SIGNAL SUBSTITUTION

By G. N. GOLDBERGER

PRECISION APPARATUS COMPANY

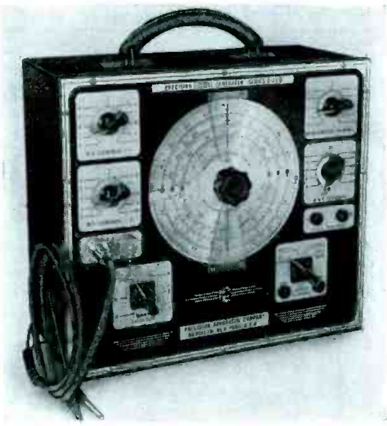


Fig. 2. Variable modulation control, incorporated in the E200, allows increased r-f audibility without r-f overload and provides a means for checking demodulation capabilities of the second detector.

It is surprising to note that, although the average Service Man may be well equipped with modern test apparatus and is well versed in the operation of his instruments, not as much attention has been given, as should be, to the systematic application of these same units to other than their most obvious intents. This seems to be particularly true of the signal generator.

This one instrument is capable of forming the foundation of a complete servicing technique or system which will allow the localization of almost any receiver trouble. A signal generator of proper design can perform amazingly more useful functions than as a mere variable frequency source for alignment.

No claim is made that the system described in this article is radically new or revolutionary. It is simply well grounded technique and application based on a few everyday principles. No additional equipment is required than what would normally be on hand in the average service shop . . . a signal generator, multimeter and a tube tester. The system is, on the whole, an orderly accumulation of many methods which you or the next man may have at one time or other employed in the solution of puzzling radio problems.

What is to follow is only a small idea of the possibilities of this servicing method, and confined to but a few examples. The system is founded on fundamental factors and its application is limited only by the operator's own knowledge, ability and confidence in what he is doing.

For the sake of simplicity let us confine ourselves to a common superheterodyne receiver, such as that shown in Fig. 1. The same system of attack, however, is applicable to all receivers regardless of variations. This receiver, let us say, has been brought to us for service with no more of a lead as to the nature of the trouble other than "Fix it, it doesn't work."

Tube Testing

It is a good policy to test all the tubes first. The immediate isolation of a shorted tube (or the finding of a very weak oscillator) is at times the entire solution to the problem. The fact, however, that all the tubes have passed this initial test does not always definitely eliminate them as a possible source of trouble. No tube tester available to the Service Man is infallible and actual try-out in the receiver is the final determining factor.

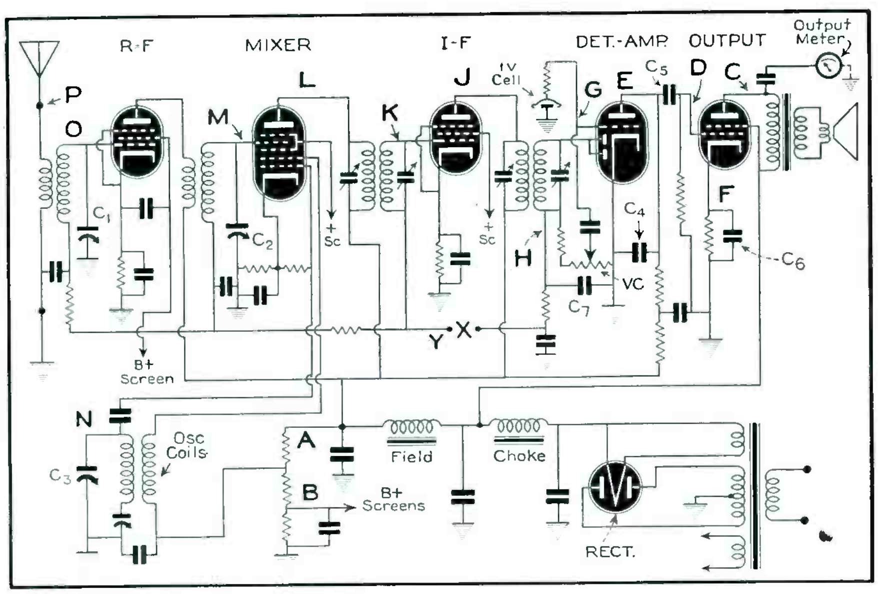


Fig. 1. Signal substitution provides a servicing technique for the systematic location of receiver faults.

Many an oscillator tube can pass both emission and dynamic types of tests and still not function in a receiver, especially if the oscillator circuit accidentally or intentionally requires a tube with high hop. Gassy tubes, on the other hand, will initially test perfectly, but if allowed to operate in the receiver or tube tester, will start to draw grid current or otherwise go sour.

Power Supply

If the tubes test ok in the tester, we can temporarily eliminate them as possible sources of trouble and proceed to the next part of the test.

