TV RECEIVER ALIGNMENT

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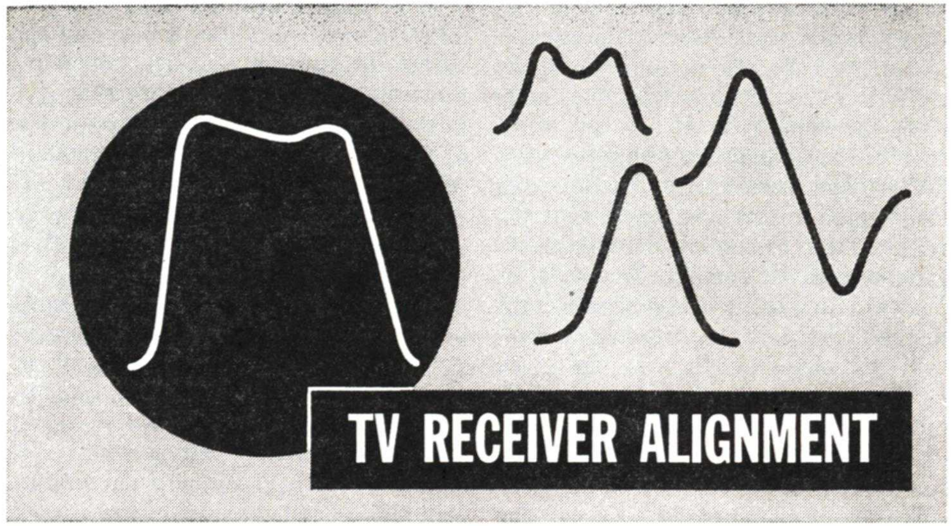


ALIGNING a standard sound receiver is a relatively simple process: the proper i.f. or r.f. signal is inserted and the corresponding circuits are tuned for a maximum output indication. (Band-pass adjustments are found only in a few high-fidelity sets.) The indications of the need for alignment of a sound receiver are quite definite — reduced output, stations coming in at incorrect points on the tuning dial, or distortion due to sideband cutting. Since sound receivers are relatively stable, the need for alignment is rather infrequent.

Aligning a TV set is not a great deal more difficult, but the indications pointing to the need for alignment are not as definite. In many cases, a set will exhibit exactly the same symptoms when some part is defective in it as it will when it needs re-alignment. In such cases, either you should prove that no defect exists before you decide that alignment is needed or you should use a sweep generator and an oscilloscope to show the response curve and thus determine whether alignment is needed.

Because many of the circuits of a TV set are heavily loaded so that they will have low Q and a broad response, there is seldom enough drift to make a complete over-all alignment necessary. On the other hand, because certain changes in the alignment affect the picture in a manner that is rather noticeable to the eye, relatively small amounts of drift, which may occur fairly often, can make spot or section alignment necessary. Tuned-circuit drift is more common in a TV set than in a radio because more heat is developed—heat that will warp coil forms and distort tuning capacitors—and because tube capacities, which are subject to change, make up part of the capacity in some tuned circuits.

In general, the sharper the selectivity (the higher the Q), the sooner alignment may be needed, because even small amounts of drift affect the outputs of high-Q circuits remarkably. On the other hand, low-Q circuits can drift considerably before the output changes greatly.

Relatively high-Q circuits are used as oscillator tank circuits and as sound and adjacent-channel rejection traps. In some of the stagger-tuned i.f. circuits, the Q is higher than the width of the pass-band might lead you to expect. It is quite possible that any of these circuits may need touch-up adjustments even when the rest of the receiver requires no alignment.

Oscillator Drift. It is rather common to find that the oscillator of a TV set has drifted so much that stations come in too near the end of the range of the fine tuning control or outside its range altogether. In a set that does not have a fine tuning control but instead depends on automatic frequency control (a.f.c.) to hold the oscillator, it is possible for the drift to cause the signal to fall outside the range of the a.f.c. network and thus for the station to be lost completely.

A certain amount of drift of the oscillator at the high frequencies involved in television is natural. It can be tolerated as long as it can be corrected by the fine tuning control or by the a.f.c. system. If the drift becomes excessive, however, it will be necessary to re-align the oscillator.

Because the oscillator circuits used in TV sets depend on the internal tube capacities for much of the tuning capacity needed, replacing the original oscillator tube with one that has different internal capacities may easily throw the oscillator section completely out of alignment. Therefore, if it proves impossible to find a replacement tube that matches the original in its capacities, a certain amount of re-alignment may be required.

Traps. Trap circuits also frequently drift out of proper adjustment. There are many traps in the average TV set. Some are tuned to the accompanying sound channel, some are tuned to the adjacent sound or picture carriers, some are used to reduce i.f. interference, and still others are used (particularly in sets using the intercarrier sound system) to reduce the 4.5-mc. grain pattern in the picture. Because these traps are sharply tuned and have much to do with the over-all response, slight shifts in their tuning may produce large increases in interference and can affect the low- or high-frequency response as much as or more than the stagger-tuned or band-pass circuits do.

Sound-Video Drift. The sound and video carriers are 4.5 mc. apart. If either or both of these i.f. sections in a conventional set drift appreciably, you may find that best sound and best picture are not obtained at the same setting of the tuning control. That is, if the picture carrier is moved up or down on the slope of the video i.f. response, the low-frequency response will be better or worse than it should be, and consequently the picture quality will be affected. A shift of the carrier may also result in a loss of high-frequency response.

In any of the above cases, you can make a touch-up alignment of the particular circuit that needs it without re-aligning any of the rest of the set. This is similar to what you do when a radio does not track the dial properly, in which case you re-align the oscillator but leave the i.f. and r.f. adjustments alone.

Of course, there will eventually come a time when an over-all alignment will be desirable. Such a general over-all alignment is called for when you are overhauling a receiver or remedying any of the characteristic conditions described in the following section.

MISALIGNMENT INDICATIONS

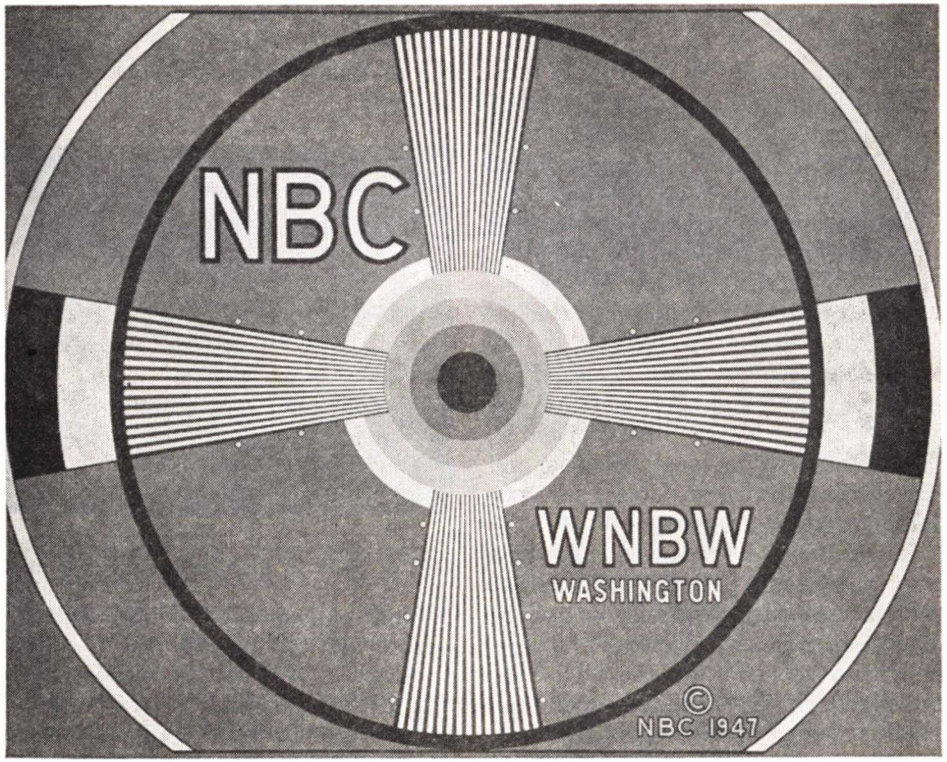
One of the most obvious conditions indicating a need for alignment is weak reception. However, unless the oscillator drifts, the alignment must shift markedly (usually in more than one stage) to produce weak reception. It is more common to find that the first indication of the need for TV alignment is a loss of the low- or high-frequency response. This is most easily seen by observing a test pattern.

Fig. 1 shows a typical test pattern. As we have shown elsewhere, this test pattern gives considerable information about the adjustment of the focus, linearity, and size controls, and also indicates when the correct contrast and brilliancy control settings have been made.

The contrast setting is indicated by the center circles: proper setting gives the complete tone range from black to white. The wedge-shaped groups of lines show many things. The vertical wedges show the high-frequency response, because they represent elements along the scanning lines. The horizontal wedges show other things, including the low-frequency response.

When we are aligning a set, we are primarily interested in how the test pattern will show high- and low-frequency response. When the set is operating normally and has a frequency response going out to 4 or 4.25 mc., the separate lines in the *vertical* wedges should be distinguishable all the way down to the center circle at which they end. If they appear to blend together short of their ends, the response of the set is less than 4 mc., either because it is intended to be or because it is out of alignment. In this case, the actual high-frequency response can be determined by observing where the lines in the vertical wedges appear to blend.

In the standard test pattern of Fig. 1, the four pairs of white dots along the lower vertical wedge are markers that indicate approximately the frequency response needed to reproduce the lines in the wedge between each pair. Thus, the first pair, nearest the bottom of the test pattern, represents



Courtesy NBC

FIG. 1. The standard test pattern broadcast by many stations.

a frequency response of 2 mc. If the lines are distinguishable between this pair but not between the next pair of dots, 2 mc. is the limit of the high-frequency response. The next pair is for 2.5 mc., the next, 3 mc.; the next, 3.5 mc.; and the ends of the wedges represent a response of 4 mc. In other words, if the vertical lines can be dis-

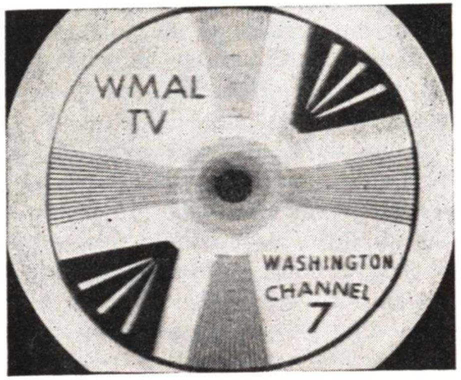


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FIG. 2. Poor high-frequency response.

tinguished sharply all the way to their inner ends, the horizontal resolution corresponds to an over-all frequency band width in the video amplifier, video i.f., and front end of 4 mc.

