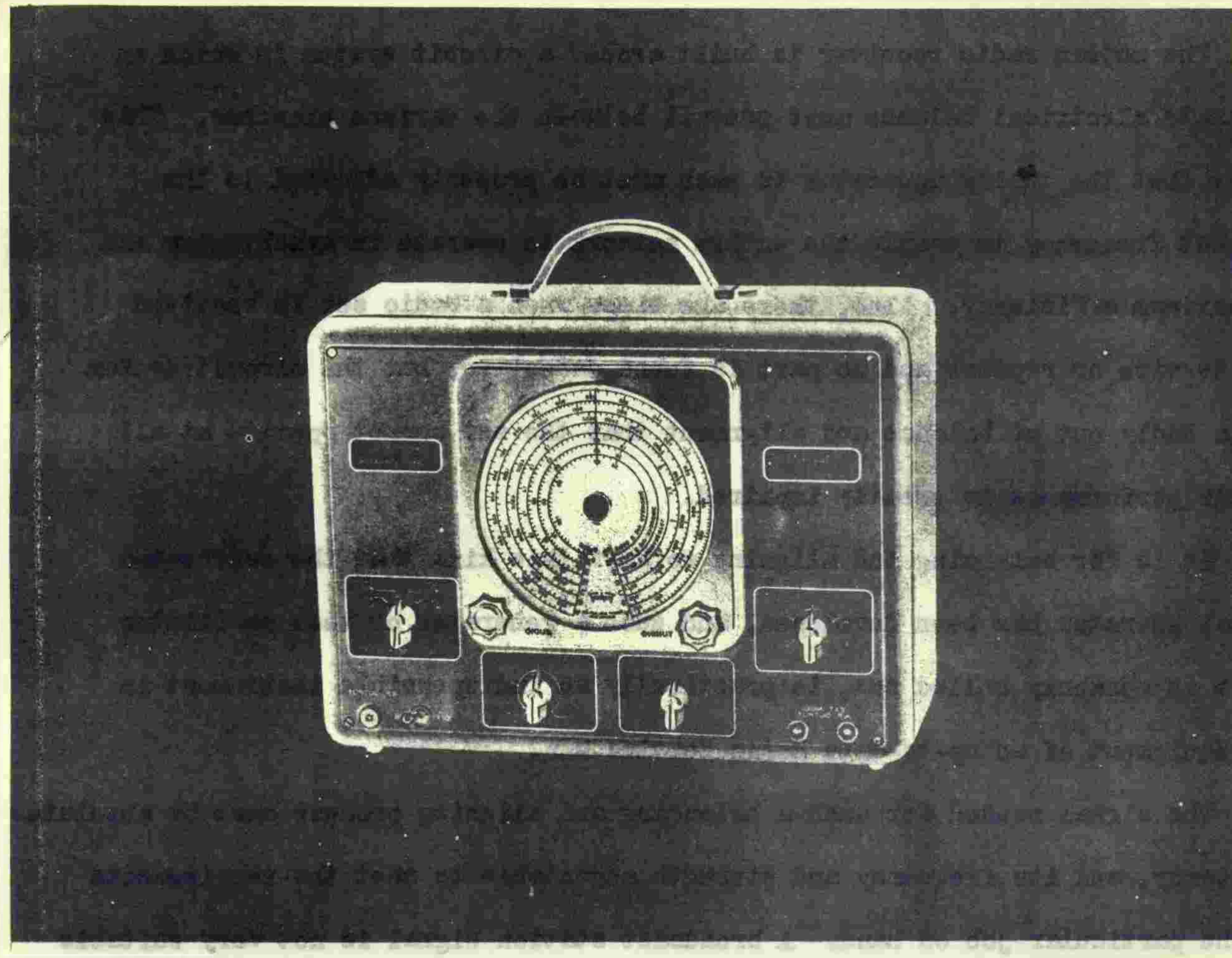

LESSON 51 R

THE RADIO SERVICE OSCILLATOR AND ALIGNING PROCEDURE

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The modern radio receiver is built around a circuit system in which an accurate electrical balance must prevail between the various branches. This means that the tuning apparatus in each must be properly adjusted to the correct frequency to enable the entire network to operate in synchronism and at maximum efficiency. Also, there are times when a radio set is received for service or repairs and no part is found defective, but the circuit system is so badly out of balance and alignment that the set cannot operate at all or its performance is greatly impaired.

It is for balancing and aligning work of this kind that the calibrated signal gnerator has been developed, and such a generator or test oscillator as it is commonly called now, is practically an indispensible instrument in the equipment of an up-to-date Radio Service Man.

The signal needed for such a balancing and aligning process must be absolutely steady, and its frequency and strength adjustable to meet the requirements of the particular job on hand. A broadcast station signal is not very suitable for such purposes because its strength is constantly changing and one is not always available at the desired frequency. It is to meet these requirements that the service oscillator is employed as a local signal generator.

