When I Think Back...

by Neville Williams

Vintage radio receiver design 7
Enhanced audio, dualwave tuners & frequency changers

During the latter half of the 1930's, the audio systems in Australian radio receivers were upgraded by the adoption of negative feedback—offering better sound for both radio and record reproduction. Up front, dual- or triple-band tuners extended their coverage to the international shortwave bands. Ornate edge-lit glass dials became routine, perhaps in anticipation of the day when they would give place to a video screen.

While these and other developments can be identified with the late 1930's, the sequence in which they appeared is ambiguous. In the pursuit of market share, manufacturers tended to major on different features at different times, with the advantage accruing to those that managed to get it right in terms of sales appeal.

In this present article, it will be more realistic simply to discuss aspects of receiver design which characterised the period from around 1936 to the outbreak of war — an event which was to put domestic radio on hold 'for the duration'.

Fig.5 in the last article typified the design of domestic 4/5-valve mains powered superhets of around 1935/6. Fitted with AGC and magic-eye tuning, and offering acceptable audio quality, they gave their owners little cause for complaint. In a laboratory situation, however, limitations were still evident — which posed an ongoing challenge to design engineers.

So it was that while the 2A6/75/6B6 series of hi-mu diode-triodes appeared to meet the immediate need, engineers knew that *they were lacking* in treble response because of the so-called *Miller effect.* Incoming signals were being 'shunted' by the valves' intrinsic grid-anode capacitance, rendered the more serious by the fact that the anode was not simply an inert electrode but one that carried an amplified version of the signal — in opposite phase to the grid input.

The end effect, according to J.M. Miller of the US Bureau of Standards, was as if the grid-anode capacitance was (M+1) times its actual value, where M represented the voltage gain of the stage. The *Radiotron Designer's Handbook* (1940) quotes the 75 as having an inherent grid-anode capacitance of 1.7pF so that, allowing for a gain of 60, this translated into a dynamic (Miller effect) input capacitance of 105pF.

Duo-diode pentodes

While it could be argued that this was less of a liability than the audio bypass capacitors included elsewhere in the circuitry, engineers saw it as a needless treble loss of original signal that should be avoided, even if only on principle.

Valve manufacturers responded to their dilemma with the 2B7/6B7/6B8 series of duo-diode general purpose pentodes. As an R-C coupled audio amplifier, these offered a potential stage gain of 100 but, with a static grid-anode capacitance of only 0.007pF, the Miller effect capacitance amounted to less than 1pF — compared to 105!

Not surprisingly, for the cost of a screen feed resistor and bypass capacitors, many engineers opted for the diode-pentode rather than the diode-triode.

Alert to a still further design option, Australia's Amalgamated Wireless Valve Co (AWV) devised a special variant of the 6B7, the 6B7S, followed by *its* octal-based equivalent the 6G8-G. Whereas the original 6B7/6B8 had been classified as 'remote cut-off' pentodes, the 6B7S and 6G8-G were redesigned with a full variable-mu characteristic, cutting off at -43V — about twice the figure for the original types.

AWV engineers reckoned that the 6B7S/6G8-G could still serve as plug-in alternatives for the original types in most audio applications.

However, the full variable-mu characteristic should enable them to be used with variable bias and the valve(s) did, in fact, find limited use as gain-controlled audio amplifiers, supplementing normal front-end AGC *systems.*

In practice, however, they found their widest application as IF amplifiers in place of the traditional variable-mu 78/5D6/6K7 pentodes — the difference being that the IF output could be fed to the 6B7S/6G8-G's own diodes for detection and AGC voltage. By so doing, the entire tuner could be standardised around two valves, with an antenna feeding into one end and an audio lead coming out the other (see Fig.2).

The audio system could then likewise be self-contained, ranging from a single high-gain valve for an 'el cheapo' mantel set, to something more pretentious for standard or up-market models.

It may seem like a small point, but it fitted in with the emerging philosophy of regarding the audio system as an audio amplifier in its own right, rather than extra stages stuck on the rear end of a radio set!

Power pentodes

Back in 1936, the greatest single limitation on audio quality in 4/5-valve receivers had to do with the power output pentode.

