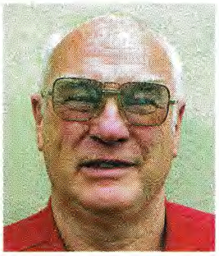
VINTAGE RADIO



By RODNEY CHAMPNESS, VK3UG

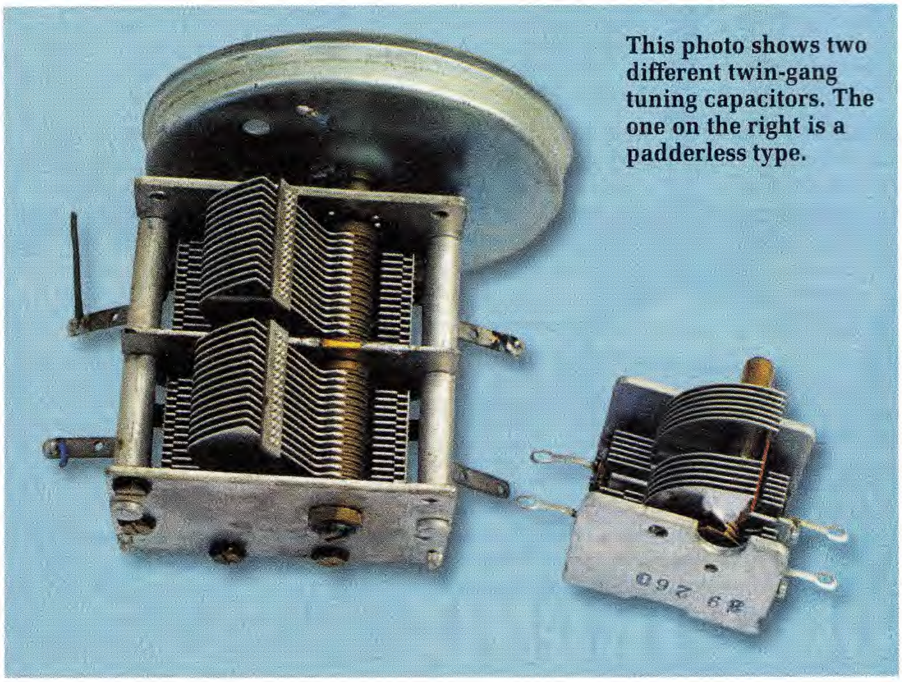
Aligning the front-ends of TRF & superheterodyne receivers

In the last two issues, we've looked closely at the IF stage in superhet receivers. This month, we take a look at the RF (radio frequency) circuits in TRF receivers, the local oscillator stage in superhets and at receiver alignment.

TRF (tuned radio frequency) sets were the most common receivers in the 1920s but their popularity rapidly decreased as the superhet became dominant in the mid 1930s. However, some manufacturers still produced cheap and simple TRF sets that could be used in high-signal strength areas. A typical set of this type is the Astor "Football" from the 1940s.

TRF radios had from one to four tuned stages. Initially, it wasn't necessary to have the stages track one another as individual variable capacitors were used to peak each station. However, this was quite a chore and the radio manufacturers soon decided to mechanically couple all the variable capacitors together in the more elaborate receivers – eg, by using brass straps and dial drums.

This made tuning much easier but it also meant that the sets had to be designed so that each stage tuned to the same frequency across the dial – ie, the stages had to track each other. However, in many cases, no attempt was made to accurately align each stage for best performance.



This photo shows two different twin-gang tuning capacitors. The one on the right is a padderless type.

Later on, a trimmer capacitor was placed across each tuning capacitor. This meant that all tuned circuits could be set to the same frequency at the high-frequency end of the dial, thereby ensuring the best performance possible.

By contrast, accurate tracking at the low-frequency end of the tuning range relied heavily on the accuracy of the winding of the tuning coils. This was helped by the fact that distributed and stray capacitance around the tuned circuit was less of a problem than at the high-frequency end of the tuning range. And as time progressed, manufacturers were able to wind the coils with quite high accuracy, which meant that it wasn't really necessary to later adjust the inductances.

However, I have found that almost all air-wound RF and antenna coils give improved performance at the low frequency end of the dial if an adjustable slug is incorporated in the coil design. Some older coils suffer from moisture ingress over the years and this causes the inductance to alter and the quality factor ("Q") to decrease, thereby lowering the gain of the stage.