The service oscillator is essentially a miniature broadcast station the operating frequency and output signal strength of which are under convenient control. Thus any desired signal frequency can be obtained at any time it may be needed. The oscillator is a high-frequency signal generator that employs a vacuum tube as a power converter to convert the direct current from a group of batteries or electric power unit into a high-frequency alternating current.

Through a suitable tap part of this energy is then made available for operating the receiver to be serviced.

The calibrated test oscillator has a wide field of application in radio service work, and the better its performance and characteristics are understood, the more uses for it will be found. For example, in tuned radio frequency receivers the oscillator serves to supply a suitable signal for properly balancing or aligning the successive amplifier stages so that all will operate in synchronism, otherwise both the sensitivity and selectivity of the receiver will be greatly impaired. In receiver systems employing neutralization of some form to suppress oscillations, an oscillator is a convenient signal source to locate the point of optimum neutralization.

For aligning a superheterodyne receiver an accurately calibrated signal generator is not only convenient but is practically necessary, for without one it is nearly impossible to adjust the radio frequency amplifier, the oscillator, and the intermediate amplifier to their proper operating frequencies. And the special tuning characteristics incorporated in some superheterodynes make the oscilhator an absolute essential. In addition there are other uses for the oscillator. It is an excellent aid in checking the condition and operating qualities of tubes on a comparison basis. With a calibrated oscillator it is also possible to make a stage-by-stage analysis of a radio set and in this way localize a faulty condition or trace trouble down to a particular circuit branch. Such a stage-by-stage analysis is always very positive in its findings. An oscillator can further be used for checking the selectivity and sensitivity of a receiver; and if the oscillator output is calibrated, actual measurements can be made of the signal gain per stage or through a section of a set.

The Oscillator Applied to Testing Tubes

An application of the service oscillator that ordinarily is too little appreciated is its use for testing tubes, for the oscillator offers a ready means of checking a tube in terms of what it actually does in its own portion of the circuit.

It is quite commonly agreed upon among engineers and tube manufacturers that the mutual conductance test is the most satisfactory test for determining the real worth and operating fitness of a tube. It is also true that a change in the mutual conductance of a tube causes a proportional change in the total amplification in a radio receiver. Therefore, if an appreciable increase in amplification gain can be obtained by replacing an old tube with a new one, it is evident that the tube should be discarded and replaced.

A portable signal generator and output meter properly connected to a receiver, are ideal for determining the effectiveness of a tube in stepping up the amplification gain. Also, the system is especially commendable because the tubes are tested under the actual operating conditions in a receiver.

The oscillator is connected to the Ant. and G'd. terminals of the radio receiver, and the output meter is connected from the plate of the output tube to chassis or from plate to plate in case two output tubes in push-pull are used. A modulated R.F. signal is used, and the oscillator and receiver are tuned to about 1000 kilocycles. If the receiver is equipped with automatic volume control, the oscillator signal is cut down to a very low level, so that the control tube will not cut in and effect the amplification gain.

It is best to start with the rectifier tube, for it applies direct current energy to the rest of the tubes. Turn on the radio receiver and oscillator as explained and note the output meter indication. Then replace the rectifier with a new tube known to be in good condition, and if the output indication does not increase appreciably, the old tube is satisfactory. However, if an output increase of 20% or more is obtained, the old tube is partially exhausted and should be replaced.

Then proceed in a similar manner with the 1st R.F. or input tube, and follow through each successive stage. Wherever an increase of 20% or more is obtained when a new tube is substituted for the old, the old tube should be discarded. When each stage has been checked in this manner, all tubes have been given an actual working test, and a marked improvement in the performance of the set should be observed with the new tubes.

The same system can also be used to detect gassy tubes in a radio receiver. The oscillator and output meter are connected and adjusted in the usual manner. When the set is turned on, the output meter will first rise to a certain level and remain steady if the tubes are in good condition; but if one or several gassy tubes are present, the output will show a marked increase or decrease when the receiver reaches operating temperature. If the output decreases, the gassy tube is very likely in the A.V.C. or oscillator circuit; while if the output increase, it may be in one of the R.F. or I.F. amplifier stages. A gassy tube in the output stage will usually be evident by a blue glow and unstable operation.

ALIGNING TUNED R.F. RECEIVERS

In a tuned radio frequency receiver there are generally two, three, or four stages of amplification in which the coupling units contain a coil that is tuned by a variable condenser. Unless these tuned systems all operate in perfect synchronism that is, all tune to exactly the same frequency at every setting of the dial, a singal will have difficulty in getting through the amplifier, and the receiver will lack both sensitivity and selectivity and the volume will be low. Such lack of synchronism between the seccessive stages may be due to slight differences in the coils and condensers or to stray capacities caused by the different lengths and positions of the connecting wires.