With their high output impedance, these exhibited an exaggerated treble response and exaggerated harmonic distortion, when operating into the highly reactive load presented by a loudspeaker. They also imposed very little electrical damping do the cone, resulting in an unnaturally resonant or 'boomy' kind of bass.

As noted in earlier articles, designers sought td counteract these effects by wiring a tubular capacitor (e.g., 1 OnF or 0.01uF) across the loudspeaker transformer Primary, and/or resorting to treble-cut elsewhere. It sufficed as an interim measure, but the need to find a more fundamental solution to the problem was hastened by the release of the high-po r 6L6 beam tetrode, which could ge crate high frequency transients across a loudspeaker load of quite startling — and destructive — proportions.

In *Radiotronics* No.71 (December 1936), AWV published a circuit which proposed the most radical approach of all to the overall problem, namely to replace the output pentode with a 2A3 filament type power triode.

Adequate drive to the 2A3 involved the use or a 6C6 resistance-coupled pentode, preceded in the tuner by a 6A7 and a 6B7S. In this so-called 'fidelity' design, the highest level of overall distortion at any signal level, any modulation percentage and/or any condition of loudspeaker load was said to be 7%.

If this seems high by present standards, similar tests on a contemporary receiver using an output pentode yielded a figure of 30%!

Despit this evidence, and to the best of my knowledge, the idea was taken up only by la few hobbyists. Manufacturers presumably looked with disfavour on the marginally larger and more awkward power transformer that would be required, and the potentially less rugged output Valve. In addition, a new scaled-down beam power tetrode was on the horizon (the 6V6), which would make for good sales promotion — even if it didn't amount to much in practice!

Negative feedback

As id happened, the sante issue of *Radiotrbnics* was cautiously optimistic about die idea of using *negative feedback* with pentode (or tetrode) output valves — for the reason that, while preserving their efficiency in terms of current drain, it could artifically reduce their output impedance to approach that of a power triode. As a result, frequency response would be flatter, distortion drastically reduced and loudspeaker damping greatly improved.

Negative feedback involved diverting a small proportion of the output voltage from the power stage back to an earlier point in the audio signal chain, such that it would be out of phase with the input signal at that point.

Inevitably, in counteracting or partially cancelling the original signal — hence the description 'negative' or 'inverse' feedback — it would reduce the apparent gain of the system and necessitate a larger input signal. It offered a vital bonus, however.

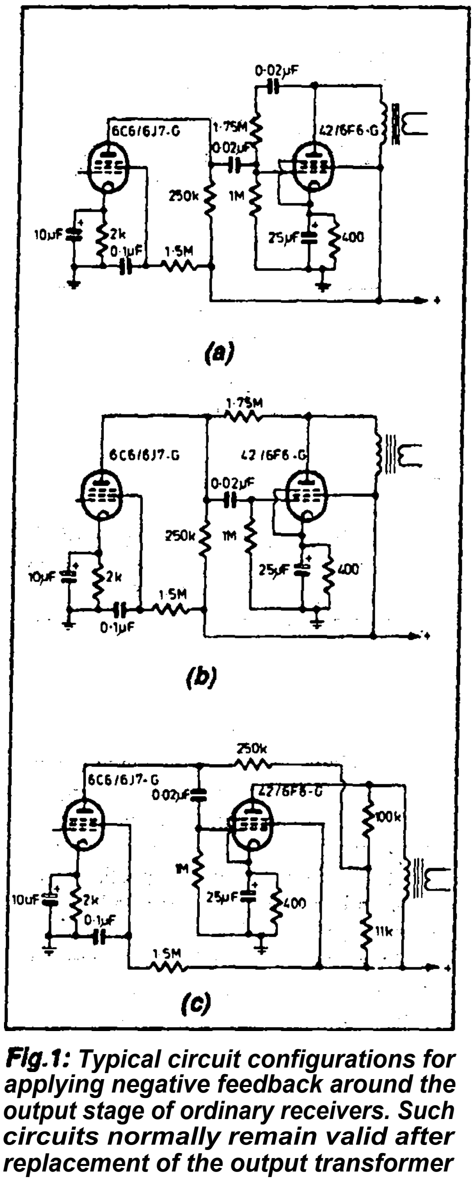

***Fig.1:** Typical circuit configurations for applying negative feedback around the output stage of ordinary receivers. Such circuits normally remain valid after replacement of the output transformer or even the complete loudspeaker.*

If the amplifier gain within the feedback loop tended to rise for any reason, over any part of the frequency spectrum, the output signal would increase accordingly. But so also would the sample fed back via the feedback path thereby increasing the degree of cancellation and further reducing the system gain.