It may happen that the test patterns of your local stations do not have calibration marks, or that non-standard wedges made with fewer or thicker lines are used. In the latter case, the frequency response may be less than 4 mc. even though the ends of the wedges are clearly distinguishable. Check with your local stations and use the best local test pattern for your alignment check.

The *horizontal* wedges do not show anything about the band width of the receiver response. Whether or not the lines in these wedges can be distinguished depends on the focus, the roundness of the scanning spot, and the interlacing of the fields. If the set is deficient in low-frequency response, however, the horizontal line wedges will be gray when the vertical wedges are black and white.

Examples. Before you can tell much about the test pattern, you must adjust the focus for maximum sharpness and set the contrast and brilliancy controls to normal positions. If the set is very close to a powerful station, overloading may occur, or you may not be able to get normal contrast without turning the control down so far that overbiasing produces a distorted response. In such cases, use another signal, or use a resistive pad in the transmission line to reduce the strength of the input signal.

Fig. 2 illustrates poor high-frequency response. Notice that the lines in the vertical wedges join well outside the inner circle.

Excessive response to any frequency, an effect that may be caused by regeneration or misalignment, may be indicated by a smearing or blurring at the position in the wedge corresponding to that frequency. This is shown in Fig. 3.

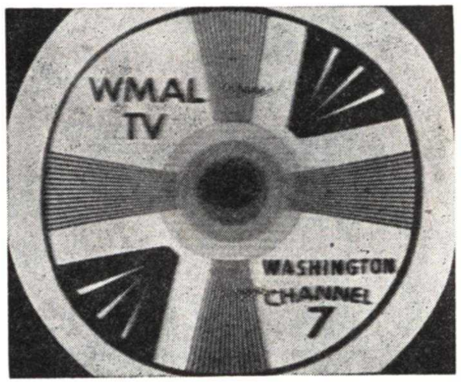

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FIG. 3. Peak in high-frequency response.

Another common indication of misalignment is the appearance of sound bars across the picture as shown in Fig. 4. This may mean that the sound traps are not properly aligned or are aligned to the wrong frequencies, but it may also indicate merely that the

fine tuning control on the set is misadjusted. If the set uses a.f.c., sound bars may be caused by excessive drifting of the oscillator or by a misalignment of the discriminator from which the a.f.c. voltage is obtained.

The grain pattern shown in Fig. 5

NRI TV Lab Photo

FIG. 4. Sound bars.

may be the result of a misadjustment of a grain trap, but it may also indicate that the co-channel sound traps in the i.f. amplifier are misaligned if the set is a conventional type.

Many of the distorted test patterns that we have just shown may be caused by other defects in the set or by external causes as well as by misalignment. Therefore, you should not try re-alignment until you have checked the other possible causes of trouble.

Before we take up the methods of aligning a TV set, let's learn what frequency response we can expect each section to have.

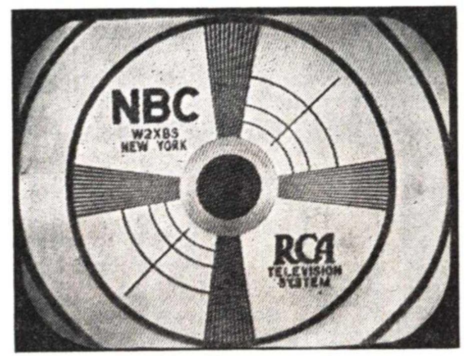
CIRCUIT RESPONSES

Front End. In general, the front-end response will be a band-pass response about 6 mc. wide so that the picture and sound signals can go through simultaneously.

Video I.F. The response of the video i.f. amplifier varies considerably in different receivers. One reason for the variation is that this response is often designed to correct for dips or peaks in the front-end response. Another is that the manufacturer may intend to locate the picture carrier higher or lower than the 50% response point, depending on whether he wants the low-frequency response to be raised or lowered. And, of course, the response of the video i.f. amplifier to the sound carrier will depend upon whether it is a conventional or an intercarrier system. Because of these wide differences, it is very desirable to have the manufacturer's alignment instructions before attempting to adjust a TV receiver.

Fig. 6A shows a typical front-end response. The exact shape of the response curve depends on the design of the set and even on the channel to which it is tuned.

If the set has a separate sound channel, the sound carrier will be suppressed. A typical i.f. response for such a set is shown in Fig. 6B. The



Courtesy RCA

FIG. 5. Grain.

over-all r.f.-i.f. response is a combination of the two, which may be somewhat like that shown in Fig. 6C.

The shape of the response curve can be varied considerably, as shown in Fig. 7A, without making any difference in the output. In other words, the output will be constant if the picture carrier is located exactly half way up any slope that is symmetrical on both sides of the carrier, regardless (within limits) of what the angle of the slope may be. Thus, the curves 1, 2, and 3 all will give approximately the same output. Because of the design of the peaking circuits and traps, however, it may be that only one of these curves can be made symmetrical, so it is necessary for you to learn from the manufacturer's instructions just what slope is to be obtained on the particular set on which you are working.

The position of the picture carrier on the slope affects the low-frequency response. If it is above the mid-point

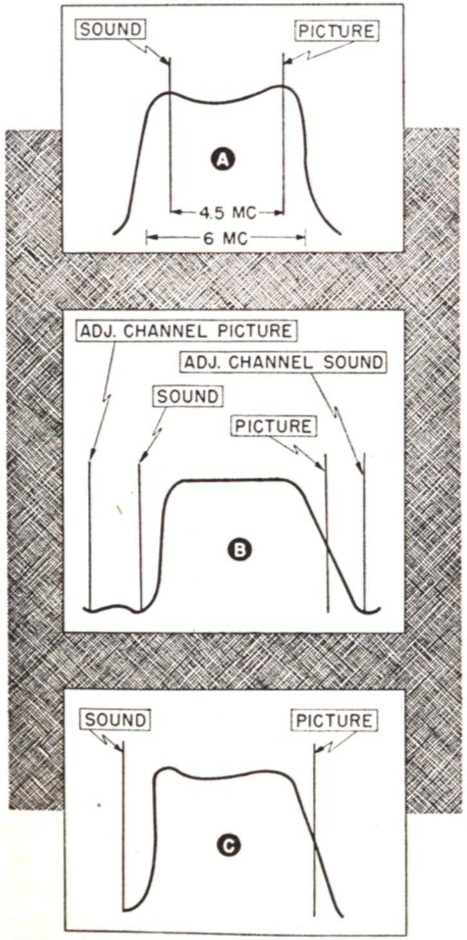


FIG. 6. The combination of the front-end response (A) with the i.f. response (B) produces the over-all response of the set (C).

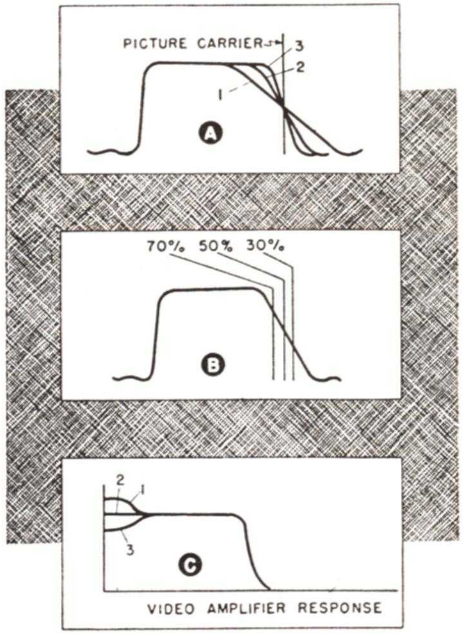


FIG. 7. The shape of the i.f. response curve (A) has little effect on the output, but the position of the sound carrier on the curve (B) can be used to compensate for variations in the video amplifier response (C).

of the curve, the low-frequency output is higher than normal; if below, the low-frequency output is lower than normal. This fact is helpful when the video amplifier response is to be compensated for. If the video amplifier response is flat as shown by curve 2 in Fig. 7C, for example, the carrier should be at the 50% point on the response curve in Fig. 7B. On the other hand, if the video amplifier response peaks at the low frequencies as shown by curve 1 in Fig. 7C, the carrier should be lower down on the curve, perhaps near the 30% point (Fig. 7B). This arrangement will reduce the amount of low-frequency signal applied to the video amplifier, thus compensating for the peak in the response of the latter. Similarly, if the video amplifier response is deficient at the low frequencies (curve 3 in Fig. 7C), the carrier should be

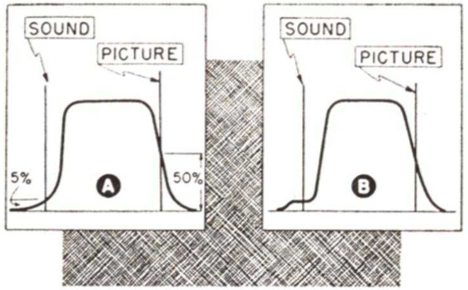


FIG. 8. Typical video i.f. responses of intercarrier sets.

farther up the slope, perhaps near the 70% point (Fig. 7B), to compensate. Once again, the manufacturer's alignment instructions must be followed.

Of course, if the receiver uses the intercarrier sound system, in which the sound signal must get through the picture i.f. along with the video signal, the response curve of the i.f. amplifier will be quite different. Fig. 8 shows two typical intercarrier video i.f. responses. The curve in Fig. 8A is nearly symmetrical on the sides, but the picture carrier is much farther up the slope than is the sound carrier. In some sets, traps are used to create a small plateau at the point where the sound carrier intercepts the response curve (see Fig. 8B). Once again, you will have to learn from the manufacturer's instructions what adjustments must be made.

Sound I.F. The response of the sound i.f. amplifier has the shape shown in Fig. 9A. The response is rather narrow, since a band of frequencies only 50 to 100 kc. wide is all that has to be passed. Hence, a response characteristic that is 200 to 300 kc. wide is entirely sufficient for most purposes and will even permit a reasonable amount of oscillator drift.

