ALIGNMENT AND NEUTRALIZATION OF THE EARLY AC TRF & NEUTRODYNE RECEIVERS

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For a radio to work as it was originally designed, it must be in proper alignment. This means that at any single point on the dial all tuned circuits must be at resonance and the dial calibration should be correct. In the case of neutrodyne receivers, additional steps must be taken to assure that each neutralized amplifier stage is adjusted properly. This will assure that the full gain can be realized.

The purpose of this article is to provide a detailed review of the steps necessary to completely align these receivers. Much was written on this subject when the radios were relatively new, but it was all directed toward working on a "modern" receiver only a few years old. Today, we must look at warped variable condensers, worn wiper contacts, poor ground connections, coil windings that have shifted position, incorrectly positioned coils, loose shield cans, and many other problems brought about by age and abuse.

The time spent doing a complete alignment will typically result in a radio with greatly improved selectivity and sensitivity. This is especially true at the lower frequency portion of the dial.

Preliminary Work

The initial work on a set must include inspection of all the components that will affect alignment. This should not be limited to the variable condenser and coils, but must include all other items that can have any effect. The following steps represent a basic outline of the preliminary work that should be carried out. Prior to final alignment, all repairs should have been made and the set should be in playing condition.

Variable Condensers. The variable condenser(s) should be checked for warped plates, off-center sections, plating "whiskers", cleanliness, etc. Caution! Do not bend or reshape any of the outer rotor plates as these are adjusted as part of the alignment.

On variable condensers that have the rotors locked to a common shaft with set screws, check that the screws are tight and that the rotor plates appear to be in their original position. Where two ganged condensers are used, be sure the rotor plates are set in identical positions.

Most of the older condensers had adjustments for the rotor shaft bearings. In many cases these can be used for centering of the rotor plates as well as setting the end-play. Use them to obtain optimum centering and minimum play. There should be no binding over the full rotation. A pipe cleaner makes an excellent cleaning tool to use between the plates. It will loosen the flakes and whiskers that appear on the surface of the plates, then they can be blown or washed from between the plates.

If deemed necessary, the variable condenser assembly can be removed from the set and thoroughly cleaned by washing in water. CAUTION: Be sure to mark precisely the position of the dial mounting on the variable condenser shaft. Open all trimmers mounted on the condenser assembly and remove the screws and mica sheets. Using hot water (150°F maximum), rinse off, clean with a brush and pipe cleaner using a spray detergent, and then thoroughly rinse. If your water has a high mineral content, the unit should be given a final rinse in warm demineralized water. Shake off, then thoroughly dry by placing in the sun, blowing off with compressed air, or drying in an oven at about 125°F.

In extreme cases, an AC voltage can be used to optimize the centering and burn off the whiskers. Ideally the voltage should be adjustable over the range of 200 to 700 V. The high voltage winding of an old power transformer can be used as the voltage source. Be sure to place a lamp (40 to 100 watts) in series with the primary to limit the current.

With the condenser fully disconnected from the set (and the frame grounded), apply the AC voltage to one section at a time. Adjust the voltage until intermittent arcing occurs, then rotate the condenser through its range. On a clean and well-centered unit, the arcing will occur at random locations while the plates are being rotated. Check the grounding of the condenser frame to the chassis. Where a flexible mounting is used, the braid or strap that may have become cracked or frayed. Be sure all fasteners used to secure the condenser are tight and lockwashers are used. Be sure to check the rotor grounding contacts for wear and proper tension.

As the last step, the bearings and rotor grounding contacts should be lubricated with a light machine oil containing graphite (4 parts oil to 1 part graphite). Note: I keep the graphite/oil in a small bottle and use a very small screwdriver as an applicator. Be sure to shake well before using; graphite settles out.

Coils. Check that all coils are firmly mounted so that they cannot shift position. All coils mounted in shield cans should be centered within the can. This is also the time to replace any defective grid leads coming out through the top of the shield cans. Check that all shield cans are properly tightened and grounded. Do not over-tighten, otherwise the aluminum will cold-flow and the can will again be loose in a few days.

Dials & Drives. The dial drive should be checked, repaired where necessary, and lubricated. When this is all accomplished, the drive should be exercised by moving it from end to end several times. This will normalize the tensions on the system and help improve repeatability.