By such -means, negative feedback would tend to counteract variations in stage gain, either up or down, so that the overall frequency response would be made smoother.

Similarly, if the stage(s) within the feedback loop generated spurious harmonics, they would be fed back to the input along with the legitimate signal. Being then amplified in reverse phase, internally generated harmonics would tend to cancel themselves, effectively reducing the level of distortion.

Again, if the loudspeaker cone tended to prolong sonic vibrations of its own accord, the mechanically generated wave trains would be fed back to the input of the amplifier in reverse phase, and serve ultimately to counteract the spurious cone movements which gave rise to them in the first place.

Research in Australia and elsewhere established that a voltage gain reduction of around 3:1 or 4:1(10 to 12dB of negative voltage feedback) was sufficient to impart triode-like characteristics to a power pentode output stage, in respect to the vital parameters mentioned above. In particular, the new and more economical 6V6-G could be expected to behave like a 2A3!

Simple circuits

Since the deficiences *in* the audio end of a typical 4/5-valve receiver related to the disparate characteristics of a power output pentode (or tetrode) and the complex anode load presented by a loudspeaker, an effective negative feedback path could most simply be provided between the anode and grid of the output valve.

Fig.1 shows a number of possible configurations, which appeared in literature of the period. Diagram (a), from *Radiotronics 71,* is probably the most obvious way of placing a feedback loop around the output valve, with a DC blocking capacitor and a series resistor simply strung from the anode back to the grid. With the grid shunted to virtual earth through its own 1M resistor and by the 250k anode supply resistor and the anode resistance of the 6C6/6J7-G, slightly less than 10% of the anode signal swing would be effective in the grid circuit.

At full output, on the basis of 3.1W into a 7000-ohm load, the signal voltage' at the anode would be about 150V RMS or 212V peak.

Of this, about 10% or 21V peak would be fed back to the grid so that instead of the rated figure of 16.5V peak, the required drive with feedback would become -(16.5 + 21), or 37.5V peak. This would be equivalent to a gain reduction of just under 2.3 times or 7dB — a rather

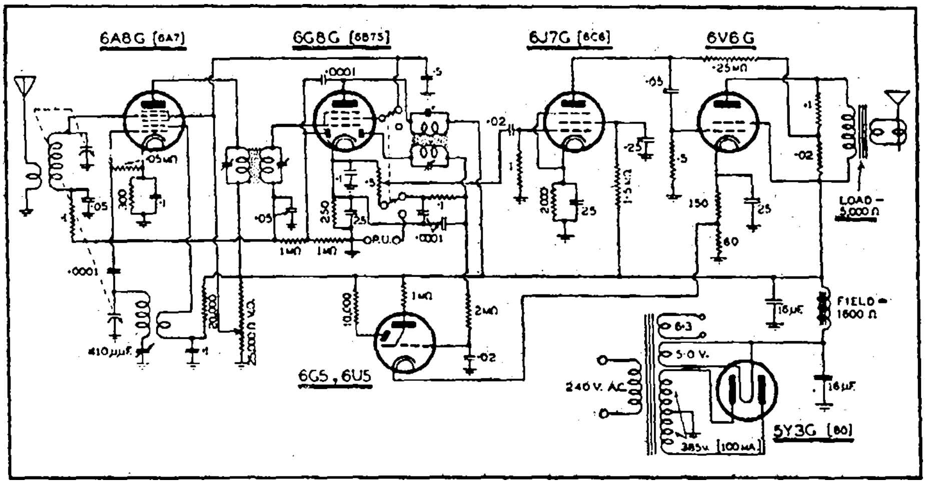

Fig.2: Circuit practice in the later 1930's, as exemplified in Radiotronics 81, published In November 1937. The choice of a 6G8-G in the IF stage allowed a 6J7-G pentode to be used as a driver ahead of the then-new 6V6G beam tetrode output valve. The circuit also assumes the use of ferrite-cored IF transformers, es indicated by the dotted area between windings.

cautious figure in terms of audio feedback design.