In order to assess alignment accuracy, it is best to measure the effect of any adjustments on the receiver. If the set has AGC, a digital multimeter (DMM) connected across the diode load or AGC line will indicate peak performance, as described in the previous two articles on IF amplifiers.

However, many sets do not have diode detectors or AGC, so measuring the audio level across the speaker terminals is one of the few options left. Note that this can only be done if a signal generator with tone modulation is used. If the alignment is done only on the apparent aural difference, the accuracy will be limited, so it's best to measure the output if possible.

It's also important to realise that a receiver front-end that's been aligned with a signal generator connected to it will no longer be correctly aligned when connected to an antenna. To overcome this problem, I adjust the signal generator output to a high level and wrap the test lead around the antenna lead. That way, the signal generator does not detune the antenna tuned circuit to any extent and the signal level into the set is relatively low.

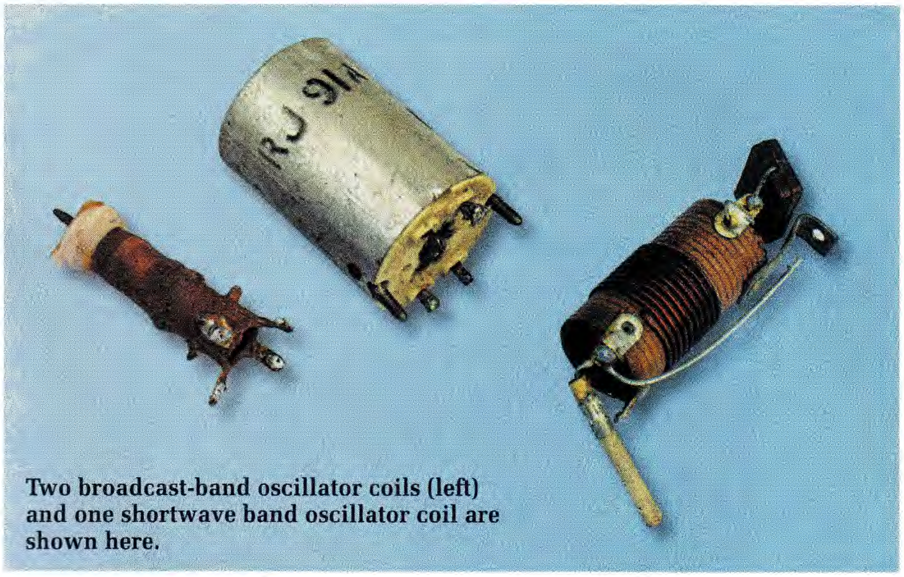
PEAKING AIR-CORED TUNING COILS IN TRF SETS

These coils are usually wound solenoid fashion on coil formers ranging from 25-75mm in diameter. Some of these coils are in aluminium cans while others are left unshielded. Invariably, they don't have iron dust cores to adjust their inductance, to ensure accurate tracking across the band.

It is fairly easy to determine whether the tuned circuits do track accurately. To do this, first tune to the high-frequency end of the tuning range and adjust the trimmer capacitors for best reception, with the trimmers nominally at half capacitance. It doesn't matter whether the stations are tuned at the correct spot on the dial for this test.

Now tune to a low-frequency station. Make a note of where each trimmer is set, then vary the trimmer capacitance up and down in each tuned circuit and note the position where peak performance occurs. Return each trimmer to its start position before adjusting the next trimmer.

Note whether more or less capacitance is needed to peak the performance in each case (sometimes, you may need more capacitance, in other cases less capacitance). If the trimmer has to be screwed further out (less capacitance) for peak performance, it indicates that the tuned circuit has too much inductance and a turn or two of wire may need to be removed to improve the tracking. Conversely, if the trimmer has to be screwed in



Two broadcast-band oscillator coils (left) and one shortwave band oscillator coil are shown here.

further, it indicates that the inductance is insufficient and a turn or two of wire will need to be added.

As a matter of fact, I had a 1931 Operatic TRF with this problem. In that case, removing two turns from one coil allowed the two tuned circuits to track each other.

