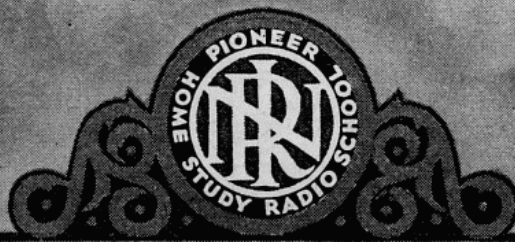




**HOW THE
CATHODE RAY OSCILLOGRAPH
IS USED IN RADIO SERVICING**


49RH-1



NATIONAL RADIO INSTITUTE

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WASHINGTON, D.C.



FACTS OR FICTION— THE VALUE OF AN INQUIRING MIND

A newspaper story describes a powerful radio receiver which operates without vacuum tubes; magazine articles tell how a man flew through the air by blowing into a queer-shaped box; a Sunday newspaper supplement tells of a man who lived for several weeks frozen inside a solid block of ice—all sheer nonsense, yet, there are countless persons who *believe* stories like these—who believe that everything appearing in print must be true. An alert person believes only those things which appear reasonable to him; doubtful statements raise question marks in his mind, and start a search for the truth.

Take things with a grain of salt; in other words, inquire into the truth of statements which you hear or read, and look for hidden meanings in phrases.

When the cathode ray oscillograph was first offered to radio servicemen, many claimed that it was indispensable to servicing. Others, more inquiring and cautious, studied the subject carefully and found that the possession of an oscillograph *did not* spell the difference between success and failure as a serviceman, but that it *was* invaluable for certain specialized types of servicing. This lesson text describes these important uses, and in addition tells about a lot of jobs which you can do better and faster with a cathode ray oscillograph than with ordinary instruments.

J. E. SMITH.

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A LESSON TEXT OF THE N. R. I. COURSE
WHICH TRAINS YOU TO BECOME A
RADIOTRICIAN & TELETRICIAN

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How the Cathode Ray Oscillograph Is Used in Radio Servicing

INTRODUCTION

The cathode ray oscillograph* technique of servicing radio receivers fills a definite need, and is not merely the result of a vogue. We want to make clear, however, that a cathode ray oscillograph is *not* an indispensable device in radio servicing. It can improve the quality of servicing you do, and in many cases help you to do a job in less time, but for the great majority of servicing tasks your regular test equipment will prove entirely satisfactory and by far the more economical as regards time.

There are, of course, tests you can make with a cathode ray oscillograph (C.R.O.) which are direct checks on a radio circuit defect; oftentimes you would be able to identify these defects by the patterns which show on the C.R.O. screen. For example, when the vertical plates of a C.R.O. are connected across a bias resistor in the audio system and an abnormally high amplitude wave pattern appears on the screen, we have definite proof that the by-pass condenser is open. But the effects that would lead you to make this test would also tell you what is wrong. In this case, a low audio output could indicate degeneration, and when accompanied by no low note reproduction would indicate an open bias resistor shunt condenser. Connecting a condenser across the various bias resistors would be a definite check, for good quality would be obtained when the open condenser was shunted by a good unit. Why then use a C.R.O., when the *effect to cause* analysis required before we could use a C.R.O. indicates the trouble? The answer is obvious—the C.R.O. would be useless.

Other defects like this can be located just as easily, after a reasonable amount of experience in servicing, by listening to the type of sound emitted by the loudspeaker and using our old standby, the *effect to cause* reasoning. The C.R.O. can, of course, be used as an additional check.

Frankly, the cathode ray oscillograph is a specialized instrument, finding its greatest application on the radio work-bench, just as the X-ray machine belongs in the medical laboratory rather than in the doctor's car. Like the X-ray machine, the C.R.O. helps the Radio-Trician to check defects which makes themselves apparent by confusing and oftentimes contradictory effects.

On calls to homes of customers the C.R.O. becomes a bulky, fragile and unwieldy device, unsuited for efficient work. Far more rapid servic-

* Strictly speaking, an *oscillograph* is an instrument which *records* permanently the wave form of a voltage or current. An instrument which only lets you *see* the wave form on a screen is an *oscilloscope*. The term oscillograph is often used when *oscilloscope* is intended, as is done throughout this lesson.

ing can be done on the job, in most cases, with simpler devices such as the portable signal generator, multimeter, socket analyzer, adapter and tube tester.

What, then, are the special advantages of this C.R.O. as a servicing instrument? This lesson will show you that for the band-passing of high fidelity radio receivers and for the adjusting of audio stages of public address amplifiers to give better quality, the C.R.O. should be used if possible. At the same time you will be shown how to do some of these jobs with ordinary servicing tools.

Undoubtedly, as service men become more familiar with the possibilities of the C.R.O., more and more uses will be found. But in the light of economical use of one's time, the different methods of doing each servicing job should be carefully considered.

CHECKING AND ALIGNING THE R.F. SYSTEM

One of the most reasonable servicing uses for the C.R.O. today lies in the aligning of a receiver for definitely desired selectivity (fidelity) and sensitivity characteristics. While the alignment and peaking procedures are best performed with an ordinary signal generator and an output indicator, the band-pass adjustment is best done with a cathode ray oscillograph and a *frequency wobbled* (automatic frequency modulated) signal generator.

You realize, of course, that when we consider both selectivity and sensitivity we must refer to a frequency-output response curve. We can use the C.R.O. as a curve-tracing device to produce this curve on the screen if we use a special signal generator to feed into the receiver under test a constant output voltage of a frequency which varies within certain desired values. The varying output of the receiver, fed into the oscillograph, appears on the screen as the resonance curve. Simple measurements of the height and width of this curve determine whether further adjustment of the receiver is necessary. The experienced service man can analyze this curve at a glance; what he sees suggests what is to be done to the receiver. We can form a mental picture of the same resonance curve, or plot the curve on graph paper, by noting the readings of an output indicator while the frequency of a signal generator is varied, provided we have the time and patience.

From what has been said in the earlier part of the Course, it should be clear that in general two types of response curves are important. They are: 1, Sharp or peaked resonance curves, which give high sensitivity for distant reception; 2, band-pass or flat-top resonance curves, which give high fidelity.

The question naturally arises: "When shall peak or band-pass adjustments be considered?" Unless the service manual on the receiver states definitely or implies by the aligning procedure that band-passing is necessary you must be governed by personal experience. As a rule T.R.F. receivers with four or less tunable stages, and superheterodynes

with one and two I.F. transformers require *peak* adjustments to obtain acceptable sensitivity and selectivity.

Band-passing will be required most often in superheterodyne receivers. There should be no question that band-passing is intended when four I.F. transformers are used (the use of four is rare). Where three I.F. transformers are found, the advisability of band-passing rests with your good judgment. If the receiver when peaked has plenty of "pep," enough to sacrifice for good fidelity—if the receiver is capable of delivering five or more watts of undistorted power (push-pull 45 or 47 tubes or tube arrangements with higher output), and the loudspeaker is housed in a large compartment (no table or mantel models), band-passing was probably intended.

So-called high fidelity receivers must be band-passed, and those with variable fidelity must be aligned by the procedure suggested by the maker. Usually the variable coupling (between a tunable primary and secondary) or a third winding shunted by a variable resistor permits the set owner to vary from a peak to a flat-top resonance response. A control on the panel is provided in either case. *Loose* coupling or *high* resistance here gives a *peaked* response.

To be sure, many receivers not intended for high fidelity can be adjusted to have flat-top resonance. Only those stages with tuned primary and secondary or with band-pass filters can be so adjusted. This usually limits the procedure to the I.F. stages of supers. Band-passing should be considered only if you are certain the customer prefers better quality to distant reception.

With this fact in mind let us turn to the two methods of creating flat-top resonance, first by the older and more tedious method employing a portable signal generator (S.G.) and output indicator (O.I.); and finally with a C.R.O. and a frequency wobbled signal generator. As the superheterodyne receiver is practically the only type you will be called upon to band-pass, our main discussion will be limited to it.

BAND-PASSING WITH A PORTABLE SIGNAL GENERATOR AND OUTPUT INDICATOR

It is always wise to peak the response of an R.F. system before attempting any band-pass adjustments. In most cases there will be no difficulty in adjusting the receiver to high gain, but should regeneration or oscillation appear, peak up to this point of "spill-over."

After peaking the receiver you may begin the band-pass procedure. If you vary the frequency setting of the S.G. from a value below the frequency setting of the receiver, through resonance, and above, you will probably notice that the reading on the output meter starts with a low deflection, increases to a maximum and decreases again to a low value.

Let us assume that the receiver is set to 1,000 kc., and the S.G. is varied from 995 kc. to 1,005 kc. If you were to plot the output meter

readings for each kilocycle of change, as at 995, 996, 997, 998, 999, 1,000, 1,001, 1,002, 1,003, 1,004 and 1,005 kc., the resultant curve would be the response of the R.F. system. You will probably get a response curve similar to curve *A* in Fig. *I*.* In this case the audio system of the receiver can be temporarily neglected, for it is merely being used as an amplifier for the output indicator.

In order to get higher quality reproduction, assuming that the audio amplifier will reproduce high audio frequency signals, a response curve similar to curve *B* in Fig. *I* should exist.† Tunable R.F. and I.F. circuits should be adjusted, usually by varying the trimmer condensers until this type of response is obtained or at least approached.

Band-Passing A T.R.F. Receiver.—Do not attempt to introduce band-pass resonance into a T.R.F. receiver unless high frequency trimmers and serrated rotor plates are included in the gang of variable condensers. It is important that you peak the receiver first at 1400 kc. with the trimmers, then peak at other dial positions by bending the rotor plates at every dial position where a segment of a serrated (split) rotor meshes fully with the stator. With the peaking completed, return the receiver and S.G. to 1400 kc., turn half the trimmers *in* (more capacity) and half the trimmers *out* (less capacity), so that as you tune the modulated S.G. from 1,395 to 1,405 kc., a practically constant output is indicated on the O.I. It is a good plan to tune the first stage to a frequency below resonance, the second stage above resonance, the third stage below, and so forth. At dial positions where a rotor segment meshes fully with the stator, band-pass by bending the rotor segments, one in, one out, etc. Vary the S.G. frequency at each such position to check for band-pass.

Band-Passing a Superheterodyne.—Again, before you can introduce a flat-top resonance characteristic, the I.F. must be peaked and the oscillator made to track the preselector by the I.F. value. As a rule, band-passing can only be introduced in the I.F. amplifier of superheterodyne sets, for other sections will not have tuned primary and secondary transformers.

To band-pass a super, connect the modulated signal generator to the input of the first detector. (Several connections will be shown later.) Connect the output indicator in the usual manner. Assume you want 10 kc. band width in a receiver having a 260 kc. I.F. frequency. Set the S.G. to 260 kc.‡ To avoid confusion follow a definite procedure each

*The curves here show gain with respect to the maximum gain in each case. Actually the maximum gain is reduced by band-passing.