The relative position of the dial, or pointer, versus the tuning condenser needs to be checked. If it appears to be secured in its original position, this should be adequate. Otherwise, the chassis should be placed back in the cabinet and the dial rotated end to end. Some dials have a reference mark at one end to set the dial position, others need to be set for symmetrical positioning at the ends.

Miscellaneous. All tubes should be removed and reinserted in their sockets a few times to assure that the contact surfaces on the sockets and the tube pins are well cleaned. All wiring associated with the r.f. stages should be checked and any with questionable insulation replaced. Permanent lead dress for all grid wires must be established prior to final alignment. Some sets have a "gain equalization" potentiometer attached to the variable condenser shaft. In these sets, be sure that the shaft coupling is secure and that the potentiometer stops are not limiting the condenser rotation.

Air Check. At this point an "air check" should be made with a minimal antenna connected. If the set oscillates at any point on the dial, the cause of the oscillation must be corrected. For neutrodynes, a preliminary neutralization should be performed. Once the set is operating in a normal manner, an initial check of the dial calibration should be made using known local stations.

During the air check, look for noisy tubes, loose connections, etc. With the set turned on and the antenna disconnected, lightly tap all the tubes using the handle of a small screwdriver. Also, tap around on other components both above and below the chassis. As a final test, with the set turned on, lift the lightest side of the chassis about 1/2" from the bench, and let it drop while listening for noise from the speaker.

After all repair work has been finished, a quick alignment should be performed. With the signal generator set to 1400 kHz, tune in the signal and adjust the generator until the sound is just audible. Now adjust the trimmer capacitors to peak the signal. When set at this peak point, adjusting the screw in either direction should cause a smooth reduction in level.

Occasionally, a trimmer will hang up, or be erratic, as it is being adjusted. If this happens, run the nut/screw in and out from full tight to completely loose several times. If this fails to solve the problem, dismantle the trimmer and check to see if it is shorting out through the mica or hanging up because of a burr, corrosion, etc.

Neutralization

The neutralization technique was developed to overcome the problem of oscillation in triode r.f. amplifiers. In a triode amplifier, a small portion of the plate signal will be fed back to the grid through the grid-to-plate capacitance. As the gain is increased, this feedback signal becomes sufficient to sustain oscillation. In a neutralized triode amplifier, a small portion of the output signal is purposely fed back to the grid circuit. This signal is equal in amplitude and opposite in phase to the signal fed back through the plate-to-grid capacitance, thereby canceling this feedback signal.

The Dummy Tube. During neutralization, a "dummy" tube (one without filament power) is used to provide the plate-to-grid capacitance and the neutralization condenser is adjusted for minimum signal "feed-through," one amplifier stage at a time. Dummy tubes used for neutralization must be intact tubes, without shorts, in order to maintain normal circuit capacitances.

In the case of indirectly heated cathodes, such as the 227, a tube with an open heater may be used. In the case of filament type tubes, such as 226, 299, and 201A, the filament should be intact, otherwise it could short to the grid. If a selection of tubes is available, it is best to work with both a "globe" style and an "ST" style tube of each type. These represent two different production periods with possible small differences in capacitances.

The filament is disabled by cutting off one filament pin flush with the tube base. In the case of 299s and 201As, the positive pin should be cut off because most of the r.f. circuit returns are to the negative pin. An alternate method, useful for the older sockets where the contact is made at the end of tube pin, is to put about three layers of Scotch tape on the end of the filament pin to prevent contact. For sets using the Kellogg type tubes, no dummy tube is needed. When neutralizing a stage, simply disconnect one filament lead from the tube, and allow it to cool down.

Some of the older instructions for neutralization suggest using an adapter socket with one filament pin open. This is inserted between the tube and the tube socket. They argue that this allows the use of the actual tube in the stage being tested. The author disagrees with this technique because the capacitances we are dealing with are in the range of only 3 to 9 uuf, and the socket can result in unwanted additional capacitances.

Neutralization Procedure. The neutralization procedure is performed one r.f. stage at a time, starting with the stage nearest the detector. Since the neutralization and alignment adjustments may have a very slight effect on each other, it may be necessary to repeat the neutralization procedure again after alignment. An audio output meter is not absolutely necessary for neutralization.

After allowing the set to warm up sufficiently to assure stability, replace the tube in the stage to be neutralized with an appropriate dummy tube. If a shield is normally used over the tube, be sure it is placed on the dummy tube.