Another method of checking the tracking is to get a small length of ferrite rod and with the set tuned to the low-frequency end of the dial, insert the rod into each coil and observe whether the performance improves or deteriorates. If it improves, more turns are needed and if it gets worse, fewer turns are needed. If there is no change in the performance, it is accurately tuned.

Some later receivers with air-cored RF and antenna coils can be converted to slug tuning for improved sensitivity. I've done this to several receivers by placing a small-diameter slugged coil former inside the air-cored coil. This is held in place by soldering the coil former lugs (no winding on the former) to the larger coil lugs, so that the former sits quite securely inside the air-cored unit.

This works well and will noticeably lift the performance of some sets.

ALIGNING TRF RECEIVERS

TRF receivers are relatively easy to align, as we shall see.

First, if the coils have no iron-dust cores, no alignment adjustments can be done at the low-frequency end of the dial – unless you are prepared to

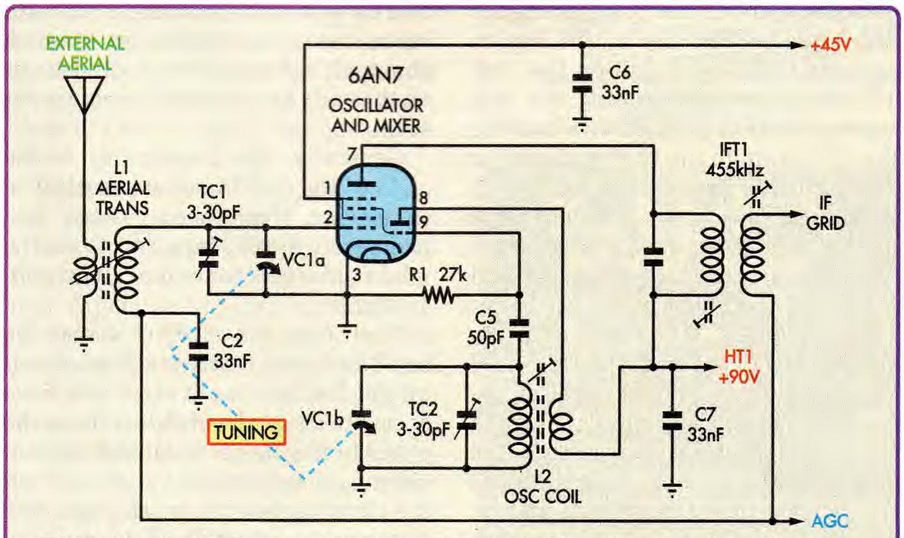
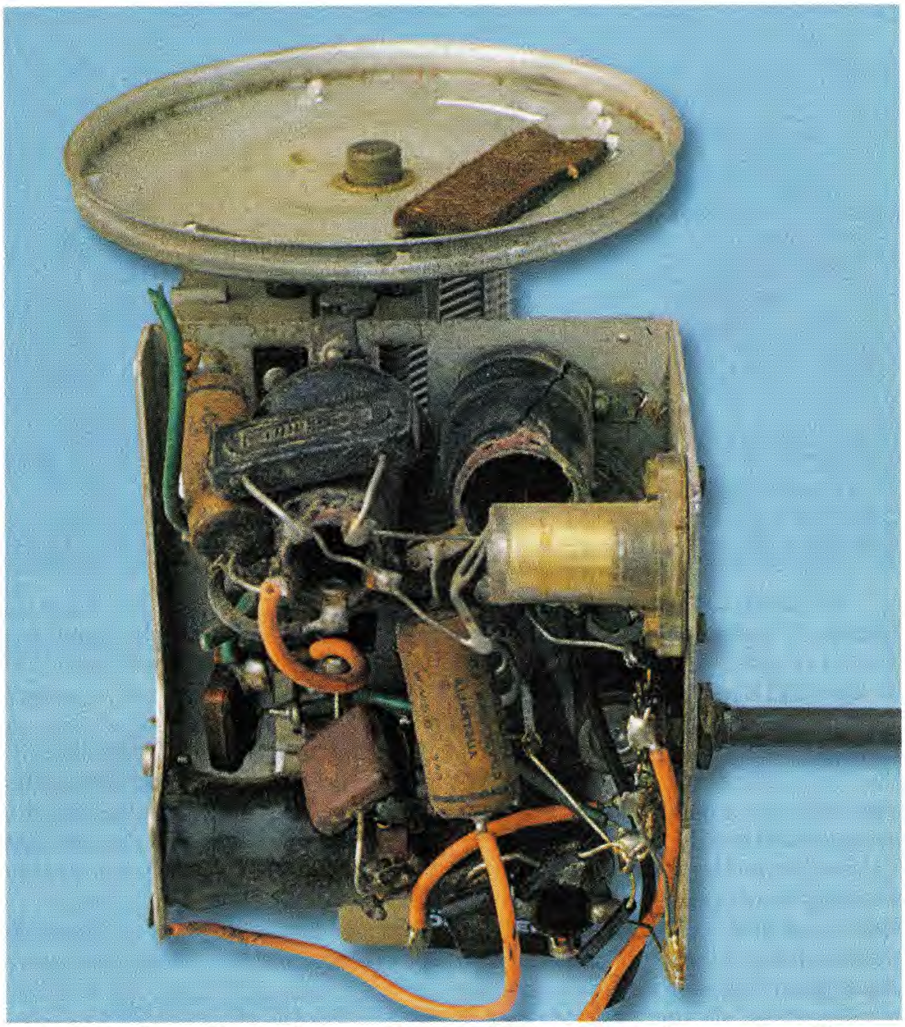