To compensate for these factors that disturb the tuning, some gang condensers have the individual sections shunted by small trimmer condensers that can be adjusted with an insulating screw driver or socket wrench (special aligning tools are available for this purpose), while others have one plate of each section slotted into about five segments. Adjustments are then made by bending these segments out or in according to whether the capacity is to be decreased or increased. The advantage of the slotted plate is that aligning adjustments can be made at several different positions over the tuning range, while with a trimmer the balancing adjustment can be made at only one frequency.

The aligning process then consists of adjusting these trimming devices until all tuned circuits respond to exactly the same frequency for various dial settings. A broadcast station signal is not satisfactory for such work, so the signal from a good test oscillator is commonly employed. For an indicating device an output meter is recommended as this is most reliable. A 1-Mfd. condenser must be connected in series with the instrument to protect the meter against the high B-supply voltage.

Disconnect the aerial from the receiver and connect the "High" side of the oscillator to the aerial post, also connect the low side of the oscillator to the ground post on the receiver with the regular ground connection remaining undisturbed. Connect the output meter into the circuit, and then turn on the receiver and the oscillator.

If the sections of the tuning condenser are equipped with trimmers, set the oscillator at 1000 Kc. and also bring the receiver dial to this frequency so that the signal can be heard in the speaker. Turn the volume control on the receiver full on and the output adjustment on the oscillator down low enough so that the pointer on the output meter stands at about the middle of the scale for the lowest usable range. Do not forget the 1-Mfd. condenser if it is not built into the meter.

Start with the trimmer on the condenser section tuning the last R.F. stage next to the detector, and with an insulating screw driver or aligning tool, whichever happens to be needed, turn the trimmer adjustment up or down so that the output meter indication increases. Continue until turning the trimmer in either direction causes the output to decrease.

Next proceed in a like manner with the trimmer across the next section of the tuning condenser, and continue toward the antenna tuning section. As the work progresses and the sensitivity of the receiver increases, the output will also increase and the meter pointer swing to the right. To keep the meter point near the middle of the scale reduce the oscillator output from time to time, and always leave the receiver volume control full on.

After all sections appear to be balanced, go over the entire process again, for it will be found that in nearly every case some readjustments are needed.

Note! - Important: During the aligning process the tuning adjustment on the receiver must not be touched or altered in any way, for this would throw off the entire results and necessitate a repetition of the whole job.

Care should be taken in carrying out the adjustments that the operator's hands as well as other parts of his body are kept well away from the condenser sections and coil units, for their presence will introduce sufficient capacity to affect the tuning of the various circuits. Do not attempt to use a balancing wrench that is not made of insulating material. When the best setting for a condenser section appears to be found, remove the wrench, and if the output meter pointer does not move, that setting is correct. But if the pointer shifts either up or down, then body capacity effects are present and the condenser sections are not properly aligned. Also, if the chassis is a completely shielded one, it is very important that all shields be i place before aligning operations are attempted, otherwisw when the shields are put in place, the inductance and capacity values may be changed sufficiently to upset the entire balance.

If the condenser sections have slotted end plates also, the aligning procedure is slightly different, but all the precautions outlined must be just as carefully observed. Adjust the oscillator and receiver to the highest frequency note the set will tune in. Turn the receiver volume control full on and cut down the oscillator output so that output meter pointer stands between one-third and one-half full scale. After these preliminaries are completed, carefully adjust each of the condenser trimmers as was done previously, starting with the section nearest the detector and working toward the antenna. Be careful not to alter the tuning adjustment during these operations.

Then with a bakelite or fiber rod see if the end plate segments which are partly in mesh with the stator plates needany adjustment, generally none is required. Turn the condenser in slowly so that the second segment of the slotted end plates are just in mesh, and with the aid of the insulating rod see if this second segment must be bent in or out as shown by the output meter pointer. Always start with the condenser section nearest the detector and work toward the antenna. Turn the condenser in further so that the third segment is just in mesh and make any adjustments that may be required. Proceed with the fourth segment, and with the fifth segment in a similar manner, using the utmost care and precision.

When the work is completed and you feel satisfied that all adjustments are as close as they can be made, disconnect the oscillator and output meter, and put the antenna back on the receiver. If the work was done right, the set should now operate with better volume, have better sensitivity on weak stations, and improve selectivity as indicated by sharper tuning on the more powerful stations. It is generally recommended that such aligning work be done only in the shop and not in the customer's home.

The small trimmer condensers that are electrically shunted across the various sections of the main tuning condenser are generally mounted right on the condenser frame so that they appear to form an integral part of it. In a few cases these trimmers are mounted separately on the chassis. Some trimmer adjustment screws require a screw driver tip, while others require a square or hexagon socket wrench. In any case, only a tool made of bakelite or fiber or other insulating material should be used to eliminate all stray capacity effects.

When the tuning condenser is mounted on top of the chassis, these trimmers are readily accessible; but if the condenser is mounted underneath, the chassis may have to be turned upside down for balancing and aligning. Sometimes small holes are provided in the chassis or shielding through which these trimmers can be reached.