The figures indicate, however, why AWV encouraged engineers to provide a capable audio driver ahead of a feedback output stage — to ensure that adequate gain would still be available, along with a distortion-free drive voltage.

Fig.1(b) is/was very similar to (a), except that the blocking capacitor was omitted, with the resistor connecting to the anode of the voltage amplifier.

With the values shown, the gain reduction Would be identical to that of 1(a) — although in practice, the values could conceivably have been juggled slightly to maintain the effective DC anode feed resistance to the 6C6/6J7-G at the then-recommended level of 250k.

Fig.1(c) emerged as the most popular configuration of the day, probably because the feedback percentage was determined by a resistive divider wired directly across the output transformer primary.

With the constants shown, the basic divider *was* set for 10% — although only four-fifths of this, or 8%, would be effective at the grid because of the secondary divider formed by the feedback/load and grid resistors.

Again, some juggling of the divider could well have been justified to get the gain reduction closer to the desirable 3:1 or 10dB.

Such details aside, most 4/5-valve receivers employing negative feedback used a simple configuration along the general lines indicated in Fig.1 — and for this we can be duly thankful. Such circuits are inherently stable, and failed components can be replaced with equivalent values without apprehension.

This applies even to a faulty **output** transformer and, provided the replacement is a functional approximation of the original, the negative feedback will continue to ameliorate possible problems with frequency response, distortion and damping.

The same cannot be *said* of the more complex audio systems found in contemporary up-market receivers or standalone audio amplifiers. In such equipment it was common practice to mount the output transformer on the chassis, rather than on the loudspeaker, running the feedback loop from the secondary of the output transformer to a point relatively early in the audio chain. The design objective was to combat possible aberrations not just in the output stage, but also elsewhere in the audio chain.

In such circuits, the polarity of the transformer connections are critical, determining whether the feedback is negative or positive — in the latter case rendering the amplifier hopelessly unstable.

Voice coil feedback

If you have occasion to change the output transformer in such equipment, the appropriate procedure is to wire the primary in the most convenient manner, effecting the necessary connections to B-plus and the anode — or anodes in the case of a push-pull output stage.

However, the leads from the secondary winding should be spot soldered in a temporary fashion to the loudspeaker socket, one lead being usually earthed while the other feeds the other end of the voice coil and the negative feedback encuitry.

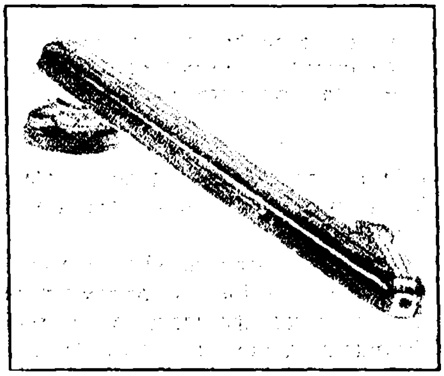

Fig.3: The earliest Astatic ,crystal pickups had a straight, rectangular metal arm. This then-new 0-7 model, featured in our December 1939 issue, had a more ornate moulded arm with offset head to counteract tracing error.

Unsolder this feedback lead and leave it disconnected for the next step. Connect the loudspeaker, switch the amplifier on and feed any available signal through it at a low volume setting.

Now, keeping your hands clear of high voltage leads, touch the feedback wire on to the point from which it had been removed. If the volume level increases or, more likely, if the amplifier emits a loud shriek or begins to 'motorboat', it is a pretty sure sign that the feedback is now positive.

In this case switch off, reverse the connections from the transformer secondary winding and try again. This time, reconnecting the feedback lead should reduce the sound level from the loudspeaker, indicating that the feedback is now negative, as it should be.

A problem with multi-stage feedback loops is that the phase of the feedback can still rotate at supersonic frequencies, to produce a degree of instability which may or may not compromise the behaviour of the system in the audible range.

Ideally, this should be checked after an output transformer has been changed — a procedure which calls for a high-performance AF/RF signal generator, square-wave generator and a wide-band oscilloscope.