Fig.1: circuit of "front end" of Kriesler 11-90. Note the use of a padderless tuning gang (VC1a & VC1b).



This photo shows the dual-wave coil assembly from a wrecked receiver. The two coils can be seen at top-right of the metal sub-chassis.

try the techniques previously mentioned to match the inductances in the various tuned circuits.

If the inductances do prove to be matched, it's a matter of adjusting the dial scale so that the tuned station appears at the right spot on the dial. This is done by loosening the dial scale pointer or grub screws holding the dial drum to the tuning capacitor and adjusting its position, while still listening to the station. It's then just a matter of retightening the screws.

Now tune to the high-frequency end of the dial and note where a particular station appears. If it tunes with the gang further out of mesh than it should be, adjust the trimmers for less capacitance until the station appears in the correct position. Conversely, if the gang is further in mesh than it should be, increase the trimmer capacitance.

Note that it is necessary to check the tuning at the low-frequency end of the dial following any adjustments at the high-frequency end, and vice versa, until the stations appear in the correct positions.

Aligning a TRF with slug-tuned RF and antenna coils is straight forward. In this case, it isn't necessary to muck about with adding or subtracting turns on the coils as occurs with some older sets.

Generally, the frequencies at the ends of the dial travel are marked in some way. If not, just assume that later receivers tune from 540-1620kHz, while older sets tune from about 550-1500kHz.

First, tune the receiver across the band and note where stations appear on the dial. Alternatively, if you have access to a signal generator, check the entire tuning range. If stations are consistently displaced (eg, by 10mm) from the correct positions on the dial, it is necessary to adjust the dial pointer by a similar amount in the opposite direction to correct this inaccuracy. A set that has all the stations displaced by a similar amount is likely to be reasonably well aligned. However, it will still have to be peaked for best performance.

Starting at the low frequency end of the dial, adjust the coil cores until the sought after station (about 600kHz) appears at the correct spot on the dial. That done, tune to a high-frequency station (about 1400kHz to 1500kHz) and adjust the trimmers for best performance. Note that some adjustment may be necessary to get the station to appear at the correct spot.

If you find that you have wound the iron cores right into or out of the coils and the trimmers right in or out and the performance is still poor, reset them all to half-way and try again. However, it's also possible that one or other of the tuned circuits has a fault and no amount of adjustment will overcome the lack of alignment.