Aligning Superheterodyne Receivers

1. THE SUPERHETERODYNE RECEIVER REVIEWED. The modern superheterodyne receiver contains initially a tuner that selects the incoming signal and feeds it to the 1st detector or mixer stage where it is combined with the signal from a local oscillator. This oscillator is tuned simultaneously with the tuning of the selector or input circuit, and the difference or intermediate frequency remains constant over the entire tuning range. In some receivers a single tube performs both functions of mixer and oscillator, while in others a separate tube is used for each. Sometimes, especially in the larger sets, the 1st detector is preceded by a tuned R.F. amplifier stage as a pre-selector that adds to the selectivity and sensitivity of the receiver.

Following the 1st detector is the intermediate amplifier which is tuned to the difference frequency between the incoming and local oscillator signals. This I.F. amplifier usually contains one or two stages, and in a few special sets three stages. The coupling transformers ordinarily have both the primary and secondary windings tuned. The I.F. amplifier is then followed by the customary demodulating 2nd detector and audio amplifier. The design of these two stages depends on the degree of amplification that precedes the detector and the power output that is desired for operating the reproducer system.

It is evident now that if a single control tuning arrangement is used for such a receiver, there are two groups of tuned circuits that must operate in unison. The first group includes the tuned r-f amplifier, the input to the 1st detector, and the tuned oscillator circuit, all three of which are commonly tuned by a 3-gang condenser. The second group includes the primary and secondary windings of the I.F. transformers which must all be resonated or "peaked" alike at the frequency at which they are designed to operate.

2. HOW IMPROPER ALIGNMENT AFFECTS OPERATION. A superheterodyne receiver properly adjusted gives good results, but its performance also drops off rapidly if any of the associated tuned circuits get out of alignment so that proper synchronized tuning cannot take place. If the r-f amplifier and detector input are out of alignment, reproduction will be weak, for maximum voltage cannot develop in each tuned circuit. Station interference may also result, and the noise level be high, for with the signal low the volume control is inevitably turned up to increase the set output. If the oscillator does not "track" properly, that is, tune in step with the r-f circuits, the difference frequency is not correct and weak response results. Interference may also be encountered.

If the I.F. transformers are not properly aligned or "peaked" at the correct frequency, the amplifier will lack both sensitivity and selectivity, resulting in diminished response and more interference. The noise level will also rise and become especially disturbing. When such a receiver is on hand for repairs, a thorough voltage and resistance analysis should always be made of the entire circuit before any change in the adjustments of the tuned circuits is attempted.

3. IF A SUPERHETERODYNE NEEDS ALIGNING. It is not often that a superheterodyne requires realigning - only after a careful inspection has failed to reveal the cause of such conditions as low sensitivity, poor selectivity, and high noise level, should the various trimmer and padding condenser settings be considered. When it appears that a re-alignment is needed, an accurately calibrated signal generator and output indicator should be used. A good understanding should also be had of the circuit arrangement and of the frequencies that are employed in the receiver.

The aligning procedure outlined previously applies to the majority of superheterodyne receivers; but with some sets special observations are necessary, and whenever possible the manufacturer's service bulletin covering the set on hand should be consulted before any readjusting is undertaken. During the alignment the chassis should be placed on a wooden-top table or bench, for a metal top may change the characteristics of the coils and the associated circuits and hence interfere with proper synchronizing.

Unless the manufacturer's specifications direct otherwise, best results are usually obtained by starting with the I.F. amplifier and peaking the tuned windings at the frequency at which they were designed to operate. Next the oscillator and 1st detector are adjusted so that the oscillator tracks properly at the high and low frequency ends of the dial. At the same time the R.F. amplifier (if one is used) and input tuner are brought into step.

4. HOW TO ALIGN THE I.F. AMPLIFIER. A typical I.F. amplifier consists of one or several amplifier tubes coupled through suitable transformers that have both the primary and secondary windings tuned. The tuning or trimmer condensers are either

of the book type with mica dielectric or of the air-dielectric type resembling the regular tuning condensers. These trimmer condensers are generally mounted in the same shielding cans with the transformer coils, and are reached through holes in the cans or by means of special screw heads that project through the top. Various forms of insulated aligning tools that fit these different trimmer arrangements are available in compact kit form.

The aligning process then consists of "peaking" these transformer windings alike and at the frequency at which they are prescribed to operate. These I.F. operating frequencies can be obtained from the manufacturer's service bulletin or from various reference books and pamphlets. It should always be remembered that the manufacturer's instructions are the all-important ones to carry out. For the aligning all tubes and shielding cans should be in place and the antenna lead-in disconnected. The ground connection, however, should remain. Sometimes it helps to connect a .1-mfd condenser from the Ant. to Gr'd. posts. If the set is equipped with a "Local-Distance" switch, this should be in the Distance position. The output meter is connected across the voice coil of the speaker or from the plate terminal of the output tube to chassis, according to which arrangement is preferable.