†When changing any amplifier having a curve *A* characteristic to one with a curve *B* characteristic, amplification will be reduced. The circuit must originally have considerable gain; in designing a receiver extra stages would be added to offset losses in gain caused by band-passing.

‡Stop the action of the receiver's oscillator stage, either by removing the oscillator tube or, in the case of pentagrid converters, by shorting the grid coil of the oscillator.

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Try one watt resistors of 100,000, 75,000, 50,000 and lower ohmage, until the desired response is obtained when the S.G. is set to some frequency in the broadcast band (perhaps 1,000 kc.), the receiver is tuned to this frequency, and the S.G. is swung from 10 kc. below to 10 kc. above the first setting. In this test the S.G. is connected to the ANT and GND posts of the receiver

Bear in mind that any band-pass adjustments will reduce the gain of the R.F. stages, and thus reduce the over-all sensitivity of the receiver. In fact, you may have to increase the output of the S.G. several times before you can approach the desired flat-top characteristic; it may even be necessary to increase the sensitivity of the output indicator. When these adjustments are complete be sure to test the receiver for sensitivity by using a standard outdoor antenna. You will note the improvement in quality, especially if you have had musical training. If the sensitivity is now too low, even though quality is better, readjust to peak resonance throughout and consider the receiver unfit for high fidelity adjustments.

Special Precautions and Hints.—When the receiver has AVC and the long method of band-passing is used, it is important that the S.G. output is set sufficiently low to operate the receiver below the threshold of AVC (the point where increased S.G. output does not materially increase the output). If you find that the S.G. output cannot be reduced sufficiently, remove the AVC tube, if possible; or remove the AVC C bias voltage and substitute a fixed bias. The latter is easily done by opening the common grid return (of the controlled tubes) to the AVC bias resistor. Connect the common lead to the movable contact of a potentiometer connected across a C battery, and ground the + terminal of the battery. Tune the receiver to any broadcast band station and adjust the potentiometer for normal output.

The signal generator used for flat-topping should not be self-modulated (grid leak-condenser modulation). Use a signal generator in which an audio oscillator (extra tube) is used to modulate the R.F. oscillator. Self-modulated oscillators will not produce constant output over any reasonable change in frequency, and the carrier may be over-modulated, which is undesirable.

If you are aligning a high fidelity receiver with variable fidelity control, always peak and align the receiver with the coupling in the band-pass circuits set to the least value (coils separated or at right angles), or to maximum resistance in the circuit of the third coil. When you are ready for band-pass adjustments, set the coupling to maximum (resistor to minimum) and swing the S.G. (connected to the input of the receiver) through 20 kc. Study the response. If it is not flat-top, connect the S.G. to the first detector (if a super) and proceed to balance the two humps. Now connect the S.G. to the receiver input, and check the over-all response on the O.I. Check for peak response when the fidelity control is set for the lowest fidelity.

You will probably find it difficult to swing the average type of S.G. about 20 kc., because this band occupies only a small portion of the tuning dial. This can be overcome by shunting the variable condenser in the S.G. by a midget variable condenser, which can be externally mounted. Run the two leads from the S.G. variable condenser to two plug-in pin jacks mounted on the S.G. panel. Mount the midget condenser on a bakelite strip and connect to pins also mounted on the strip, which are spaced to slip into the jacks provided on the S.G. A 0 to 50 mmfd. midget condenser will be needed for the I.F. band; a 0 to 20 mmfd. midget will be best for the broadcast band. Mount a 180 degree dial, marked from 0 to 100, on each midget condenser shaft, and place on the condenser frame an indicator mark or wire pointing to 100 on the dial when the rotor plates are all in. It is a good plan to place each midget condenser in a shielding can, connecting the can to a third pin. This pin plugs into a panel jack which is grounded to the S.G. shield, space the three pins in such a way that the midget trimmer can be plugged into the S.G. in only one position.

It is necessary to recalibrate the signal generator when a midget condenser is attached. Set the modulated S.G. to the desired frequency (with the trimmer condenser out of the jacks) and tune an all-wave receiver (A.W.R.) to this frequency and to maximum output. Set the midget condenser to 50, and plug it into the S.G. Leaving the A.W.R. setting fixed, tune the S.G. until you hear its signal again in the receiver. Record this S.G. setting, for you must tune to that setting instead of to the original calibrated setting whenever you use the midget condenser. Twice the frequency difference between the two S.G. settings will then be approximately the band width covered by the midget condenser as it is varied from 0 to 100.

As the band width for each midget condenser will vary with the frequency setting of the S.G., it is a good plan to determine the band width for different broadcast and I.F. settings of the S.G., and plot (for each plug-in condenser) new calibration curves for each S.G. range in which that condenser will be used. These curves, which may be placed on the same graphs as the original S.G. calibration curves, should show: 1, The frequency produced at different S.G. dial settings when the plug-in condenser is set at 50; 2, the band width produced by the plug-in condenser at various S.G. dial settings.

BAND-PASSING WITH A WOBBULATED FREQUENCY GENERATOR AND CATHODE RAY OSCILLOGRAPH

Preliminary Concepts.—In the previous explanation covering the procedures for band-passing you noticed the necessity of shifting the frequency over a band width of more than 10 kc. while noting the output readings on the meter from an A.F. modulated signal generator. If you remove the A.F. modulation, leaving the R.F. signal unmodulated, you will get no deflection on the output meter while it is connected to the

audio system. However, if a D.C. milliammeter is connected into the plate circuit of the audio demodulator (as for example the second detector of a superheterodyne receiver), variations in the strength of the signal produced by the S.G. or variations in the response of the R.F. system of the receiver produce a varying current which is indicated by the meter. In fact, you could flat-top a radio receiver with this simple output indicator.

For an alternate flat-topping method which is preferable in many circuits, especially in those using a diode detector, you can connect a D.C. voltmeter across any device in the detector circuit which has an appreciable resistance. The D.C. current in the plate circuit of the detector, and consequently the D.C. voltage across any part in the circuit, will depend on the type of detector used, on the supply voltage (fixed) and on the effect produced by feeding an unmodulated R.F. signal into the detector. Where diode detectors are used the voltage

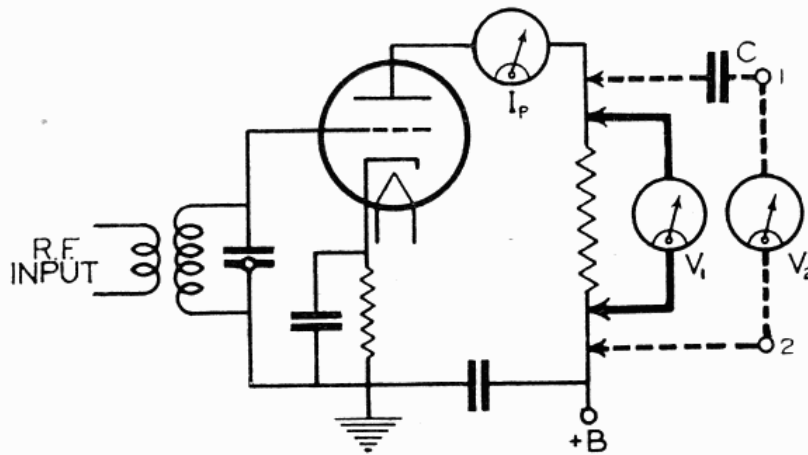


Fig. 3. If V_2 gives a reading for an unmodulated r.f. signal, connect an r.f. by-pass condenser between the plate and ground to keep r.f. out of the meter.

across the diode load resistor will vary *only* with the R.F. signal in the circuit; no initial drop will exist.

To further clarify this explanation, refer to Fig. 3. Assume that the tube is automatically biased for detection. If no *R.F.* is fed to its input, the current meter I_p and the voltmeter V_1 , both D.C. instruments, will show readings, their steady values depending on the tube used and upon the plate and C bias voltages. Meter V_2 (a rectifier type A.C. voltmeter) will not indicate, as condenser C blocks the current in this circuit. Now suppose an *unmodulated R.F.* signal is fed steadily to the grid circuit. Since the tube is connected as a C bias detector, a grid signal will cause the readings of I_p and V_1 to increase, a normal condition. Meter V_2 will still remain at zero. If this unmodulated R.F. signal is now *audio modulated* at a constant percentage of modulation, I_p and V_1 will not change, as they read average values. V_2 , a rectifier meter, will indicate, as the audio signal passes through C . This is essentially what we did in the previous long procedure of flat-topping a receiver, for there the O.I. (a rectifier type A.C. meter) was really connected across the detector

output, as is done here. The audio stages simply serve as an amplifier for the output indicator.

Going back to the condition where an unmodulated R.F. signal is fed to the receiver, let us wobble* the R.F. signal frequency. As we do this the plate current will vary, these variations reaching V_2 through condenser C . If V_2 is a D.C. milliammeter and the wobble is not taking place too rapidly meter V_2 will follow the change. If the change is too rapid for a D.C. meter then an A.C. meter will be required. Fortunately, the cathode ray oscillograph will follow any frequency of wobulation.

When we connect the vertical plates of a C.R.O. to terminals 1 and 2 (Fig. 3), the fluorescent spot will move up and down on the screen in step with the speed of wobulation, for frequency changes send current changes through the C.R.O. input resistor in the same way that these changes caused the meter V_2 to indicate. For example, assume the S.G.

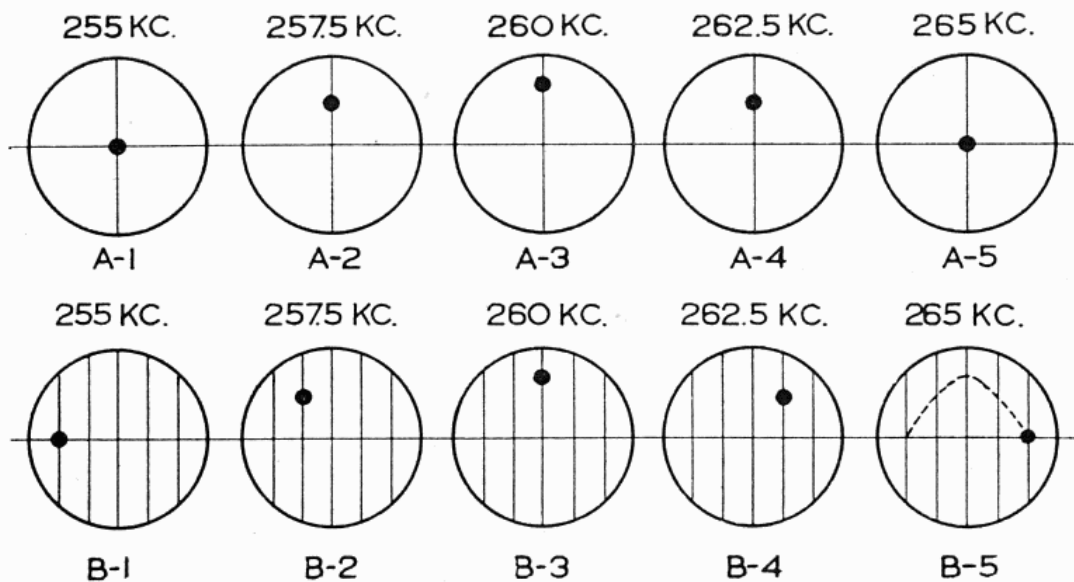


Fig. 4

is connected to a 260 kc. I.F. amplifier and the vertical plates of a C.R.O. are connected as shown to 1 and 2 in Fig. 3. When the S.G. is set to 255 kc. and no signal gets through the I.F. amplifier, the C.R.O. spot will be at the center of the screen (Fig. 4A1). As we sweep the S.G. from 255 to 265 kc., the spot will take the positions of Figs. 4A1 to 4A5, in the order shown. In fact, if we were to wobulate rapidly from 255 to 265 and from 265 to 255 kc., we would observe a vertical line instead of a moving spot.