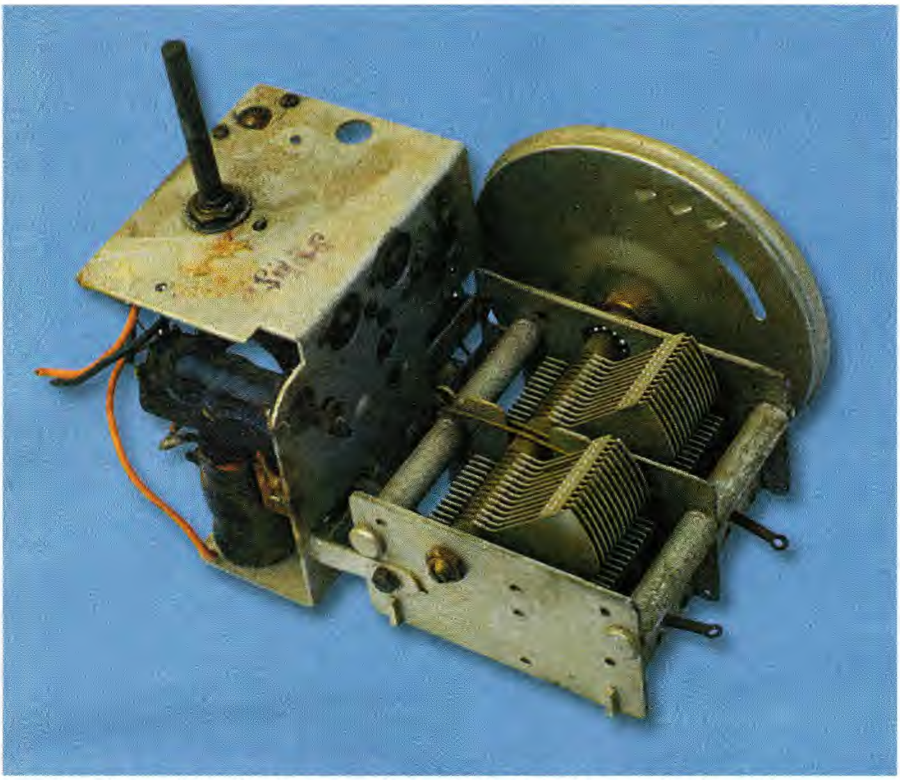
Alignment of TRF receivers on shortwave bands involves the same principles as those used on the broadcast band. However, there aren't many shortwave TRF sets about and those that do exist tend to have fewer tuned circuits (often only one in a regenerative detector circuit).

THE SUPERHET RECEIVER

The RF and antenna circuits of a superhet receiver are identical with those used in TRF sets of the same era. Instead, the big difference between the two types of sets is in the variable tuned circuits, due to the addition of a local oscillator in the superhet. This local oscillator is tuned to a frequency that's offset from the antenna and RF circuits by the intermediate frequency (IF).

In most sets, the IF is 455kHz and the local oscillator must accurately maintain this offset right across the band. This is not an easy task. Receivers using tuning gangs with identical capacitance ranges (plate shape) will usually only have the local oscillator displaced exactly 455kHz from the signal frequency circuits at three spots across the tuning range.

This means that the tuning of a superhet receiver can vary sufficiently for differences in sensitivity to be apparent across the band. However, this is mainly a problem in earlier sets – later receivers use automatic gain (volume) control (AGC) and therefore these inaccuracies are hardly noticed.



Another view of the dual-wave coil assembly from the wrecked receiver.

On some "broadcast band only" receivers, it became reasonably common to use a twin or triple section tuning gang which had one section specifically for the oscillator tuning. This section usually had fewer plates and they were shaped differently to achieve accurate tracking. These are called "padderless tuning gangs" as no padder was required.

The miniature tuning gangs used in broadcast-band transistor sets are of this type too. One such tuning gang can be seen in one of the photos, where one section is noticeably smaller than the other. The smaller section is used for the oscillator. The maximum capacitance for each section is 210pF for the signal frequency section and 90pF for the oscillator section.

By the way, I have several transistor sets (different brands) that use the 3-gang version of this tuning capacitor (MSP). Unfortunately, I have found that the oscillator and the antenna and RF tuned circuits do not track, not matter what I try do to overcome the problem. Whether this was just a faulty batch or is due to some other problem, I don't know. On the other hand, my Kriesler 11-90 and 11-99 sets use another brand of padderless gang and they track perfectly. As a result, their performance is very good.

Padderless tuning gangs are only suitable to use on the broadcast band and in sets with a 455kHz IF. They can be designed for other bands and IFs but I've not seen any. Where multi-band operation is required, all sections of the tuning gang are identical.

ALIGNING THE FRONT-END OF A SUPERHET WITH A PADDER

Early superhet receivers used air-cored coils in both the RF/antenna circuits and the local oscillator. This meant that it was necessary to have some means of adjusting the oscillator at both the low and high frequency ends of the dial, so that the stations were at their correct locations on the dial.

