by an adjustable bronze bush in the front panel. Permeability tuned radios tend to require large operating torque, even when everything inside the radio is working properly. Extra friction introduced by a wrongly adjusted support bush must be avoided, but this fault is nevertheless quite commonly seen. Be sure to adjust the position of the lockable bush last of all, preferably just before the radio is to be fitted into its cabinet. Obviously, in order for the bush to be effective, the shaft must be dead straight. Gentle bending with an adjustable spanner can prove highly beneficial, if undertaken with care.

All permeability tuned BFOs seen by this writer, have input shafts in the form of a very fine leadscrew. Typically, this is connected to the operator's shaft by a bellows coupler. Make sure the coupler is at its natural, ie unstretched/uncompressed length, with the BFO set to the centre of the IF passband. Comments relating to relubrication of the internals of the BFO canister are generally as for VFOs, though the job is easier due to the absence of the tracking corrector stack.

Any shaft grounding springs must be making contact properly, and well lubricated to avoid galling of the mating surfaces.

13.8 VFO types other than Collins

Drake permeability tuned VFOs never seem to give problems, and rarely need adjustment despite their relative simplicity. They track within 1kHz, even though the ferrite arrangement looks really crude. Overall, the Drake VFOs surely represent a more elegant engineering compromise than the Collins approach.

British precision VFOs found, for instance in the S880/2 and RA17, tend to use high quality variable capacitors from the likes of Wingrove & Rogers, rather than permeability tuning. They generally benefit from replacement of doubtful looking ordinary Rs and Cs, but never seem to require retracking.

13.9 PBT as used in Collins Designs

The PBT arrangement used by Collins in the 75A-4 relies on rocking the VFO frame in synchronism with movement of the BFO capacitor, using a spring loaded bronze belt & pulley arrangement. It all works very well in practice, though there are two special points worthy of mention.

The right valvecans must be used, these being of slightly shorter than standard height. This is to stop the VFO cans hitting the support frame at either end of the PBT travel.

VFO subchassis earthing, and bearing endthrust, are tasks performed by a single wavy Beryllium Copper washer behind the VFO canister. This component needs to be present, undamaged, and properly adjusted. Experience leads to a firm caution against the use of an ordinary plated spring steel replacement in this application.

13.10 Setting the IF Gain on Collins Designs

One of the last adjustments to be performed on the Collins family of permeability tuned radios, is the IF gain level. The handbook shows how to set this to the minimum value consistent with giving specified sensitivity performance. This adjustment procedure should be followed exactly, in order to achieve the best possible dynamic range. Any Collins designed radio needing its IF gain control set to maximum is not operating correctly, and requires attention.

14. Performance Benchmarks

This section outlines the key performance measurements needed to verify the health (or otherwise) of your radio. Figures of typical performance are presented, and a star performer is identified for each category. For consistency, these are drawn from the popular 2RF + multiple IF, single conversion category (AR88D, HRO, SP210, BRT400, SX28, CR100/B28, S940C, B40 etc) having an IF of 455kHz or 500kHz.

14.1 AGC Threshold

Radios having two RF, and two or more IF stages usually start developing AGC at about 2µVpd input. Thereafter, a +100dB RF step should generally result in <+9dB rise in AF output. For radios having one RF or IF stage fewer than the above, the AGC action typically starts at about 4µV, above which a +80dB RF step gives <+9dB audio rise.

Maximum AGC voltage varies from about -10V on radios having simple AGC circuits, to -45V in the case of radios having complex AGC distribution arrangements and AGC amplification.

The star AGC performer in my collection is the GEC BRT400K, for which a +100dB step above 3µV gives +2.5dB AF. This set has separate RF and IF AGC voltage delays, a complex anode bend AGC detector, and feeds only a part of the available AGC to the final IF (6BA6) stage. Further evidence of excellent AGC management in the BRT400K is the way the recovered audio SNR rises rapidly and progressively with the RF input signal level. Certain other radios are able to match this receiver for audio levelling, but none yet measured by this writer does as well on SNR recovery in the difficult 1µV to 10µV signal region when receiving an AM signal.

The BRT400 family uses an S130P neon HT regulator for its oscillators and for the RF/IF screened grids. This type shows unusually large sample-to-sample variability as regards actual regulated voltage. Samples varying between 110V and 147V are held at this address. In general, GEC shouldered-glass types are at the top end, and Cossor balloon-top types are at the bottom of the range. Care is needed to select an S130P sample which gives adequate voltage stability over a reasonable range of mains input voltage.

14.2 Noise Figure

If a noise generator such as an R&S SKTU is available, it is easy and worthwhile to measure the receiver NF on the 10m band. This may typically measure as low as 6dB for sets with 2 miniature RF amplifier tubes, or as high as 18dB for radios with only one first generation octal RF amplifier tube.

The truth is that noise figure on the HF bands need not actually be better than about 11dB for normal terrestrial shortwave reception. Of the vintage manufacturers, only Collins, Drake and Racal seem to have properly understood this. Other manufacturers generally produced receivers that had excessive gain, and hence suboptimum dynamic range.

My star performer is the Eddystone S940C, for which a genuine 5dB NF can be reliably recorded on 10m, making it very suitable for use with low gain, low noise UHF down-converters. This radio has an RF architecture employing a cascode ECC189 feeding a 6BA6 second RF, then a ECH81 mixer. An excessively gainy design, but very sensitive indeed.

14.3 Image Rejection

For single conversion radios, it is instructive to measure image rejection on the 10m band. Radios with 2 RF stages, having ceramic or plastic valve sockets & waveswitch wafers, air spaced trimmer capacitors and large coilformers of high quality material, usually give 40dB image rejection when properly aligned. For radios fitted with bakelite valve sockets, paxolin waveswitch wafers, ceramic trimmers and small paxolin coilformers, 25dB is more normal. Each of these dB figures will be halved if the radio has only one RF stage, unless clever inter-stage coupling is used to improve performance as on the British Army R107 for instance; or unless a 1.6MHz IF is used as on some Eddystones.

In general, the LF skirt of the overall RF selectivity characteristic will be steeper than the HF skirt, so better image rejection will be obtained by radios which run their local oscillator LF of the signal frequency, even though this will be at the expense of tracking difficulties that may restrict the tuning range.

My star performer is the AR88D, a genuine 50dB of image ratio being achieved on 10m when running with its local oscillator LF of signal on the top range. Is mine the only example to track correctly this way? The handbook indicates that this is not how the radio ought to be aligned. (I suspect the handbook is wrong.)

Note that for proper image performance, the radio should be fed from the source impedance specified in its handbook. This applies to alignment, testing and actual service. If the radio has a balanced input, especially one that has to be adjusted for correct balance as well as for resonance, be sure to feed it from a balanced source of correct differential impedance. For alignment purposes, this may often be achieved by a toroid and a network of impedance stabilising resistors.

14.4 Third Order Intercept Point

Third order intercept point is somewhat time consuming to measure properly on an individual basis, but can become quite quick when performing a batch of measurements together as a group. This parameter is especially important for those intending to select a vintage radio for serious use on about 7MHz after dark in the winter months, with a good aerial.

There is little advantage in having intercept points in excess of 0dBm, at least for everyday HF operation with ordinary antennas. When the receiver is to be co-sited with an independently operated large HF transmitter installation, or when high gain VHF/UHF down-converters are to be used in front of the HF receiver, then there may be functional benefits to be obtained by choosing a receiver with an intercept point above +10dBm. Realistically, only solid state receivers are likely to achieve this figure. The best bet for an old valved receiver working under such conditions of excessive RF input is to insert a 20dB pad in its antenna input line. Most of these sets have 10db to 20dB of excessive sensitivity on the LF bands, which may as well get sacrificed in the search for better overall performance. The beneficial effects of a 20dB input pad include a 60dB increase in third order input intercept point and a 100dB increase in 5th order. The result especially on the LF bands, will be to make the receiver appear extremely deaf on air. Good! This says that many unwanted spurious responses have been very greatly reduced. See how clever is the Racal approach used on the RA17L and RA117, in fitting a multi-step aerial attenuator as standard. The puzzle is why more manufacturers did not do this. Even Collins missed this rather obvious trick. The technique of seriously detuning the antenna resonating trimmer is very much a second best, but this is all that can be done on most old sets.