The "high" side of the test oscillator is connected to the grid of the 1st detector tube and the ground lead to the Gr'd terminal on the set or directly to the chassis if the latter is grounded. If a separate oscillator tube is used, it is removed during the I.F. aligning, or the rotor and stator of the oscillator tuning condenser are shorted so that the oscillator is inoperative. The volume control on the set is turned to full on.

The test oscillator is then set to deliver a modulated signal at the prescribed I.F. frequency, and the attenuator is turned up only far enough to cause the output meter to give between one-third and one-half full-scale deflection.

If the set is equipped with A.V.C., the oscillator attenuator must be kept sufficiently low so that the signal will not cause the A.V.C. to cut in. Begin with the I.F. transformer nearest the 2nd detector and adjust the secondary trimmer until the output meter gives maximum deflection. Then similarly adjust the primary. Repeat these two adjustments, for changes in the tuning of one winding are reflected in the tuning of the other - hence the need of these re-checks. Continue similarly with the next I.F. transformer, and if three are used, continue with the third. Always proceed from the 2nd detector toward the mixer or 1st detector. When both or all three transformers are adjusted, repeat the entire process to pick up any discrepancies that may have been made.

Some service men prefer for a final check-up to connect the test oscillator directly into the R.F. stage that is under adjustment. For example, if the plate trimmer is being adjusted, better accuracy is obtained if the test oscillator is connected directly to the grid or input circuit of the tube, etc.

5. ALIGNING FLAT-TOP I.F. TRANSFORMERS. In flat-top I.F. transformers the primary and secondary windings are closely coupled so that the reaction between the two coils causes the primary to tune with a flat-top resonance characteristic instead of a sharp peak. In other words, when such a transformer is correctly aligned, the test signal can be shifted over a range of 7 to 8 kilocycles, (3½ to 4 kilocycles on either side of center) without affecting the output meter indication. For example, on a 456 Kc. intermediate frequency the flat-top resonance range may extend from 452 to 460 kilocycles. In the so-called hi-fidelity receivers this flat-top range may extend to 15 kilocycles, (7½ Kc. on either side of center.)

To "flat-top" such a transformer it is first resonated at the prescribed frequency as explained in the preceding paragraphs. Next the test oscillator frequency is varied slowly and at the same time the primary and secondary transformer trimmers are detuned slightly, one up and the other down. Gradually it is possible to establish a frequency range over which the oscillator signal can be shifted with no appreciable change in output indication. Although the process may appear a little tedious at first, with a little practice and experience it will soon be possible to accomplish the aligning in good time.

The methods outlined above for I.F. amplifier alignment apply to superheterodynes having a single-band tuning system as well as to those having a 3 or 4-band (all-wave) tuner, for after all the tuner only selects the signal input to the 1st detector or mixer, and from this point on the resulting intermediate frequency has no dependence upon the type of tuner employed.

6. IMPORTANCE OF PROPER OSCILLATOR TRACKING. In order that the tuning system of a superheterodyne can display the proper selectivity, it is necessary that the input tuner (and R.F. amplifier if used) be in perfect tune with the desired signal and at the same time produce the correct intermediate or difference frequency over the entire tuning range on the dial. Since the difference frequency must always be of the same constant value, this requires that the oscillator tuning be in step with or properly "track" the R.F. tuner. And what further complicates this tracking is that the oscillator tuning capacity must change at a different rate than the R.F. tuning capacity.

Although a number of different schemes have been tried to secure this oscillator tracking, the most common arrangement employed is a trimmer and padder condenser in connection with the main oscillator tuning condenser. In other words, the oscillator condenser is shunted with a small trimmer for proper tracking at the high frequency end of the tuning range, and for the low frequency end has another condenser called the "padder" connected in series. It is this padding condenser that corrects the rate of capacity change for the oscillator tuning. In some receivers the padder consists of a fixed condenser shunted by a small trimmer. For proper tracking the oscillator thus requires two adjustments, one at the high frequency end and generally at 1400 kilocycles, and the other at the low frequency end at around 600 kilocycles.

For aligning the 1st detector input, the R.F. amplifier, and the oscillator circuit, each section of the condenser is shunted with a trimmer from stator to rotor and in addition the oscillator circuit is provided with the series padder mentioned in the previous paragraph. Quickest results are generally obtained by manipulating all three together and thus establishing unified action between them.

7. ALIGNING THE OSCILLATOR AND 1ST DETECTOR. The high side of the test oscillator is connected to the Ant. terminal of the receiver and the low side to the Gr'd. terminal. Sometimes a dummy antenna arrangement consisting of a .00025-mfd. condenser in series with a 200-ohm resistor is necessary between the test oscillator and the Ant. terminal on the set. The manufacturer's instructions advise when this is needed. The oscillator tube in the set is returned to its socket if it was removed during the I.F. alignment, and any other circuit changes that may have been made are restored to normal. All tubes and shielding elements must be in their proper places. The output indicator remains as it was connected for the I.F. alignment.