This was achieved by having an adjustable padder (mounted on the chassis) to align the circuit at the low-frequency end of the dial, plus a trimmer capacitor to align the high-frequency end. There was only one adjustment for the antenna or RF coil and that was done at the high-frequency end of the dial.

The first step is to shift the dial pointer (if necessary) so that it has equal overlap at either end of the dial scale. Then, with the receiver operating, check that the stations are received at the correct dial locations

This assortment includes one 13mm ferrite rod and one 9.5mm rod (both without windings), plus an antenna assembly from a wrecked set.

(they probably won't be at this stage).

Next, at the low frequency end (around 600kHz), adjust the padder so that a known station appears at the correct dial location. That done, go to the high-frequency end (around 1400-1500kHz) and adjust the oscillator trimmer so that a known station appears at the correct spot. For best results, double check these two adjustments.

Next, adjust the antenna/RF circuit trimmer(s) at around 1500kHz for best performance. Now if all is well, the set is correctly aligned.

In some cases, however, the alignment may not be correct for the antenna and RF circuits at lower frequencies. To check this, slide a small ferrite rod into these coils and observe any differences in performance, as described earlier for TRF receivers.

If the performance improves, this indicates that the antenna/RF coils have insufficient inductance. In that case, there are three ways in which the alignment can be improved:

(1) Overwind a few turns (experiment with the number) of enamelled copper wire onto the coil. That done, connect one end in series with the grid end of the coil and the other end to the point in the circuit where the grid connection had originally been made.

(2) Install a small amount of ferrite material inside the coil.

(3) Reduce the "apparent" inductance of the oscillator coil by reducing the padder value. This means that the tuning capacitor plates have to be more in mesh for a given oscillator frequency.

Method three is the easiest to implement. First, tune to a weak station at the low-frequency end of the dial. Now adjust the padder so that the station appears closer to the end of the dial and note any improvement in signal strength. Keep doing this until no further improvement can be obtained.

It is then necessary to alter the dial pointer so that it points to the appropriate frequency or marking on the dial scale. That done, readjust the oscillator alignment at the high frequency end of the dial and peak the RF/antenna circuit(s).

However, in some cases, it many no longer be possible to receive all the stations that should be received. The receiver may now only tune from (say) 600-1600kHz instead of 550-1600kHz. If this proves to be the case, then this particular method of obtaining the best performance at the low-frequency end of the band isn't appropriate. Instead, one of the other methods must be used – or you can just forget about getting the best performance at the low-frequency end of the dial.

If the antenna/RF coils have too much inductance, there are only two ways of improving the low-frequency alignment:

(1) Do the same as (1) above (ie, by overwinding the coil), except the turns must now be in series opposing; or

(2) Adjust the padder to higher values of capacitance so that the tuning capacitor plates are further out of mesh for a given oscillator frequency. That done, continue to adjust the circuits in the same way as mentioned above, except that the padder is continually increased in value. Do this until the performance is at its best.

ALIGNING FRONT-ENDS WITH IRON DUST/FERRITE CORED COILS

It is much easier to adjust the front-end of a receiver if all the coils have iron-dust or ferrite cores, plus trimmer capacitors. However, you must use a non-metallic alignment tool to make the adjustments if the core is inside the coil.

The first step is to adjust the dial pointer so that it travels from about the 520kHz mark (ie, maximum capacitance) to about the 1620kHz mark (the exact frequencies at either end of the band will vary from model to model). That done, tune to a frequency around 600kHz and adjust the oscillator so that the station appears at the correct spot on the dial, then tune to around 1400kHz or 1500kHz and do the same by adjusting the oscillator trimmer.

Repeat this procedure until the stations appear in the correct positions on the dial (or as near as practical).

Now do exactly the same thing for the antenna and RF coils but use a frequency nearer 1600kHz for the high frequency adjustment. Note that these adjustments should be carried out with the set coupled to the antenna. In each case, you adjust the coils and trimmers for a signal peak by measuring the AGC or detector output voltage, as mentioned earlier in the article.

When ferrite rod loop antennas are used, the coil (or a small auxiliary coil) is simply slid along the rod for best performance at the low-frequency end of the dial. It's then locked in position with some bees wax (or similar).