This writer normally measures third order intercept point on 10m, since in the case of multiple conversion receivers, by choosing different tone separations the performance of the first and second mixer chain can be analysed separately. In the case of tunable first IF designs such as the 75A-4, tones spaced at 20kHz will pass straight through the RF and first IF systems, so that the performance limitation will usually stem from the second mixer. With 100kHz spacing, both fundamental tones and the third order intermodulation products will still pass through the nose of the RF tuning, but the most remote tone will generally now be sufficiently far down the skirt of the first IF response for the second mixer not to be subjected to these two strong tones at the same time. The measured performance will then be determined by the first mixer. Or by the RF stage(s), if the first mixer is unusually robust as may indeed be the case with a 6BA7, 6K8 or Mazda/Ediswan 6C9.

When taking measurements with close tone spacings, the signal sources used must have very low phase noise, otherwise performance will be masked by reciprocal mixing mush. Also, the attenuators must be truly linear, and must not interact with each other or with the combiner network. This writer uses an identical pair of Marconi TF144H/4S signal generators, each of which uses a high level unsynthesized 5763/QV03-12 oscillator without any subsequent amplification, followed by entirely resistive output padding. To combine the two generator outputs into a single 50Ω feed to the receiver under test, an Olektron B-HJ-302U dual directional coupler is used. This provides good inter-generator isolation without excess transmission loss in either leg. Tubular 10dB fixed BNC pads are fitted directly to each port of the coupler to provide a further 20dB of inter-generator isolation, and to provide a reasonably accurate 50Ω source impedance for the receiver under test. The path from each individual generator thus has 10 + 6 + 10 = 26dB loss in the line. On the end of this chain, is an 8-way Raven 50Ω multicoupler unit. This uses a pair of FET devices to provide sufficient overall gain, together with a very high IP and low noise figure. This test system provides accurate and repeatable results down to 5kHz tone spacings. Intercept points are measurable to beyond +20dBm as and when (rarely) necessary.

An even better way ahead, especially when measuring with very close tone spacings indeed, is to use high level crystal oscillators to provide the tones. The crystals need to be tightly specified, of exemplary quality, and designed especially for the job. You should expect to pay very good money for a suitable crystal. The precision oscillator circuits are usually bipolar designs containing a special amplitude feedback mechanism which is quite separate from the oscillator RF circuit. This approach reduces the output problems due to limiting noise and waveform distortion. The output voltage is usually derived from the current flowing through the crystal slice.

A supporting rationale for the choice of 10m as the basis for critical third order intercept point measurements of valved HF receivers, is as follows.

1. Nearly all valved radios deliberately operate with restricted gain on the LF bands where good strong signal handling was understood to be needed, but have high gain on the HF bands where ultimate sensitivity was considered to matter far more. Thus the 10m intercept performance will be the most severe case. Yet it is fully representative if the receiver is to be used as a tunable IF with a VHF down-converter, or if it is to be used with a good single-band 10m beam for contest use at a time of high MUF.

2. Some sets have so much front end selectivity on the LF bands that they get extra intermodulation performance for free just by attenuating one of the fundamental tones in the RF tuning system. This prevents the furthest distant tone from being amplified fully, even with offsets as small as ±10/20kHz. Radios with such superb pre-selectors include the R4C and the RA17L/RA117. Intermodulation performance on the LF bands with these receivers is determined at least as much by the tuned circuits as by the active stages, especially when the tone spacing much exceeds 50kHz. For this reason, measurements on these bands have less value as an engineering diagnostic technique than test results obtained at the higher frequencies of coverage.

In bench testing on 10m with 20kHz tone spacing, extremely variable 3IP test results are recorded from model to model. Over-gainy sets with poorly designed mixers may be as bad as -30dBm. Carefully designed valved sets with deliberately low overall gain even at HF, but correct distribution throughout the block diagram, can do much better.

The star performer in my collection is the US military R-390A, which gives +5dBm. The best of the single conversion 2RF + multiple IF class that I have measured is the S940C, which gives -17dBm. This result is all the more remarkable considering that this set also gives excellent sensitivity.

The lemon giving the -30dBm result is the HRO-MX, the main problem appearing to be its inadequate mixer, even though the level of injection from the local oscillator is quite high. This radio is noteworthy for having a very transparent mixer and front end. This causes a very high level of local oscillator breakout from the antenna port on the higher frequencies. This was a well known problem with this model in the days of Band I television broadcasting. To make things worse from an intermodulation viewpoint, the HRO maintains high levels of gain right down to the LF bands. Perhaps in the spectrally uncontaminated days when it was designed, the smaller number of signals made outright sensitivity a necessary design target even at low frequencies.

In the event of problems being indicated by a poor third order intercept measurement, this writer would suggest moving to the 1dB compression technique to try to find a solution. This is because the average receiver does not take kindly to having scope probes attached to tuned anodes or grids to look at the waveforms. Additionally, the use of a spectrum analyser as a diagnostic tool is made difficult by the fact that its own intermodulation performance may well be worse than your faulty receiver. Unless of course, the radio is severely overdriven to produce a high level of intermodulation products or is very seriously defective. The technique of trapping-out the two strong signals to artificially increase measurement dynamic range of the spectrum analyser is definitely not recommended. This approach is likely to reduce measurement accuracy by introducing unwanted slopes and unknown losses. In any case, it may not save the analyser front end from expensive damage if things go even slightly wrong.

14.5 1dB Compression Point

This is a single tone parameter which is easy to measure, and with caution it can be used to solve problems found when measuring third order intercept point in a two tone intermodulation test. In an ideal system, the 1dB compression point has a value typically 17dB below the third order intercept point. However, the exact relationship depends on curvature characteristics of the system under test and can vary a few dB either side without being particularly indicative of linearity problems. In the case of HF receivers, noise and skirt limitations can be the major cause of significant deviation from the 17dB figure.

In an idealised receiver, all stages would compress at the same antenna input drive level. In the same way, all stages should start to intermodulate simultaneously. In the case of semiconductor receivers these ideals ideal can be approached fairly closely, but the early stages of valve receivers tend to over-gain to a greater or lesser degree depending on the basic design quality. When tuned to the adjacent channel of a single strong signal so that the receiver gets full severity without the benefit of any AGC, signal crushing will occur first in the stage preceding the IF filtering. Thus in the case of a 75A-4, the second mixer will compress at a much lower input level than that necessary to compress any other stage.

As the strong signal is then detuned so that it falls down the skirt of the first IF response but stays within the RF bandwidth, the first mixer will become the stage that crushes first. This will occur at an input level lower than the adjacent channel measurement by a factor equal to the conversion gain of the second mixer plus the skirt rejection of the first IF. Sometimes, the second mixer will not ever compress under these conditions because the first mixer will be quite unable to deliver enough power through the first IF selectivity skirt to achieve it, however much input drive is applied to the antenna socket.

As the signal is further detuned so that it starts to fall down the skirt of the RF selectivity, then the RF stage(s) will become the part of the receiver most susceptible to compression, though at a fairly high level depending on the absolute value and distribution of the RF selectivity.

A non-intrusive method of detecting the onset of compression involves the use of a small, electrically insulated 3 turn coupling link held in loose proximity to the anode coil of the stage concerned, say an inch away from the end of the coilformer. With the coupling link cabled to a spectrum analyser, it is easy to discern the onset of crushing. The 1dB compression point will be where the coupling link detects a rise of only 9dB when the input level step is actually 10dB, as set by exact adjustment of the signal generator attenuator. The arrangement used by Marconi on their older signal generators for instance the TF144 series, which have separate 1db and 10dB stepped attenuators, makes it very easy to identify the 1dB compression point. Experimentally moving the link a little further from the anode coil when the receiver is thought to be overloaded, will ensure that the analyser does not compress before the stage being measured. This simple check will confirm that the measured test result is truly due to receiver performance limitations, and not due to problems with the measurement system.