Since the sound is f.m., the discriminator response has the standard S-curve shape shown in Fig. 9B. The distance between the peaks on this S curve varies from set to set; once again, your adjustments must be guided by the manufacturer's information.

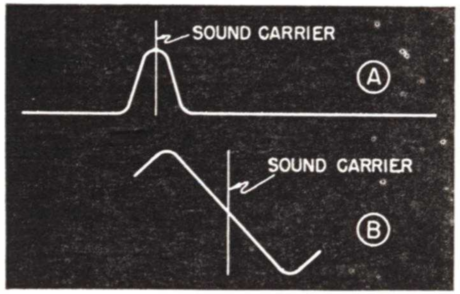


FIG. 9. Sound i.f. (A) and discriminator (B) responses.

Methods of Alignment

The pass band of a TV set, as you have learned, must be wide and flat and have very carefully shaped skirts. Either band-pass or stagger-tuned circuits are used in the front end and video i.f. amplifier sections to make the response sufficiently wide and flat, and traps are commonly used both to eliminate undesired carriers and to shape the response. Any one or all of these circuits may need to be aligned.

It is possible to align stagger-tuned circuits with an ordinary signal generator by adjusting each for maximum output at its proper frequency. The combined response curve of all the circuits will then have the desired shape.

A signal generator can also be used to align band-pass circuits fairly well, but a sweep signal generator is far better for the purpose. This same sweep signal generator can also be used to align stagger-tuned circuits if a cathode-ray oscilloscope is used as the output indicator; the oscilloscope will make the response curve visible, and any defects shown in the curve can easily be remedied.

Before we learn just how to align the various sections of a TV receiver, let's see what requirements the equipment used to do so must meet.

SWEEP SIGNAL GENERATORS

The sweep signal generator used in television resembles the frequency-modulated or "wobbulated" signal generator that is used to align high-fidelity sound receivers. The only basic difference is that the television sweep signal generator covers a wider sweep band.

As you know, the output of a wobbulated signal generator consists of a signal voltage that is swept back and forth over a range of frequencies on each side of a tunable operating or center frequency. For television use, this sweep must extend over a rather wide range—it is common to use sweeps 10 mc. (or more) wide for TV alignment.

This sweep can be obtained either mechanically or electronically. Three kinds of mechanical sweep generators are shown in Figs. 10A, B, and C. In the one shown in Fig. 10A, a motor rotates a tuning condenser plate so that the capacity in the L-C circuit is continuously varied. In that in Fig. 10B, a vibrator vibrates one plate of the condenser with respect to the fixed plate so that the capacity is varied. In that in Fig. 10C, a vibrator moves a disc with respect to the tuning coil so that the inductance is varied.

An electronic generator is shown in Fig. 10D. Here a reactance tube (like the one used in a.f.c. systems) is connected across the oscillator tank circuit. The grid of the reactance tube is fed from an a.c. source. As a result, its reactance varies at the a.c. frequency and therefore varies the frequency of the oscillator.

A major defect of the motor system shown in Fig. 10A is that there is no easy way to vary the width of the range over which the signal frequency is swept. In the other systems, we can vary the range over which the frequency change occurs by varying the amplitude of the a.c. voltage applied to the vibrator or to the grid of the reactance tube. An increase in the voltage will cause an increased change in capacity or inductance and consequently an increase in the width of the sweep. Conversely, a decrease in the voltage will cause a decrease in the width of the sweep. It is very desirable to be able to vary the width of the sweep, since we want a width of less than 1 mc. for f.m. and audio section alignment, and a width of 10 or 15 mc. for video alignment.

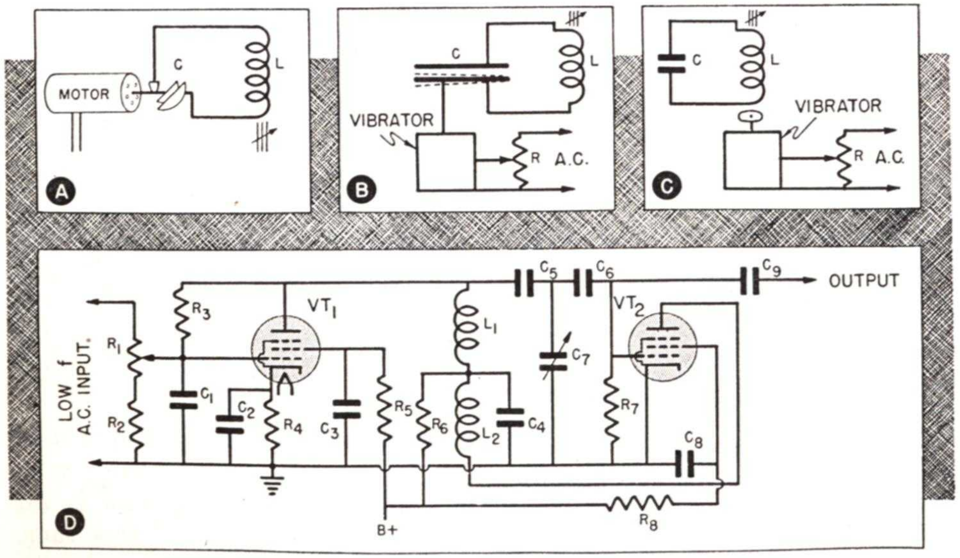


FIG. 10. Sweep generators used in sweep signal generators.

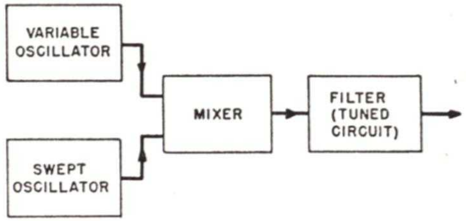


FIG. 11. Block diagram of a sweep signal generator.

The sweep *rate* is equal to the frequency of the a.c. signal used to vary the output frequency of the generator. In other words, it is the number of times per second that the output of the generator is swept through its range and returned to its starting point. This sweep rate need be only high enough to be within the response range of an oscilloscope. A 60-cycle a.c. is readily available from the power line or from a filament winding, and 120-cycle a.c. can be obtained from the ripple output of a full-wave rectifier. Either can be used for the sweeping signal if the oscilloscope has a reasonably good response at these frequencies.

The heterodyne principle is used in all practical sweep signal generators to simplify the problem of getting sweeps of adequate width at any desired center frequency. The block diagram in Fig. 11 shows the general arrangement of such an oscillator. As you can see, it consists of two oscillators, a mixer stage in which the outputs of the two oscillators beat together, and a filter circuit that passes only the difference frequency produced by the beating process.

One oscillator, called the swept oscillator, has a fixed center frequency that is sweep-modulated over the desired range. Since the center frequency of this oscillator is very high—usually well over 100 mc.—it is easy to vary the reactance in its tank circuit enough to produce a sweep range of 10 or 15 mc. The frequency of the other oscillator, called the variable oscillator, can be adjusted to any desired single value within a fairly wide range.

To see how this sweep signal generator works, let's suppose that the swept oscillator has an output of 125 mc. that is swept over a range of 15 mc. The center frequency of the output of the generator will be equal to the difference between 125 mc. and the frequency of the variable oscillator. If we adjust the variable oscillator to a frequency of 100 mc., for example, the generator output will have a center frequency of 25 mc. (125 – 100), which will be swept over a 15-mc. range.

To be useful for television servicing, a sweep signal generator should have an output voltage that is practically flat over the entire tunable frequency range, or at least over the range over which the signal is swept. This output voltage should be high, because as much as .5 volt may be necessary to give a usable response on an oscilloscope when the signal is fed through a single i.f. stage. There should be some provision for attenuating this output, however, since only 500 microvolts or less may be wanted when you are checking the over-all response of a set that has high gain.

It is necessary, of course, to synchronize the horizontal sweep of the oscilloscope with the sweep of the generator to produce a steady pattern on the oscilloscope face. Some gener-

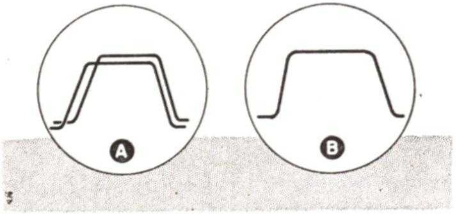


FIG. 12. A double trace (A) should be overlapped to produce a single trace (B) by adjusting the phasing control of your sweep signal generator.

ators supply a synchronizing signal that can be used to lock the sweep of the oscilloscope to the right frequency; others furnish the horizontal deflection voltage for the oscilloscope directly. (The latter is applied through the horizontal amplifier instead of the oscilloscope sweep voltage.)

It is possible for a sweep signal generator to produce a single trace pattern, but whenever a.c. is used to produce the sweep, the output will be a double trace. Thus, if the center frequency is 25 mc. and there is a 10-mc. sweep, the signal will be swept from 20 through 25 to 30, then back from 30 through 25 to 20. Thus, it goes over the frequency range twice for each complete sweep—once from the low end up, and once from the high end down—and therefore produces a double trace on an oscilloscope. For easiest observation, these two traces should exactly overlap each other as shown in Fig. 12B instead of appearing as separate traces as in Fig. 12A. This overlapping will be produced if the phase of the output is arranged properly; therefore, a control is incorporated in the sweep generator to permit the phase to be adjusted.

In general, therefore, a sweep signal generator will have a frequency control to adjust the operating frequency, an attenuator to control the output, a phasing control to permit the sweep image to be overlapped properly, and a sweep width control to vary the width of the swept band.

MARKERS

The manner in which a sweep generator produces its output makes its calibration subject to rather large errors. For example, let's suppose that two oscillators operating at 125 mc. and 100 mc. respectively are being used to produce a 25-mc. beat output frequency. Assuming a 1% accuracy for each oscillator, the output of one may be between 126.25 and 123.75 mc., and that of the other may be between 99 and 101 mc. The beat may therefore be anywhere between 22.75 and 27.25 mc., meaning that it may be as much as 9% away from the desired 25-mc. frequency. Further, there is no guarantee that the sweep will be exactly the same width on either side of the resting frequency or that the width of the sweep will be accurately known.