On the other hand, if we could arrange to have the spot appear as shown in Fig. 4B1 for 255 kc., and move progressively *to the right* as it moves up and down with frequency changes, as shown by Figs. 4B1 to 4B5, the path taken would be that shown by the dotted line in Fig. 4B5.

* Vary the setting of the S.G. tuning condenser dial repeatedly back and forth by one or two divisions—or the wobulator condenser from 0 to 100 and 100 to 0 alternately.

We could see on the C.R.O. screen this resonance curve for the I.F. amplifier if the wobulation from 255 to 265 kc. was made faster than about 8 sweeps per second. All this is possible in a modern cathode ray oscillograph, in which the sweep circuit, controlled by the rate of wobulation, feeds the horizontal plates with a sweep voltage which moves the spot across the face of the C.R.O. screen. We shall now study in greater detail how this is accomplished, and how different sweep conditions produce different curves on the screen.

The Wobbulator.—Service men who use the C.R.O. provide themselves with a special signal generator constructed to shift or “wobulate” the frequency automatically and regularly over a given band width. The width of this band varies with different oscillators, and is usually between 15 and 30 kc. This is accomplished by connecting a special variable trimmer condenser in parallel with the main tuning condenser in the

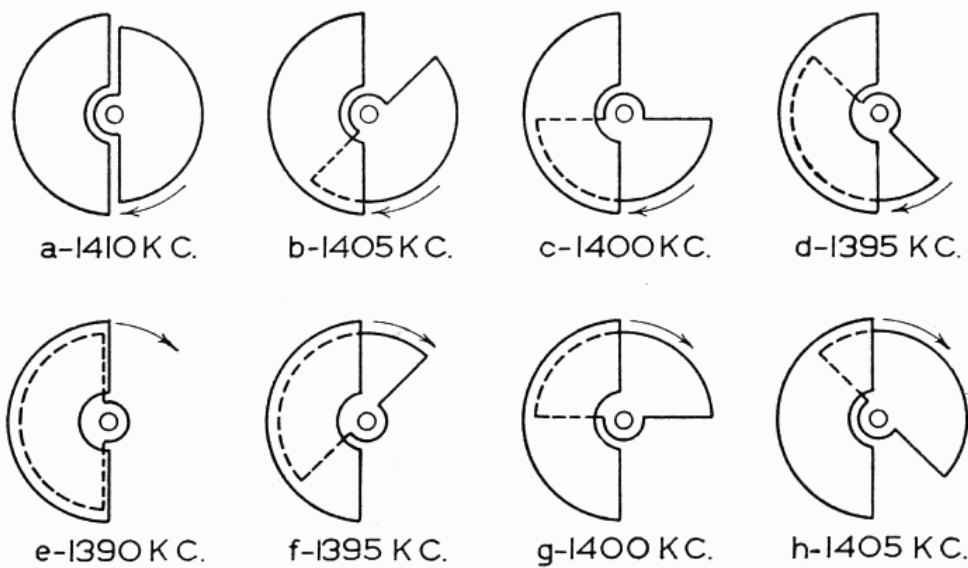


Fig. 5

signal generator, then rotating this trimmer condenser by an electric motor. The rotating trimmer with its driving motor is built into some oscillators. It is also supplied separately to permit attaching to any ordinary unmodulated signal generator. The rotor of this trimmer condenser usually is fastened directly to the shaft of the electric motor, so that as the trimmer rotates 360 degrees the rotor starts at zero capacity, reaches maximum capacity in one-half turn (180°) and then decreases to zero capacity again in the second half turn. If the oscillator used with this trimmer is adjusted so that exact resonance with the circuit under test occurs when the trimmer rotor meshes *half way* with its stator, two resonance peaks will occur for each complete rotation. This can be understood by referring to Fig. 5, where it can be seen that when the rotor turns from *a* to *h*, the S.G. frequency is swept from 1,410 to 1,390 and then from 1,390 to 1,405, to return finally to 1,410 in position *a*. This assumes that the S.G. is originally set at 1,410 kc. Note that the positions of the rotor in *c* and *g* each will give signals of 1,400 kc. The

frequency produced by the wobulated S.G. with the rotor meshed half way (as in *c* or *g*) is called the "periodic frequency."* This periodic frequency is determined by the setting of the S.G. tuning control.

The electric motor driving the trimmer condenser rotates with constant speed, the usual value being somewhere between 900 and 2,400 r.p.m. A speed of 2,400 r.p.m. would be 40 revolutions per second, and the "periodic frequency" of 1,400 kc. (referring to the preceding example) would occur 80 times per second, because the periodic frequency occurs twice for each revolution of the wobulator condenser. If we now set the wobulated signal generator to a 1,400 kc. periodic frequency, set the receiver to 1,400 kc., and connect the vertical plates of our oscillograph to the output of the receiver's second detector, the spot on the screen will rise to a maximum 80 times per second for a simple single peak resonance characteristic.

Let us first connect to the horizontal plates of the C.R.O. a linear sweep voltage which has a frequency corresponding to the r.p.s. speed

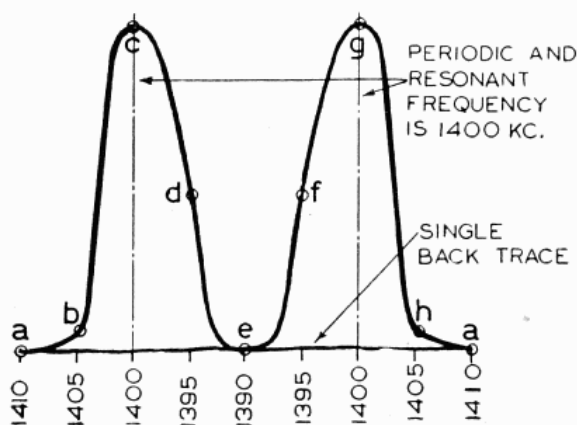


Fig. 6

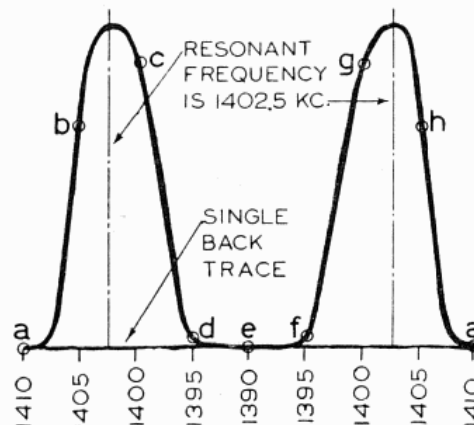


Fig. 7

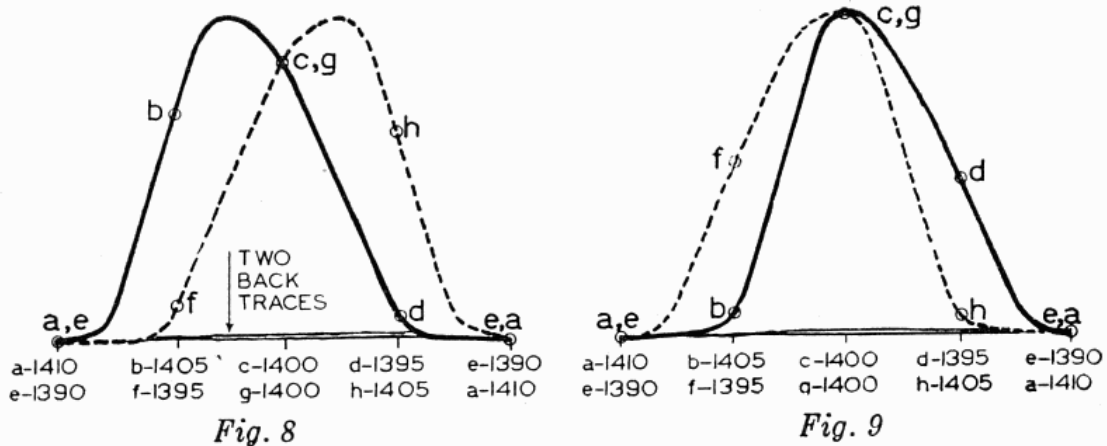
of the motor, namely 40 cycles per second. (How this sweep circuit is synchronized with the aid of a synchronizing voltage delivered by the wobulator is discussed later in this lesson.) Bear in mind that the periodic frequency will be obtained 80 times per second. Therefore, if our receiver is tuned to resonance at the periodic frequency of 1,400 kc., we can expect a double-humped (twin resonance) curve like that shown in Fig. 6. Notice that we have purposely chosen a circuit which tunes sharper between 1,405 and 1,400 kc. than between 1,400 and 1,395 kc. This is done to bring out the fact that the left-hand hump of the double response curve is the inverse of the right-hand hump. The positions of the spot on the screen of the oscillograph which correspond to the rotor positions shown in Fig. 5 are indicated.

If we now detune the receiver so it is resonant to a frequency of

* When the wobulator trimmer condenser, which is always of the straight line capacity type, is set at mid-capacity (to produce the periodic frequency), we have the "periodic capacity." As a rule the periodic frequency equals the mid-frequency of the band we desire to sweep across, or the peak frequency if a single hump resonance curve is desired.

1,402.5 kc., then the two humps will separate (space *d* to *e* to *f*) as shown in Fig. 7. It is rather difficult to estimate or even notice the change unless a carefully marked scale has been prepared and fastened over the screen of the cathode ray tube. We will now show how to overcome this difficulty by using a linear sweep frequency which is twice the r.p.s. motor speed.

When we use a linear sweep frequency of 80 c.p.s., with the receiver set to 1,402.5 kc., the two humps of Fig. 7 will form an overlapping double image like that shown in Fig. 8. The letters again indicate where the spot will be for each of the rotor positions in Fig. 5. Notice that spots *a* and *b*, *b* and *c*, *c* and *d*, etc., are now twice as far apart horizontally, making the curve in Fig. 8 twice as wide as that in Fig. 7. Also notice that there is only one position of the periodic frequency of 1,400 kc., *c* and *g* overlapping. The fact that the two curves do not fit exactly over one another shows that the receiver is not in resonance with the periodic frequency. If we now retune the receiver to 1,400 kc., then the tops of the patterns will overlap as in Fig. 9. In other words, in Fig. 9 we have an advantage over Fig. 6 in being able to tell just when we are tuned



to resonance with the periodic frequency, because then the tops of the curves will overlap each other.