Adjust the volume control and any sensitivity switch for maximum gain. Set the tuning condenser to about 1000 kHz, attach the modulated signal generator to the antenna terminal through the dummy antenna, and adjust for an audible signal. A local radio station signal could be used for neutralization, but with the old radios there is a chance the station signal may "leak" into the various r.f. stages and confuse the procedure. Adjust the tuning condenser for peak signal, then adjust the neutralization condenser for minimum signal output while maintaining the signal level of the generator so the signal is just audible. Repeat this procedure until no further reduction of signal is possible. Replace the dummy tube with the original tube and allow the tube to warm up. Check that the set does not oscillate while tuning over the entire band. Repeat the above procedures with each successive preceding stage until all the r.f. stages have been neutralized. When completed, disconnect the signal generator from the antenna terminal and tune the receiver across the band to check for oscillations.

If after completing the neutralization procedure there is a tendency toward oscillation, the source of feedback must be eliminated. This is a difficult problem to analyze, but the following suggestions may help:

1) Try to determine whether the oscillation is occurring in one stage, or the feedback is occurring across several stages. Pulling the tubes, one at a time, may help.

2) Directly substitute a known good capacitor across the various decoupling capacitors in the r.f. stages.

3) Try breaking up the common r.f. return circuits (such as B+ or AVC feeds) by adding 1K to 4.7K resistors in series with one or more of the circuits, plus possibly an additional decoupling capacitor.

4) A small piece of sheet metal may be used as an experimental shield. Be sure to attach a ground lead to the metal. Try placing it in various areas in the r.f. stages to

see where a permanent shield might be helpful.

5) Try reducing the plate voltage for one or more r.f. stages. If this stops the oscillation, experiment with various values of decoupling resistors. This will drop the voltage and increase the decoupling at the same time.

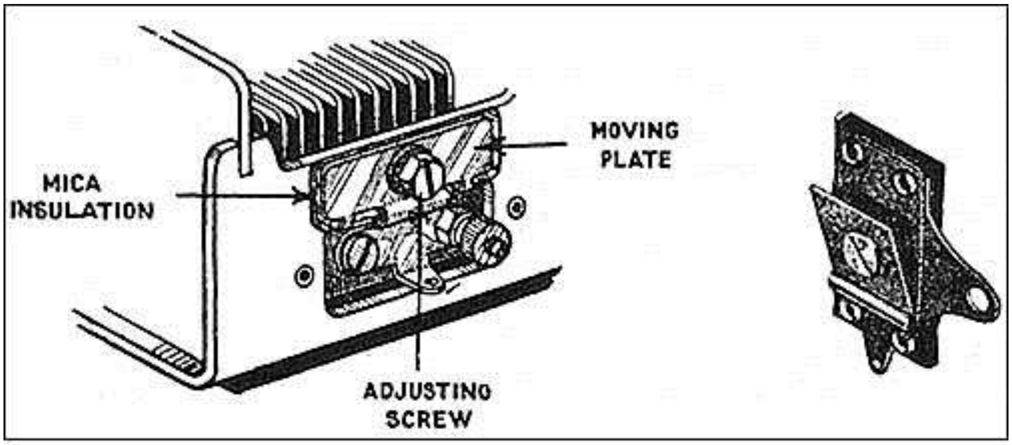

Figure 1. Trimmer capacitors as mounted on variable capacitor frame (left) and mounted individually.

Special Alignment Tools

Tuning Wand. This tool is used to check for resonance in tuned circuits. By inserting it into the magnetic field within a coil, the inductance can be slightly changed. One end of the wand contains iron that increases the inductance; the other end contains brass that decreases the inductance. If a tuned circuit is at resonance, either a decrease or an increase in inductance will reduce the signal level. A tuning wand can easily be made by installing iron and brass ends on a piece of 1/4" or 3/8" diameter insulating rod. The rod needs to be long enough so that the hand does not disturb the circuit being checked.wand. An old tuning core can be used for the iron end. Cut the core's threaded rod to a length of about 1/4" and screw it into a tapped hole in the insulating rod. A piece of shrink tubing will help protect, and insulate the powdered iron.