But this assumes another level of expertise and is really outside the scope of this present article. Domestic 4/5-valve receivers rarely used voice coil feedback, if only because the output transformer was conventionally treated as part of the loudspeaker, rather than of the chassis.

Typical circuit

It fell to my lot to draft the circuit shown in Fig.2, which was devised by AWV Applications Engineer R.H (Dick) Errey. Published in *Radiotronics* 81 (November 1937), it was intended to epitomise appropriate circuit practices for contemporary 4/5-valve superhets.

The tuner was concentrated around a 6A8-G aril 6G8-G — in the latter case for reasons outlined earlier. (A separate article in the same issue of *Radiotronics* explains why a high performance pentode should be provided for in feedback circuits such as those illustrated in Fig.1).

The circuitry to do with detection and AGC broadly follows recommendations discussed in the last article, as also does that involing the 6G5/6U5 remote cut-off `magic eye' tuning indicator.

Series resistors in the HT supply to G2 of the 6A8-G and 6G5/6U5 target are intended to provide a self-compensating effect, particularly if the HT supply voltage should ri above '250V as a result of mains fluctuations.

By way of further explanation, the article says that investigation of early complaints about unduly short life of tuning indicators reveals that it had commonly been dud to excessive target current leading, some cases, to the target structure oming red hot!

It is a so noteworthy that the circuit provides for Radio-Phono switching, with one switch pole to select the desired input and the other to silence the tuner by interrupting the supply to the 6G8-G screen grid. The latter provision was to prevent Possible break-through of noise interference or powerful radio signals when playing records.

It was about this time, as I remember, that crystal pickups (Fig.3) were making an initial! impact on the market. While the early Astatic piezo models were rather Clumsy compared with their postwar lightweight counterparts, they had more output and a much fuller sound than typical 1930-style magnetics. They contributed significantly to the mid-1930's swing combination 'radiograms'.

The beam tetrode output valve is referred I to in *Radiotronics as* 'the new 6V6-G' — of potential interest to set makers cause it represented new technology, offered a marginal increase in sensitivity and an extra watt of power Output, albeit at about 10 milliamps extra current drain.

Note hat the feedback circuit follows Fig .1(c) but with an increased ratio of 20% — which according to *Radiotronics* ends up as an effective 10% at the 6V6-G grid.

Emphasis on feedback

In effect, AWV chose to divert the extra sensitivity of the 617/6V6 combination to the negative feedback, to provide a further contribution to quality rather than to gain — an indication of the emerging design philosophy of the day.

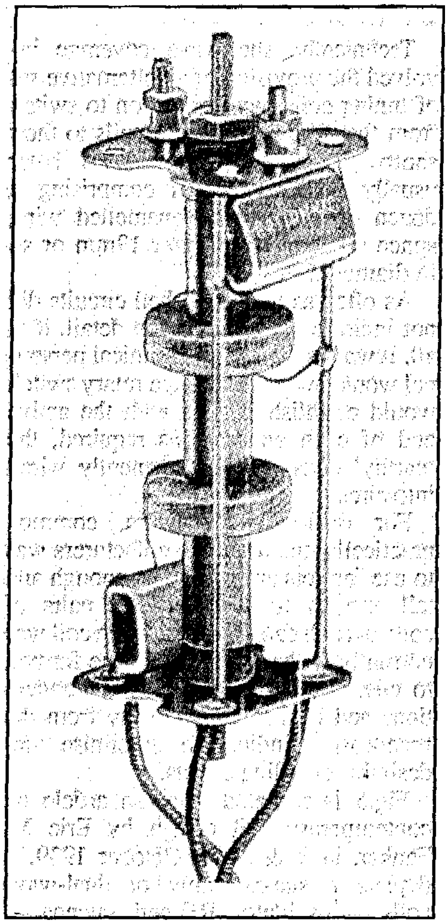

Fig.4: From the April 1941 issue of R&H, this Britannic IF transformer, minus its shield can, uses Utz pie-wound coils, fixed tuning capacitors and adjustable ferrite slugs for alignment.