The fact that the bottom portions of the patterns in Fig. 9 do not overlap shows us that the receiver response at 1,405 kc. is not the same as that at 1,395 kc. By adjusting the trimmers in the receiver we can make the two curves overlap entirely, to give the appearance of a single pattern. We will know then that the response above 1,400 kc. is identical with the response below 1,400 kc. This is an important adjustment in receivers, if we want equal amplification of the side-band frequencies. Further adjustment of the trimmers will allow us to spread the tops and sides of the curves in Fig. 9 until they have the appearance of the dotted band-pass curve in Fig. 1, provided we have enough tuned stages to work on.

Need for Synchronizing Voltage.—The patterns of Figs. 6, 7, 8 and 9 require careful control of the frequency of the linear sweep voltage. A separate sweep frequency control is built into the average C.R.O., unless

some other method is used to keep the sweep frequency in step with the speed of the wobbulator motor. If this frequency of the linear sweep voltage does not correspond to the speed of the motor, then these patterns will drift continually to one side of the screen. This drift is not serious with the double type of overlapping pattern, for even though the two curves are drifting slowly across the screen, you can tell when they overlap and can stop them at any time by readjusting the sweep frequency control. To hold the patterns stationary at all times, the manufacturers of motor driven wobbulator condensers have arranged for the generation of a separate voltage to be fed into the grid of the sweep circuit Thyatron (gaseous triode) tube. Even if the frequency control knobs are not set exactly to the correct frequency, or if the rotating condenser changes its speed slightly, this synchronizing voltage will stop movement of the pattern.

The synchronizing voltage is generated by attaching a permanent bar magnet to the shaft which rotates the wobbling condenser. This rotating magnet induces in a pick-up coil (mounted near the shaft as in

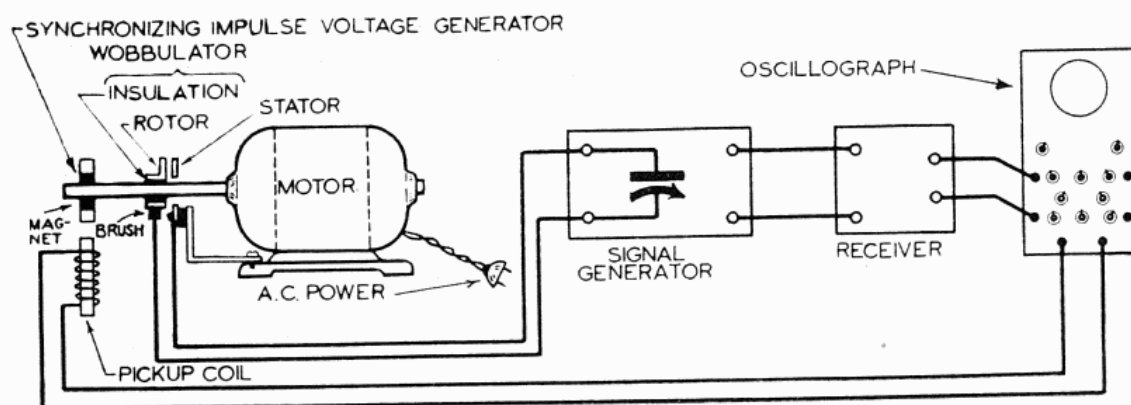


Fig. 10

Fig. 10) an A.C. voltage having a frequency which is twice the frequency of rotation, this being the frequency required to hold the double patterns stationary.

The manufacturers' instructions covering cathode ray oscillographs will specify the location of the input terminals for such a synchronizing voltage. As a typical example we have shown in Fig. 10 how the RCA type TMV-128A wobbulator condenser with its synchronizing voltage connections is connected to the RCA type TMV-122B oscillograph.

An arrangement similar to the above, shown in Fig. 11, is used for the National Union Type 3-5 oscillograph.* The synchronizing voltage from the pick-up coil is here amplified by a built-in one-tube amplifier (input V_1 and G) before being fed to the grid of the Thyatron tube. The output of the receiver under test is fed to the other one-tube C.R.O. amplifier (input H_1 and G), and the amplifier output is connected to the

* On a later model, type B3-5, a single selector switch on the front panel gives any desired connection between amplifiers, plates and sweeps, eliminating all back panel terminals.

vertical deflecting plates V_p by connecting A_R to V_p . The linear sweep voltage, generated with the aid of the Thyatron tube inside the C.R.O., is fed to the horizontal deflecting plates by connecting S to H_p .

In Figs. 10 and 11 the wobulator is connected across the main tuning condenser of the signal generator. It is apparent that the addition of the wobulator condenser will change the calibration of the signal generator; for this reason it will be necessary to recalibrate the S.G. because of the change produced by the wobulator condenser. Earlier in this lesson you were told how this was done and what band width would exist. It is also apparent that the band width will vary for various settings of the signal generator tuning condenser.

In order to overcome the inconvenience of working with a variable band width, the Clough-Brengle Company has developed a special signal generator using two R.F. oscillators feeding into a 6A7 mixer tube. The general arrangement of the parts is shown in block form to the left of Fig. 12. The output of a variable frequency R.F. oscillator is mixed with

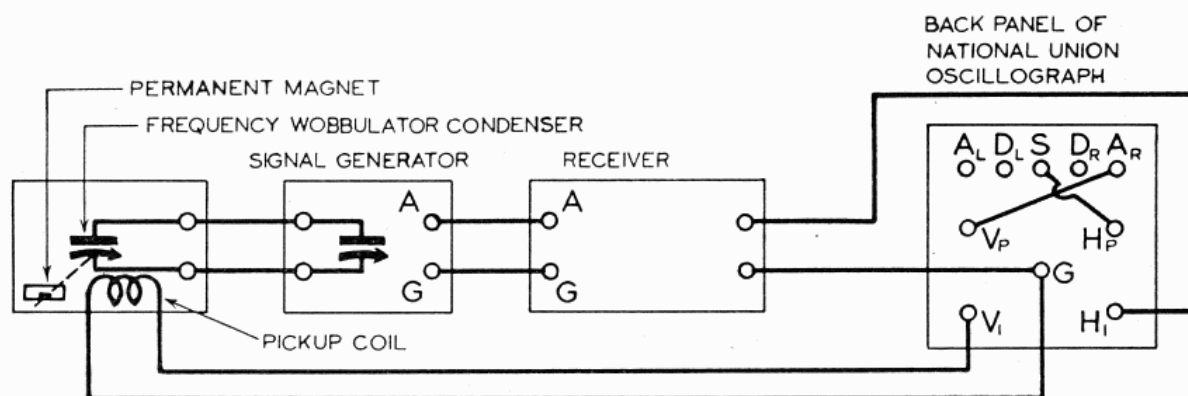


Fig. 11

the output of an oscillator having a *fixed frequency* of 670 kc., which can be varied 30 kc. by a motor-driven wobulator condenser. When the wobulator is used the periodic output frequency will be the sum of or difference between the frequency of each oscillator, the band width always being 30 kc. If the wobulator condenser motor is stopped and the wobulator condenser set to periodic capacity, the output frequency will be constant and equal to the periodic frequency when wobulation was used.

In the RCA and National Union cathode ray oscillographs, the sweep voltage for synchronizing the horizontal deflection when wobulating the signal frequency is produced in the C.R.O. itself, using an impulse voltage from the wobulator to control it. In Clough-Brengle equipment, a special sweep voltage produced by an interlocked wobulator mechanism is used, and is supplied if an external D.C. supply is used. Their signal generator has a cable ending in a 4-prong plug, which fits into a 4-hole socket in the C.R.O., automatically draws a D.C. voltage from the C.R.O., and feeds the horizontal plates of the C.R.O. with a sweep voltage.

This special sweep voltage is produced in a very simple manner. A commutator is placed on the shaft driving the wobbulator condenser. One-half of the revolving commutator is insulated, so a brush makes contact through the commutator for only one-half of each revolution. A condenser, a resistor and the commutator are connected in series, the condenser shunting the horizontal plates of the C.R.O. The C.R.O. plates are fed with a D.C. voltage through an adjustable resistor of high ohmic value. When the commutator is shorted, very little voltage is fed to the horizontal plates, the spot moves to the left of the C.R.O. screen, and there is no horizontal movement of the spot for one-half revolution of the wobbulator. When the commutator opens, the condenser starts to charge through the resistor in the supply line, this increasing (linear sweep) volt-

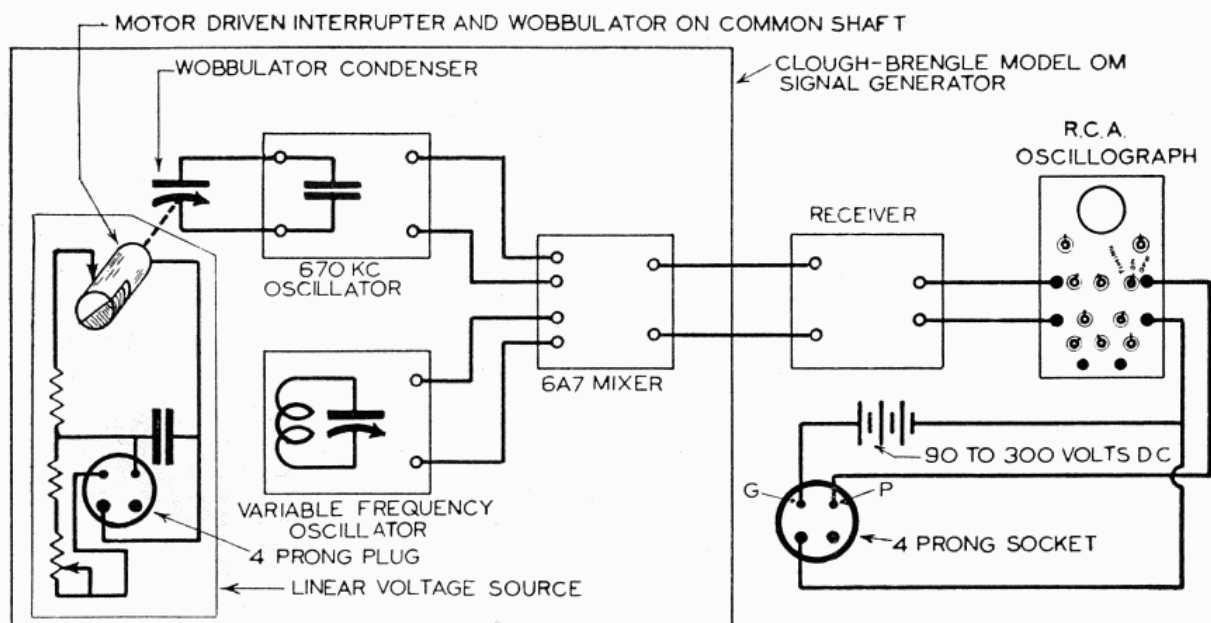


Fig. 12

age being fed to the horizontal plates to sweep the C.R.O. beam to the right, producing the resonance characteristic.

