THE SERVICEMAN

Blowing hot and cold over a problem

Next to the straightout intermittent fault, there is probably no more time consuming problem than the heat sensitive fault. While it has the advantage of being consistent, it can often require a lot of skill, time and equipment to track it down.

This story was related to me by my amateur friend but, although it involves a piece of amateur equipment, very similar situations could just as easily occur in a more conventional appliance.

The device in this case was a VHF FM receiver. More precisely it was the receiver section of a complete mobile transceiver system, which had originally done duty in a commercial application. It had eventually been discarded when the authorities narrowed the bandwidth available for these services. Although old and bulky by modern standards, my friend was happy to acquire it for a nominal sum, and subsequently modified it to operate on 146MHz in the two-metre amateur band.

When first put into operation it performed extremely well but, significantly as it turned out, this was during the winter months. With the advent of warmer weather, strange symptoms began to appear. Superficially, the problem appeared to be loss of audio gain, accompanied by distortion. However, it was not consistent and, initially, my friend was not even sure that the trouble was in his receiver or the other fellow's transmitter.

But things came to a head one very warm day when my friend decided that his workshop battery needed charging. Significantly, the charger was located immediately underneath the receiver shelf. At the same time, since he planned to be working in and around the workshop for most of the day, he switched the radio on to take advantage of any "CQ" calls which might occur.

At first, all was well, and he listened to spasmodic amateur traffic as a background to his work, without paying a great deal of attention beyond being aware that the receiver was working normally. Then, a couple of hours later, after a period of quiet, more traffic commenced and my friend realised that the signal had become weak and distorted. What was more, each of the several stations now involved was effected, so it was most unlikely that they were at fault.

My friend immediately suspected that it was a heat-sensitive fault, and proved the point by switching everything off while he stopped for lunch. When he returned about an hour later, and switched the set on, everything appeared normal. However, it did start to pack up again late in the afternoon, after several hours' running.

When it did, he made one more step in the diagnosis; he decided that the trouble was in the "squelch" or "mute" circuit. For those not familiar with these terms, a few words of explanation may be in order.

All high-gain receivers create a lot of noise when they are not receiving any signals. While broadcast receivers are seldom switched on unless there is something to listen to, receivers operating in communication networks are, of necessity, required to operate continuously. Which means, in practice, that they are required to operate for long periods at maximum sensitivity with no signal being received. The resultant noise can be very annoying, to the point where less responsible operators will turn the equipment off, rather than put up with it. The "mute" circuit was designed to counter this problem.

While there is a large variety of circuits, all function in the same basic manner. In effect, they disconnect or disable the audio end of the receiver from the detector or discriminator until such time as the front end of the system senses the presence of an RF signal. Only then is the audio system connected or activated. Thus the receiver remains quiet until a signal is received.

One arrangement uses a valve or transistor in a switch or series configuration, and normally biased into "cut-off" condition, so that no signal can pass through it. A counter bias or bucking voltage is generated by the presence of an RF signal, sometimes as part of the AGC system, sometimes by means of a separate rectifier and filter network. This is applied to the appropriate element of the switching device in such a manner as to bring it into conduction and thus allow the audio signals to pass.

An alternative arrangement, and a popular one, is to simply bias the first audio valve into its cut-off condition, then use the bucking voltage to restore the bias to normal.

Because the precise point at which the mute should open is governed by a number of factors, this is finally determined by a variable control, such as a pot, mounted either on the main chassis or the control panel. When it is on the main chassis a switch is provided on the control panel, giving a simple "mute on" or "mute off" selection.

As can be imagined, the circuitry for all this is rather critical. A number of quite stable voltages are required if the system is to retain its original calibration and there is usually a fairly complex voltage divider system, possibly operating from a regulated power supply. So there were plenty of things that could go wrong.

The symptoms, in this case, were that prolonged operation made the mute progressively more difficult to open. Whereas, under normal conditions, opening the mute with the control pot required only a small movement, and resulted in a healthy roar from the speaker, in the "hot" condition it was necessary to rotate the pot as far as it would go, and even then the result was only a faint crackle.

My friend's first reaction was to suspect the valve used in this part of the set, a 6SN7GT twin triode. These valves have always been rather prone to run into grid current, particularly where, as in this case, the grid circuits contain resistance values of several megohms. Add to this the possibility that the valve, being very old, could be gassy, and the elevated temperature which was obviously triggering the fault, and the stage was all set for exactly the kind of symptoms which he had observed.

Unfortunately, sound as the reasoning was, it didn't stand up to a practical test. A new 6SN7GT, which he happened to have on hand, made no difference to the set's behaviour. So that was that.