The brass end, about 1/2" long, can be either a cylinder, or a piece of solid rod. The cylinder will give greater inductance shift than the solid rod. It can be made from a piece of tubing and installed over the turned, or filed, end of the insulating rod. If a solid piece of brass is used, it can be installed by using a short piece of threaded brass rod tapped into both pieces. A piece of shrink tubing should be installed for insulation.

Dielectric Strips. A dielectric strip is a piece of insulating material that is inserted between the plates of the tuning condenser to experimentally increase the capacitance. The higher the dielectric constant, the greater the capacitance change. Also, the better the fit between the plates, without distorting or moving them, the greater the change. The strip can be made from about any material, from plastics to cardboard. Ideal materials are; Nylon, Mylar, Teflon, acetates, and fishpaper. I have used, on a one-time basis, business cards, material from file folders, and other heavy paper materials.

The thickness of the material needed will depend on the tuning condenser being adjusted. For the early TRFs, the strip should be about .015" to .020" thick. The later condensers in the superhets of the 1940s and 1950s will require a strip thickness of .005" to .007". The width of the strip should be about 3/4" for the older sets, and about 3/8" for the small tuning condensers in the more modern radios. Make the strip long enough so that it can be inserted completely into the condenser while keeping the hand at a distance to avoid detuning.

Alignment

Adjustment Principles. The purpose of alignment is to assure that all of the tuned circuits remain resonant at the same frequency at all settings of the dial. If one or more are tuned to a slightly different frequency, both the selectivity and the sensitivity will be affected. During all alignment procedures, the tuning condenser must be rocked back and forth to assure that you are setting it to as near the center

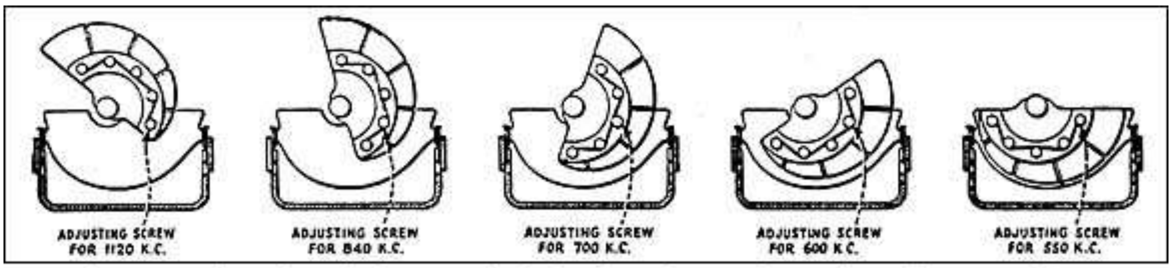

Figure 2. Slotted end plate as might be found on each section of a ganged capacitor. Set screws are provided for adjustment at five different positions.

of the signal peak as possible. In a badly misaligned set the signal peak may be very broad, but it will narrow down as the set is brought into alignment.

The tuning of a properly aligned radio will be smooth and symmetrical as you approach and leave the peak signal point. The tuning should be checked for symmetry at several points across the band. Remember that the tuning will always appear broader at the lower frequency end of the band. Though, in fact, the bandwidth remains essentially fixed, it becomes an increasing percentage of the frequency as the frequency decreases.

Trimmer condensers (Figure 1) are used in most sets to correct for minor differences in the tuned circuits. They are usually adjusted at 1400 kHz, where the variable condenser is almost fully open. Typically these are mounted directly on the variable condenser. Some sets have the trimmers mounted separately, while a few of the very early sets have no trimmers.

Once the trimmers have been set, the "tracking" of the tuned circuits is then accomplished by adjustment of the variable condenser sections, or as a last resort, the coils. Most condensers have the outer rotor plates slotted at four or five places to allow bending of the plate segments. This allows adjustment of the capacitance at five or six settings of the condenser. A few sets have screws for the bending of the plate segments. Figure 2 shows a typical variable condenser with the adjustment positions and frequencies indicated.

Some sets have outer rotor plates without slots, but in most cases a means for tracking adjustment is provided. Some early sets use individual variable condensers ganged together by metal bands, cams, and other schemes. In such receivers, special tracking adjustments might be provided. Otherwise, the set screws must be loosened to change the relative position of the individual condensers on the shaft (Figure 3). While the alignment tracking requirements are the same, some ingenuity must be applied in figuring out how to adjust some of these systems.