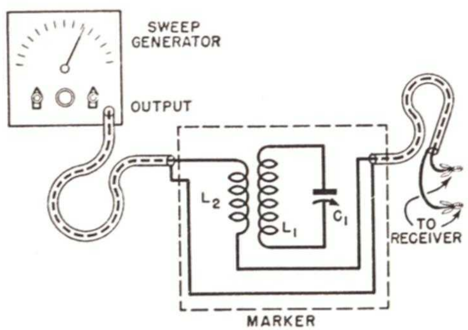


FIG. 13. How to connect a dipper marker.

Since it is important to know exactly what frequencies are produced by a signal generator, it is necessary to use some "marker" with the generator that will produce accurate frequency indications on the sweep trace on the oscilloscope. This marker must be accurately calibrated; an accuracy of .1 mc. is not good enough, even though this represents 1/10 of 1% at 100 mc.

Dipper. Perhaps the simplest form of marker is an absorption wavemeter like that shown connected to the cable of a sweep generator in Fig. 13. Some

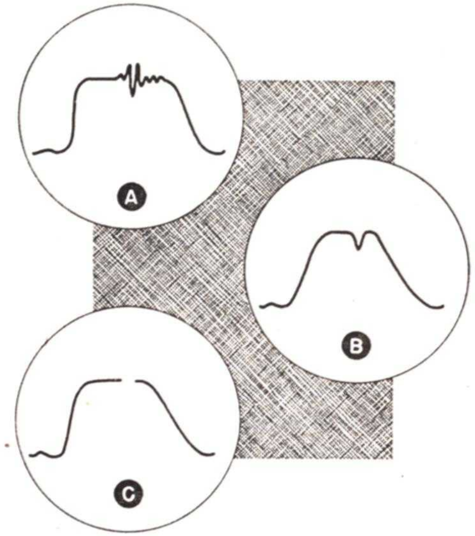


FIG. 14. Frequency indications produced by a sweep generator marker (A), a dipper marker (B), and a blanker marker (C).

sweep generators have a marker of this kind built in.

Essentially, this marker is a tuned circuit made with high precision from quality parts. It has a calibrated dial that indicates accurately the frequency to which it is tuned. When it is connected between a generator and a receiver as shown in Fig. 13, the tuned circuit will absorb energy at its resonant frequency from the coil L_2 and hence will produce a drop in the voltage supplied to the receiver at this particular frequency. This gives a "dip" in the response curve like that shown in Fig. 14B. If you change the resonant frequency of the absorption marker by turning its tuning condenser to some other position, the dip will move along the response curve to a position corresponding to the new resonant frequency. Thus, the marker dip can be used to indicate exactly the frequency to which any particular point on the curve corresponds.

Pipper. It is also possible to use an accurately calibrated signal generator as a marker. If the output of the signal generator is fed into the circuit in parallel with the output from the sweep generator, a "pip" will appear on the response curve seen on the oscilloscope, as shown in Fig. 14A. However, whereas the absorption tank circuit produces a single dip, a marker signal generator will produce a number of "wiggles" along the response curve, since there will be beats between the signals of the signal generator and the sweep signal generator that will cover an infinite band. All that limits the number of beats that are visible are the band-width response of the video output with the oscilloscope connected and the response of the vertical amplifier of the oscilloscope. An oscilloscope with a limited response produces a limited series of beats (Fig. 15A), but one with a wide-range re-

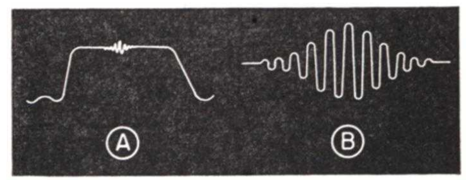


FIG. 15. Marks produced by a signal generator marker on an oscilloscope with a narrow response (A) and on one with a wide response (B).

sponse passes a number of beats (Fig. 15B). As we shall point out later, it is necessary to have only a narrow band of beats reproduced if the pip marker is to be used. If the oscilloscope response is too good, therefore, the response must be narrowed at the point where the oscilloscope is connected to the set. In this case, an inexpensive oscilloscope with a reduced response is as useful as a wide-band, high-quality instrument. (For other TV uses, of course, the more expensive instrument is better.)

Incidentally, the marker can be any good signal generator that covers the frequencies involved, provided that it is accurate in its calibration or that a crystal calibrator is used with it. Since few service generators cover the right frequencies, however, TV markers are usually bought especially for this use.

Blanker. A third way to produce a mark is to mix the marker and sweep signals and to ultilize the beat output to produce a high negative voltage that is applied to the grid of the oscilloscope. In this case, the response curve will be blanked out, as shown in Fig. 14C, at the point corresponding to the marker frequency.

At the present time, blanking markers are not commonly available.

Calibrators. A dipper marker must be accurately calibrated. Once this has been done properly, the calibration should remain accurate if the instrument is of reasonable quality. The calibration of a signal generator may become inaccurate after a time, however. If such an instrument is to be used as a marker, therefore, it must be re-calibrated frequently.

A very accurate crystal oscillator is often used for this purpose (in fact, some TV marker generators have such crystal oscillators built in). The fundamental and harmonic frequencies of the crystal can be used as calibration points. If a 5-mc. crystal is used, for example, its output will contain harmonics every 5 mc. This fact makes it possible to locate points at 5, 10, 15, 20, 25 (etc.) mc. accurately. If you adjust the marker generator so that it zero-beats accurately with the oscillator output at these points, you can be reasonably sure that it will be accurately calibrated between these points. The exact method of producing and detecting the zero beats depends upon the equipment you have: the manufacturer of your marker generator will supply calibration instructions with the instrument.

THE OSCILLOSCOPE

The oscilloscope used for alignment can be any of the standard types used for radio receiver servicing. It must have a fairly good response down around 60 cycles and a reasonable sensitivity, but it need not have a good high-frequency response. Of course, if the oscilloscope is to be used for other TV servicing uses, it should have a very good high-frequency response, high gain, and low input capacity.

The oscilloscope is absolutely necessary for making a band-pass alignment or for checking the over-all frequency response. However, when you are peak-aligning stagger-tuned circuits, you can measure the output with a vacuum-tube voltmeter or a 20,000-ohms-per-volt multimeter (preferably the former) instead of an oscilloscope.

ALIGNMENT TOOLS

TV alignment tools are very similar to those used in ordinary receiver alignment. It is important to use nonmetallic alignment tools insofar as possible, and the types with long, thin shanks may be needed to reach some of the adjustments. Any special alignment tool needed for a particular set can be obtained from the manufacturer, his local distributor, or your regular supply house.

When you align over-coupled or band-pass circuits, it is sometimes advisable to use two tools and to adjust the primary and secondary of each transformer more or less simultaneously. Of course, it is possible to adjust first one and then the other, but you will waste a lot of time moving a tool rack back and forth between the adjustments. (Usually, one adjustment is above the chassis and the other below.)

Now that you have a general idea of the tools, equipment, and procedures involved in alignment of a TV set, let's discuss the alignment of each of the sections of a TV set. As we said, most of the time you can remedy alignment defects merely by readjusting one or two circuits; however we shall give the complete procedure so you will know just what needs to be done if the set should need complete alignment. Once again we must caution you to follow the manufacturer's instructions carefully.

In making a complete alignment, it is quite common to align the sound system first, then the video i.f., and finally the front end. Some manufacturers, however, recommend that the video i.f. be aligned before the audio system. Actually, unless the sound signal passes through one or more of the video stages, it makes little difference which section is aligned first. It is wise to follow the order suggested by the set manufacturer, however.

Video I. F. Alignment

Before we discuss the processes involved in aligning the video i.f., there are several preliminary matters we must take up. Let's do so now.

Obviously, you must be able to identify each adjustment you are going to use. Unless you are quite familiar with the set, therefore, you must have the manufacturer's layout so that you can locate these adjustments.

Fixing the Bias. In aligning the video i.f. amplifier, we have to consider the fact that the contrast control (or the a.g.c. system, if the set has one) varies the gain of the video amplifier by varying the bias on some of the stages. The over-all response of a group of stages depends, of course, on their individual gains. If the gains of some of the stages are changed, as they will be if there is change in bias, obviously the over-all response of the i.f. amplifier will be greatly affected. For this reason, the bias on each stage that is to be aligned must be kept constant during the alignment procedure.

Manufacturers usually recommend the use of a moderate bias voltage so that the alignment will be made under the conditions that would exist if a reasonable local signal were being received. In sets without a.g.c., the contrast control is set to produce the desired bias, which is measured with the aid of a vacuum-tube voltmeter. As the alignment progresses, this voltage is remeasured from time to time, and, if necessary, the contrast control is reset to bring the voltage back to the right value.

Most manufacturers of sets in which a.g.c. is used recommend that the system be blocked either by removing a tube in the a.g.c. chain or by connecting a large condenser to the a.g.c. network. This condenser must make the time constant so long that it will be impossible for the a.g.c. to follow the variations in output caused by the alignment.

If a set is constructed so that the a.g.c. system or the contrast control cannot be adjusted to produce a fixed voltage of the desired value, the manufacturer may recommend the use of a bias from a separate source. Fig. 16 shows a typical arrangement. The potentiometer across the 4.5-volt battery can be used to adjust the bias. When

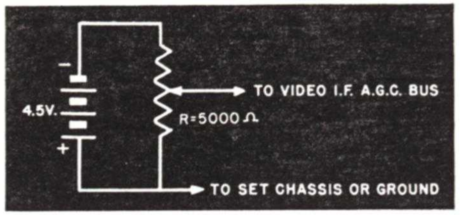


FIG. 16. Alignment bias source.

such a separate bias is used, the a.g.c. network or the contrast control is usually disconnected at some point. The manufacturer's instructions will tell you where.

COUPLING TO VIDEO I.F. STAGES

An important point to remember is that a signal generator can never be connected directly across a tuned circuit that is to be aligned. It must always be decoupled from this circuit. The simplest way of doing this is, of course, to connect the signal generator to a stage that is nearer the antenna than the one that is being aligned. If you connect your signal generator to the grid circuit of the tube ahead of the tuned circuit you are going to align, for example, the tube will act as a decoupler and prevent the generator from detuning the circuit.

Manufacturers recommend two basic approaches to video i.f. alignment: 1, a stage-by-stage process; and 2, an over-all technique. In a stagger-tuned section, the over-all technique is usually followed unless the stages are very far out of adjustment because of excessive drift or of tampering. An over-all technique will work on band-pass circuits also, but here the response curve depends so much on exact amounts of coupling (which may vary from stage to stage) and on precise adjustments, that the stage-by-stage method may be recommended.