The Clough-Brengle Company claim certain advantages for their special type of linear sweep voltage, which produces a pattern (C.R.O. image) like that shown in Fig. 13. In reality this is similar to the curve in Fig. 7, with the sweep voltage stopped at position *a* while the vertical deflections are produced by the wobbulator condenser, compressing (or folding) the left-hand curve into a vertical line on the screen. After the first resonance hump is completed the sweep voltage comes into play, sweeping the spot across the C.R.O. screen to produce a regular resonance curve like that at the right in Fig. 7. The advantage claimed for the curve in Fig. 13 is that the height of the left-hand "folded curve" always remains in one position, simplifying height (gain) measurements, while the right-hand curve can be gauged for band width.

It should be noted that the band width is shown in Fig. 13 as 20 kc. for purposes of comparison to Figs. 6 and 7, while in actual practice the

type OM Clough-Brengle band width is 30 kc., or 15 kc. on each side of the periodic frequency, no matter what this latter value may be.*

In the RCA or National Union oscillographs a double hump pattern is obtained by making the sweep frequency equal to the speed of rotation (in revolutions per second) of the wobulator condenser; an overlapping double pattern is produced when the sweep frequency is twice the speed of the wobulator condenser. For example, if the wobulator condenser is driven at 40 r.p.s., a 40 c.p.s. sweep will produce a double hump pattern, and an 80 cycle sweep frequency will produce an overlapping double pattern. With an 1,800 r.p.m. wobulator driving motor (30 r.p.s.) the correct sweep frequency for an overlapping double pattern would be 60 cycles. If the third type of pattern (semi-folded) is desired in addition to the other two, connect a model OM Clough-Brengle signal generator to an RCA oscillograph in the manner shown in Fig. 12. Now, when the horizontal plate switch of the RCA oscillograph is set to the "TIMING" position either the double hump or overlapping double patterns can

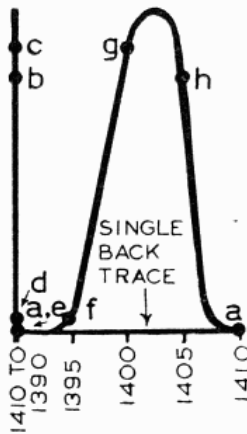


Fig. 13

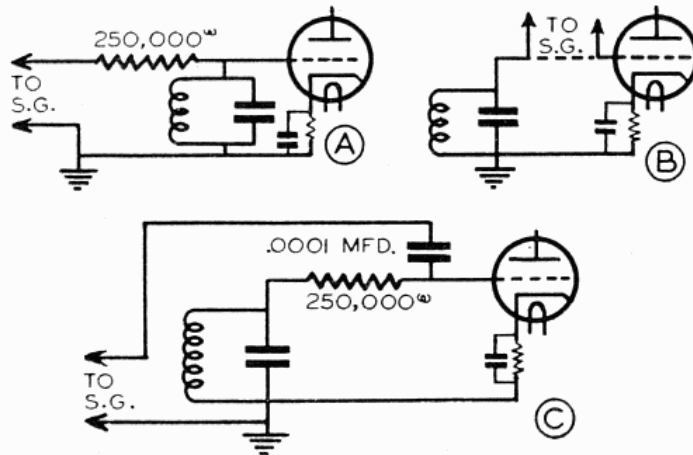


Fig. 14

be obtained by changing the sweep frequency; with this switch set either to the "OFF" or "ON" positions the folded pattern is produced.

Connecting the C.R.O. and S.G. Properly.—It is highly important that the cathode ray oscillograph and the wobulated signal generator be properly connected to the receiver under test, if false resonance curves are to be avoided. Whatever connections are made must not disturb the characteristics of the receiver.

First consider the wobulated frequency generator. A direct con-

* In a later model Clough-Brengle signal generator, the type OM-1, a synchronous motor, operating from a regular 60 cycle A.C. power source, drives a variable inductance (a metal disc mounted eccentrically on a shaft inside a fixed inductance), which is connected into the 670 kc. oscillator circuit. The band width created by this variable inductance is 40 kc. A 60 cycle A.C. or a 120 cycle voltage obtained from the full-wave rectifier of the S.G. is used as a sweep voltage on the C.R.O. This procedure is feasible because a sine wave is practically linear over the major part of the curve; the deviations from the linear or saw-tooth wave, occurring at positive and negative peaks, crowd together the lower parts of the resonance curve when a 60 cycle sweep is used, and with 120 cycles one side of the curve is distorted. This is not objectionable because only the central portion of the resonance curve, including the two resonance peaks, is of value in servicing. Unlike the earlier model, this S.G. has no provision for folding up one of the resonance curves.

nection to the aerial and ground terminals of the receiver will as a rule be satisfactory; it is well, however, to determine first if the manufacturer's service manual covering the receiver you are aligning gives definite instructions for signal generator connections. Generally it is considered good practice to place a 250 mmfd. mica condenser in series with the antenna posts on the receiver and the signal generator.

If the input is to be made to some other stage, such as is often done to adjust an individual R.F. transformer or the I.F. stages in a superheterodyne, the connection should be made in such a way that the electrical characteristics of the circuit are least affected. Several recommended connections are shown in Figs. 14A, B and C. The first is the simplest and will generally suffice; that in Fig. 14B is possible only if a conductive path exists through the signal generator used, in order that the grid bias will not be removed by a series condenser in the S.G.; the

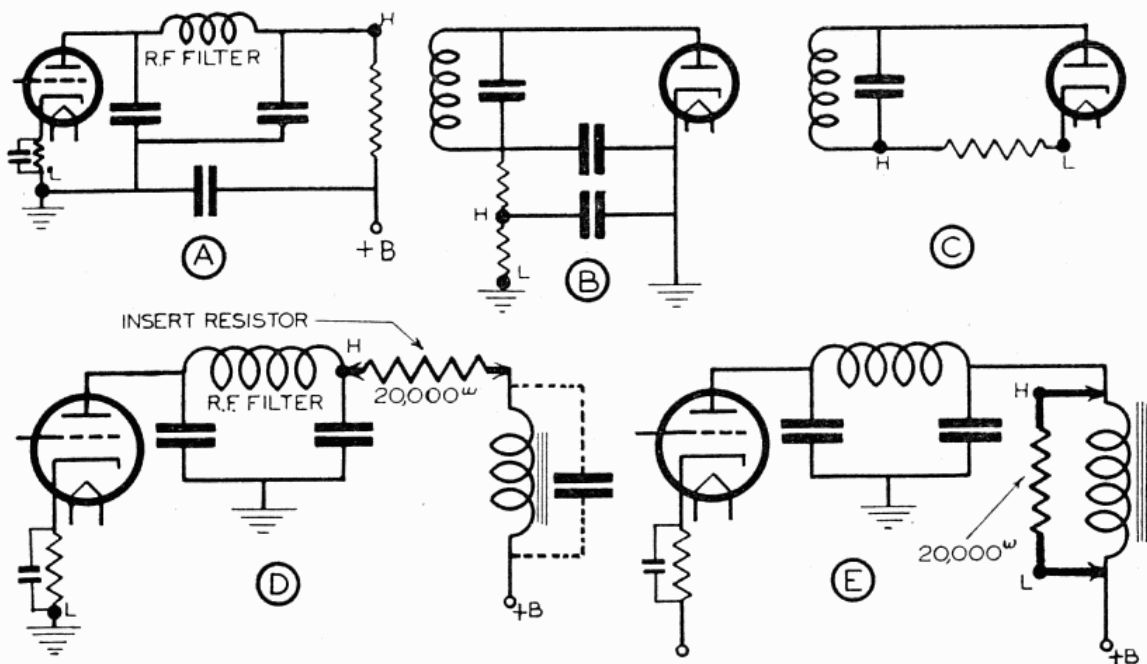


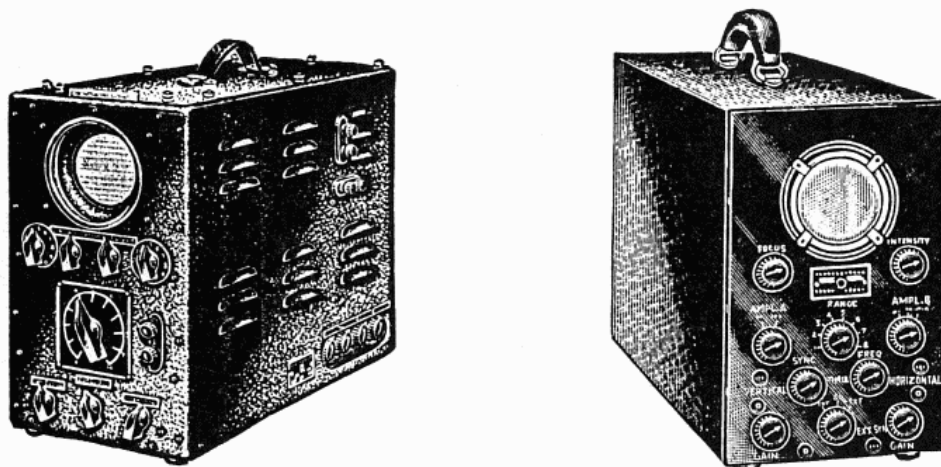
Fig. 15

method shown in Fig. 14C is generally most effective at high frequencies. Always connect the grid to the *HIGH* R.F. terminal of the signal generator.

A little more thought should be given in making the connection to the vertical plates of the oscillograph. The low or ground terminal of the vertical plates (marked on the C.R.O. as *O* or *L*) is generally connected to the receiver chassis. Frequently, however, this terminal is connected to a point in the circuit which is not at ground potential, as in Fig. 15E. If the low potential terminal (*L*) on the C.R.O. already is at a ground potential and the grounds of both devices are common, an undesirable current will flow, perhaps burning out some receiver part. Most service men first connect a D.C. voltmeter and then an A.C. voltmeter temporarily in series with this lead. If a deflection is obtained in either case, a 1 mfd. or larger condenser is connected in series with the lead; if there is no deflection a direct connection may be made.

The high side of the deflecting plates is generally connected to a point in the circuit whose potential will vary with respect to the chosen ground. Different methods of connecting the vertical deflecting plates of a C.R.O. to a receiver are shown in Fig. 15, *H* representing the high potential deflecting plate terminal of the oscillograph, and *L* the low potential terminal.