An excellent example of a valve radio with textbook 1dB compression performance is a Collins 75A-4 when modified by replacement of the 6BA7 first mixer by an E88CC twin triode, and replacement of the 6BA7 second mixer by a heavily padded 7360 beam deflection valve. The block diagram is then: 1) 6DC6 pentode front end; 2) E88CC single-triode (sic) first mixer injected with 5V p-p to generate a 1.5 to 2.5MHz tracked & tuned first IF; 3) 9dB resistive attenuator; 4) 7360 beam deflection second mixer injected with 11V p-p local oscillator which differentially feeds selectable 455kHz mechanical filters. Note that the 2nd LO has to be beefed-up with an EF95 at V15 to achieve the 7360 injection figure quoted. This particular receiver has been further modified to include a 2.1kHz IF tailing mechanical filter, and is exceptionally pleasant in use, especially under SSB contest conditions. On 20m, with a strong signal only 5kHz off tune, the input level needs to be -24dBm before the second mixer compresses by 1dB. The third order intercept point here measures -29dBm. With a strong signal 100kHz off tune, the input level needs to be -18dBm before the first mixer compresses by 1dB. At this tone spacing, the third order intercept point measures -7dBm. When 500kHz off tune, the input level needs to be -2dBm before the RF amplifier compresses by 1dB, corresponding to a measurement of +14dBm for the third order intercept point. It may be that even this performance is not all this superb radio could achieve, given further tweaks to its gain distribution. As supporting information, this radio has an RF selectivity system based on two tuned circuits (one either side of the single RF amplifier valve), and a first IF selectivity system comprising one top-capacity coupled double tuned circuit. The selectivity characteristics on 20m are as follows, measured using a TF144H/4S signal source and a loosely coupled 3-turn link feeding an HP141T spectrum analyser system.

REJECTION	RF B/W (total)	1st IF B/W (total)
3dB	100kHz	40kHz
6dB	175kHz	60kHz
10dB	300kHz	80kHz
20dB	550kHz	140kHz
40dB	2MHz	300kHz

14.6 Mains Current

A useful measurement is the AC current drawn from the mains during normal operation. This is usually in the range 0.15A to 0.6A for 230V radios, and of course double this for 110V sets. It is a useful figure to hold on file, to help the diagnosis of future faults before they develop into anything really threatening to the mains transformer.

Because of the potential seriousness of an equipment fire if you are a careful collector, it may be wise to consider the construction of an over-current trip box which cuts the mains supply to your radio(s) in the event of its current demand rising to more than 50% above the normal figure.

An earth leakage trip may also be worthwhile. However, certain radios may trip out even when operating normally, unless the mains input capacitors are completely disconnected from the chassis. The B40 in particular, has very high value mains input decoupling capacitors. You are advised not to wear headphones unless the chassis is well earthed.

It is worth pointing out that mains fuses cannot be relied on to protect your radio from disaster. Their principal job is to protect the mains power network from faults occurring in your radio. They achieve this objective by breaking at about three times their rated current, on a continuous overload. Important: Mains fuses inside your radio will certainly not protect it against faults present in the line cord, and may not protect it against faults present in the mains RF decoupling network.

15. EMC Considerations

15.1 Emissions

Radios with valves often had very high levels of local oscillator injection to the first mixer, causing high levels of unwanted conducted emission into the antenna feeder. Often, this conducted emission will be 455kHz above the operating frequency. On the higher frequency bands, the front end valves will provide little reverse isolation of the fundamental or harmonic frequencies of the local oscillator, and the RF tuned circuits will do little to stop the local oscillator getting into the anode of the preceding stage. The HRO is especially bad in this regard. The antenna will be reasonably efficient at the LO frequency, since its resonance is only some 1½% removed from the radio's operating frequency at 30MHz. This obviously assumes that the antenna is correctly adjusted. The net result can be a high level radiated emission from the antenna structure occurring at the local oscillator fundamental frequency, or at harmonics of it. The fundamental can cause problems to other users of the frequency band you yourself are operating on. The third harmonic can fall into ITU-R broadcasting Band II, in Europe at least. The situation can be worsened appreciably if any RF screening plates are loose, or if any valve cans are missing.

Unwanted local oscillator voltage can be conducted out of the mains port, and can be at a high level in the case of radios that do not have integral mains filters. It must be said that this is unlikely to cause a significant problem unless several of your radios are operated from a common mains supply. A proper mains distribution filter would then be helpful.

15.2 Immunity

In the domestic EMC environment, it has been accepted by CENELEC and ETSI that the ambient unwanted field strength may reach a severity of 3V/m. Worse still, this "real world" level is increasing at the time of writing. Certain things can be done to help old receivers work as well now as they did when they were new, in the quieter radio spectrum that existed at that time.

Additional immunity from unwanted common mode RF injection into the antenna port may often be obtained by more intelligent use of the antenna terminals, which on the older radios tended to be more comprehensively provided than on today's models. Wherever possible, use a balanced feeder. Best of all, some radios had provision for a fully screened **and** balanced antenna input feeder, for example the SP600 and R-390A. To make optimum use of the R-390/R-390A input arrangement, put an electrically noisy hairdrier right next to your feeder but spaced several feet from the radio itself, then adjust the balance trimmers for minimum noise output on the ranges you actually use, with the antennas you actually use. If you do not have a noisy hairdrier, then a nearby PC or SMPU may do this job just as well!

The addition of a mains low-pass filter may improve performance on the LF bands. If you include a varistor surge limiter too, here you have a cheap way of protecting your valuable mains transformer and preventing destruction of the rectifier cathode in the event of gross surges on the mains supply. Some radios had inbuilt mains filters, for instance the R-390/R-390A and the Hallicrafters S36. This is viewed by the writer as an indicator of unusual design excellence.

16. Photographs

16.1 Marine Radios: the RCA AR8516L, Marconi Atalanta.

These are ship's Class B HF receivers, operating from 110VDC floating supplies. Both designs have 240VAC to 110VDC transformer/rectifier assemblies mounted on the inside of their rear cabinet cover. These power supplies run whenever the set is plugged into the mains, something that modern day owners need to be very wary of. The radio front panel on/off switches are in the DC line between the power supply and the radio. The filament strings are all in series. The Atalanta has its chassis metalwork directly connected to the negative DC pole, but the entire chassis assembly is insulated from the cabinet and front panel by using large amounts of Tufnol. The Atalanta has a neon regulated LO and a crude Marconi mechanical filter called in the handbook a "magnetostrictive resonator". To provide good tracking, this radio uses harmonic mixing on its top range. There is no built in S-meter, but there is a well contrived external metering box that can be used to speed diagnosis in the event of a fault. The Atalanta has a product detector, but the BFO covers USB only. The dialplate calibrations stop at 28MHz. There is a very useful fine tuning control. These sets were so well designed and so well built that many remain in service today. Now looking at the AR8516L, this design uses mighty roller chains to connect the bandchange shaft to two complicated parallel wafer switch banks running from front to rear of the chassis. The original tongue & groove couplers had excessive slop, and have been replaced here by solid types. Note the idler pulleys. On the whole, this is not a successful mechanical arrangement. The chassis is connected directly to earth, but the electronics it carries are fully isolated except for a single 33kΩ pull-down resistor. There is no neon, and the valves are extremely unusual B7G types with 600mA heaters, for example 3BE6, 3AL5. There is only a single RF amplifier. This is fitted with low-Q coils. Although the first IF is much higher than 455kHz, its predecessor the AR88D nevertheless manages a convincingly superior level of image rejection on 10m! The AR8516L has a 455kHz second IF, with an excellent Collins 3.1kHz tubular mechanical filter. Twin VFOs are used. Despite two adjustable BFO frequencies (centered on 45kHz and 455kHz), there is no product detector, and SSB copy is poor. The mixing scheme is strange in the extreme and scale linearity is inadequate, though readout accuracy is actually far better than on the Atlanta. Numerous variable capacitors are used in the AR8516L, more in fact than on any other set yet seen by this writer (though the SX-28 comes close). The AR8516L design originated in the USA but it was produced and manufactured in England, using very poor quality components. There are two massive electrical design flaws. Each is a simple decade resistance error. This writer suspects that the American prototypes worked fine, but the job of transferring production to the English RCA factory in Sunbury-on-Thames was botched due to misreading two of the resistor value multiplier rings. After corrective action, performance improved from very poor indeed to just about adequate. There are two serious mechanical design flaws in the AR8516L as well. Changing the dial bulbs requires major stripdown. Weak undersize brass screws are used to hold the major subassemblies to the chassis, and these shear all too easily. The AR8516Ls gained a very bad reputation, and were quickly withdrawn from service. This is hardly surprising.