At this point my friend's reaction was to give the problem away for the time being. For one thing that particular part of the chassis was not easy to work on. For another, there were practical problems in moving the set from its wall-mounted position to the work bench and keep it operational at the same time. Something to do with lengths of interconnecting cables, as I understood it.

As a result, he put off doing anything about it for a few weeks. Until, in fact, he had occasion to telephone me on another matter, and this problem came up in the course of conversation. My first reaction was that it was a classic case calling for the use of a freezer aerosol – being something of a champion of these devices. My friend agreed, but explained that he did not possess one. And, although he didn't say it, I assumed that he was hesitant about spending the money for something which he might require only occasionally.

"Well," I replied, "There is one other trick you can try. You can try heating various sections of the set, in an effort to create the fault, rather than cool them in an effort to cure it".

Then I went on to suggest that an ordinary domestic hair drier provided a very simple means of applying heat to a small localised area of a set. Granted, it is not as selective as an aerosol in regard to individual components, but it can often pinpoint the fault within a few square inches. Given that much information, it is a lot easier to find the culprit by individual testing than if the whole of the set is involved.

He thanked me for the suggestion and intimated that a hair dryer was available. All he had to do was smuggle it out of the house. First, however, he had to get the set operating on the bench. Even as we talked, he decided he would tackle this part of the problem the following weekend.

As it transpired, this problem was solved more easily than he expected. A certain amount of improvisation, and the loan of one interconnecting cable by a fellow amateur, enabled him to have the set upturned on the bench, and working, by early Saturday morning.

Once satisfied that the set was working he switched off to ensure that it would remain in a cool condition. Then he studied the circuit and traced out as many of the relevant components as he could. Many of these were scattered around the chassis, but about half of them were mounted on a terminal board supported on one side of the chassis. Because it was most convenient, he decided to make this his first target.

Armed with the hair drier he switched the set on, opened the mute to its fullest extent, and turned the volume right up. The result was a healthy roar, almost intolerably loud, from the speaker. Then he switched on the hair drier and aimed the stream of hot air at the panel.

As he put it – "Things happened so fast, I just couldn't believe it. The set went dead as if it had been switched off. I really believed I had triggered another, more drastic, intermittent fault".

He switched the drier off and listened to the speaker more carefully. There was still a faint crackle there and, even as he listened, it seemed to be getting stronger. Thus encouraged he switched the drier on again, but without the heating element, and directed a stream of cold air on to the panel. Again things happened faster than he expected. Not quite as rapidly as before but, within about 30 seconds the set was back to normal.

Just to make sure, he went through the cycle twice more, with identical results. Satisfied that he had located the general area he then tried directing the hot air so that it favoured one half of the panel more than the other. By comparing the response from each half he hoped to narrow the search still further. Unfortunately, results were inconclusive.

Seeking another solution my friend suddenly spied the soldering iron on the bench. Of course! If the iron could be used to heat each of the components in turn, and the faulty one was as sensitive as previous tests had suggested, it should be a simple matter to pick it out.

There were three resistors and four capacitors on the panel, three of the capacitors being mica type and one a paper type. The soldering iron was a Scope type and it was quite easy to locate the business end of the barrel on or close to the component, press the ring, and apply heat. He tried the resistors first, without result, then the mica capacitors, also without result. This left the paper capacitor.

As my friend explained it, "I left this until last because I hoped I wouldn't have to test it. It was one of those wax impregnated things and I didn't feel too confident about getting the iron close enough to do any good, without actually touching it and probably damaging it unnecessarily. But after I had tested the other components I was beginning to feel pretty sure that this was the culprit. Or at least I was thinking, 'It had better be!' "

Nevertheless, I gathered that he was not exactly prepared for the way it reacted. This time he heated the iron first, almost to red heat, then quickly placed it alongside the capacitor, approximately a quarter of an inch away. Once again the set went dead almost as though it had been switched off.

My friend repeated the experiment a couple of times, just to make sure, then pulled the capacitor out for a closer look. It was a fairly standard old-fashioned wax impregnated paper type, carrying a well-known brand. It was rated at .05uF, at 400V. (The ".05" figure gives some idea of its age.)

He quickly replaced it with a nice modern plastic type, then tested the whole thing again with a prolonged blast of hot air from the drier. When several minutes of this failed to produce any adverse effects, he considered the point proved.

Later, when he told me this story, we were able to check the capacitor on the high ohms range of the VTVM. Initially, it showed a leakage of several hundred megohms, but dropped to only a few megohms when a soldering iron was held underneath it.

At the same time he produced the circuit and we were able to make a rough assesment of its operation and the reason the faulty capacitor caused it to fail. While a detailed study of the circuit would have involved more time and effort than either of us could afford, we quickly established that the offending capacitor was part of a decoupling network in the grid bias supply line to the audio amplifier.