The nominal value of the padder capacitor for the broadcast band and a 455kHz IF is 425pF. For a 175 kHz IF, it is around 550pF or higher. On the shortwave bands, the padder value can vary from upwards of 2200pF to 4500pF. In some cases, the manufacturers didn't worry about tracking

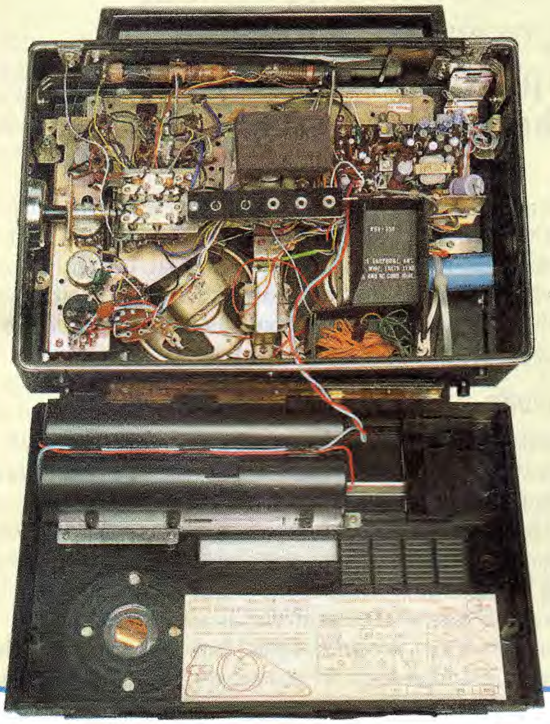


Photo Gallery: National Panasonic R-100 4-Band 9-Transistor Radio

Purchased at a charity bazaar a few years ago for the princely sum of $10, this National Panasonic R-100 4-band 9-transistor radio was the top-of-the line model from Matsushita in the late 1960s.

Covering the range from 525kHz to 26.1MHz, the R100 has an IF of 470kHz. Most of the transistors are on a tightly-packed PC board but the oscillator and antenna coils are chassis-mounted, as are the band switch and trimmers.

Weight without batteries is 4.2kg. This unit has been modified to run from a 9V DC plugpack and still performs very well. (Note: if anyone has a manual, please contact Leo Simpson).

on the shortwave band and dispensed with the padder altogether.

RECEIVER ALIGNMENT ON SHORTWAVE BANDS

On the shortwave bands, the local oscillator operates above the received frequency – with a few exceptions. The alignment procedure is the same as for the broadcast band. However, the problem of image breakthrough is quite evident, as discussed in the earlier articles on IF alignment.

Assuming that the IF is 455kHz, a station on 17MHz will be heard on the receiver dial at both 17MHz (or close to it) and at 16.09MHz (the image frequency). For this reason, make sure that the antenna/RF coil(s) are peaked on the 17MHz frequency.

Unfortunately, shortwave stations are often difficult to identify. Several frequencies often carry the same program and fading is common, all of which makes alignment rather difficult.

It's best to use a signal generator for this job, as this eliminates any ambiguities in the results. Once again, tune the receiver to about 17MHz, then adjust the signal generator to 17MHz. Adjust the receiver for a response on or near 17MHz, then shift the signal generator frequency until the receiver responds to another frequency.

It should respond when the generator is shifted to 17.910MHz if the receiver is reasonably well aligned. However, if it is badly out of alignment, the response will be at 16.09MHz instead.

The correct alignment frequency is the lower generated signal. If the response is at 16.09MHz, the oscillator trimmer will have to be reduced in value so that the receiver can respond at 17MHz, as marked on the dial scale. The RF/antenna coil trimmers are adjusted for peak performance on this frequency, if the tuning range is 6-18MHz.

Shortwave bands are very approximately aligned, with few receivers having accurate dial calibrations. In fact, shortwave bands on many sets were purely a selling point, with poor performance, poor dial calibrations and inadequate alignment facilities.

SUMMARY

So that's it – a comprehensive alignment procedure for most TRF and superhet receivers. In summary, the general procedure is to adjust the coil cores (or padders) at the low-frequency end of each band and the trimmers at the high-frequency end for peak performance. That said, you should be guided by the alignment procedure for each model if this is available. **SC**