Here it is necessary to point out that a form of distortion known as phase distortion will generally appear in the C.R.O. curves, unless the vertical plates are connected to a resistance load right at the detector. This phase distortion, originating in the audio stages, does not detract from the operation of the receiver as far as sound reproduction is concerned because the ear cannot detect a phase shift. The distortion does affect the C.R.O. resonance curves, often sufficiently so they cannot be



Two Typical Cathode Ray Oscillographs—Left: Clough-Brengle Model CRA; Right: RCA Model TMV-122B. Both have built-in amplifiers and linear sweeps.

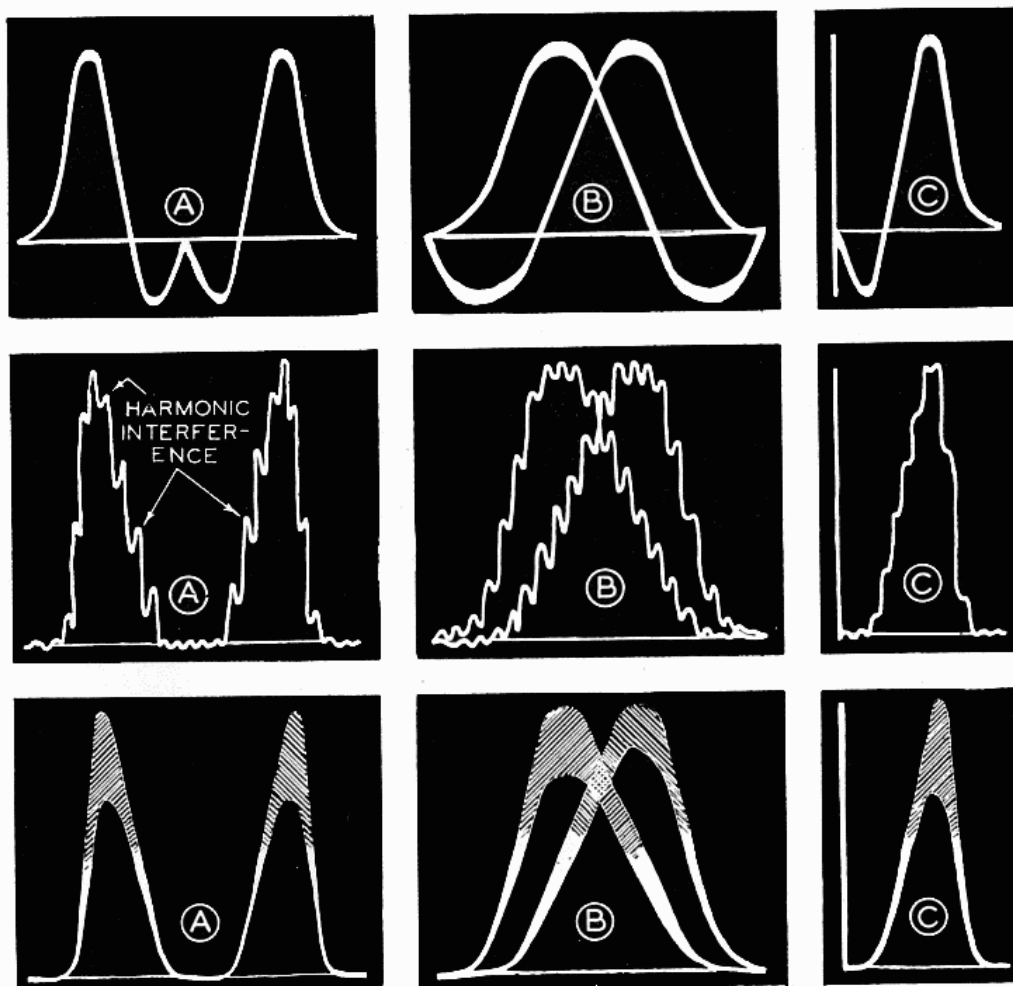
used in making adjustments. As the amount of distortion may cause an inaccurate adjustment, it is recommended that C.R.O. connections always be made to the output of the detector (second detector of a superheterodyne). Connect the C.R.O. plates across a resistance load here, or supply this load artificially if necessary, as is done in Fig. 15, *D* and *E*.

In the case of grid control detectors which are followed by resistance coupling (Fig. 15*A*) the high potential connection is the plate after the R.F. filter choke or resistance. In the case of diode detectors, the connection is made across the diode load, as shown by Figs. 15*B* and 15*C*. When an impedance or transformer load exists, as shown by Fig. 15*D*, avoid distortion by inserting a 20,000 ohm resistor in the plate lead after the R.F. filter, connecting the high side of the vertical plates to the plate side of the resistor, and shunting the choke or primary of the transformer with a 1 or 2 mfd. condenser. Another alternate method is given in Fig. 15*E*.

You will have no trouble in recognizing phase distortion if you compare Figs. 7, 8 and 13, which show no phase shift, with Figs. 16*A*, 16*B* and 16*C*, which have phase distortion. The back trace here is at the center of the screen, the pattern forming both above and below this trace.

If the pattern is entirely above or below the back trace, phase distortion is absent.*

Summarizing the foregoing, it is highly important that the vertical deflecting plate be connected to a load which has no appreciable capacitive or inductive effects, for otherwise phase distortion would bring a portion of the curve below the back trace. Removing the reactive components by using artificial resistance loads eliminates this difficulty. Of course, anything you do should not alter the voltages and currents you are analyzing.



Top Row: Fig. 16 Middle Row: Fig. 17 Bottom Row: Fig. 18

Figure 15E shows how a resistor is connected temporarily across the primary of a transformer to remove the inductive effect, this being the most usual connection for a transformer load. When a phase distorted resonance curve is observed, reduce the value of the resistor to which the vertical plates are connected; this eliminates enough of the phase distortion to give a symmetrical resonance curve.

* Some C.R.O. connections may give confusing patterns. If connections to the vertical plates are reversed the spot will first move down instead of up, and the patterns will appear as Figs. 16, 17 and 18 would be if viewed with the page upside down. If the spot is swept from right to left by the sweep voltage applied to the horizontal plates, the sweep voltage being reversed, you would see mirror images of the patterns shown here. A combination of both conditions can also exist, but these patterns, if recognized, are just as valuable in cathode ray technique.

The receiver *must* be operated below overloading, unless you are particularly interested in studying overloading effects. This means that patterns *must* be formed with a normal signal from the signal generator, yet the signal should be strong enough to “over-ride” tube noises and the interference which comes with high amplification in the receiver. Figure 17 shows how a C.R.O. reproduces mild interference from noise or a heterodyne with a broadcast signal. Remember that noise produces irregular wavy patterns, whereas the wavy patterns are more regular where heterodyne action takes place. Working with a stronger signal will generally eliminate the wavy portions in the curves. If the wavy lines become more prominent when signal strength is increased, cross-modulation is indicated. This may in turn mean that the R.F. tube bias voltages are low in stages which are not intended to cross-modulate.

Receivers which are thrown into self-oscillation or regeneration when a signal is tuned in will produce patterns like those shown in Fig. 18.

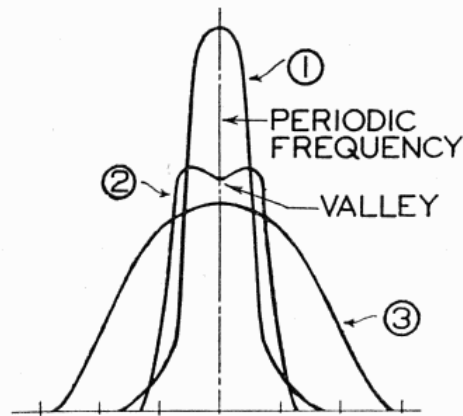


Fig. 19

Corrective measures for cross-modulation, regeneration or oscillation are considered elsewhere in the Course. Here we are merely interested in recognizing these defects by means of a C.R.O.

In order to get representative results the receiver under test should be operated at normal signal level. If the receiver has AVC and a wobulated frequency generator is used to supply the signal, it is not necessary to remove the AVC feature, inasmuch as the average AVC could never follow the speed of frequency change. You could remove the AVC and introduce fixed C bias, but it is better to allow the AVC to show its effects. The input signal should be sufficiently great to operate the receiver above the AVC threshold point.

General Line-Up Procedure.—Once the wobulated S.G. and C.R.O. are connected to a receiver, make those adjustments of the C.R.O. controls which are necessary to get a pattern of proper height, representative of the true conditions of the receiver. The receiver adjustments for band-passing are identical with those previously given for the output indicator method. If undesirable effects not due to poor alignment are present, service the receiver for these first. Although the aligning procedure should be perfectly obvious now, a review will show how simple it can be with the proper equipment.

Assume a receiver with three I.F. transformers and a band-pass pre-selector. If you are definitely planning to flat-top the R.F. system, use the cathode ray oscillograph as an output indicator. Set the apparatus exactly as you would for bandpassing; use a horizontal C.R.O. sweep and a wobbled frequency signal. The sweep is set for double overlapping images. Peak the I.F. and align the oscillator with the preselector at a high and low preselector frequency, using the peak of the resonance curve as a guide. A curve like 1 in Fig. 19 should be observed.

Now connect the wobbled S.G. to the first detector, turn the primary trimmer of each I.F. transformer *in*, the secondary trimmer of each transformer *out* in 1/8th turn steps until the pattern becomes broad and round at the top, then proceed slowly until the double hump appears, like curve 2 in Fig. 19. Continue until the response curve width is of



A Typical Test Oscillator—RCA Model TMV 197-C, with 90 to 25,000 kc. R.F. frequency range and 400 cycle audio output signal.

desired value, about 10 to 15 kc. if ordinary good audio quality is desired, and 15 to 20 kc. if higher fidelity is wanted. If the valley gets too deep but the band width is satisfactory, load one or more intermediate transformers with a resistor across the secondary or primary, choosing a value that drops the humps to a satisfactory level. Another procedure involves peaking slightly one of the I.F. transformers, so as to get three humps and raise the valley. Unless the I.F. transformers have been designed to have optimum coupling the double hump may not appear, and a response like curve 3 of Fig. 19 will be obtained. Always adjust to maintain the original symmetry of the curve.

Having band-passed the I.F. section, connect the signal generator to the receiver ANT and GND posts. Set the receiver and S.G. to 1,400 kc. and to 600 kc. and check for perfect preselector and oscillator alignment. You will probably find that the pattern on the C.R.O. has now lost its flat-top or double hump appearance. By band-passing the pre-selector the double hump will return. Starting with a 1,400 kc. wobbled signal, proceed exactly as with the I.F. transformers, turning one preselector tuning circuit trimmer *in* 1/8th turn or less and the other *out* an equal amount, until the double hump reappears. Again loading with

a resistor may be necessary. Now turn the gang of variable condensers until the first segments of the serrated rotor plates mesh fully with the stators. Adjust the S.G. until the patterns on the C.R.O. screen overlap, then adjust the split segments for the desired band-pass characteristic. Repeat for each segment. Flat-topping the R.F. system is now complete.