Since the circuit required that both the grid and cathode of this valve be "jacked up" by quite a substantial voltage above chassis – with a suitable bias difference between them – any leakage from the grid circuit to chassis, via the faulty capacitor, would seriously upset the bias. More precisely, it would make the grid much more negative than it should have been, possibly to the point of cut-off.

At the time my friend related all this to me, we both regarded it as the end of the story. I made the necessary notes to enable me to write it up in detail when time permitted, and at a time when it appeared that a story of this length would be most appropriate. In fact, these two conditions never seemed to coincide over the next few months and the notes simply sat in my file while I processed more appropriate stories.

Which was a good thing, as it turned out, because the story had a most interesting sequel. Towards the end of the summer, my friend became aware that all was not well in the receiver. The situation and the symptoms were much the same: a warm day with the set operating continuously in the workshop; the charger running on the shelf beneath; and even the same symptoms involving the mute control and the audio gain.

My friend's first reaction was, "Oh not again!" and to wonder what had failed this time. It was unlikely to be the replacement capacitor, yet it was obviously something which was producing exactly the same effect. But would it be easy to find?

Fortunately, he was better off in two respects this time. He had organised matters so that it was now a simple matter to operate the set on the bench; and he had purchased an aerosol freezer.

So, with the set upended on the bench, and sounding very sick, he squirted freezer on each component on the resistor panel, in turn. The result was negative.

Next, he began identifying the more scattered components associated with the same stage. The first ones he identified were three resistors, connected in series, which ran across the chassis from one of the terminals on the panel. More or less "on spec", he squirted one of them. There was a second or so delay, and the set sprang into life.

My friend should have been jubilant at this, but he wasn't. As he put it, "I didn't really know why, but I wasn't convinced that I had found the fault. Perhaps it was the small time lag but, whatever it was, I didn't feel inclined to jump to a conclusion".

In an effort to clarify his thoughts, he then squirted the next resistor along the line, which produced exactly the same result. (It was also significant that the set reverted to its faulty condition after only a few minutes.) Finally he squirted the third resistor and produced a similar, but much slower, result.

Still not prepared to believe what was superficially obvious, he went through the exercise again, then a third time, with the same results each time. However, as he finished the third exercise he suddenly realised that underneath the resistor string, and hidden partly by it and partly by a bunch of cables, was a capacitor; a paper capacitor rather similar to the previous faulty one.

Pushing the thin extension tube on the aerosol nozzle down past the resistors until it was against the capacitor, he gave it a short squirt; considerably shorter than he had previously used on the resistors. There was no time lag this time. The set came good as if a switch had been thrown, and he knew he had found the real culprit.

He also realised why he had been deceived before. The overspray from the resistors had fallen on the capacitor and had been sufficient to cure its leakage – after a brief time lag.

When he finally fished the capacitor out and took a closer look at it he realised that it was a twin to the previous one; same make, same value, same voltage rating and – probably – the same batch. Needless to say, a new one cured the trouble.

Once again we held a post mortem. Once again the VTVM showed a leakage which started at several hundred megohms and dropped rapidly as it was heated. And once again an analysis of the circuit revealed that the leakage would have upset the bais on the audio valve grid. In fact, although not immediately obvious from the original circuit, it was only one resistor removed, along the decoupling network, from the first faulty capacitor.

I feel that there are a couple of interesting lessons to be learned from these stories. One is that, when chasing a heat sensitive fault, it is very desirable to be able to apply heat in a localised form, as well as by means of an "oven" or by wrapping the appliance in a blanket. The latter arrangment may be useful for establishing, initially, that the fault is heat sensitive, but does little to pinpoint the faulty component, or even the area, involved. The hair drier will not only heat a small area but, with the heater switched off, can also rapidly cool the same area. This is most valuable when one wants to double check the initial observation.

The other lesson concerns the freezer aerosol. Maybe those of us who have used it for some time may not realise it, but there appears to be a certain amount of skill required to use it correctly. Or, at any rate, to interpret the results correctly. Among other things one must develop a sense of "response" by the components under test; particularly how rapidly they react to the spray.

Which raises another point. If you are used to a particular brand of freezer, and have learned how typical faulty components react to it, you may be confused if you change to another brand which freezes significantly faster or slower. Personally, I prefer one which freezes as fast as possible; it seems to make interpretation just that much easier.

Relevant portion of the audio/muting stage. The left hand triode is a straight audio amplifier but has both cathode and grid well above chassis. The two .05uF capacitors were the offending components, their leakage increasing the negative bias on the grid.