Moisture in the coils can have an effect on the alignment. Prior to final alignment, the set should be played for several hours to be sure the coils are thoroughly dried out and stable. Playing the set with a cardboard box over the chassis helps to dry things out. *Be careful!* Don't let the set get too hot and don't set the box on fire!

The coils can be adjusted for alignment purposes, but this can be a difficult procedure and is used only as a last resort. The effective inductance can be altered by changing the winding length of the coil, by changing diameter and/or size of the shield can, and also by altering the relative position of the primary to the secondary windings.

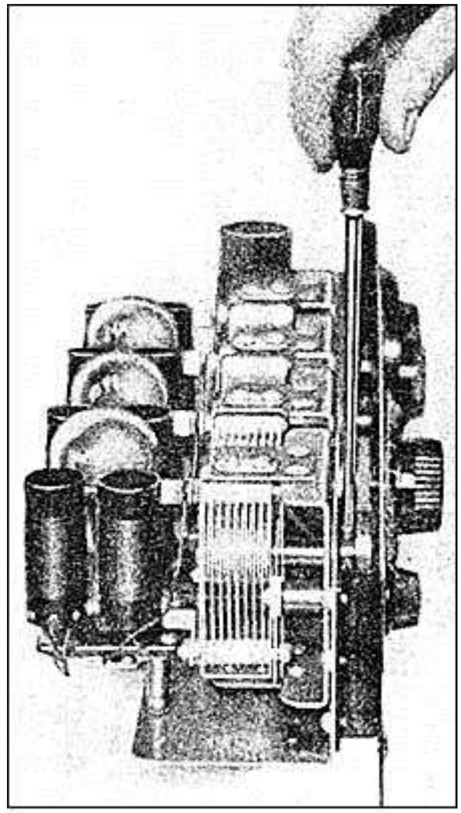

Figure 3. Loosening set screw to adjust position of an individual variable condenser in a group that is ganged by metal bands.

Alignment Setup. During the following alignment procedures, an audio output indicator should be used. Without a signal level indication, the final peaks cannot be set properly because the ear does not have the required sensitivity. If the set being aligned has AVC, the AVC voltage makes an excellent signal level indicator. A high resistance meter must be used (at least 20Kohm/volt) to prevent loading of the AVC circuit. The voltage should be measured as close to the detector, or AVC tube, as possible. If there is no AVC, use an audio output indicator.

The signal generator should be connected to the antenna and ground terminals through a dummy antenna (Figure 4). If a dummy antenna is not available, a 220uuf series capacitor should be used. Otherwise, the r.f. input stage will not tune/track properly.

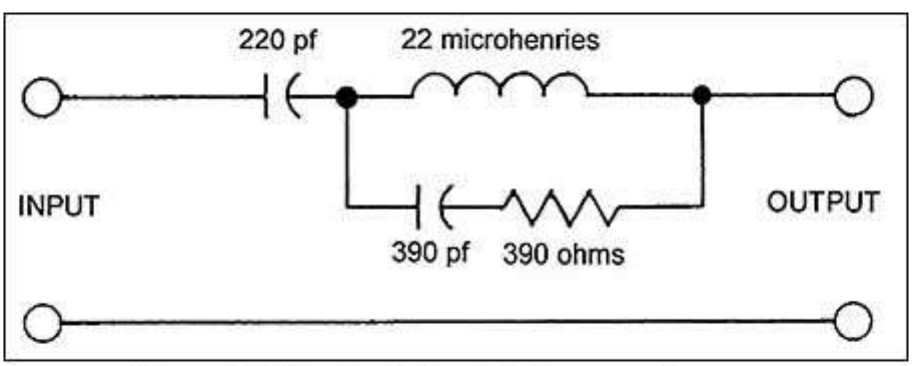

Figure 4. Circuit of a typical dummy antenna.

During all alignment procedures the r.f. output level of the signal generator should be kept as low as possible. This is especially true when aligning sets with AVC. A modulated signal must be used when using an audio output indicator. If the modulation level is adjustable, maintain the level at 30% to 50%.

If the radio volume control is one which controls the gain of one or more r.f. stages, it should be kept at maximum gain. Any sensitivity switch should also be set for maximum. An audio-type volume control should be kept at as high a level as possible commensurate with good response from the output level indicator.

Prior to final alignment all shields must be in place, including any bottom cover/s. If access to adjustments is blocked by the covers, small access holes may be added.