So too, perhaps, was the tacit acceptance of a 100mA power transformer and the specification of 16uF filter capacitors, presumably to ensure adequate filtering with the somewhat reduced value of field coil impedance.

On the subject of gain, AWV suggests that the sensitivity should still be adequate for the reception of interstate broadcast stations or for use on the shortwave bands.

The addition of an RF stage, they say, would result in a high performance receiver with ample gain and good quality reproduction from both radio and records. As such, the design would become the 1937 counterpart of the high-performance 175kHz circuit featured earlier in this series.

A point of note is that a pattern of dots between the windings of the IF transformers seeks to convey the idea that each of the relevant coils has a central ferromagnetic core — normally slugs of powdered iron or oxide, moulded with an insulating binder and cemented inside the former on which the coils were wound.

As pointed out in the last chapter, the merit or Q-factor of IF transformers had already been boosted by winding the coils with litz wire, which offered a significant reduction in their RF resistance. It transpired that insertion of a suitably formulated ferrite core through the centre of each winding could provide the required inductance with fewer turns, therefore with less wire and a still further reduction in RF resistance.

This, plus the use of low-loss moulded formers (e.g., Trolitul) and Trolitul-based varnish pushed the Q-factor of 465kHz IF transformers to the point where designers, once again, had to balance selectivity against loss of treble due to sideband cutting.

(The emergence of Trolitul was featured in the very first issue of our predecessor *Radio & Hobbies* — April 1939 — in a feature article and in an RCS advertisement.

The same issue contained a contemporary discussion of selectivity by R.H. Errey, mentioned earlier. Further articles on selectivity and coil design appeared in the June, July and October 1939 issues, written by Eric M. Fanker -- chief engineer of Thom & Smith, makers of 'Tasma' receivers).

The use of litz wire and ferrite cores became so routine from then on that they were taken for granted, and not necessarily designated in circuit diagrams.

It also became routine to mould cores and formers with a matching thread, so that IF transformers and tuning coils 'could be aligned by positioning cores in the formers, thereby reducing reliance on trimmer capacitors (Fig.4).

This subject will be discussed in detail in a later article, to do with receiver alignment

Shortwave coverage

What triggered consumer interest in shortwave listening in the 1930's is open to speculation, although *EA's* shortwave listening columnist Arthur Cushen may have offered an inadvertent clue in his recent mention of the commencement of the BBC's World Service from Daventry, UK, in 1932.

Perhaps it was also due in part to diminishing interest in ordinary long dislance reception. With 'me too' programming and the increasing use of transcription discs, distant Australian stations no *longer* sounded all that different from the locals.

By contrast, periodic re-broadcasts of overseas stations often highlighted news, sport and events from countries that were still weeks away by steamship, and equally remote in terms of culture. With more and more overseas broadcasts penetrating Australian airwaves, it was intriguing to discover that they could be accessed with an otherwise normal receiver equipped to cover the shortwave bands.

For listeners in rural areas, shortwave reception offered a further bonus in that shortwave transmissions, both overseas and local, could often be heard at times when atmospheric . conditions had obliterated broadcast band reception.

Appearing on the market from about the mid-1930's, shortwave coverage began almost as a fad, but attracted attention as the overseas political situation edged towards war.

Most of the resulting receivers were D/W (dual wave) types, with coverage from about 16-51 metres (19-6MHz) in addition to the normal broadcast band. More pretentious receivers often boasted two shortwave bands in addition to the broadcast band, covering 13-39 metres (23-7.7MHz) and 35-105 metres (8.6-2.9MHz) — the latter taking in both the 40m and 80m amateur bands.

Because shortwave signals were commonly weaker Than local broadcasters, adequate receiver sensitivity was essential. But a normal 4/5-valve D/W superhet, with the ability to log interstate stations, was usually capable of a useful performance on short waves. The 5/6-valve circuits with an RF stage were invariably better, in terms both of sensitivity and signal/noise ratio. Even a few 3/4-valve mantel sets boasted shortwave coverage, although with strictly limited performance.