If the preselector cannot be band-passed, a slightly different procedure should be used. Adjust the I.F. for a double hump with a fairly deep valley. Peak the preselector so this valley is filled in. If the triple hump is too obvious, shunt the tuning coil in the preselector transformer secondary with a resistor high enough to remove sharp humps. As the effects of each adjustment show immediately on the C.R.O. screen, you can readily experiment and make such changes as you see fit.

Remember that in any double resonant circuit, no matter what type of coupling is used, increased coupling rounds out and eventually double-humps the resonance curve. Loosening the coupling tends to peak the response. Adding a shunt resistor has the same effect as increasing the coupling; decreasing the size of the shunt resistor gives greater width to the resonance characteristic curve. Quite often it is necessary to use both methods, tuning the primary and secondary and inserting shunt resistances to get the desired effect. The use of a third winding with variable resistor control on the coupling transformer has the same effect as varying a shunt resistor.

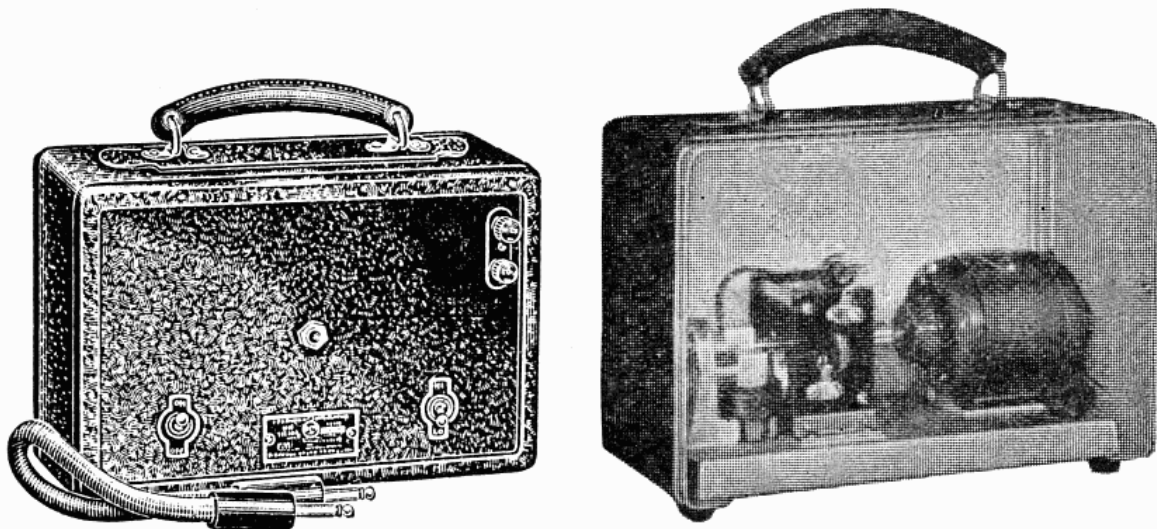
CHECKING AUDIO AMPLIFIERS

Introducing flat-top resonance into the R.F. system of a radio receiver does not necessarily mean that the sound emitted will be of high fidelity; the audio amplifier and the loudspeaker will in many cases determine the quality of the receiver output. As a rule the audio amplifier is able to handle higher audio frequencies than those fed to it by the R.F. and detector systems; flat-topping the R.F. system will then have the immediate effect of improving the response. However, it is wise to check the response of the audio system, especially where band width sufficient to handle over 5,000 c.p.s. is desired.

Conclusive fidelity tests on an audio amplifier, and this includes amplifiers used in radio receiver and public address systems, must include: 1, A check for amplitude or wave form distortion; and 2, a check for equal response over the desired band of frequencies.

A simple audio channel distortion *check* is made by comparing the wave form of a signal produced by an audio frequency generator before and after the signal has been sent through the audio system. The audio oscillator should preferably produce a sine wave of a single frequency somewhere between 400 and 1,000 c.p.s. The S.G. output should be controllable, a potentiometer being placed in its output circuit if there is no volume control. The audio signal generator is first connected to the vertical plates of the cathode ray oscillograph, and adjustments of the

C.R.O. and S.G.* are made to produce on the screen a single cycle stationary pattern of a reasonable size. The curve is then traced on tissue paper or any other semi-transparent paper which can be placed over the screen. Now the signal of the audio generator is fed to the input of the audio system. Reduce the gain of the cathode ray oscillograph amplifier and the output of the generator until the new pattern is the same size as the original. Compare the pattern on the tissue with that now on the screen. Double humps or single central peaks in each half cycle or alternation indicate *third harmonic* distortion; a slight dip in one-half of each half cycle indicates *second harmonic* distortion. An output wave with a gap between each alternation indicates excessive negative C bias on a class B push-push amplifier in which regular triodes are used at cut-off bias.



A Typical Frequency Modulator for oscillograph work, the RCA unit having two sweep ranges (15 and 30 mmfd.) is shown at the left. Back view (right) shows the 1,550 r.p.m. motor which drives the sweep condenser and synchronizing voltage generator.

With experience many other defects will be observed on the screen and identified; knowing these defects, corrective measures may be applied.

Although checks of A.F. distortion can readily be made with a C.R.O. and an S.G. producing only one audio frequency signal, the second check, of uniform response, requires a variable range audio oscillator. This type of oscillator is usually found only in laboratories or at those service benches where the most conclusive tests are considered essential. An audio beat frequency signal generator producing sine wave signals of various amplitudes (level control) within a frequency range of 30 to 10,000 or more c.p.s. is generally used. This A.F. signal generator is connected to the input of the audio amplifier, the receiver output is fed to a C.R.O., and the wave form is traced on the screen. Signals of equal strength but different frequencies are fed to the amplifier and the amplitude and wave form checked in each case. A chart made by plotting frequency against amplitude provides you with a frequency response characteristic which tells whether the audio amplifier will satisfactorily pass

* Under no conditions should the audio generator signal be so strong that it would overload the amplifier if it were fed into the audio stages.

the desired band of frequencies. Incidentally, many radio laboratories have built frequency wobulated beat frequency audio signal generators, in order to show the entire response curve on the screen of the C.R.O. With this type of S.G. the effects of audio amplifier changes are seen immediately on the screen.

OVER-ALL RESPONSE

When a simple over-all distortion check (aerial to loudspeaker input) is desired, an R.F. signal modulated with an audio sine wave is fed to the input of the receiver and the output voltage at the voice coil is reproduced on the cathode ray tube screen. Deviations from a sine wave are easily detected and the defect located by making a stage by stage check of the receiver. Audio signals are fed to the audio system and audio modulated R.F. signals to the R.F. section, the R.F. frequency depending upon the stage (I.F. or preselector) under test.

By using a signal generator giving constant R.F. output and fixed percentage modulation for a number of audio frequencies, an over-all fidelity check is possible. By comparing the sine wave input patterns to the output patterns at each audio frequency, wave form distortion can be spotted; by comparing input and output amplitudes (with constant input) at each frequency, unequal frequency attenuation is checked.

IMPROVING AUDIO FIDELITY

If the audio channel is unable to reproduce the audio signals fed to it by the R.F. system, it is foolish to consider the high fidelity adjustment complete without further work on this section of the receiver. Improvements in A.F. fidelity are likely to increase hum output, A.F. regeneration and oscillation, but these defects can be removed by methods considered elsewhere in the Course.

Now we will consider a few methods of improving the audio channel, which includes: 1, The detector (audio demodulator); 2, the A.F. amplifier; and 3, the loudspeaker.

Detector.—The C.R.O. should be connected to the input of the *first* A.F. amplifier tube, and a signal generator modulated with a sine wave A.F. signal should be connected to the input of the *receiver*. Analyzing the wave form of the A.F. signal at the output gives definite information on wave form distortion; checking the amplitude of the A.F. output for various A.F. values tells us what frequencies are discriminated against.

Consider first, adjustments on diode detectors. If the *wave form* is distorted try increasing the ohmic value of the diode load. If you find that low or high frequencies suffer attenuation, increase the capacity of the condenser shunting the load to reduce the highs, and vice versa. No adjustment should be made at the expense of wave form distortion. If any control exists in the diode circuit it must be so connected that its variation will not disturb materially the load or capacity value and affect the wave form.

Distortion in C bias detectors is observed in the same way. Always

be sure that the plate voltage is at the recommended value. The C bias voltage may be varied (vary the ohmic value of the cathode to $-B$ resistor) for minimum wave form distortion. Increasing the C bias shunt capacity will improve low frequency response. Quite often increasing the plate load's ohmic resistance will increase the lows; decreases will raise the highs. Be sure to check the output R.F. filter. If a single shunt capacity is used, increasing its value will tend to drop the highs and lowering its capacity will tend to raise the highs. The latter will be necessary in most cases.

Audio Amplifier.—In the case of a radio receiver, checking of the A.F. amplifier may be done with the audio modulated R.F. signal generator connected to the input of the receiver; the C.R.O. should be connected to the voice coil terminals. In a straight A.F. amplifier (as used in P.A. systems) the input must be a variable frequency A.F. signal gen-

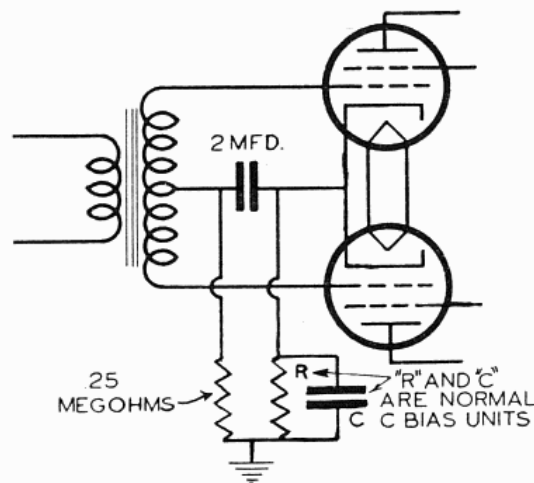


Fig. 20

erator. Of course, the latter may be used in a receiver, connected to the input of the first A.F., if the detector is considered properly adjusted. Distortion is determined by analyzing the wave form, and frequency discrimination by comparing the output amplitude for various A.F. frequencies.

In the case of resistance or impedance coupled stages, increasing the capacity of the coupling condenser will bring up the lows. If a resistor in shunt with a condenser is placed in series with a coupling condenser (a condenser connected between a plate and a grid) the lows will be reduced and flat response will be obtained at the sacrifice of over-all gain. Resistors from .1 to 1 megohm and condensers between .0001 and .1 mfd. may be tried.

Shunting the secondary of an audio transformer with a 50,000 to 500,000 ohm resistor will raise the highs; shunting the secondary with a .001 to .01 mfd. condenser will raise the lows. If the response shows a rapidly falling characteristic at low frequencies, shunting the C bias resistors of the amplifier tubes with a 1 to 20 mfd. condenser will raise the lows; a circuit to prevent degeneration, shown in Fig. 20, may also be

used. Should the response characteristic curve show peaks or valleys, try various condenser and resistor shunts across the secondaries of transformers. If wave form distortion exists when maximum allowable signal is fed to the amplifier input, set each plate and screen or suppressor grid voltage to normal value, then vary the C bias until minimum distortion is obtained.

