THE CHANALYST

The Development that Preceded the Finished Unit

By JOHN F. RIDER

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THIS business of radio servicing has been in existence now for a good many years and the one subject that is of primary importance to every man actively connected with it is how a defective receiver should be tested or inspected in order that the fault may be found accurately, quickly, and easily, because unless the test be conducted so that these conditions are met, the chances are good that the serviceman will not show a reasonable profit on any one particular job.

Ream after ream of paper has been covered describing all manner of test procedures—some good—some fair—and others decidedly not so good. There have been advocates of one system or another and they apparently find one suited to their needs for they have built up a successful business. Yet when each and every one of these systems of testing be analyzed—taken apart to see upon what it is based, it will be found that there are almost as many bases as there are systems. Now to our way of thinking—and we feel sure that you will agree with our premise—there is just one way to test any machine or system—no matter what its variations may be—and that is to decide what is the essential factor that is responsible for the functioning of the system; then when that has been determined, to investigate its behavior as it progresses through the system and performs useful work. All too often this thought of the power itself is sidetracked and because of some reason, a multitude of minor procedures comes into practice that check the *parts* of the system but not the fundamental or driving force itself.

For example, when a steam generating plant is tested, upon what are the observations made? The live steam itself—the moving force that performs work. If you were to look in at such a test, you would find the engineers reading gauges and thermometers, watching flow meters—inspecting the condition of the steam as it progresses through the system . . . watching the force itself, as it were. True, you would find men taking the temperature of the fire with a pyrometer—checks being made on the gases going up the flue with a CO_2 analyzer—records made of the amounts of the coal and water being consumed—but these are only to calculate the overall efficiency of the installation—it is the steam itself that is the important factor.

Now apply this same line of reasoning to the testing of a radio receiver—*any* receiver, mind you—old or new or yet to be designed—a-c or d-c operated—trf or superhet. . . . Just what is the one essential factor upon which the functioning of every radio receiver ever built or ever can be built, is based? What is this common denominator of all receiving systems—the fundamental—the elemental? *It is the signal itself.*

What is it that is superimposed upon the carrier wave? The signal. What is it that every condenser, resistor, transformer, tube or any other part in a receiver works on? The signal. When you are called into a customer's home, you are wanted because the receiver is not functioning as it should and the signal has been affected in some way or other. Perhaps it has become distorted—perhaps hum is superimposed upon it—maybe there is a reduction in the sensitivity or a loss of control or maybe no signal at all. . . . Any way you approach it, *the signal*, and the *signal alone*, is the all-important factor. And this is what you as a serviceman must restore to its normal state. . . . No matter *how* you do it, it is your job to fix the trouble as easily and as quickly as you can.

Diagnosis All-Important

But before the signal can be brought back to normality, the condition or conditions causing the trouble—and they may be external as well as in the set itself, although the chances are that they will be the latter—must be discovered. And that brings us back to our starting point: the testing of the receiver—the diagnosis of the condition that is affecting the signal. You know as well as we do that it is the ability of a serviceman to diagnose trouble that makes him valuable to his business. . . . The locating of the fault is 90% of the whole job of bringing back the signal and if the time to do this great percentage can be reduced, even a few minutes, then that will automatically make for increased profits.

And that is what we have been striving to do and it is our belief that we have found a way that you can localize the faulty condition in a receiver more quickly and more efficiently that it has been possible to do heretofore.

First of all, if one method of finding out what is causing the signal's abnormality could be equally well applied to *any* type of receiver, matters would be simplified enormously. Furthermore, if this method could be applied to any *new* receiver as well as those now on the market, then it would be unnecessary to clutter up your mind with a thousand and one details. Now taking the premise that in every radio receiver essentially the identical things happen to the signal, a good start towards universality has been made.

In general terms the signal in every receiver is detected, amplified at audio frequencies, and then the electrical energy is delivered to the actuating mechanism of a loud speaker. If the signal be amplified at radio frequencies before detection that still does not spoil the picture . . . it is just an additional step—just as the introduction of avc or afc would be. . . . Also if a locally generated current be mixed with the signal before it is detected that is just one more step that does not detract from the main idea. Think in generalities and you will find nothing complicated. If you will look into the future a bit, you will see that unless the whole system of braodcasting be entirely changed—and there is little chance of that coming to pass—receivers of the future will have exactly the same features as those of today . . . perhaps a few refinements and embellishments but nothing to affect the main idea. (Editor's Note—Any new radio service such as FM, Television, etc. uses a signal as the basis of operation.)* It is just like the automobile industry: new models are introduced annually with knee action, improved brakes, balloon tires and what have you but still the same old fundamentals are there—you have a motor in which the expanding gases push a piston down and that mechanical energy makes the rear wheels revolve.

* Note added by RCA Mfg. Co., Inc., May, 1941.