The test oscillator is adjusted to deliver a modulated signal at exactly 1400 kilocycles. The receiver is also tuned sharply to 1400 kilocycles, and the manual volume control is turned to maximum, unless this should interfere with the operation of the A.V.C. system. After these various settings have once been established, they must not be disturbed or changed during the entire aligning process.

If the oscillator and 1st detector are not seriously out of alignment, an output indication should be obtained with the above settings. The oscillator trimmer is adjusted until maximum output swing is indicated on the meter, and then the trimmer in the grid circuit of the 1st detector is adjusted for maximum output. The two adjustments should then be repeated so that any slight errors can be pickedup. With the oscillator and 1st detector input now in proper alignment, the trimmer (or trimmers) in the R.F. stage are then brought into step at the 1400 kilocycle setting.

The oscillator padder is next adjusted at the low frequency end of the tuning range. For this the test oscillator is tuned to 600 kilocycles and the receiver is also tuned to this frequency. The padding condenser is then adjusted until maximum output is again secured. It may be necessary here to "rock" the receiver condenser back and forth slightly through the 600-kc. position while the padder is being manipulated, and it may also be found that maximum output is obtained when the receiver is tuned slightly off 600 kilocycles. In such cases it is better to operate the receiver a little off calibration than to cut down the selectivity by leaving the padder condenser off resonance. During this low-frequency aligning the high frequency trimmers must not be changed in their settings.

The oscillator and receiver should then be tuned back to 1400 kilocycles and the high-frequency adjustments rechecked. It is always advisable to go over the various operations several times, for the interaction between the different circuits generally make minor improvements in the settings possible. Many service men develop pet schemes and wrinkles of their own for carrying out this alignment work, but the procedure outlined here should always be observed as a basic route.

8. ADJUSTING TUNING CONDENSERS HAVING SLOTTED END PLATES. In some receivers the end plate of each condenser section is slotted. These slotted sections make it possible to adjust the tuned circuits at four or five different frequencies over the tuning range, according to the number of sections in the plates. The adjustments are made by bending the sections in or out. By bending the sections

in, the distance between the plates is decreased and the capacity increased, but by bending the sections out the capacity is decreased. In some condensers the sections are adjusted by small screws. With such condensers the manufacturer's specifications generally indicate at what frequencies the various adjustments should be made.

9. ALIGNING RECEIVERS EQUIPPED WITH A.V.C. An output meter as explained above, however, cannot be used for aligning a receiver equipped with automatic volume control (A.V.C.), for the function of this automatic control is to maintain the signal at a constant level, and hence quite wide variations in trimmer adjustments could be made without affecting the output indication. It would thus be nearly impossible to determine the point of exact resonance in such manner.

The A.V.C. action must therefore be cancelled in these receivers during the alignment process, and the way in which this is done depends entirely on the circuit arrangement employed. The circuit diagram must be studied and the most appropriate method of cancellation determined. The simplest expedient is to use a weak signal below the level at which the A.V.C. action cuts in. This works especially well with delayed A.V.C., for then the signal can rise to an appreciable level before the control action takes place.

In some circuits the A.V.C. tube can be removed and the receiving circuit will continue to function, but this ordinarily is not recommended, for the removal of the tube may upset the voltage and current balance of the circuit and this will interfere with the proper alignment. It is better, if the circuit action permits, to open the lead which supplies the signal to the control grid of the A.V.C. tube, for this renders the tube inoperative as far as the A.V.C. action is concerned. Another scheme that works in many sets is to open the lead that supplies the A.V.C. potential to the controlled R.F. and I.F. tubes. But if this is done, the grid returns of these tubes must be brought directly to ground or chassis so that the normal initial bias is supplied to the tubes. Special observations must be made in the case of tubes that serve in a dual or triple capacity such as 2nd detector, 1st audio, and A.V.C., for generally some slight circuit change can be made that will aid to nullify the A.V.C. action. In some receivers the tuning meter or "magic-eye" tuning indicator can be used to indicate the state of resonance. If none of these schemes work, it will be necessary to consult the manufacturer's aligning instructions.

10. ADJUSTING ANTENNA WAVE TRAP CIRCUITS. Some superheterodyne receivers that employ a high intermediate frequency (around 456 to 465 kilocycles) have a wave trap or rejector circuit in the antenna input circuit. This trap is tuned to the intermediate frequency, and serves to reduce interference from commercial stations that may be operating in the vicinity at the same frequency as the intermediate frequency of the set. To adjust such a trap circuit, the test oscillator which is tuned to the intermediate frequency is connected across the Ant. and Gr'd. terminals and the output attenuator is turned to maximum. The volume control on the set is also turned full on. The trimmer on the wave trap is then adjusted for minimum response on the output indicator.