16.2 Turrets: the Murphy B40D.

This design has an unusually well engineered turret tuner, combining good accessibility with individual screening of each coil. This set is mechanically quite different from anything else, clearly the thinking of a very fresh design team. The RF unit, AF/PSU unit, front panel and mainframe are all cast Aluminium structures. The tuning gang is a ceramic shaft type mounted at the very top of the RF unit. It is operated via two grease-packed gearboxes with a long interconnecting beaded chain drive between them. Each tuning range covers two complete revolutions of the drum, which rises and falls on a hefty threaded leadscrew. Construction is modular. Early variants had fragile mains transformers, and used the rare Philips B8G (like loctal) valves drawn from the E20 series of Philips valves such as ECH21/CV302, EF22/CV303 and EL22/CV304. The CV versions originally fitted to these sets were all metal clad, except for the hot-running types. The original B40 had no band indicator other than the illumination bulb for the range in use. Later variants such as this B40D were much improved, and used miniature valves throughout. This is in fact the final production variant. It had an external local oscillator trimmer for use on the higher frequencies. A high slope front end is fitted, complete with an "anti cross-mod" front panel control to adjust the RF amplifier curvature to minimise unwanted distortion products. The crystal filter is a simple 2-pole lattice type, and appears to be a copy of the design found in the earlier Eddystone B34/358X. The AGC operates in negative feed-forward mode to the audio amplifier, and in negative feedback mode to the RF and IF strips. Stability was sufficient to allow these sets to handle teleprinter traffic under battle conditions on board warships. In fact, better stability than the older Marconi B28/CR100 was a prime design requirement for the B40. Despite being made almost entirely of Aluminium, this is one of the heaviest of all valved receivers. This particular example is a pre-production B40D. Variants included the B41 LF version and the 62B SRE receiver. The special transistorized FAZ SSB adaptor used with the B40 was made by McMichael. This device had electronic discriminator feedback to compensate for LO drift. The result was that all voices were reproduced at a constant average pitch, though there was slow drift during pauses in the speech. The resultant reproduced audio sounds very bizarre! The simplified equivalent to the B40 which was used in small ships was the CAW/CAZ Tx/Rx/PSU radio assembly rack. Each rack included a Murphy AP100335 or later AP100375 (SSB) receiver - or the inferior equivalent types made by Rees-Mace, who were actually Pye. The Murphy and Rees-Mace designs were functionally identical to each other, but totally different in detail. The Murphy variant was conventional compared with the B40 but it was still unusual, and very compact.

16.3 Wafer Switches: the AME 7G1680BA.

This French dual conversion receiver uses grossly over-size wavechange and IF bandwidth wafers. It dates from 1952. There is a chassis heater, which is automatically switched into circuit whenever the radio power switch is set to OFF. All wiring is uninsulated. This is a highly unusual and visually elegant arrangement, but very prone to shorts if anything is disturbed or if there are any solder splashes. The entire design is extremely spacious, and the set is correspondingly large and heavy. These features appear to indicate that this product was intended for operation in high humidity environments, or in extreme cold. Output comes from a single 6V6, despite which the HT chokes (plural), mains transformer and output transformer are all enormous. Two 5Y3GTs are employed. There is the usual octal neon. This set uses the unusual MG series of valves, including the almost unobtainable 6H8MG. The MGs are like metal-clad GT octals, but rather taller. In fact they are just as tall as the standard shouldered glass envelope. A 6AF7 magic eye is fitted, similar to type EM34 but with a 300mA heater and an over-size bakelite base. The HT fuse is an ordinary MES bulb, which glows dimly during normal operation and thus acts as a useful quick visual indicator of general HT health. Whether it would fail as reliably as a full-size HT fuse seems most unlikely. The IFTs are all plug-in octal based pot core types encased in resin. These had all drifted HF beyond the available adjustment range by the time this set was acquired. This fault was compensated for (rather than corrected) by the systematic addition of low value ballasting capacitors rather than by rewinding all pot the cores, which would have been impractical. The L:C ratios are thus nowadays slightly low on this radio, but not enough to seriously change the overall IF performance. The final IF has a crystal filter at 80kHz, which is extremely sharp. The two tuning gangs appear to be gold plated. They are carried on huge gravity-cast Aluminium subchasses which are supported on fibreglass insulating bearers. A clear plastic material similar to Perspex is used for the coilformers, valve sockets and switch wafers. The dialdrive requires very many turns to get from end to end on the scale. The gearbox is a surprisingly puny grease-packed worm drive affair with its endstops operating on the output shaft. Because of the enormous mechanical advantage, this had resulted in the wormwheel becoming damaged at some time. Very difficult repairs were needed. Pointer travel is controlled by a long leadscrew, which is very precise in operation but less than totally free from backlash. This set originally had an octal female socket as its mains chassis connector, necessitating male pins on the mains line cord! A 3-pin Bulgin professional male chassis connector is now fitted. The antenna patch panel has also been rebuilt to make use of standard connector types.

16.4 Restoration Techniques: the Marconi CR100/B28.

This specimen has been rebuilt using ceramic pillar standoffs paralleled by wire ended capacitors, rather than re-using the original metal tubular capacitors. Each of these 1940s components had a 2BA earthing stud at its chassis end. Direct replacements for the original components are nowadays unobtainable. It was felt necessary to retain the original grounding points for all the decouplers, for the following reason. The restoration of this set was undertaken primarily to identify how it would have performed when new, to identify the truth or otherwise of the widespread rumour that CR100s were hopeless receivers that always drifted wildly at HF. This radio has been entirely rewired except inside the coilbox, where the original insulation was PVC or something similar. This was a high technology material during the war, and was fitted by Marconi to prevent tarnishing of the Silver plated wavechange contacts due to the release of Sulphur from rubber insulation. The coilbox wiring proved to be fine, in fact it required absolutely no attention at all. This rebuilt example now works very well indeed. It does not drift too badly even on 10m - about the same as an HRO-MX in fact. The lack of any cover over the tuning gang is not too important as the cabinet is poorly ventilated. So the ingress of draughts & dust is not significant. The IF/detector strip is particularly praiseworthy as regards its response shape, audio SNR recovery and AGC action. The ergonomics are however very poor. In particular, the fine tuning has some backlash due to the use of an overly simple Jackson Brothers ball reduction drive. The result is that this set is not particularly pleasant to use. Maybe it would have been better when new. At least the kHz/revolution figure is quite low, which helps the situation. The S-meter replaces the RIS circuitry originally built into this receiver, which was originally constructed as an RN B28 production variant. There was a drawing office error on the CR100 chassis layout which resulted in the bandchange shaft not lining up correctly through all the bandswitch wafers. This basic mechanical design fault appears to have been properly corrected only on the final versions. To enable deliveries to continue under wartime conditions, mid-production radios such as this example were given a split bandchange shaft with tensioning screws spread at intervals along its length. This gave a sufficient degree of self-alignment. This particular CR100 was built as a B28 variant for the RN. It has the D63 noise limiter option, complete with its toggle switch which lives inside the main cabinet. There is an important electrical design error which is quite easy to identify. After fixing this design fault, the limiting action is distinctly better than on most other wartime radios. The BFO circuitry of the CR100 was crammed inside a tightly fitting metal cover. Typically for a CR100 the BFO cover originally fitted to this particular radio has been discarded at some time, no doubt due to short-circuits in the rubber wiring. It is now missing. The cabinet has been drilled to accept the rare post-war companion CW transmitter. Unfortunately this subassembly is no longer fitted. Rather few of these units exist nowadays. They were built for use by the 1950s UK civil defence network when training for a nuclear war. These 6V6 transmitters were very effective in use. A special small-envelope shouldered glass 6V6G was specified, but most surviving examples have an ordinary 6V6GT or 6V6GT/G fitted.