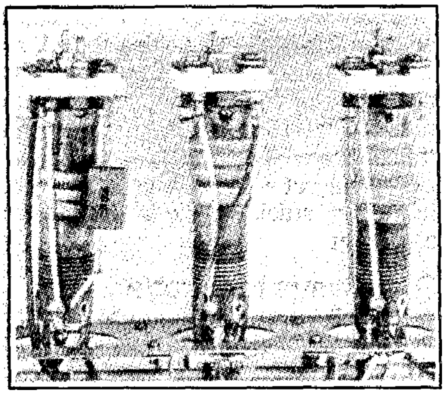

Fig.5: A sub-assembly of (presumably) Tasma coils from the late 1930's, ready to be bolted Into a chassis and fitted with cans. Alignment trimmers are at the top, normally accessable through holes in their respective cans.

Coils and switches

Technically, shortwave coverage involved the provision of an alternative set of tuning coils, with provision to switch from the normal broadcast coils to their shortwave counterparts — the latter usually being solenoids comprising a dozen or so turns of enamelled wire, space wound on a former 19mm or so in diameter.

As often as not, published circuits did not indicate the switching in detail, if at all. It was assumed that technical personnel would understand that a rotary switch would establish contact with the active end of each winding, as required, the 'earthy' ends being permanently wired into circuit.

For dual-wave receivers, common practice by the major manufacturers was to use formers and cans long enough and tall enough to accommodate pairs of coils in each can. The shortwave coil was normally at the lower end of the former, to ensure the shortest possible connections and be far enough away from the broadcast winding to minimise undesirable coupling effects.

Fig.5 is repeated from an article on contemporary coil *design* by Eric M. Fanker, in *R & H* for October 1939. It depicts a sub-assembly of dual-wave coils — oscillator, RF and antenna — presumably as used in an up-market Tasma receiver.

Alignment trimmers, one for each winding, are so positioned as to be accessible through the top of the individual cans. In the accompanying article, Eric Fanker explains the role of ferrite cores in the broadcast coils but says that, at higher signal frequencies, core losses would tend to overtake anticipated benefits, rendering them of little value.

Normal layout practice was to mount the coils alongside the tuning gang, with the decks of a rotary bandswitch immediately below and the relevant frequency changer — and possibly RF amplifier — valves nearby.

For each model, bench wirers were required to adhere strictly to a predetermined wiring pattern, to ensure the shortest possible signal paths on the high frequency band(s) and to minimise possible stray coupling between them.

The first rotary bandchange switch that I can recall was a dubious device with a separate, rather cumbersome wafer mechanism for each pole, supported by side-rods and spacers. The common contact on each wafer was a plated semi-circular strip, the other half-sector accommodating an arc of rounded brass rivets, each provided with a solder tag.

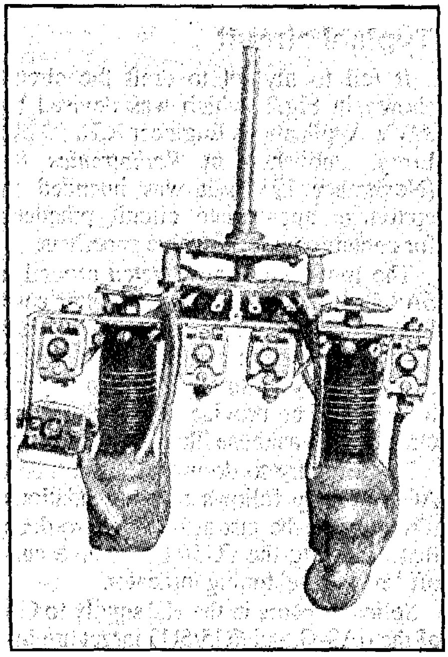

Fig.6: A Britannic pre-assembled dual-wave coil unit advertised In the April 1941 Issue of RSH. Mounted on a bracket attached to a Yaxley switch, It Is typical of units often used In home-built or small production-run 4/5-valve superhets.

Contact between strip *and rivets* on each wafer depended on a springy wiper blade, supported on a central rotatable shaft by moulded spacers.

One end of each wiper rested on the relevant contact strip; the other end was so shaped, with a hole or dimple, that it would mount and drop over the selected stud, establishing the desired circuit connection.