11. HOW TO DETERMINE THE VALUE OF AN UNKNOWN INTERMEDIATE FREQUENCY. It may happen that a receiver is on hand for alignment but the value of the intermediate frequency is not known. In such cases this frequency can usually be determined experimentally, assuming the receiver is otherwise in operating order. The test oscillator is connected to the grid or plate terminal of the 1st detector as the case may require, and the attenuator is turned up for maximum output. The output meter is connected in its proper place, and the speaker is left in operation so that the signal coming through will also be audible. The volume control is turned full on.

The oscillator is adjusted to the highest I.F. value used in superheterodyne receivers, about 480 Kc., and slowly tuned lower. Unless the receiver is too badly out of alignment, a frequency is soon reached at which a signal comes through. If the oscillator is tuned still lower, another point is reached where a signal is heard but slightly fainter, and further down perhaps at a third point and still fainter.

Since the oscillator is delivering fundamental frequencies throughout the range it is tuned, the first point at which a signal is heard must be the intermediate frequency of the set. The signal at the second point is the 2nd harmonic of a lower frequency (half the intermediate frequency of the set), and the signal at the third point is the 3rd harmonic of a still lower frequency. For example, if as the oscillator is tuned through the customary range, the first signal appears at 457 kilocycles, the second signal would be heard at 228.5 kilocycles, and the third at 152.3 kilocycles. It would at once be concluded, then, that the intermediate frequency of the set must be 457 kilocycles. However from experience it is known that no such odd frequency as 457 kilocycles is in common use. Undoubtedly the correct value should be 456 kilocycles, and the intermediate amplifier is aligned at this frequency.

12. HARMONICS IN AN OSCILLATOR. Although for every setting of the tuning condenser an oscillator should generate one basic or fundamental frequency corresponding to the resonant frequency of the tuned coil system or tank circuit as it is called, there are also present in the output of the oscillator frequencies that are direct multiples of the fundamental. These higher order frequencies are called harmonics, and can also be used for test and alignment purposes when higher frequency signals are wanted.

The generation of these harmonics is caused by the fact that due to the bias on the grid of the oscillator tube the current pulsations in the plate circuit do not resemble the applied grid signal potentials but are considerably distorted. And it can be shown mathematically that such a distorted wave form can be analyzed or broken up into a fundamental frequency and a number of higher frequencies or harmonics of the fundamental.

For example, if an oscillator tuned to operate at 600 Kc. is coupled to a broadcast receiver, the signal can be heard in the receiver if its dial is set at 600 Kc. Further, if the receiver is tuned to 1200 Kc., an oscillator signal can again be heard. This signal is called the "second harmonic" of the fundamental, for it has twice the frequency. If the receiver could be tuned to 1800 Kc. another signal would be heard, the third harmonic with three times the fundamental frequency. The order of a harmonic is always equal to the number of times its frequency is as great as that of the fundamental. The 2nd, 4th, 6th, etc., are called the even harmonics, and the 3rd, 5th, 7th, etc., the odd harmonics. The strength of intensity of the harmonics becomes less as the order of the harmonic increases, namely, the 4th harmonic is weaker then the 2nd, etc.

If harmonics are employed as explained above, a wide range of frequencies is available from a single oscillator. If an oscillator has a dual range, say 150 to 500 Kc., and 550 to 1500 Kc., the following chart shows only a few of the many harmonic frequencies that can be obtained.

Fundamental	2nd Harmonic	3rd Harmonic	4th Harmonic	5th Harmonic
150	300	450	600	750
200	400	600	800	1000
250	500	750	1000	1250
300	600	900	1200	1500
400	800	1200	1600	2000
500	1000	1500	2000	2500
600	1200	1800	2400	3000
700	1400	2100	2800	3500
800	1600	2400	3200	4000
1000	2000	3000	4000	5000
1200	2400	3600	4800	6000
1500	3000	4500	6000	7500

Stage by Stage Analysis

Much time can be saved and needless testing eliminated in servicing a radio receiver by localizing or isolating the trouble to a particular stage of the circuit, and then analyzing this stage and its related parts by point-to-point voltage and resistance tests. Such an isolation process, however, should always be preceded by a preliminary inspection to eliminate first the aerial and ground as well as the power supply lines as a source of trouble. The tubes should be tested and any defective ones replaced, and a surface inspection made of the chassis to see that there are no loose shielding cans or loose tube caps, and that no dirt or other foreign matter is impairing the operation of the set.

Only after such preliminary tests fail to reveal the cause, is it necessary to bring in testing instruments for an analysis of the internal circuit system. It is in this internal circuit analysis that much time can be saved or wasted according to the procedure followed. Some form of output indicator is needed to show whether or not the signal is coming through the various stages as they are being checked.

It is always advisable first to study the circuit diagram of the receiver to be tested so that you will be properly acquainted with the circuit system employed, and know where and how to connect the signal generator, where to connect the output meter, and what to expect at each setting, etc.