16.5 Gearboxes: the Collins R-390.

This design is the most complicated of them all, the fore-runner to the more numerous R-390A. The R-390 design was by Collins, and early examples were all made by them in their own factory. This late model was manufactured by Motorola for Collins, and was in scrap condition when acquired. This design was built to satisfy procurement contract 14214-PH-51. The R-390s run very hot because the thirsty HT system is fully regulated by a pair of beefy 6082s. Worse still, there are lots of valves on both the top and the bottom of the chassis, without much room for ventilation. The R-390 tuning is rather heavy because of all the mechanical transmission, but everything does work well enough. The Collins 307E-1 4:1 geared reduction knob shown here, is a modification fitted by a previous owner, and was originally a costly option for the 75A-4. The rear panel fitted tools are missing, as usual. The weakest part of the R-390 electrical design was the calibrator, which was not only complicated, but also prone to producing the wrong output frequencies! Early sets had badly designed kHz shaft endstops which could be over-ridden. Production of the R-390 receivers was so expensive that a cost reduction exercise had to be instigated. This resulted in the simpler R-390A. The 26Z5W & 6AK6 valves, and also the 3TF7 barretter are all proved to be rather fragile in service with the R-390, despite which all three of these types were designed into the later R-390A.

16.6 Permeability Tuning: the Collins R-390A.

This is the front end RF assembly. Late production subassemblies such as this one had ball bearings in each slot roller as well as in each cam follower. This gives lighter tuning than on early models such as the Collins seen behind it, which had plain slot bearings. The underside photo shows extensive earth strapping not found on early units. This was a production modification to reduce the quantity and level of spurii. The R-390A was a simplified and updated version of the earlier R-390. It had only one RF amplifier instead of two; no squelch; simplified audio filtering; an unregulated main HT system with electrolytic capacitors; pressed instead of cast chassis fittings; simplified mechanics and second LO; and mechanical filters instead of LC filters. The early winged emblem R-390A mechanical filters are robust. Later round emblem ones work better but were more cheaply made, using foam (which nowadays will be rotting) to support the filter assembly inside its cylindrical can. These later filters are prone to irreparable failure under mechanical shock, and look certain to become a serious problem in the years to come. Replacement types are now (at last) becoming available to the collector’s market.

Despite being simpler and cheaper, the R-390A was not really inferior to its predecessor. This represents a significant engineering achievement. Many manufacturers made the R-390A. The complete list together with the estimated delivery quantities (originating from N5OFF to whom go the author’s thanks) is: Collins 6185, Motorola 14202, Stewart-Warner 6587, EAC 11686, Capehart 4237, Amelco/TSC 3642, Capehart o/b/o Adler 5, Imperial Electronics/TSC 3976, EAC/Hammarlund 118, Dittmore-Freimuth 215, Fowler 2. This last order was as late as 1984. Total production of complete R-390A radios was thus 50855. Very many modules were also manufactured as spares. The complete radio photographed here shows Collins serial number 24 of order 14214-PH-51. This order was satisfied by the very last R-390 deliveries as well as by the very first R-390A deliveries. This set is thus the twenty-fourth production R-390A model ever made. It is in excellent condition following a very detailed restoration. Every one of the modules is original to this particular chassis. The front panel is a late-production engraved example. The original silk screened front panel is in fair condition, and safely stored for posterity. This set has one non-standard mechanical filter, open-frame line and audio output transformers, and a 6BE6 product detector. It is otherwise exactly as built by Collins.

16.7 An Unusual Chassis Design: the RME model 99.

The RME99 is a very rare radio - at least in the UK. This example is unfortunately rather corroded, but now once again fully functional after many years of damp storage in a shed. Note the cast Aluminium frame, onto which is screwed a flat tinplate chassis bed. There is no separate front panel, because the radio chassis assembly slides into the case from the rear. All the markings, the meter and the glass are directly carried on the front of the box. This unusual construction must have caused production of the RME99 to be rather expensive. There are lots of loctal signal valves, plus an octal neon and a UX4 rectifier. The Iron components are far larger than normal for a set of this class. The main tuning dial is the tiny window on the right, which has a superb hand-marked vernier scale. The big dial is for amateur radio bandspread. This set works very well indeed, and is a credit to its designers all those years ago.

16.8 Tuning Racks: the National NC100XA.

This set represented a technological dead-end. The highly unusual mechanical arrangement combines generally bad chassis accessibility with a severe shortage of headroom for nearly all of the chassis components. The RF tuned circuits are well isolated from each other, which is a very good feature of this design. The huge cast "catacomb" carriage bears a rack which is moved from side to side by a spring-loaded pinion mounted on the bandchange shaft. The RF/IF design features are generally similar to those of an HRO. In this case, the early style filter with its demountable crystal is used with the later metal octal series of valves. There is only one RF amplifier, a low performance 6K7. An infinite-impedance detector is used for generating AGC. The lack of any cover over the tuning gang is not too serious as the cabinet is poorly ventilated, reducing the ingress of dust and draughts. Adjusting the dialdrive endstops is extremely tedious. A clever mechanical arrangement lengthens or shortens the traveling pointer to indicate the range in use. The PSU and audio area of this chassis is non standard. This radio originally required 110VAC mains, and required an external output transformer for its output stage.

16.9 The Best of the Wartime Sets: the RCA AR88D.

This radio has a superb, anti-vibration mounted RF unit that used edge of technology materials when first introduced. To satisfy the design intent of producing a truly leading edge receiver, the variable capacitors were housed in a box inside another box, to reduce the ingress of draughts. This improves the short term LO frequency stability. The RF trimmer capacitors are airspaced tubular types, each fitted with ceramic guides at the top and bottom. All valve sockets and switch wafers are ceramic. All RF coilformers are polystyrene, or something very similar. The only real weaknesses in this design were the wax in the IFTs which proved to be hygrascopic, and a definite tendency to eat HT Iron components caused by a leaky grid capacitor feeding the 6K6GT output valve. The back bias HT system is used in the AR88D. This sometimes gives problems with burned out dropper resistors, and the big decoupling capacitor block can weep oil from the base seals. This particular AR88D is an early example. Those AR88Ds kept in service with the UK armed forces after World War II had the front panel machined flat, the Chromium plated horizontal strips removed, and the legending engraved. All this was to allow easier decontamination by Fuller's Earth, in the event of fallout occurring during a nuclear war. Some of these long-serving sets were rewired in PVC by McMichael, and would probably represent the best of the many survivors of this model. Some AR88Ds were released new and crated in the 1960s. Variants included diversity models and the CR93, which had front-panel control of IF crystal phasing. There was also the excellent AR88LF version, which had a 735kHz IF, different rear panel arrangements, a simpler (but superior) 6V6GT output stage and screened rear panel connections. This variant had no topband coverage, which made it unpopular with radio amateurs.

16.10 British Post-war AR88 Equivalent: the GEC BRT400D.

This set used octal, B8G (similar to loctal), B4 and B7G valves. Later variants such as the BRT400K, used B9A and B7G valve types whilst keeping the B4 neon and a couple of octals. What a strange mixture of valve bases! This particular radio has the BRT403 calibrator fitted. The BRT400D was broadly equivalent to the AR88LF & AR88D combined, but GEC fitted a calibrator as well. (In comparison, none of the AR88 family was ever given a calibrator.) The underside photo shows the inaccessibility of the RF unit which cannot be dismantled, since all its partitioning bulkheads are not only riveted, but soldered into position. Only the LO gets the benefit of ceramic switch wafers, though all signal valve sockets are also made of this material. These sets run very hot indeed because of the unusual active smoothing arrangements. Two beefy KT81 beam tetrodes are used - one for the audio output, the other for the HT smoothing. The HT current drawn by a healthy BRT400D specimen is no less than 167mA. This is almost double the requirement of most similar sets. (The later BRT400K used EL84 pentodes, and got by with a more modest 140mA of HT current drain.) The BRT400 has an anode bend AGC detector which works well, and there is a particularly praiseworthy signal detector and audio system. These features make BRT400s very suitable for SW broadcast reception. The pointer travels on a stranded steel wire. Each range dial strip is individually lit. The dial register is backlit by a bulb which also illuminates the interior of the set. Yet more bulbs are fitted to the dial vernier and to the meter - making ten bulbs in all, plus two spares! This is surely a record number for an HF receiver. In general, BRT400s are found well cooked and in very poor condition. But service lives of 50 years are known. This indicates their toughness, and the excellence of the components. Moral: the Brits could make decent receivers when they really tried.