Over-all Video I.F. For over-all alignment of the video i.f. amplifier, the signal generator can be connected to the grid circuit of the mixer stage or even tc the antenna connections of the set. Although a signal fed from the antenna will be reduced by the r.f. stage, its level at the input to the video i.f. amplifier may be about as high as it would be if it were fed to the grid of the mixer, because the grid circuit of the mixer may contain a trap tuned to the i.f. frequency that would reduce the input to a low level. In such cases, the manufacturer may give special instructions for making connections in the input tuner, because it is necessary to feed the signal through the mixer to align the i.f. transformer in its plate circuit properly.

Getting a simple connection to the circuit is sometimes a problem. In some instances, the manufacturer will instruct you to make up a dummy tube—one with one or more pins cut off—that will provide the necessary connection for the signal generator.

Another and even simpler method of connection is shown in Fig. 17. There will be sufficient capacitive coupling between a shield of this sort and the tube elements to transfer the signal without greatly upsetting the circuit to which the tube is connected. Of course, the shield must fit so snugly that it will not slip down the tube and touch the chassis; if it did, the hot side of the signal generator output would be grounded.

When you are making an over-all alignment, you can connect the output indicator to the plate load of the video detector (or even to the output of the

video amplifier if a modulated signal is used.) The kind of output indicator will depend on what you use as a signal source—if it is a standard signal generator, as it will be when you align a stagger-tuned i.f., you should use a vacuum-tube voltmeter or a multimeter as the output indicator. On the other hand, if you use a sweep signal generator in making an over-all check on alignment, the output indicator should be an oscilloscope. We shall describe the connections of these devices in more detail a little later.

Stage-by-Stage Video I.F. Alignment. There are two methods of getting a stage-by-stage alignment. In the more popular one, the output indicator is connected to the detector plate load, and the signal source is moved from the last i.f. stage back toward the converter stage, a stage at a time. However, a few manufacturers recommend that the signal source be connected to the converter or to the antenna connections and that the output indicator be moved from the first video i.f. stage back toward the video detector, a stage at a time. Essentially the same results will be obtained by either method. You must follow the manufacturer's instructions, however, particularly

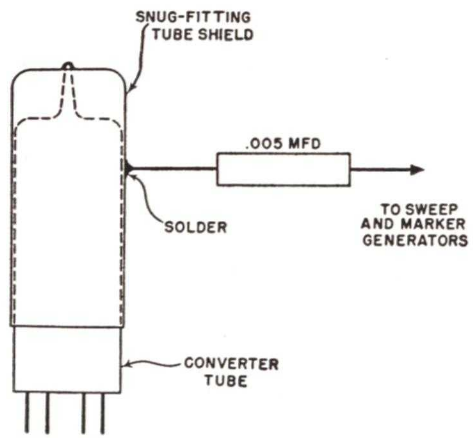


FIG. 17. Simple method of coupling a signal generator to a set.

when you align band-pass circuits, because that is the only way you can duplicate the curves that he shows in his service manual.

As far as making connections is concerned, it is somewhat more difficult to align by moving from the output back toward the input, since you must move both the sweep generator connections and the marker signal generator connections each time you align a stage. Going in the other direction, you need to move only the oscilloscope connection, but a special coupling device consisting of a rectifier and an R-C decoupling network must be attached to the end of the oscilloscope cable to make it possible to use it this way. We'll describe a simple coupling device that can be used for this purpose a little later in this text.

CONNECTION HINTS

When you align any section of a TV receiver, you must make sure that good ground connections exist between all of the pieces of equipment that are connected together. Some manufacturers even recommend the use of a metal-topped bench to insure good common grounding; such a bench is dangerous from other standpoints, however, so you should use some other means to make the ground connections. If you find at any time that moving the cables or bringing your hand near them causes the signal strength to vary or the frequency to change, you do not have an adequate ground connection between the set and equipment.

Although all of the cables that are commonly used for making connections have clips for grounding, these may prove insufficient. Pieces of shielding braid with heavy clamps on the ends can be used to connect various pieces of equipment together.

You must take special precautions if

any piece of your test equipment or the set on which you are working is of the a.c.-d.c. type that has a direct connection to the power line. If you have a piece of a.c.-d.c. test equipment, it is advisable to install an isolating transformer between it and the power line. (An isolating transformer has a one-to-one turns ratio: it does not change the voltage, but it does separate the device from the power line.) Such a transformer is needed when you work on sets that use filament strings and voltage-doubling power supplies so that there will be no chance of short circuits developing through your grounding connections.

When you align a set that does not have a series filament string, you can leave the picture tube out if it interferes with easy handling of the set chassis. (Leave the deflecting yokes plugged in, however.) If the filament of the picture tube is in series with others in a filament string arrangement, either leave it in the set or connect a 5-watt, 10-ohm resistor across the filament terminals of its socket to take its place. Of course, you should never attempt to remove the tube while the receiver is on.

If you remove an electromagnetic tube, you must do something to make the high-voltage lead safe. Either fasten this lead in a position where you will not be able to touch its terminal and where the terminal will not be able to touch the chassis, or make the high-voltage supply inoperative. The latter may be accomplished either by removing the high-voltage rectifier tube (or tubes) from its socket or by removing the r.f. oscillator tube or the horizontal output tube, depending on what kind of power supply is used in the set.

It is very important not to use too strong a signal for aligning any section of the TV set, the video i.f. in particular. If the input signal is too strong, some of the stages will be overloaded to such an extent that they will act as limiters and thus produce a false flattening in the trace of the over-all response on the face of the oscilloscope. The alignment cannot be properly made under such conditions. To prevent overloading, limit the input enough to keep the voltage across the video detector load under 2 volts.

If you align the i.f. stages with the signal generator connected to or ahead of the converter, it is always possible for the local oscillator in the receiver to beat with the signal and thus give a number of spurious frequency indications. If this proves annoying, you may have to kill the local oscillator completely by removing the tube, replacing it with a dummy tube to complete the filament circuit if the set has a series filament string. (A dummy tube for this use is a regular tube from which the grid and plate prongs have been removed, leaving only the filament operative.)

Of course, if the oscillator is a section of a dual tube, you may not be able to remove it. In such a case, it may be practical to tune to some channel far removed from the i.f. frequency (one of the upper channels on the high band) so that the oscillator frequency will be as far removed as possible from the signal you are using.

Now let's learn how to align video i.f. stages.

STAGGER ALIGNMENT

When the video i.f. amplifier uses stagger-tuned circuits, the most usual method of alignment is to adjust the tuned circuits, one at a time, with the aid of a standard signal generator and an output meter. The manufacturer's instructions will usually have you start with the traps, which are adjusted to give minimum responses,

after which you adjust the regular tuned circuits for maximum outputs at their resonant frequencies.

Using such a system, and of course changing the signal generator to the proper frequency for each alignment adjustment you make, you can be reasonably sure that you will get the desired over-all results. If you have any doubts after you have completed the stagger-tuned alignment, you can always use a sweep generator, a marker, and an oscilloscope to check the over-all response and make any necessary corrections in it. As a matter of fact, you can use the sweep generator and the marker combination to align these circuits in the first place by adjusting each trimmer until the over-all response is that desired for the particular set you are working on. The difficulty with this arrangement is that if the trimmers are far out of adjustment, you may find it very difficult to get the proper over-all response with maximum output. In such a case, you will probably have to align the stages to approximately their right frequencies before making a sweep alignment.

Let us run through the adjustment procedure you should use to align stagger-tuned circuits, first with a standard signal generator and an output meter, and then with a sweep generator and an oscilloscope.

Standard Generator. Aligning the video i.f. amplifier with a standard signal generator and an output meter is a process that is very similar to the one you use to align a radio receiver. If the circuits are not too badly out of alignment, the signal generator may be connected to the grid circuit of the mixer or even to the antenna terminals of the set.

The output meter may be either a vacuum-tube voltmeter or a multimeter of high sensitivity. Connect it across the load of the video detector. You will often find that the receiver is equipped with a convenient terminal on the top or rear of the chassis for making this connection. Refer to the manufacturer's instructions to see if this is true of the set you are working on.

If you are using a standard signal generator, you can use it modulated or not, as you wish. In either case, a d.c. voltage will be developed across the video detector load; measuring this voltage with your output meter will give your output indication. Of course, the proper polarity for your output meter connections depends upon the picture phase for which the video detector is adjusted. If the video detector load resistor is in its cathode circuit (cathode to ground), connect the negative lead of the voltmeter to ground. If the video load is in the plate circuit, connect the positive voltmeter lead to ground.

You can also measure the a.c. voltage produced by the modulation of the signal generator if you wish, but since most signal generators are modulated only about 30% to 50%, the a.c. output voltage will be rather low.

If you are using a marker signal generator, you may find that there are no provisions for modulating it. In this case, you must depend on the d.c. indication.

You must, of course, refer to the manufacturer's instructions to learn exactly what frequencies each of the traps and the tuned circuits must be set to and in what order the stages should be aligned. Follow this order exactly. If you do not, you may get two of the circuits aligned to the same frequency, in which case feedback may be set up, and some stage may go into oscillation. If you make the alignment in the proper order, the normal staggering of the tuning arrangement will prevent the resonant frequencies of the circuits from crossing each other in this manner.

A stagger-tuned video i.f. amplifier always has several traps, each of which must be adjusted to the frequency specified for it in the manufacturer's instructions. To align a trap, set the signal generator to the proper frequency and then adjust the trap to produce a minimum output indication.

Usually, though not always, the manufacturer's instructions will tell you to adjust the various traps first.

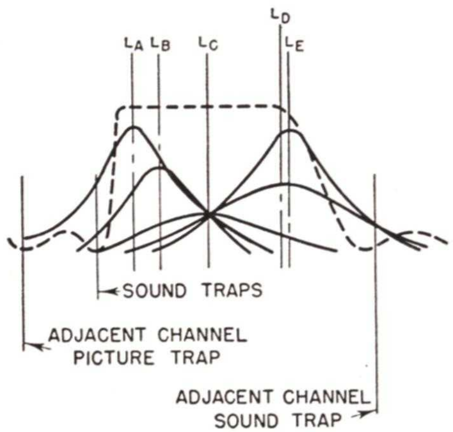


FIG. 18. Individual and over-all responses of a stagger-tuned i.f. section.