Adjusting Trimmers. With the generator set to 1400kHz, tune the receiver dial for maximum signal. If the dial is calibrated in frequency, check to see if the dial reading is close to 1400kHz. If the dial reads correct, adjust the trimmer condensers for peak signal. If the dial reading is off frequency, slightly increase the single generator level while moving the dial to correct the reading until the signal is just audible at the 1400kHz dial setting. Then peak the trimmers. Repeat this procedure until the dial reading is correct and all the trimmers have been peaked.

If one or more of the trimmers cannot be peaked when the dial is set close to the proper frequency calibration point, recheck the dial position relative to the variable condenser. If the mechanical positioning is correct, tune the condenser and peak the trimmers until the dial is as close to reading the correct frequency as possible with all the trimmers peaked.

Some of the older sets have dials that are calibrated in wavelength (meters). Wavelength can be calculated by dividing 300,000 by the frequency (in kHz). A few of the radios have dials that are just calibrated 0 to 100. In this case you can either guess at the position for 1400kHz, or, set the condensers to wide open and peak the trimmers for between 1600kHz and 1650kHz. A point should be found where all the trimmers will peak and will be near the center of their range of adjustment.

Tracking The Variable Condensers. Set the signal generator to 600kHz and tune the variable condenser for maximum signal. Rock the condenser back and forth to get a feel for the tuning symmetry. If the tuning peak is broad, try to set the condenser to the midpoint. Insert the tuning wand into the end of each coil, one at a time, to determine which tuned circuits need adjusted and in which direction. Do not insert the tuning wand slug any further into the coil than necessary to obtain a signal level change. Note: The tuning wand may be used alongside the coil also, but the effect is not nearly as great.

When a tuned circuit is at resonance, the signal level will decrease when both the iron and the brass slugs are inserted into the coils. If the signal increases with the iron slug, the capacitance/inductance needs increased, if it increases with the brass slug, the capacitance/inductance needs decreased.

If a tuning wand is not available, or the coils are not accessible, a dielectric strip may be used. Insertion of the dielectric strip between the condenser plates increases the capacitance by increasing the dielectric constant between the plates. To use the strip, insert it into the space between the condenser plates just enough to observe a signal level change.

If the signal level goes up, the capacitance or inductance needs increased. If the signal level goes down, adjust the tuning condenser in the direction of decreasing capacitance until the signal can just be heard. Again insert the strip, and if the signal level increases, the tuned circuit is near proper adjustment. If the signal goes down, then the capacitance/inductance needs to be decreased.

Before doing any adjusting of the condensers, the above steps should be repeated at four or five other frequencies across the dial. A good set of frequencies to use is 600, 800, 1000, 1200, and 1400kHz. If the radio uses a tuning condenser with split outer plates, choose the condenser settings where the slots are just opposite the top of the stator plates. From the above checks you should now have some feel for how the tuning tracks, and what adjustments are needed for the individual resonant circuits. Some things to look for are:

1) Do the individual condensers all need the capacitance adjusted in the same direction? If this is the case, then the relationship between the tuning condenser and the dial may need to be reset.

2) Is there a random need for increased and decreased capacitance across the dial and between condensers? If so, the condensers probably just need a small amount of adjustment for proper tracking.

3) Does just one condenser need increased or decreased capacitance all across the band? If the radio uses ganged individual condensers, then maybe just the one condenser needs adjusted relative to the others. If the set uses a single tuning condenser assembly with several sections fixed to the shaft, then the individual coil may have to be adjusted.

Now is the time to decide how to approach the tracking adjustments. Some logic must be applied in order to determine what course of action is to be taken. If it is determined that the condenser plates just need "tweaking," start with the highest frequency slot adjacent to the top of the stator plates and adjust the segment for maximum signal. Repeat for each segment progressing downward in frequency. Recheck the trimmer settings at 1400 kHz, then again check each segment for optimum setting.

If a coil is thought to be at fault, the shield should be removed and the coil inspected. If necessary, the coil assembly can be removed and dismantled for inspection. Look for indications that the windings have moved from their original position, possible shorts between turns, etc.

If it was determined that the coil needs less inductance, turns can be removed one at a time and the tuning checked. If the coil needs more inductance, then the turns can possibly be moved apart or more turns can be added. Once any change has been made on a coil, then the alignment for at least that section must be repeated before further decisions are made.

References

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