16.11 Rare and Complicated: the McMurdo DST100.

This very strange receiver uses many American or Canadian chassis parts in its construction. It is a double-superhet constructed on two chassis. These have to be unwired from each other before removal of either unit from the cabinet is possible. All five top, bottom, side and rear plates are removable, to leave the chasses and front panel in position supported only by the steel skeleton frame. There is variable RF reaction, preset IF reaction and an infinite impedance signal detector. The seven IFTs are all plug-in octal types. Unusually for a wartime British radio, a tone control is fitted. There are no fewer than three tuning controls, all mechanically interconnected. This set has two meters… neither of which works as a conventional S-Meter! The front panel RF trimmer adjusts the mixer grid, not the aerial circuit. This set is very large and heavy, despite which it needs an external HT and filament power supply. The front end valve is a VP41 with a 4V heater which is fed from a dropper resistor. All other valves are standard 6.3V international octal types. The RF valves are mounted upside-down underneath the chassis. The lack of any cover over the tuning gang is not significant as this component is also hidden away underneath the RF chassis. There are seven turret tuned ranges covering from 50kHz to 30MHz with no gaps. On the lowest range, twelve 110kHz IF coils are operational, giving remarkable selectivity. Over the various ranges, three different conversion schemes are used. General accessibility is very good indeed, and the quality of the circuitry design is truly exceptional. The only real design weakness is the second LO, which could have been crystal controlled, but wasn't. These sets were made on a farm near Whitby in Yorkshire. Although designed for the Army, most of the 1000 or so DST100s that were manufactured, were actually used in RN shore stations. These sets were made by made by McMurdo and RAP.

16.12 Fire Hazard: the Hammarlund SP600JX-6.

Radios like this one should be treated with deep suspicion unless all of the original Sprague Black Tubular capacitors have been replaced, and unless the winding/chassis insulation of the HT choke has been checked carefully. Removal of the RF unit on this radio is very difficult, and the turret stator contacts are impossible even to inspect without prior removal of all biscuits from the drum. The ceramic biscuits are not individually screened, but are extremely well made. The variable capacitor has a ceramic shaft. The HF coverage of this set exceeds 50MHz. A 5R4G is used as the rectifier, which is a highly unusual (unique?) choice in this class of equipment. The SP600s did not stay in active service long because of their incendiary tendencies. Many of them were quickly made available to American amateurs for use on MARS USA-Vietnam communication links. The on-air performance is generally good, other than suffering overload problems due the excessive RF/IF gain caused by the many 6BA6s and 6BE6s. There were many production variants, including at least one VLF type. This example is the relatively common US Navy SP600JX-6 type R-274B/FRR, which was built to JAN specifications.

16.13 Styling: the Hallicrafters Super Skyrider SX28U.

This clever wartime set switches an RF amplifier out of circuit on the ranges where it is not needed, has two independent AGC systems, a proper Lamb IF noise silencer, and push-pull audio. A high slope front end valve is fitted on the MF and HF ranges, and there is bandspread on the HF amateur frequencies of the day. For all this complexity, there is no neon. This set is more cheaply constructed than the AR88D and is much its inferior as regards drift and image rejection at 30MHz. The SX28 would have been much better with proper top, front and bottom covers over the RF unit, better coilformer materials, ceramic switch wafers and airspaced trimmers - all of which the AR88D has. The pointer length is controlled by the wavechange switch, and its image is optically projected onto the tuning scale to indicate the range in use. The design of the coilbox is extremely unusual, and very elegant. The coils and trimmers are carried on individual removable bulkheads, making servicing easier than any comparable radio yet seen by this writer. These radios were much used by the US armed forces, and were very common in airfields all around the world long after the war. The only real design faults are a tendency to develop modulation rise in a 6L7 located in the IF strip when receiving a strong Medium Wave signal; and a more serious tendency to burn out Iron HT components due to leakage in the grid coupling capacitors feeding the 6V6GT output valves. Interestingly, the later SX28A variant used much smaller RF coils. This made for much simpler and cheaper coilbox, but it worsened what was already the least good feature of the basic design: its RF performance.

16.14 Overkill for SSB: the Hoffman CV-157.

This ISB adaptor was initially intended for use with the the R-390, but it is equally usable with the R-390A. It is very large and heavy. This equipment contains 44 valves, almost half of which are double-section types. There is motorized AFC, and the sideband filters are physically huge. In the days when this was made and for many years afterwards, it was conventional to operate the radio with a much wider IF bandwidth than would be considered acceptable today. This was necessary for the AFC to work properly. Each sideband filter in the CV-157 is 6kHz wide. It is important to understand that this unit was primarily designed for teleprinter sideband traffic, not voice.

16.15 Collectability: the Eddystone S940C.

There is no doubt that valved Eddystones of all types are reasonably good investments by the standards applicable to this hobby. This is the S940C, which was designed to use up Eddystone's old stock of subassemblies and components. Early sets had metal knob skirts, and a slightly different dial plate. The mains transformer is over-size, and produces a considerable excess of HT voltage. This radio was quite well specified, and is understandably popular with collectors. It has push-pull audio, a cascode ECC189 front end, and a proper product detector. Weak points in the design are: a) pulling effects due to AGC being applied to the mixer (remove AGC from the ECH81 for an instant and substantial performance improvement); b) the poor dynamic range of the 6BE6 heptode product detector; and c) the lack of any cover over the tuning gang. Eddystones of this and earlier periods are full of poor quality passive components which will need to be replaced en masse during restoration. The mechanical design is based on excellent castings, but the overall performance is let down by cheap materials, poor grounding and small RF coils which cause mediocre image rejection on 10m. The meter has the usual Eddystone nonsense calibration, scaled 0 to 10.

16.16 Heavily Screened: the Eddystone S880/2.

This novel design of radio has 1MHz ranges and extremely elaborate screening for the various oscillators, in order to reduce oscillator breakout to extremely low levels. The construction is modular. Unfortunately, the tuning is very stiff due to the complexity of its permeability tuning mechanism. Rather than using cams and followers, this set uses screw jacks to raise and lower the slug platform, which carries very many cores. The RF coils warrant very close inspection to discern their design and manufacturing cleverness, which easily out-did Collins in terms of design elegance. The VFO uses a precision Wingrove & Rogers variable capacitor, and is extremely stable and linear. The IF strip relies on quartz 500kHz twin-slice B7G filters which were inadequate compared with competing radios fitted with Collins mechanical filters, or those other radios using a 100kHz final IF. This set does have a proper product detector (albeit of suspect design using a 6BE6 heptode); AGC tailored for SSB; 50kHz/revolution main tuning; a separate electrical fine tuning vernier; and a switchable fixed or variable BFO. These are all features which make the S880/2 feel fairly modern to operate. The front panel is a casting, which can be unplugged from its cableforms to aid servicing. This set is extremely heavy due to its extensive use of brass plate, much of which is Silver plated.

16.17 Coilpacks: the Eddystone 358X/B34, National HRO-MX.

Both of these radios use plug-in coilpacks and external power supplies. The American design works better than the British one because its coilpacks contain tuning elements for two RF stages instead of one. The HRO's plug-in subassemblies are fitted below the valves and so LO drift is far less of a problem than on the Eddystone, which mounts its coilpacks on top of the tuning gang just below the cast cabinet lid, and right next to the EL32 power output valve. In the days when the 358X was made, Eddystone seemed to use metal castings wherever they could, whereas the National set is more conventional in construction, except for its PW dialdrive. The Eddystone drive is far superior, in fact this is one of the best ever made. Neither mechanism has the benefit of any proper positive endstops. Both of these sets were notorious for their high levels of local oscillator radiation. Neither was ideal for use on board ship as the position of the receive antenna could all too easily be located by hostile direction finders. Nevertheless, both types were pressed into service at sea. The HRO S-meter is an authentic illuminated type taken from a scrap early example, and is less useful than it looks because its movement is very underdamped. This particular HRO-MX was originally fitted with a plain Marion Electric 1mA FSD item. The Eddystone meter is for current testing the various stages, by means of a front panel rotary switch. This particular 358X receiver was built as a B34 variant for the RN. It has the EA50 noise limiter option and a 2-pole quartz lattice filter, as indicated by the suffix X on its commercial 358X part number. HROs of all types are easy to restore. The Eddystone is slightly harder, because of its overcrowded detector screening box.