When you have adjusted them, proceed to align the various stages in the specified order. To align a stage, set the signal generator to the proper frequency and turn whatever adjustment the stage has until you get maximum output.

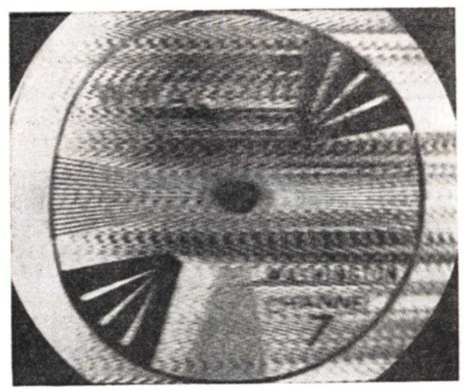
When each trap and stage has been properly adjusted, the over-all response should have the form shown by the broken line in Fig. 18. This response curve is the resultant of the responses of the individual stages (shown by the solid lines), and the notches cut by the various traps.

The proper response curve may not be produced by this method of alignment, however, if there has been a change in the bias applied to one or more stages or if the characteristic of some tube has changed because of aging. Either of these causes will affect the gain of a stage; and, unless the gains of all the stages are affected equally, the over-all response of the i.f. section will therefore be changed from what it was at the time the set was made. An incorrect response curve may also be produced, as we pointed out earlier, if too strong a signal is used. You can avoid this possibility by following the manufacturer's instructions carefully.

Oscillation. A severe misalignment may produce oscillation. If you suspect the alignment, and have another set like it, move all the adjusting screws of the set on which you are working to approximately the positions of those in the set that is working normally; the circuits should then be somewhere near the right adjustment—perhaps near enough so that you car go on to make a proper alignment. If not, you may have to align the circuits, one at a time, by aligning the last i.f. stage first and working back toward the input. In such a case, it is necessary to block the oscillation. If the receiver has four i.f. tubes, for example, remove the third i.f. tube to block all signals coming from stages nearer the antenna. Then connect your signal generator to the grid circuit of the fourth i.f. stage and align this stage for maximum output. Next, put the third tube back in place, remove the second tube, and connect the signal generator to the grid of the third tube. Progressing in this manner, you should be able to reach an adjustment that will stop the oscillation, after which you can make the final adjustment in the proper order.

Incidentally, when a set is severely out of alignment, a procedure of this type may be necessary whether or not oscillation occurs. When you are feeding a signal into the grid of one tube, the tuned circuits that are between the plate of the preceding tube and the point where your signal is applied may act as an absorption trap and reduce the output from your signal generator to a low level. By removing the preceding tube, you remove that tube's capacity and so detune the circuit that such absorption is unlikely. Of course, any procedure that involves the removal of a tube cannot be used in a set that has a series filament string unless you can put a dummy in place of the one you wish to remove.

Sweep Alignment. If you want to see the over-all response after having aligned the circuit in the manner just described, or if you want to align with the sweep generator, you can connect a sweep generator and a marker in



NRI TV Lab Photo

One type of i.f. oscillation.

place of the standard generator and connect an oscilloscope as the output indicator.

If the oscilloscope has an excellent high-frequency response, the beat between the marker and the signal generator will spread over such a wide band that it will not be practical to use it. In such a case, the high-frequency response must be reduced. One way of doing this is to connect a resistance of 10,000 to 25,000 ohms in series with the hot lead going to the oscilloscope. This will cause the cable capacity (between the point of connection and the oscilloscope) to act with the resistance as an R-C low-

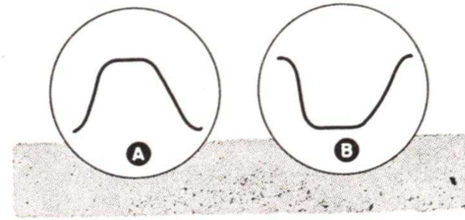


FIG. 19. A "normal" (A) and an inverted (B) trace of the same signal.

pass filter, thereby reducing the input to the oscilloscope at high frequencies. Another way to reduce the response is to shunt the detector load with a small condenser. The size of such a condenser would have to be determined by experiment if there is no recommendation in the oscilloscope instructions.

You may sometimes find that the oscilloscope picture is upside down, as shown in Fig. 19B, instead of having the normal position shown in Fig. 19A. Some oscilloscopes have a switch that permits you to turn over the trace by reversing the oscilloscope connections.

An upside-down picture is just as useful for alignment as a normal one is, so if your oscilloscope has no phasing switch, you can use the trace, or if you prefer, you can get the picture to turn over by inverting the picture phase, which you can do by connecting your oscilloscope to the output of the first video stage following the detector. If you do so, remember that you must not short-circuit the B supply. If your oscilloscope does not have a blocking condenser in its input lead, you must connect one in series with this lead to prevent such a short circuit.

The proper method of connecting the sweep and the marker depends on the equipment you have. If the marker is an absorption wavemeter or dipper, it will just be connected in the output lead from the sweep signal generator to produce a dip in the response. If the marker is a signal generator, however, it may be connected in parallel with the sweep generator, it may be connected at another point in the circuit, or it may be connected directly to the oscilloscope, depending on its type.

You may get into some trouble because the marker output may be far higher than is necessary. If its attenuator cannot reduce the output sufficiently, you may have to include a resistance in series with the hot lead from the marker generator. A 100,000-ohm resistor is generally used.

Some of the newest marker signal generators are quite different from the kind we have already described. These contain a built-in mixer-detector stage in which the marker signal is mixed with a small amount of energy taken from the output of the sweep generator. The resulting beat output is then fed directly to the oscilloscope, where it is connected in parallel with the sweep output that is coming from the set. In other words, only the sweep generator signal goes through the receiver, but the output of the marker unit has the necessary beat at the right point (since it is in synchronism with the sweep) to indicate the frequencies on the curve shown by the oscilloscope. Instruments of this kind have crystal calibrators built in them for checking the marker generator alignment from time to time.

Some servicemen couple a marker generator to a receiver capacitively simply by placing the marker lead near the mixer circuit. In general, you should follow the instructions accompanying your marker and generator combination in connecting them to a receiver.

As a simple check on whether the marker is properly connected, set up the sweep signal generator and oscilloscope and get a response. Next, connect the marker and turn it on. The response curve should then have the characteristic wiggles of a pip on it, but should otherwise be unchanged. If it does change, either the marker output must be reduced or the marker must be connected at a different point so that it does not upset the sweep output.

The sweep generator-marker-oscilloscope method of alignment has two advantages: it lets you see whether the over-all response curve has the right shape, and lets you determine whether the curve covers the right frequency range. It is always possible for the response to have exactly the right shape but to be shifted above or below the correct frequency range. You can tell whether this has hap-

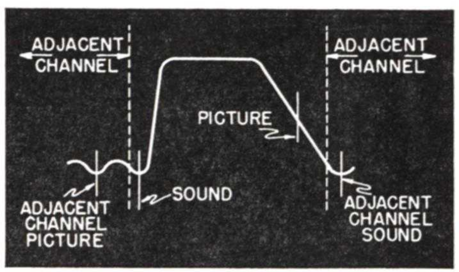


FIG. 20. Position of carriers on a response curve.

pened by using your marker to locate various frequencies—such as the carrier frequencies—whose relationship to the curve is known. Fig. 20 shows where the various carriers are supposed to occur in many sets. If you find, with the aid of your marker, that the picture carrier is not half-way

down the slope of the response, you know at once that the response curve does not have the frequency range it should have. The manufacturer's instructions will show you where the various carriers should be with respect

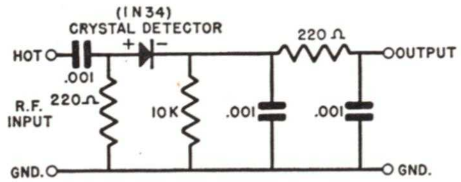


FIG. 21. Schematic of a crystal detector probe.

to the response curve for the set you are interested in.

BAND-PASS ALIGNMENT

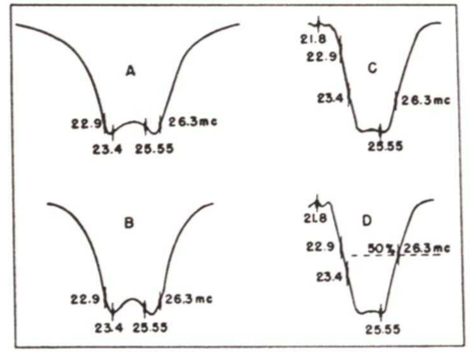
Two basic kinds of band-pass circuits are used in video i.f. stages. In one, each circuit covers practically the full band width, in the other, the circuits are band passed but are also somewhat stagger tuned in their arrangement.

It is sometimes possible to align either kind of band-pass circuit fairly well with a standard signal generator (we will show you how later on). It is far better, however, to use a sweep generator and an oscilloscope for the purpose.

Band-pass circuits, because they are overcoupled, are critical in their adjustment. It is very easy to get them out of adjustment so that the response curve is lopsided or consists of two widely separated peaks having a valley between them. The best way to avoid such difficulties is to adjust the primary and secondary simultaneously on each transformer as you move along.

As we have pointed out, there are two basic ways in which you can make the alignment. One is to connect the oscilloscope to the detector load and then move the sweep generator and marker back a stage at a time toward the input. The other is to connect the marker and sweep generator to the converter stage and move the oscilloscope from the input toward the output, a stage at a time. In the latter case, the oscilloscope must be connected to the set through a rectifier and decoupling network like that shown in Fig. 21. You can buy such a coupling unit made up in an enlarged probe, or you can make one if you are careful to arrange it to take a minimum of space.

No matter which way you move through the video i.f. amplifier in a stage-by-stage alignment, you must have the manufacturer's instructions so that you will know what response curves you should see for the various groupings of the stages that you have.



Courtesy General Electric Co.

FIG. 22. Partial and over-all responses of a band-pass i.f. section.

That is, you will need to know what the response curve for one stage alone looks like, then what shape the curve for two should have, and so on.

A typical example of such curves is shown in Fig. 22. Part A of this figure shows the curve for one stage (the output stage); B, that for two stages; C, for three; and D, the over-all response. Notice that the other curves do not closely resemble the one showing the over-all response.

It may be possible to make an over-all alignment adjustment of a band-pass i.f. when the trimmers are not very far out and when the coupling need not be disturbed. If the coupling has to be adjusted, however, the proper pass-band shape can usually be obtained only by making a stage-by-stage adjustment.