The analysis is started by connecting the output meter across the voice coil of the speaker and feeding the "high" side of the oscillator to the plate terminal of the amplifier tube preceding the detector (2nd detector) with a .001 condenser in series. If the circuit is a superheterodyne, this tube is an I.F. amplifier and the oscillator must be tuned to the intermediate frequency used in the set. If it is a tuned R.F. system, the oscillator is tuned to 1000 Kc. The ground lead of the oscillator is connected to the chassis of the receiver.

When all is ready, the oscillator is turned on and a signal supplied to the receiver. If the output meter gives a reading, it indicates that the oscillator signal is coming through and that the audio amplifier is in working order. If no sound is heard from the speaker and the meter shows a reading, it is evident that the speaker is not operating. If no indication is observed on the meter, the signal is not coming through and the trouble lies somewhere between the plate of the I.F. tube and the speaker. It has thus been readily established whether the trouble lies in the high frequency section of the receiver or between the I.F. output circuit and the speaker, and this information will now serve as a guide for the next move to further localize the defect by shifting the oscillator or meter as the case may require.

If the trouble lies between the I.F. plate and the audio output, a check of the audio system and detector is in order. Move the meter connection to the plate of the output tube, and if a deflection is obtained here, the speaker coupling transformer is defective. With no deflection shift the meter to the grid of the output tube. A deflection now indicates that something is wrong with the output stage. At no deflection connect the meter to the plate terminal of the detector. A deflection means that the trouble is in the coupling unit.

If still no deflection is obtained, an analysis of the detector stage is necessary. The steps to be taken here and the meter connections to use will depend on the kind of detector circuit that is employed, whether it is of the grid-biased triode type or a dual-purpose diode that also serves as a 1st audio stage, etc. To check the last R.F. or I.F. transformer, shift the oscillator (tuned as previously) to the detector grid input terminal or to each of the diode plates, whichever the case may be. A deflection means that the I.F. transformer was at fault, but no deflection signifies that something is wrong with the detector stage.

Should it develop that the trouble has been localized in the detector or in one of the audio stages, every resistor, condenser, volume or tone control and any other components used in or related to this isolated stage, should be thoroughly checked by making suitable point-to-point voltage and resistance tests. All bypass and coupling condensers should be checked for breakdown, open-circuit and leakage. However, if the receiver is found to check satisfactory from the I.F. plate through the loud speaker, then an analysis of the R.F., I.F. and oscillator stages is necessary.

To check the various stages of a receiver ahead of the detector, the output meter is again connected across the speaker voice coil, and the ground lead of the oscillator is left attached to the receiver chassis. By shifting the "high" lead of the oscillator to different points, the signal can be introduced at various places, until two portions of the circuit are found between which the signal will not pass. The trouble must then lie in this portion. The oscillator was previously connected to the plate terminal of the last R.F. or I.F. tube and the output meter clearly indicated that the signal was coming through from that point on.

The oscillator lead is then shifted to the grid terminal on the same tube, and if the meter still shows an output, the tube and its input circuit are in good condition. With no indication, however, something is wrong either in the tube or the input circuit. A cathode resistor may be open, a bypass condenser shorted or open-circuited, the secondary winding on the coupling transformer may be open, a trimmer condenser may be shorted, etc. Any of these defects can easily be detected with a volt-ohmmeter. When testing with an oscillator in this manner, always be sure that both the oscillator and the circuit under test are tuned to the same frequency or else the signal can not get through, even though the circuit continuity is all right.

The oscillator lead is next moved to the plate terminal on the preceding tube, which may be either a 1st detector (mixer) tube or composite oscillator and 1st detector. The test oscillator is still tuned to the intermediate frequency, and if the meter shows an output, the circuit is in operating order from here on.

The oscillator is then connected to the grid terminal of this 1st detector tube, but now it must be tuned to some value in the broadcast range, around 1,000 Kc. The receiver is also tuned to the same frequency. If the output meter shows a deflection at this time, it is evident that both the 1st detector and set oscillator are functioning properly. If there is no deflection, however, then very likely there is something wrong in the oscillator stage or in the coupling element. The test oscillator is then substituted for the set oscillator, and for this purpose it must be tuned to a frequency equal to the broadcast frequency to which the set is tuned plus the intermediate frequency, for then the difference frequency established in the 1st detector will be equal to the required intermediate frequency. If a meter indication is obtained, then a careful point-to-point voltage and resistance analysis must be made both of the oscillator stage and the coupling elements. Lastly the test oscillator is again connected into the R.F. amplifier section ahead of the 1st detector and worked toward the antenna terminal, if it appears that the trouble lies in this section.

COVER PHOTOGRAPH

On the cover of this lesson is shown a photograph of the Triplett Model 3432 Signal Generator. This generator covers 165 kc to 120 mc in 7 bands (36-120 mc on harmonics). Long scales are readable at a glance. With a 10 to 1 ratio vernier tuning. This generator is designed to operate from a line voltage of 110-120 volts, 50-60 cycles.

- END OF LESSON -

EXAMINATION QUESTIONS ON FOLLOWING PAGE