The use of an ordinary multirange meter in conjunction with manufacturer's specifications will allow immediate determination as to whether the proper voltage is available at the power supply and at points A and B (Fig. 1). If the proper voltage is not obtainable, i.e. no reading, excessive reading or below normal, the type of reading obtained will indicate the nature of the trouble. Little difficulty is ever experienced in cases so simple as this. However, should the difficulty not be directly associated with the power supply, and should the operator not desire to make a systematic stage by stage voltage test, the trouble will definitely appear during the systematic signal analysis.

Audio Stages

Let us now set our signal generator for the 400-cycle sine-wave output and start the analysis right at the output transformer. The instrument employed must have sufficient signal output of good wave form to allow direct application at the point C (Fig. 1). At this point both the audio output transformer and the speaker are simultaneously tested. By starting with a sine-wave signal a speaker deficiency such as a slight rubbing of the voice-coil frame to pole piece, with consequent distortion, is readily detected. At the same time the output transformer is tested directly. In all these tests (and in those which follow) the return probe is connected to the receiver chassis.

Moving the audio probe to D requires a reduction in the signal generator a-f attenuator proportionate to the gain of the output tube. No signal (as evidenced by a silent speaker, monitored by the multimeter) localizes the difficulty, the exact nature of which can be readily detected by a multimeter test in this small portion of the receiver. It could be an open grid resistor, bias resistor or possibly a leaky C5. If C5 were good, a shorted tone compensator (C4) would then severely reduce the gain but not cut it off completely because of the effective series reactance of C5 at 400 cycles. Moving the probe to E, however, would immediately detect this condition, or an open C5.

Condensers

The probe at F discloses the effectiveness of C6 as an audio by-pass. If it is open a signal will appear in the output circuit. If the condenser is operating properly no signal should appear in the output since these condensers are of rather high capacity, anywhere from 1 to 50 mfd. If smaller capacities are used, they should severely attenuate the signal, if not cut it off completely, when the probe is applied to these elements. This test applies equally well to r-f test signals as used with r-f by-pass condensers in i-f and r-f circuits. The method should reveal the condition or efficacy of r-f by-passes and filter circuits such as C7.

Audio Gain

With the volume control (VC) set to the maximum position, we now set our signal generator probe to the point G (Fig. 1). The audio attenuator should again be reduced proportionate to the gain in the audio amplifier. The output meter (or signal-generator attenuator) should indicate the approximate gain in audio amplifier. The ratio of output meter reading with the probe at D and at G indicates the audio amplifier voltage gain. For example, assume that an audio signal applied at D is adjusted to make the output meter read 10 volts. Transfer of the same signal to G causes the meter to read (let us say) 200 volts. Thus, a gain of 200/10 or 20 is experienced in the audio voltage amplifier. The greater the gain to be expected in the amplifier the lower the initial setting of the generator attenuator and output meter reading to avoid overloading.

With the probe at G, audio amplifier difficulties can be discovered. Moving the probe to H allows the testing of the volume control (VC) and the associated coupling condenser. A modulated i-f signal tests the operation of the r-f by-pass C7.

In all of the foregoing and following tests the multimeter is employed as soon as the troubles are localized, such as for plate- and screen-voltage tests, resistance measurements, etc. A 20,000-ohm-per-volt meter unit is usually quite sufficient, permitting measurement of bias, avc and voltages in resistance coupled circuits, in addition to leakage potentials on the grid side of audio coupling condensers.

I-F Channel

When employing the output cable of a signal generator, it is advisable to ascertain whether the high lead already includes a series blocking condenser, otherwise both grid bias and plate voltage will be shorted out as the probe is