Notice that the various marker positions are very carefully indicated in Fig. 22. It is quite important to make sure that the various points on the response curve occur at the right frequencies.

If you do not have a sweep signal generator, you may be able to use the method shown in Fig. 23 to align a stage in which an over-coupled transformer is used. A load resistor of the size recommended by the manufacturer (usually 1000 ohms or less) is connected across one of the circuits; then the other is aligned. Next, the resistor is moved to the other circuit, and the circuit across which it was first placed is aligned. As shown in Fig. 23A, for example, a resistor is used to load the primary, and the secondary is tuned to resonance. Then, as shown in Fig. 23B, the resistor is moved to the secondary, and the primary is tuned to resonance. When the resistor is removed from both windings, the over-coupling that will be present without the resistor should give the band-pass response shown in Fig. 23C.

INTERCARRIER RECEIVERS

Receivers that use the intercarrier method of obtaining the sound may either be stagger tuned or have band-pass circuits. The alignment procedures for these sets are quite similar to those that we have just described. One difference is that you seldom align the sound i.f. amplifier of a conventional set unless it actually needs it, whereas it is customary to align the sound i.f. amplifier of an intercarrier set as a matter of course before aligning the video i.f. amplifier. About the only difference between the two kinds of sets in the alignment of the video i.f. amplifier is that you want to get an over-all response curve in an intercarrier set that is somewhat different from the one you want in a conventional set, since the video i.f. amplifier of the former must pass at least a small portion of the sound carrier.

In general, the over-all video response curve of an intercarrier set is more symmetrical on the two sides than that of a conventional set is. If there are any traps for the accompanying sound signal, they will not have the high Q of those used in conventional sets or will be detuned sufficiently to permit a certain amount of the sound carrier to go through.

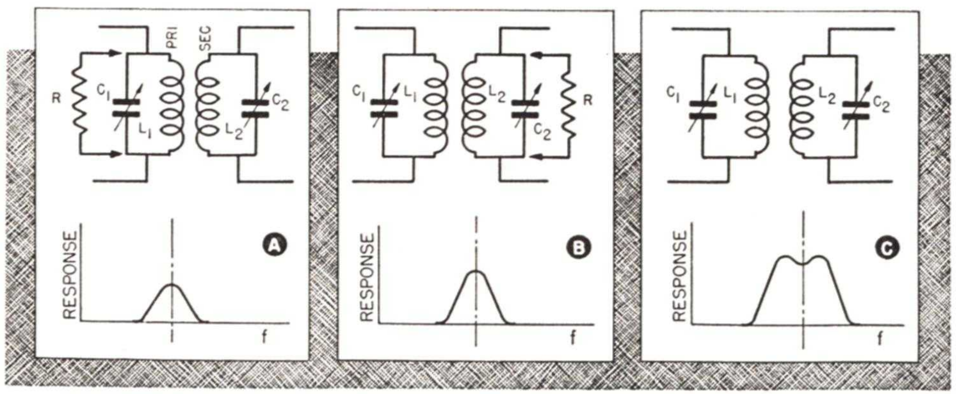


FIG. 23. Method of aligning a band-pass i.f. section with a non-sweeping generator.

Once again, you should follow the manufacturer's instructions concerning the exact order of the trimmer adjustments and the response curves that should be obtained.

Grain Traps. A grain trap is commonly used in an intercarrier set at the point of sound take-off (and sometimes also in any following video stage) to remove the 4.5-mc. beat from the picture signal before it is applied to the picture tube. Such traps are also used in some conventional sets.

The adjustment of a grain trap is quite simple. Just apply a 4.5-mc. signal to the first video amplifier, then adjust the trap until a minimum amount of grain is visible on the picture tube of the set. If you prefer, you can connect an oscilloscope having a rectifying probe to the output of the video amplifier and adjust the trap for minimum signal on the oscilloscope. This adjustment must be made with the contrast control in its maximum position if the contrast control is located in the video amplifier. If the contrast control is located in the video i.f. amplifier, its setting is immaterial, unless you are watching a picture on the picture tube to determine when the grain is minimized instead of using a signal generator.

Although this trap is in the video amplifier, not in the video i.f. amplifier, we have included its adjustment here because it is usually adjusted after the video i.f. amplifier has been aligned.

Sound I. F. Alignment

The sound i.f. section of a TV receiver is aligned in just the same way that the i.f. section of an f.m. radio is. We shall sketch the method briefly here; full details were given earlier in your Course.

The sound i.f. amplifier itself consists of from 1 to perhaps 3 stages that are tuned to the sound i.f. frequency. In an intercarrier receiver, this frequency is 4.5 megacycles. In a conventional set, this frequency is 4.5 megacycles below whatever the video i.f. carrier frequency may be.

Although these amplifier stages may be coupled by semi-band-pass circuits, the pass band is usually narrow enough for them to be peak aligned. Therefore, you can use either a signal generator and a vacuum-tube voltmeter (peak alignment) or a sweep signal generator, a marker, and an oscilloscope (sweep alignment).

You must connect your signal generator to some point ahead of the place where the sound signal is taken off. In a conventional set, a logical place is at the grid of the mixer-converter. In an intercarrier set, you can feed the signal in anywhere in the video amplifier ahead of the sound take-off.

The point to which you should connect your output indicator depends upon whether the set uses a limiter-discriminator or a ratio detector.

If the set uses a limiter, it is considered best to adjust the sound i.f. circuits for a maximum indication across the grid resistor of the limiter, so that is the logical place to connect your vacuum-tube voltmeter or oscilloscope. If you use an oscilloscope, connect a decoupling resistor of about 50,000 ohms in series with the hot lead to prevent the input of the oscilloscope from affecting the time constant of the limiter circuit too much.

After the circuits up to the input of the limiter have been adjusted for maximum response, you must move your output indicator to the output of the discriminator. At that time, you can make the proper adjustment of the transformer that connects the limiter to the discriminator. We shall say more about this adjustment in a moment.

A set that uses a ratio detector has no limiter stage (or has only partial limiting). In such a set, the proper place to put the output indicator is across the ratio circuit, as we shall show. Once again, the purpose of the adjustment is to produce maximum output.

F.M. DETECTOR ALIGNMENT

Although it is possible to adjust a discriminator or a ratio detector with a signal generator and an output meter, it is better to use a sweep signal generator and an oscilloscope. We'll describe both methods.

Peak Adjustment. The transformer that feeds the f.m. detector must be very carefully adjusted if best results are to be obtained. You must first set the signal generator to produce the sound i.f. center frequency, then tune the primary to obtain maximum output, and then tune the secondary to get a minimum output. Be careful in adjusting the secondary—a slight misadjustment beyond the correct point will cause a reversal of the polarity of the output voltage. Since many vacuum-tube voltmeters will not indicate a reversed voltage, you have to be careful in approaching zero output to be sure you do not go too far. If you suspect that you have, reverse the test leads and see if you get a reading. If you do, readjust the secondary slightly. You will have gotten the right adjustment when the reading remains as near zero as possible when you reverse the leads.

The output meter connections for this adjustment depend on the type of detector circuit. If the set uses the standard discriminator circuit shown in Fig. 24, connect the v.t.v.m. between point Y and ground, and adjust the primary trimmer C_1 until you get a maximum reading. Then connect the v.t.v.m. between point X and ground, and adjust the secondary trimmer C_2

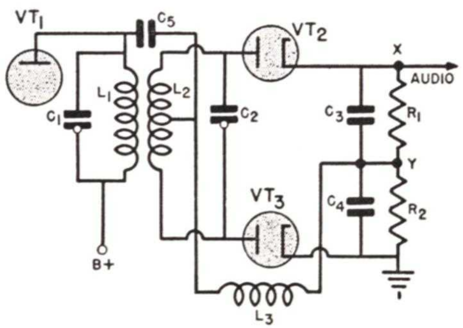


FIG. 24. Output meter connection points in a standard discriminator circuit.

until you get a minimum output. You may have to go back and forth, repeating each adjustment one or more times, because of interlocking between these circuits.

When the ratio detector is used, the connections will depend on the design of the circuit. In the balanced detector shown in Fig. 25, there is a center-tapped resistor network across the charge-storing condenser C_3. Connect the v.t.v.m. between point Y and ground to align the primary for maximum output, and connect it between point X and ground to align the secondary for minimum output. You should also connect it between point Y and ground for use as an output meter

when you align the preceding i.f. amplifier circuits. These circuits should be adjusted to produce maximum output when the v.t.v.m. is connected in this manner.

The ratio detector shown in Fig. 26 is unbalanced. When you align this

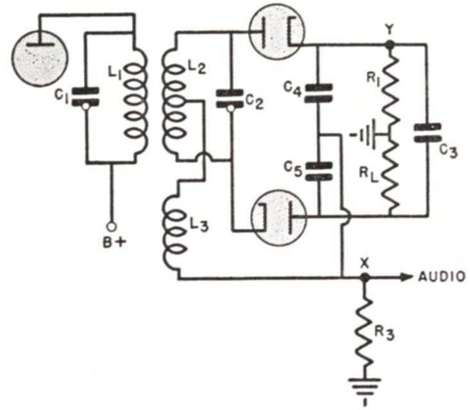


FIG. 25. Output meter connection points in a balanced ratio detector circuit.

kind of detector, you should connect the v.t.v.m. between X and ground to align the primary circuit L_1-C_1 and the preceding i.f. amplifier circuits to produce maximum output, just as you do when you align a balanced detector.

To adjust the secondary circuit L_2-C_2, however, you must establish an artificial balance point, because the load resistor R_1 has no center tap. To do so, connect two resistors of about 100,000 ohms (R_2 and R_3) across R_1 as shown. These resistors should have the same resistance within 5%. Then connect the v.t.v.m. between the junction point W and point Y, and adjust the secondary to get a minimum reading.

Notice that two core adjusters are indicated for L_2 in Fig. 26. These are provided so that the secondary can be adjusted to feed the proper signal to each diode. Adjust them simultaneously for minimum output between W and Y.

This peak adjustment procedure does not necessarily give a symmetrical response curve. For this reason, sweep alignment (which does give a symmetrical curve) is preferred.