Loudspeaker.—It is a good plan to vary the A.F. signal frequency when the C.R.O. is connected to the voice coil. If the voice coil is floating (loudspeaker is reproducing the simple tone of modulation), a sharp increase in wave amplitude will appear when the loudspeaker is in resonance with the signal fed to it. Usually this occurs below 100 c.p.s. This causes the usual “boom-boom” so characteristic in some receivers. If this low-note distortion occurs when the loudspeaker is in the cabinet, line the inside of the loudspeaker chamber with rock wool pads, porous felt or wool pads, or even Celotex. Be sure the loudspeaker presses *gently* against the front face of the loudspeaker chamber. Incidentally this face or baffle should be backed up with a special baffle board at least one-half inch thick and of soft wood or Celotex. The felt on the loudspeaker rim should be soft. The depth of the loudspeaker chamber should not as a rule exceed *eighteen* inches. The back should be open, but if the cabinet is placed against a wall the back should have soft wool strips hanging from the top to the bottom. Strips of rugs with the fuzzy surface towards the loudspeaker may be used. If these measures do not correct cavity and loudspeaker resonance try moving the loudspeaker 1/32” or more away from the front baffle.

Now let us consider the high frequency output. If the response of the A.F. amplifier is peaked at 4,000 to 8,000 c.p.s., no further loudspeaker correction will be necessary. If the response is flat or even starts to drop at 4,000 c.p.s., the addition of a tweeter loudspeaker is recommended. A crystal tweeter is ideal. Connect a 50,000 ohm potentiometer between the plates of the output tubes (push-pull or push-push will be the usual condition), protected by a .1 to .5 mfd. series condenser at each plate connection. With a single tube output stage, connect the potentiometer between the output tube plate and the chassis. Connect the tweeter to the movable and to one end contact of the potentiometer. Place the tweeter inside the dynamic speaker or above it on the baffle, in this case cutting a hole in the baffle. The potentiometer, mounted on the receiver panel, is adjusted for best treble* output. You can always check highs by tuning in a local station, preferably one known to transmit programs of high fidelity, and listening to the announcer and performers. When the receiver is set for normal audio output, you should be able to hear the letters *s*, *t*, *d* and *k* pronounced, hear the breathing of performers and hear studio noise and echoes, if the receiver gives good reproduction on the highs.

* High audio frequency.

QUESTIONABLE TESTS WITH A C.R.O.

Inasmuch as a cathode ray oscillograph is a voltmeter having a very high resistance, and will respond to any frequency, many technicians like to use it in checking the dynamic characteristics of radio parts. The receiver is excited with a modulated R.F. signal and the vertical plates of the C.R.O. are connected across the part to be checked. By comparing the observed wave form with that which is expected, defects in the unit are "spotted." Filter condensers in a power pack may be checked by viewing on the C.R.O. screen the ripple voltage across each unit; use power line frequency in the sweep circuit.

In testing the A.F. section of the receiver the C.R.O. and its usual built-in amplifier will suffice, for as a rule the amplifier will handle frequencies up to 90,000 c.p.s. When checking the R.F. and I.F. sections the amplifier built into the C.R.O. cannot be used, and an external radio amplifier is necessary. Many technicians use for this an all-wave receiver (150 kc. to 20,000 kc.). The part to be checked is connected to the ANT and GND posts of the receiver, with a resistor in series. The ohmic value of the resistor should be about ten times the

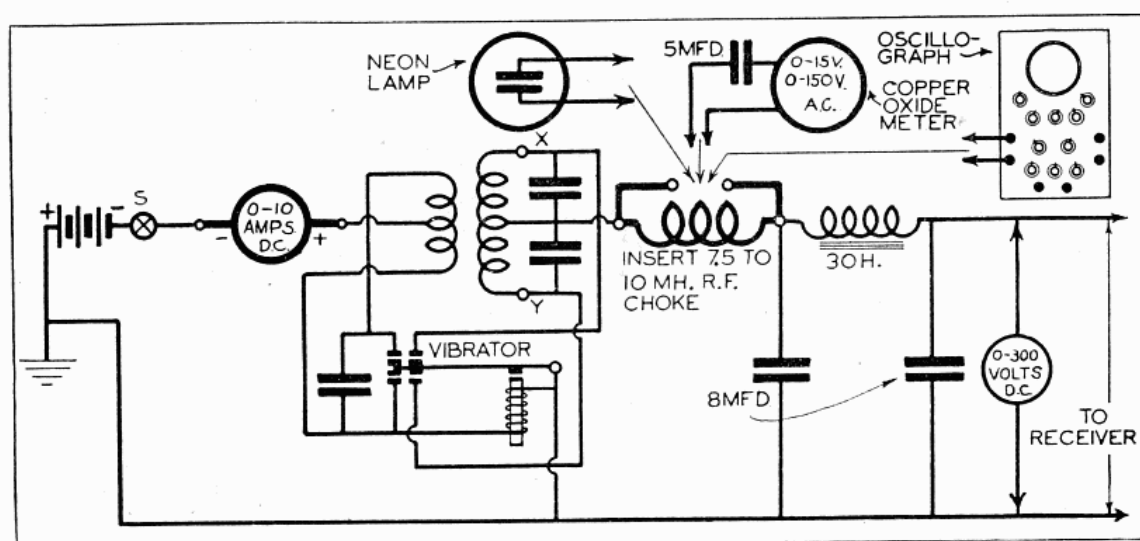


Fig. 21

impedance of the part under test. For example, when checking across a 500 ohm bias resistor † use a 5,000 ohm series resistor; when checking across the secondary of a tuned transformer whose impedance may be roughly considered 20,000 ohms, use a .25 megohm series resistor. The vertical plates of the C.R.O. are connected across the secondary of the last I.F. transformer of the A.W.R.; the trimmer condenser of this stage is adjusted to compensate for the capacity of the C.R.O.

The disadvantages of the C.R.O. for such tests are many. The C.R.O. tube is expensive and its life limited; why waste it on tests better done by other means? An effect to cause reasoning will as a rule isolate the defect; a stage by stage elimination test will isolate the defective stage, and a stage check will reveal the defective part. Dynamic tests can be made with a vacuum tube voltmeter or copper oxide rectifier voltmeter, instruments which are less expensive initially, less costly to operate and which give all the results wanted except wave form. Of course, if you are making a detailed study of certain defects or carrying out research work on the design of radio parts a cathode ray oscillograph will be invaluable.

† If a D.C. voltage exists, place a .1 mfd. blocking condenser in series with the extra resistor.

THE C.R.O. AS AN AID IN VIBRATOR ADJUSTMENTS

The vibrator, extensively used in auto, aircraft and farm radio receivers, often requires replacement or repairs. Although the C.R.O. is not absolutely necessary here, if you possess one it can be used with considerable success for checking vibrator repairs. As you already know, the vibrator contacts should first be filed smooth and parallel, and the gaps initially adjusted to a .003" to .006" clearance (about the thickness of this page).

A vibrator is best adjusted under actual operating conditions, preferably when connected to its receiver by a special extension cable, which can readily be made. A 0-10 ampere D.C. ammeter is inserted in the vibrator primary supply and a 0-300 volts D.C. voltmeter connected across the output of the filter, as shown in Fig. 21.

The contacts are next adjusted (with the vibrator connected to its radio receiver) for minimum sparking when input current is a minimum (about 3 amperes), and D.C. output voltage is a maximum (about 180 volts or more). Manufacturers' specifications are well worth following.

Better adjustments can be made if an R.F. choke is inserted in the output, as shown in Fig. 21. A neon lamp, an output meter, or a C.R.O. connected

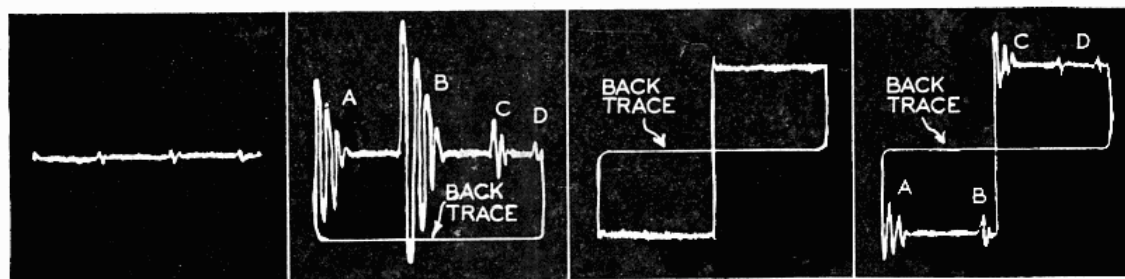


Fig. 22

Fig. 23

Fig. 24

Fig. 25

across this choke will show minimum voltage when sparking at the contacts is a minimum. If the sweep is applied to the C.R.O., a pattern like Fig. 22 indicates good adjustment. The pattern shown in Fig. 23 indicates sparking and poor adjustment.

If the C.R.O. is connected across the secondary of the step-up transformer at points *x* and *y* in Fig. 21, a pattern like that in Fig. 24 indicates good rectification; the pattern in Fig. 25 would then indicate excessive sparking. The wavy portions at A, B, C and D may not always be visible, especially if the C.R.O. screen has a slow response. Gaps in the pattern would then indicate poor adjustment. Each alternation should be alike—a flat top without gaps or variations.

TEST QUESTIONS

Be sure to number your Answer Sheet with the *number* appearing on the front cover underneath the title of this text.

Place your Student Number on every Answer Sheet.

Never hold up one set of lesson answers until you have another ready to send in. Send each lesson in by itself before you start on the next lesson. In this way we will be able to work together much more closely, you'll get more out of your Course, and the best possible lesson service.

1. Should the cathode ray oscillograph (C.R.O.) be used in the customer's home?
2. Will band-passing an R.F. stage reduce its gain?
3. How many times does the periodic frequency occur for each revolution of the wobulator condenser?
4. If a wobulator condenser connected to an S.G. is rotated 40 revolutions per second, what horizontal sweep frequency should be used on the C.R.O. to produce an overlapping double pattern?
5. When connecting a C.R.O. to the plate of the second detector of a super, what feature of the pattern tells us that no phase distortion exists?
6. Is it necessary to remove the AVC action when a C.R.O. and motor driven wobulated signal generator are used for band-passing?
7. What *two* fidelity tests on an audio amplifier must be considered?
8. What is indicated if the output wave from a *push-push* amplifier shows a gap between the alternations?
9. What will happen to the highs when an audio transformer secondary is shunted by a 50,000 to 500,000 ohm resistor?
10. What simple aural check when the receiver is tuned to a high fidelity broadcast indicates that the loudspeaker is reproducing the highs satisfactorily?