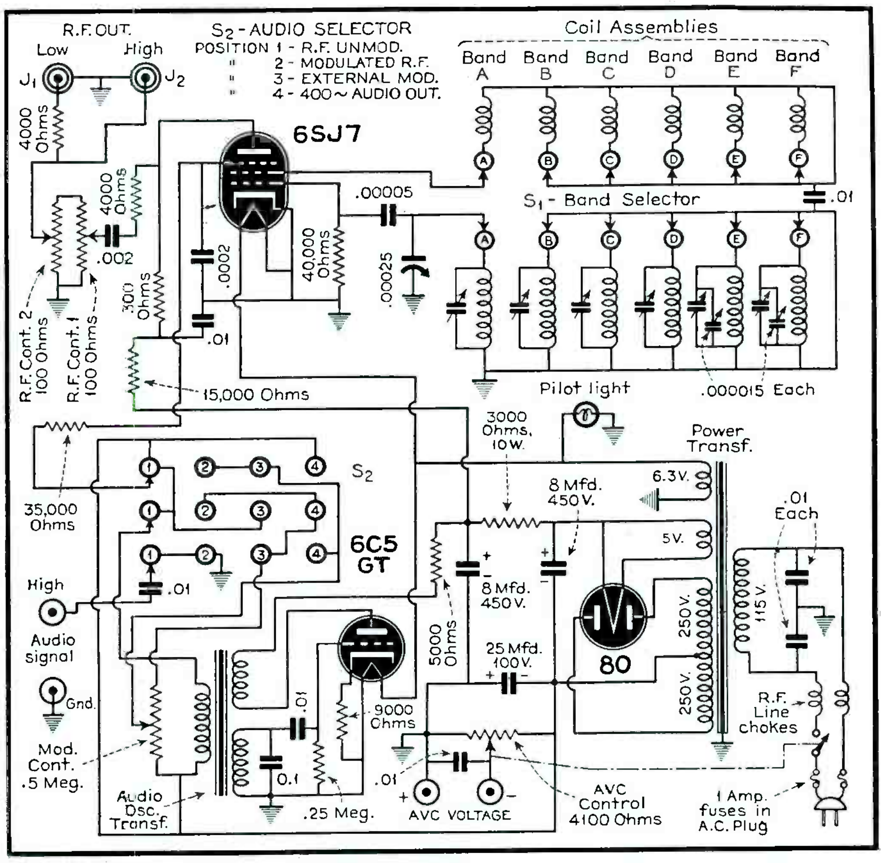


Fig. 3. The avc substitution voltage, provided in the E200, may be varied and adjustments made and measurements taken under bias conditions simulating normal receiver performance.

applied. Receiver manufacturer's service notes should be followed for dummy antenna, and series resistance loads specifications.

To check the i-f stages a 400-cycle audio modulated signal is employed. With the signal generator set to (say) 456 kc, and a suitable blocking condenser connected in series with its output, the probe is applied to position J as indicated in Fig. 1, and the generator output is increased until an audio note is heard at the speaker or indicated on the output meter. (If something is wrong with the stage, little or no signal will be obtained.) Rock the oscillator tuning dial above and below the proper i-f peak, until the output meter indicates a maximum. The generator dial reading thus obtained gives the point at which the stage is aligned. If this reading does not coincide with the proper i-f, it can be corrected immediately. Should it be impossible to realign to the proper frequency, shorted turns or otherwise reduced inductance is indicated. A new i-f coil should then be installed.

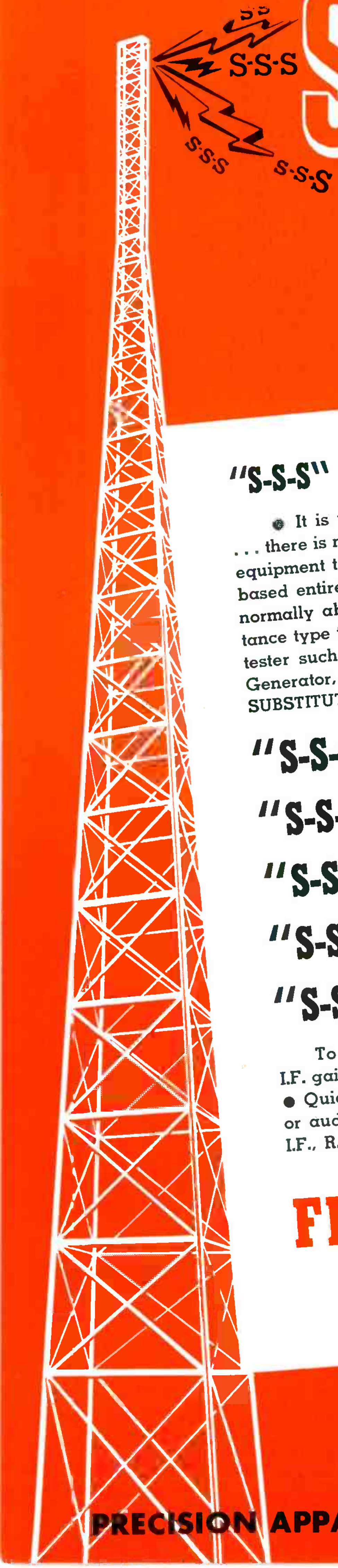
In other words through proper application of the signal generator we are able to determine not only whether the circuit was working, but also, if misaligned, we can correct the condition immediately.

Automatic Volume Control

As we move our probe to K we must remember the leveling action of avc systems and the broad tuning effect on alignment by ordinary output meter methods. Inasmuch as avc voltage at X reaches a peak as the various controlled stages are resonated, an alignment resonance indicator may be the receiver's own tuning eye, a tuning meter, a vtvm or 20,000 ohms/volt meter between X and ground.