Signal Tracing

Granting that all receivers are alike fundamentally in their action on the signal, some way had to be found whereby the signal could be inspected from the instant it enters the receiver at the antenna until it arrives at the output. Moreover if some practical way of doing this existed, it would make possible the locating of the point at which the signal departed from normal . . . where it became distorted . . . where it weakened or where something else happened to it. Yet no matter how desirable such a procedure might prove to be, with the equipment available to the serviceman such a method was out of the question. Therefore, in order to employ this signal-checking procedure, which we consider to be universally practical, it was first necessary to develop some apparatus that would give the information required under actual operating conditions and without influencing the signal in its passage through the receiver. Moreover, theoretical analysis of the problem showed that if such apparatus could be developed, it would not only localize the fault in some particular circuit, but it would also go a long way in tracking down the part that caused the signal to depart from its normal condition.

Going another step forward in our considerations it was found that measurements of the various voltages represented the best secondary or supplementary test in finding the defective part and this measurement must be such that it can be made simultaneously with the signal-tracing test. Furthermore, such voltage tests would have to be made without impairing the operation of the receiver. This includes readings of the control voltages developed by the signal as well as the operating voltages. If all this could be accomplished, we would have a systematic procedure based entirely on the signal itself, which we took as the fundamental basis.

With all this before us, a thorough study of existing test equipment was made . . . apparatus that would be most likely found on the benches of progressive servicemen. True, capacity meters are valuable for checking condensers. The same thing can be said about ohmmeters for finding the d-c resistance of a circuit or component. The capabilities—and the limitations—of the signal-generator method of probing were considered and those same factors pertaining to the vacuum-tube voltmeter were weighed. We not only studied these and other instruments to see what they would do, but also—and this is indeed important—what they could not do; these factors were considered as well as their costs and ease of operation.

Accessibility of Parts

We then turned our attention to the physical side of the receivers themselves. Granting the signal-tracing system of testing to be the best, would it be possible to get at the different points in the sets where connections would have to be made and what effect would such connections have not only on the readings but on the operation of the receiver? Schematics of all kinds were examined as well as the chassis of a large number of existing receivers. . . . Design engineers were consulted concerning the electrical and physical trends in the sets to come; what would be the result if the ideas of today were incorporated in the sets of tomorrow? All our findings were encouraging; the further we went, the firmer were our convictions that we were on the right track. As far as we were able to discover the parts in the new receivers were to be as accessible as possible in order to assure simple and economical maintenance. And it goes without saying that if the parts are easily reached, then the paths along which the signal flows will also be accessible. Furthermore, as our method offered no interference with the receiver's operation, the complex interlocked circuits would not offer any problem in respect to its application.

The problem was also considered from the point of view of the servicemen's technical capabilities in relation to the new design of receivers. It was clear that a new attack—a new method of approach was in order so that the trouble in a receiver could be diagnosed systematically, efficiently, and quickly. As our readers will admit, although receiver design has advanced with gigantic strides in the last few years, the serviceman's methods of trouble localization might well be described as belonging to the Stone Age. It has been conceded that some new method must be devised if the service industry is going to survive by mastering the problems presented by the new receivers. We wish that you would think back over the last few months' work and remember the number of conditions that you were unable to check in late receivers or the number of things you had to assume—mainly because it was impossible for one reason or another to check them.

Three Essentials

With all these facts marshalled before us, we arrived at the conclusion that this signal-tracing method of testing required three major items in order to be effective; it must have universal application, positive identification, and speedy operation. In no one of the methods in use up to the present time are these three factors incorporated and you can readily see that they are necessary for rapid and accurate work. Although the signal is really the basis of the system, yet its tracing through the receiver is the primary, but not the only test. It is supplemented by a voltage test which although secondary, plays an important part. The primary test locates the trouble in some certain portion of the receiver—sometimes the exact defective part. The supplementary test identifies the defective part in many cases—but in every case furnishes the required information.

Now what must we be able to do in finding the portion of the receiver that is not functioning correctly and locating the faulty component? First we must be able to trace the passage of a signal entering the receiver through the antenna post throughout the various signal-current-carrying circuits, no matter if it be at radio frequency, intermediate frequency or audio frequency. Then the signal must be traced throughout the receiver without essentially altering the constants of the circuits and as a consequence, impairing the operation of the receiver and so nullifying the observations. Simultaneously, the operation of the receiver oscillator also is checked. The voltage tests must be of such a kind that they will take care of the operating voltages and also the control voltages that are developed by the signal. These voltage measurements can be made simultaneously with the observation of the signal and at points common to both the signal and the voltage. The measurement of the d-c voltages must be made with reasonable accuracy with respect to the true voltage present at the point under test without changing the constant of the circuit.

It is our belief that you will agree that the different points outlined above would go far towards helping servicemen over many difficult spots, if it were possible to perform the signal-tracing tests and make the various voltage measurements. And all this *is* possible. After several years of painstaking laboratory work, a device operating upon the principles outlined has been completed. It has been turned over to a manufacturer for production and sale. We are sure the service industry will find it of great value.

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