16.18 Post-war Super Skyrider: the Hallicrafters SX62A.

This was really a super broadcast receiver rather than an out & out communications receiver. It uses a conventional twin pentode 6AG5 RF strip and eight-gang variable capacitor all the way up to broadcast Band II, though the mixer is a loctal triode type 7F8. A 455kHz IF is used on the lower frequencies, and 10.7MHz at VHF. This receiver is single conversion on all ranges of coverage. It runs hot because of thirsty push-pull 6V6GT audio. The lack of any cover over the tuning gang or any screening under the coilpack means that drift on Band II is always a problem. There is a neon HT regulator, but no AFC, tuning indicator or signal strength indicator. So retuning on FM broadcast stations is a frequent event with this set. The reproduction quality is truly excellent. The user handbook supplied when new, shows 7H7 and 7A4 loctals in the IF strip, but this example actually has 6SG7 and 6J5 octals fitted instead. There is a non-original 240V/110V autotransformer mounted piggyback on its mains transformer. This was fitted by the dealer when the set was sold new in Switzerland. Cost-cutting in the design is evidenced by the lack of any fuses whatsoever. To make things worse, the mains filter capacitors are of the notorious Sprague BT type. These are very prone to crack, and develop serious leakage.

16.19 Last of the Line: the Drake R4C.

This design is a hybrid which uses valves for the signal stages and transistors for the ancillary circuitry. The performance of these sets is excellent but depends on expensive multipole plug-in crystal filters. As always with Drake the ergonomics were unusual, and the tuning feels rough due to the use of cheap plastic gears. The very last few R4Cs used brass gears, which worked much better. This is a mid-late production variant, with 6EJ7 mixers. Earlier R4Cs had 6HS6 mixers, and the ability to select only one CW crystal filter. This situation is typical of Drake’s seemingly endless variations in production build standard. The design quality of the R4C is very variable. The signal stages are superbly engineered. In contrast, the power supply is very badly designed and prone to burning its printed circuit board. Class A audio is used to avoid DC line fluctuations on speech peaks, a design nicety evidently not understood by those who would have you fit a modern class-B audio chip instead. However, it has to be said that the standard R4C audio output transistor is mounted directly below the VFO, and this does cause slow thermal frequency drift. This problem could so easily have been avoided by a using better physical layout. There was a hum problem on nearly all R4Cs caused by the layout of the chassis, and its wiring. Part of the reservoir AC current was allowed to flow through the audio board. On the very last few R4Cs, some additional thick wiring was used to route this AC hum current past the audio board without having to flow through the Copper print on its way back to the rectifier anodes. The R4C does not share its mixing configuration with any Drake transceiver except the rare, and much later TR5.

16.20 The Most Famous Ham Receiver: the Collins 75A-4.

This radio was extremely expensive when new, being roughly the same price in the UK as a contemporary Jaguar car. Plug-in B9A mechanical F455J-series filters provided the IF selectivity. The angular position of the PTO subchassis was ganged to the angular position of the BFO capacitor in such a way that front panel control of passband tuning was provided. The coupling mechanism was a flexible bronze drivebelt. This same technology was also used to raise or lower the slug rack. A regenerative adjustable notch filter was fitted, and the set had an early twin-triode product detector. This particular example has been modified to incorporate an E88CC frame-grid twin triode first mixer and a 7360 beam deflection second mixer. An IF tailing filter has been added, clamped to the inside of one of the chassis apron sidewalls. The result is a considerable improvement on the original circuitry, which used two 6BA7 mixers and was very prone to premature overload. Although impossible to quantify, the 75A-4 has a very nice “feel” when in operation, and it is an unfatiguing set to operate for long periods. Collins lost these nice ergonomic touches with their later S-line equipments.

16.21 A Competent HF Transceiver: the Collins KWM-2A.

This example has the 136B-2 four valve TRF noise blanker option, which was fed from an external VHF whip antenna. It also has the rare B&W 340-A notch filter option. Early winged emblem examples such as this one used hard-wired unencapsulated relays on the underside of the chassis. They gave regular trouble in service. This set has been fitted by the RAF with the enclosed plug-in relays found on later round emblem radios. The receiver section of this radio works very well indeed, despite most of the valves also performing transmitter functions. The piggyback speaker and mains power supply unit is the model PM-2, which was intended for light duty work only. The mains transformers were rather fragile. This example has had a Gardners unit fitted by the RAF. It is of far higher quality than the original Chicago Standard Transformer Co item. The only operational irritation when using SSB mode, is the lack of an RIT control. In the days when Collins were the only SSB manufacturer, this feature would not have been needed because everyone else was also using Collins gear. None of it drifted much, and all of it drifted in the same direction in any case. The CW mode of operation is rather poor, as this radio gives a 1.5kHz receive frequency offset and has no narrow filter. The radio was in scrap condition when acquired from the RAF, and required a lengthy rebuild using many mechanical parts taken from another junked set. This particular example is kept in a model CC-2 fitted suitcase. By the time the KWM-2 was produced, Collins dealers were well versed in the art of persuading purchasers to also buy a wide range of expensive accessories, to increase the overall profit in the sale.

16.22 Wadley Loop Implementation: the Racal RA117A.

This was a derivative of the earlier RA17, and could be externally controlled by an early synthesizer called a Racalator. The design simplification was achieved by using a bandpass IF strip instead of the tuned and mechanically tracked arrangement of the earlier model. All members of the RA17/117 family are electrically and mechanically unconventional. The circuitry uses the Wadley loop principle to give a full set of 1000kHz ranges without a bank of individual conversion crystals. It has high slope frame-grid pentode mixers, and a modular form of construction which is based on a cast Aluminium RF platform. Readout of frequency is presented on an excellent filmstrip scale. This variant was designed for the North American market. Therefore it has a 6AQ5 audio output stage and standard US valve types except for the E180F mixers. The RA218 ISB adaptor seen here has 3kHz wide SSB filters, and provides a useful fine tune function as well. Some aspects of the RA117 and RA218 alignment sequences require patience and good test equipment, but this RA117/218 combination works well when correctly set up. On the RA117A, the VFO does drift a bit. This characteristic is unlike earlier and later variants, which were notably stable. The radio's IF filtering is reasonable, but a mechanical filter would have helped greatly. On all radios in this family, it is essential to keep the bottom covers well fitted in order to avoid gross spurii at multiples of 1.000MHz.

16.23 Early HF/VHF: the Hallicrafters S36/BC-787-B.

Although billed on its front panel as an "Ultra High Frequency" receiver, this radio covers 28 to 144MHz in three switched ranges. The BC-787-B is the military variant of the Hallicrafters S36. This one dates from July 1944. Its forerunner, the S27 was a very similar set which had played an important part in the development of military airborne navigation systems. The S36 was later developed into the S36A, which had permeability tuned IFTs. The S36 uses a single conversion 5.25MHz IF strip with a choice of two bandwidths, and is capable of demodulating CW, AM and FM signals. The power supply uses a 5U4G rectifier plus octal neon, and the audio is this manufacturer's standard 6SL7GT & class A 6V6GT push-pull arrangement. The IF system uses metal octal valves throughout. The really interesting part of the design is the RF unit, which is a substantial compartmentalised plated metal box containing the classic 956 front end, 955 local oscillator and 954 mixer acorn valve lineup. A puzzle is why the RF amplifier used a vari-μ valve, when no AGC was applied. It would seem that a 954 would have given somewhat better sensitivity. The tuning mechanism uses a conventional three section variable capacitor which is very well engineered. The rotor sections are insulated from each other. The switching, valve socket arrangements, and general constructional techniques pioneered on this receiver, set the industry standard for fifteen years. A proper mains input RF filter is fitted, which is always a sign of careful detail design. This radio is extremely heavy. It drifts very little, a tribute to sound mechanical and thermal design and the quality of components & workmanship employed in its construction. Unfortunately, the design is marred by inadequate mains wiring which is just ordinary thinly insulated stuff carried in the main loom. As is often the case with American designs, a single fuse is in one mains line and a single pole switch is fitted in the other.