Sweep Alignment. When you use a sweep signal generator, you must connect the oscilloscope to the point in the output circuit of the discriminator to which the audio frequency take-off lead is connected. You will then get an "S" curve somewhat like that in Fig. 27A if the oscilloscope is swept from the sweep generator. If the sweep generator furnishes a sync voltage instead of a sweep voltage to the oscilloscope, you can get the double response curve shown in Fig. 27D by reducing the horizontal sweep frequency to one-half that of the sweep generator. This pattern is sometimes useful in obtaining perfect balance in the discriminator response, because it is easier to determine whether the two sections of the double "S" curve are

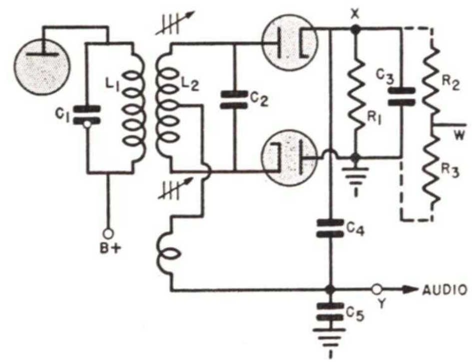


FIG. 26. Output meter connection points in an unbalanced ratio detector circuit.

alike than it is to compare halves of a single curve.

You should use a marker signal generator to determine the exact midpoint of the S curve (point 1 in Fig. 27A). This marker should be modulated by an audio tone. If the marker is not modulated, the pip it produces will be visible if it occurs near one of the peaks of the discriminator curve (at point 2 in Fig. 27B, for example), but it will not be easily visible if it occurs at the midpoint of the S curve. If the marker signal generator is modulated by an audio tone, however, a series of beats will show up on either

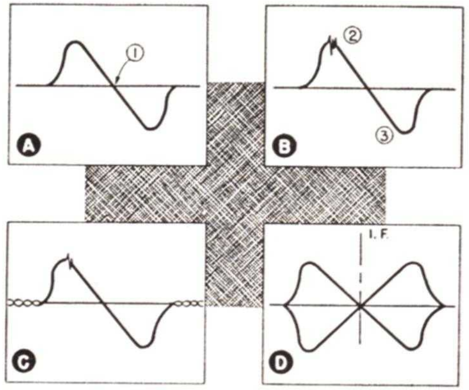


FIG. 27. The text describes the use of these curves in aligning a discriminator.

side of the S curve, as shown in Fig. 27C, *except when the marker is tuned exactly to the midpoint of the curve.* In other words, as long as the beat pattern appears outside the S curve, the marker frequency is not the same as the center frequency of the S curve. The beats will disappear when the two frequencies are the same. Incidentally, this is practically the only case in TV alignment in which it is desirable to modulate a marker.

As you adjust the secondary of the discriminator transformer, you will move the S curve from side to side. When the transformer is properly adjusted, the positive and negative peaks should be equally distant from the reference line, the S curve should be straight between the two peaks, and the frequency separation of the two peaks should be what the manufacturer recommends. This separation (which represents the pass band of the discriminator) may be anywhere from 200 to 500 kc., depending on the set. Use your marker to determine exactly where these peaks occur.

You should align the sound system as accurately as the video section. If you happen to align the sound system to the wrong center frequency, the points of best picture and best sound may not be at the same setting of the fine tuning control. If it is necessary to make any great change in the alignment of the sound circuits, and the set uses automatic frequency control (a.f.c.), it may be necessary to re-adjust the oscillator as well to make it possible for the a.f.c. system to maintain control.

Front End Alignment

Because it drifts so much, the oscillator circuit needs re-alignment more frequently than does any other TV circuit. The fine tuning control or the a.f.c. system used in most sets has a wide enough range to compensate for a rather large drift. Sooner or later the drift will exceed the adjustment range of these compensators, however, and then the oscillator alignment must be touched up.

It may also be necessary to re-align the oscillator if the oscillator tube burns out, because the interelectrode capacities of this tube affect the tuning, and a replacement tube is very unlikely to have exactly the same capacities. Before you make the re-alignment, however, you should try a number of different tubes to see if you can find one that is exactly right. If you are not lucky enough to find such

a tube, use the one that comes nearest to being right so that a minimum of readjusting will be necessary.

Once again, you should be guided by the instructions furnished by the manufacturer of the set. In some sets, the oscillator circuits are entirely independent of each other, which makes it possible for you to re-align only the channel or channels that are improperly adjusted. More commonly, however, the oscillator coils for the various channels are in series, which means that adjusting one channel will affect the adjustments of all of the channels having lower frequencies. If you re-align channel 9, for example, you will find that the adjustments for stations on channels 7, 5, and 4 will be off. When you re-align the front end of a set in which the oscillator coils are in series, therefore, you must align all channels, starting at the highest-frequency channel and working downward.

A skilled serviceman may be able to find a reasonably good adjustment by using the stations themselves as signal sources. In general, however, it is best to use a standard signal source of considerable accuracy for this purpose.

Getting accuracy at such high frequencies is not easy. For this reason, the most practical signal generator for TV front-end alignment consists of a crystal-controlled oscillator having separate crystals for each channel. It is possible to connect such an instrument to the input of the set and to adjust the oscillator, channel by channel, for maximum output. Then, if necessary, you can make a final touch-up adjustment by using the available stations as signal sources on the stations themselves.

When you adjust the oscillator, you must set the fine tuning control somewhere near the middle of its range. If the set uses a.f.c., you must disable the a.f.c. circuit temporarily in the manner recommended by the set manufacturer.

R.F. ALIGNMENT

The r.f. circuits of the average input tuner are rarely adjustable. In general, the original adjustment that was made at the factory was made by spacing the coil turns and by making other physical adjustments to give the proper band-pass response. Factory equipment must ordinarily be used to re-adjust such circuits. If the r.f. end is badly out of alignment for any reason (a very rare occurrence), you should remove it and return it to the factory for re-adjustment.

There are usually one or two adjustments, however, that can be made in the r.f. section. These usually consist of adjustments for channels 6 and 13, the highest channels in the two bands. If there are local stations on these channels, it is usually possible to set each of these adjustments correctly by turning it to produce maximum output with the set tuned to the appropriate station. Use a v.t.v.m. across the load of the video detector to measure the output. If there are no local stations on these channels, you can use a signal generator to furnish the necessary input signal.

A disadvantage of this maximum-output method of aligning the front end is that it may upset the band-pass characteristics of the receiver. It is therefore a good idea to check the response with a sweep signal generator after making a maximum-output adjustment. You can check the response on all channels this way. If you want to see what the r.f. band-pass characteristic looks like, connect your oscilloscope with a crystal detector probe to the output of the mixer circuit. If you want to check the over-all response instead, connect your oscilloscope to the video detector output; the resulting characteristic curve will include the response of the r.f. circuit and of the video i.f. amplifier as well. Of course, make sure that the video i.f. amplifier is properly aligned before making this latter check.

Should you ever check the response of a TV receiver in this manner, you may be surprised to see how much difference there is in the responses that are obtained on the different channels. Don't worry about such differences as long as the responses are within the tolerances specified by the manufacturer. As a general rule, you will find that the tuned circuits for the upper-frequency channels are far wider and give lower outputs than do those for the lower channels, because most manufacturers find it impossible to prevent the Q of a tuned circuit from decreasing as the frequency to which it is tuned increases.

R.F. TRAPS

There may be several adjustable traps associated with a front end. For example, there is often an i.f. trap associated with the grid circuit of the mixer. To adjust such a trap, connect a signal generator or marker to the antenna terminals, tune the generator to the video i.f., and adjust the trap to produce a minimum output across the load of the video detector.

There may be other traps that are intended to eliminate interfering signals, such as those from f.m. stations. If you wish to use such a trap to eliminate an interference having a known frequency, you can use a signal generator to supply a signal of that frequency while you adjust the trap for a minimum output. If you do not know the frequency of the interference you want to eliminate, wait until the interference is present, then tune the trap through its range to see if it has any effect on the picture as far as the interference is concerned.

We have advised you many times in this Lesson to follow the manufacturer's instructions. This applies both to the instructions for the receiver you are working on and to those that accompany your servicing equipment. You will find a number of important hints for speeding up your alignment work and for carrying it out in the proper order given in these manuals. If you follow the set manufacturer's instructions faithfully and use your test equipment as it is supposed to be used, you should have little difficulty in getting the desired alignment.

Most of this text has been devoted to the video i.f. stages because we wanted to give the methods of sweep and stagger-tuning alignment in detail. Much of this information also applies to the alignment of the sound i.f. stages and of the front end.

Lesson Questions

Be sure to number your Answer Sheet 65RH-4.

Place your Student Number on every Answer Sheet.

***Send in your set of answers for this Lesson immediately after you finish them,* as instructed in the Study Schedule. This will give you the greatest possible benefit from our speedy personal grading service.**

1. If, after focusing a receiver properly, you find that the lines in the vertical wedges of a standard test pattern blend together short of their ends, in what respect is the receiver deficient?
2. If, after focusing a receiver properly, you find that the lines in the horizontal wedges of a standard test pattern are gray while those in the vertical wedges are black, in what respect is the receiver deficient?
3. What is the purpose of the "phasing" control that is found on sweep generators that are swept sinusoidally?
4. Why is it necessary to reduce the frequency response of a wide-range oscilloscope to use it with a marker generator for alignment?
5. What will happen if the bias on the stages being aligned is not kept constant during alignment?
6. Why is it desirable to connect your signal generator to the grid circuit of the tube ahead of the tuned circuit you are going to align?
7. If you find that moving the cables that connect your test instruments to the set that you are aligning causes the signal strength to change, what is the matter?
8. What may happen if too strong a signal is used in aligning the video i.f. section?
9. In what way does the video i.f. response for an intercarrier set differ from that of a standard set?
10. Where are grain traps used in an intercarrier TV set?

Be sure to fill out a Lesson Label and send it along with your answers.

COMMENCEMENT—AND YOUR FUTURE

This is your last regular Lesson in the NRI Course. With it, you have received a thorough basic training in Radio, Electronics, and Television. But more than this, you have learned to think for yourself; you have acquired the ability to locate and use printed information which has been prepared by others; you have learned to answer questions precisely, briefly, and clearly—you have learned to do exactly the type of work which leaders of men must do to gain their successes.

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It has been a real thrill for me to watch your progress through this Course, to see you tackle and hurdle even the toughest Lessons in the Course. My admiration — my heartiest congratulations — my wishes for happiness and speedy success go to *you*—a man *who will not quit* when new problems arise!

J. E. Smith