At best, the mechanism had a rather stiff and imprecise action, rendered so by the need to disengage and re-locate each wiper on a new stud in the somewhat flexible assembly. At worst, it was necessary to 'wiggle' the knob each time it was moved to ensure adequate contact_

If a collector should come across a vintage receiver with a switch answering this description, you will be looking at an historical relic — but a potentially troublesome one!

Fortunately, before many such receivers were produced, 'Yaxley' brand switches appeared on the market — followed, some years later, by a look-alike which was marketed locally under the

AWA/Oak banner. Both used a front clicker plate to provide positive indexing, and wafers able to accommodate multiple poles. These employed small, low-drag, silver-plated contacts.

Notably trouble-free, YaxleyOak inspired rotary switches are still with us decades later, and used for a variety of purposes.

Prefab coil units

In the major factories, it was possible to use separate coils, switches, capacitors and valves because the optimum placement for every component and every lead could be determined in factory prototypes and duplicated, as a mandatory requirement, by Production line assemblers and wirers.

But in the realm of hobbyists and kit suppliers, cottage industry assemblers and even small factories, rigid control of wiring was less practical and shortwave performance could suffer as a consequence.

Reacting to the situation, componc Et. suppliers made available a variety of pre-wired sub-assemblies which could be mounted in otherwise complete chassis, and installed by connecting up a few external leads.

The least pretentious of such sub-a :mblies comprised a Yaxley or Oak switch on a bracket, on which was mounted two antenna coils and two oscillator coils, as for a 4/5-valve superhet.

The assembly was often held in place by the lock-nut on the switch shaft and wired up according to the maker's instructions. (See Fig.6).

At the lather extreme were complete and much more expensive tun& sub-assemblies carrying the tuning gang and even the sockets for the frequency changer — and possibly RF — valves, all pre-wired and pre-tested.

Bolted into a suitable space in the host chassis, such units largely obviated any uncertainty about 'will it work?' Any number df variants between these two extremes may turn up in reclaimed valve receivers.

Frequency changers

At this point it had been planned to include a few paragraphs about the associated dial mechanisms and the problem of locating and tuning shortwave stations, but for space reasons, this has had to be held over until the next article.

It is appropriate, however, to round off this present discussion with a few relevant observations about frequency changer valves.

Throughout the mid-1930's, most mains powered receivers had used a pentagrid converter in the 2A7/6A7/6A8-G series. These lid done a useful job on both the broadcast and shortwave bands, although limitations had become apparent in the 20MHz region when changing conditions heightened interest in the 13-metre (22MHz) band.

At this frequency, the somewhat makeshift triode oscillator in the pentagrid series tended to become unreliable with ageing valves or reduced supply voltages, as well as exhibiting frequency shift with fluctuating AGC or other voltages affecting the mixer section. The resultant detuning tended to exaggerate the effect of signal fading.

In *Radiotronics* 84 (March 1936), AWV announced the pending] release of two new frequency changer valves to replace the 6A8 series: the 6K8-G and 6J8-G. These would use the same base and socket connections but could offer improved performance, given minor changes in the associated circuitry'.

As I recall, the 6K8-G was the first to become available in quantity, possibly because it had greater support on the American market.

Described as a triode-hexode, the triode was a separate structure, with a transconductance of 3mS (3mA/V) — being a very willing oscillator as a result!

In the mixer section, GI was the remote cut-off signal input grid, and G2 a screen grid; G3 was tied internally to the triode grid for oscillator injection, with G4 tied to G2 to provide further screening.

The input and output impedances of the mixer were higher than those of the 6A8-G, offering the designer improved performance by increasing the dynamic resistance of the input and output tuned circuits and optimising the oscillator grid current.

Compared to the pentagrid series, oscillator frequency shift due to applied voltages was said to be reduced by about 10:1.

The 6J8-G, described as a triode heptode, also featured a separate triode but differed from the 6K8-G in having a supressor grid, G5, in the mixer. This was tied internally to the cathode.

It had slightly lower oscillator and conversion conductance than the 6K8-G but, as I recall, was credited with higher output impedance, even better oscillator stability and a better signal/noise ratio. In Australia, at least, it ultimately became the more popular of the two types.

Other frequency changers appeared in Australian receivers in the 1930's, such as the Philips/Mullard octodes. But while they had their supporters, they were very much in the commercial minority.

(To be continued)