16.24 For the Avro Lancaster Bomber: the RAF R1155A.

The radio was designed by Marconi, who made by them in Chelmsford. Also manufactured by EKCO down the road in Southend on Sea. The R1155 is a truly superb design which manages to cram more block diagram into its box than almost any other receiver of similar vintage. The cleverness of the R1155's design extends well outside the radio, to encompass an extensive harness system which included the companion T1154 transmitter, a crew intercom and a highly elaborate direction-finding arrangement. This particular radio arrived in scrap condition. Typically of those surviving into the 1990s, the DF equipment had been ripped out and a mains PSU and output stage fitted instead. The rebuild to sort out this mess involved the fitment of many new components, especially replacements for all the original three-in-one metal tubular decoupling capacitors. A 6V6G output stage was later refitted to this chassis for convenience, and an external PSU/loudspeaker was built. The power requirement is unusual in that the HT supply needs to be fully floating. The BFO and the local oscillator are unusually pure, with the result that this radio manages to sound like a fairly well sorted SSB design fitted with a product detector. The RF coilbox design is especially praiseworthy, managing to be both compact and easily serviceable. An unusual (unique?) design feature is that the BFO runs at half-IF frequency, in a successful attempt to reduce the quantity and level of harmonic spurii. The R1155 had a very complex production history. Many variants were developed to cover the extension of deployment to MTBs etc (requiring steel cabinets in place of the original Aluminium and a different frequency coverage), and to include anti-jamming circuitry to prevent interference from high level unwanted carriers. Later R1155s were built with a greatly improved dialdrive. Earlier examples such as this particular EKCO R1155A, received this modification when in the RAF workshop for periodic overhaul. That is probably why this example is fitted with the later assembly.

17. Glossary

Some useful materials are described below, together with alternative names used in some territories, where known. I strongly recommend you to study the safety notes provided with each chemical that you intend to use, as in some cases the information I provide here might be incomplete, misleading or even incorrect. There may be legal requirements applicable in some territories, covering for example acquisition, licensed usage, handling precautions, storage, disposal, access by pets and children, and maximum storage lifetime. All chemicals need to be correctly labeled. Some of the product names I have used may be registered as trademarks. You may wish to check before purchase, to ensure you are being offered the “real thing” and not an inferior substitute.

Araldite: Epoxy resin adhesive made by Vantico AG. The adhesive is supplied as a twin-pack comprising equal measures of base adhesive resin, and oxidizing hardener. These components must me mixed thoroughly before application. “Hard” and “Rapid” grades are available. In reality, these have setting times which are best described as extremely slow (days), and slow (hours) respectively. The actual setting time is very dependent on temperature. Araldite has excellent insulating properties, and can be used as a potting agent. Non-hazardous in use, but very inclined to create a sticky mess if mishandled.

EP90: Extreme pressure lubricant of SAE90 viscosity rating. Widely available as a specialized lubricant for hypoid automotive, agricultural and commercial vehicle rear axles. Most types are mineral-based, but fully or partly synthetic versions exist such as Syntrans and Syntrax. The EP90 lubricants have good “stay put” properties, and are very useful on radio dialdrives and gearboxes.

Evostik: Impact adhesive made by Evode Ltd. A heavy petrochemical base is used to support a rubber adhesive which bonds quickly on contact. This solvent is extremely flammable. Can be used as a small gap filler as well as an adhesive. This adhesive sets very quickly.

Fluxite: An acid grease flux for use when soldering a chassis or other large steel assemblies. Corrosive. Excess flux needs to be washed off after use - I use methylated spirit to do this job.

Iso-Propyl Alcohol: IPA. This is a general purpose organic solvent which is not too harsh, and generally does not attack colour rings on resistors. It is considered safe to use, though flammable. Leaves a very unpleasant smell. Iso-Propyl Alcohol is generally considered to be the successor to Carbon tetra-Chloride, which was banned in the UK a few years ago due to safety concerns.

Jenolite: Ferropro. This is a rust pacification agent based on Phosphoric acid. Hazardous to use, so wear gloves and goggles. Start by wire-brushing or sanding the loose rust away, so that the metal surface is as clean as possible. Wash the radio and also yourself thoroughly afterwards. This material converts rust to a black phosphate which can be over-painted. A variant of this material is Kurust, which appears to combine a rust pacification agent with a grey paint primer.

Jizer: This is a derivative of paraffin which is intended for use as a de-greasing agent. Water-soluble, so can be removed by washing after initial application with a stiff brush. A similar chemical available in the UK is called Gunk. This is black, and a lot more oily. It is even better than Jizer for removing extremely dirty old grease and congealed oil. B40 and other chain-drive owners might find this stuff especially useful. (-;

Kilopoise 0868S: A specialized super-viscosity lubricant made by Rocol, comprising a silicone lubricating base thickened with soap and loaded with silica. Useful for lubricating balldrives. This material is extremely sticky, and very difficult to remove after application. Somewhat inclined to creep away from the point of application. Incompatible with mineral oils and greases, all traces of which must be removed before applying 0868S. Non hazardous to use, but very inclined to create a sticky mess if mishandled.

Kwikfyl: A specialized wax crayon stick which is available in a wide range of colours. Useful for filling the engraved characters found on panels, escutcheons, bezels and knobs. Applied with a candle, any excess material being removed with a rag immediately. Non hazardous.

Methylated Spirit: Meths, wood alcohol, de-natured alcohol. In the UK this stuff contains Pyridine dye, which is a strongly basic violet-coloured additive. Methylated spirit is very useful as a cleaning agent, since it is cheaply available in the UK. Because there is extensive water content, this material works as a combined organic and inorganic combined solvent. For this reason, methylated spirit tends to remove oily dirt rather better than anything else does. It is considered safe to use, though flammable. Has been known to wreck silk screened tuning scales, and can dissolve varnish finishes surprisingly quickly. Methylated spirit can stain metal surfaces pink or purple, and can leave corrosive salts behind when the surface has dried. For these reasons, it is often a good idea to finish with a water wash and then thorough drying. Tolerable smell, which departs after a couple of hours.

MS4: A clear silicone grease made by Midland Silicones. Excellent waterproofing and insulating properties. Not designed for extreme pressure lubrication applications, so of limited use in repairing gearboxes and dialdrives. Safe to use, and non-flammable. Has an extremely wide storage and operational temperature range. Difficult to remove, as it is strongly resistant to being dissolved by solvents. Tends to spread far beyond the point of application. Incompatible with many polishes, and can permanently smear dialplates if accidentally applied there. Needs to be kept well away from friction drive mechanisms.

Paraffin: Kerosene. This commonly available petrochemical is heavier than automotive petrol, but lighter than diesel. Good organic solvent. Less hazardous than petrol, though still flammable. Can dissolve plastics. Has a mild, distinctive smell. Slightly oily, and takes ages to evaporate after use. Leaves no residue. Seems fairly well suited to removing lightly congealed grease.

Petrol: Gasoline. An excellent inorganic solvent, though very harsh. Tends to dissolve resistor colour rings, also paraffin wax as used on old capacitors. Very inclined to dissolve plastics. Highly dangerous to use, as this material is very highly flammable. Very strong and unpleasant smell which seems to hang around for days even after all traces of the liquid seem to have finally disappeared. The leaded variety tends to leave a white deposit after drying. For this reason (and for safety) it appears best to use the unleaded variety.

Servisol: Specialized cleaning fluid for switches. In the UK, available as an aerosol with a long thin plastic application spout, or as bulk liquid supplied in an ordinary unpressurized metal can, intended for application by brush. Comprises a solvent, mixed with a contact lubricant which remains long after the solvent has evaporated. Often gives a long lasting, sometimes even a permanent repair for a noisy potentiometer track. Highly flammable.