To avoid avc leveling action, Service Men have been instructed to use signals below the avc threshold, so that avc is effectively interrupted. However, in so doing, the controlled stages are operating under considerably different conditions of grid bias than that developed in the diode circuit by average local signals. This bias variation has been proved to shift the resonance point of the related tuned circuits because of the change in the controlled tube input capacity. This input capacity is directly in parallel with the i-f and r-f coils. Hence, if the receiver be aligned below

(*Continued on page 26*)



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SIGNAL SUBSTITUTION

(*Continued from page* 15)

the avc threshold, it will not be functioning with optimum performance under normal conditions.

If we were to substitute a fixed bias in place of the varying avc voltage, and were able to adjust this fixed bias to any desired value equal to that which normal local signals develop in the diode, we could then align and test this receiver under practically true operating conditions, and without detrimental avc interference.

The signal generator employed in developing this article furnishes a variable bias voltage between zero and fifty volts specifically for avc substitution. All that is required is to open the avc circuit at X, and connect the substitute bias with the negative end toward Y. Alignment of the receiver can then be carried out as if no avc were present.

With the probe at K, the i-f stage can be analyzed, the output section of the i-f transformer adjusted and the diode winding alignment rechecked. By-pass condenser efficiency can be determined in the manner suggested for the audio stages, and shorted turns can be detected readily as mentioned above.

At the same time i-f and r-f gain per stage measurements may be made if the generator employed is provided with a calibrated output control.[1] This is done briefly as follows: With the r-f probe at J, set the r-f attenuators and modulation control to give some arbitrary reading on the output meter near the middle of the scale. Note the attenuator setting. Shift the probe to K. Reduce the attenuator setting until the output meter indicates the same reading as that obtained when the probe was at J. Again note the attenuator setting. The ratio of the two settings indicates the gain of the stage directly.

The probe at L tests the transfer of signal through coil to K, just as the probe at J checks the signal through to the diodes. Placing the probe at M, and still employing the 456-kc signal, allows complete alignment of the input i-f transformer and also allows check of operation of the first detector at the intermediate frequency.

R-F and Oscillator Stages

We are now ready for a complete test and adjustment of the first detector and oscillator. Set the receiver dial to the high end of the broadcast band, about 1500 kc, and apply the r-f probe to M with the generator set for 1500 kc, 400-cycle audio modulated, output. If the oscillator is oscillating and tracking, the audio tone should be heard from the set's speaker. If no signal is heard the oscillator should be checked first. It should be oscillating at 456 kc plus the dial reading (456 plus 1500) or 1956 kc. If the oscillator is oscillating but not tracking, the signal should be heard from the speaker when the generator dial is rocked around the 1500-kc position. If the oscillator is not oscillating at all, regardless of what generator setting is used, no signal will be heard in the speaker.

To check this, connect the generator probe at N and an antenna at M, switch off the generator's audio modulation and tune it to approximately 1956 kc. Attempt to tune in a station in this manner using the signal generator as a substitute for the set's oscillator stage.

In some cases, where a receiver employs a separate oscillator tube coupled to the first detector through a small condenser, the condition of this condenser can be determined by placing the probe before and after the condenser. If the condenser is open or a lead broken the signal will appear only when the probe is at the mixer side of the condenser.

Once having ascertained that the first detector and oscillator are working, the probe may then be advanced to O where the 1500-kc signal is again applied and the first-detector trimmer adjusted. The r-f stage gain may be measured, if desired, in the same manner as outlined for the i-f stage. If no further difficulties exhibit themselves during this test, the probe is finally placed at P, and if the antenna coil, leads, etc., are continuous and no turns shorted, we proceed with the low-frequency padder adjustments and our set is complete.

It is realized that, as presented, things may appear rather sketchy, however, space limitations do not permit extended treatment. Nevertheless, it is hoped the reader has been able to formulate in his own mind the extensive application to which basic test equipment may serve, and how one's problems can thereby be systematically approached and solved.

[1] "Gain Measurements in R-F and I-F Stages," by Jack Avins, SERVICE, May, 1937, p. 273.

HOME RECORDING

(*Continued from page* 13)

a bias cell. The mike gain control is in the plate of the preamplifier. Note the mixer circuit; one side is fed from the mike gain control and the other from deck No. 1 bringing in radio programs from the diode detector or phonograph. A conventional tone control is used.

The Lafayette S53, a 9-tube push-pull combination radio recorder (see Fig. 5) switches to any one of 5 functions by means of a 5-position, 4-deck rotary switch. A 6SQ7 preamplifier is used for microphone recording and p-a applications. The 6U5 visual indicator tube is used both as a resonance indicator and as a level indicator during recording.

In p-a applications it is possible to reduce, or even eliminate acoustic feedback by providing avc in the audio amplifier. Too much avc will spoil the quality and cause excessive volume compression, but a certain amount will help obtain a proper input level.

Automatic record changer phonographs are coming out with recorder