Foolproof loudspeaker protection

Your trusty docile amplifier is a dangerous menace to your speakers. It could lash out at any time, to damage both itself and your loudspeakers and land you with a repair bill running into thousands of dollars. Does this sound like exaggeration? And if it is not, is there a way to avoid the risk? Read on.

by LEO SIMPSON

Your ever-faithful stereo amplifier really does present a risk to your loudspeakers and to the rest of your home. Hard to believe? Consider the following case history which demonstrates just how big a risk there is.

It happened fairly recently. A reader phoned to ask how a loudspeaker could catch fire. He explained that it had happened to one of his well-loved speakers which were part of a system of European origin and impeccable reputation. The speaker had caught fire which then ignited the curtains and then the pelmet. The timber window frames were well on the way too by the time the fire was luckily discovered. Well, you might think it was lucky until your hear the rest of the story.

The luckless reader also wanted to know what to do about some new loudspeakers and then just casually mentioned that his amplifier was also in for repair. While he didn't know it, he had just fingered the culprit in this unhappy turn of events.

Loudspeakers by themselves do not catch fire. They can't. But amplifiers can and do fail. When they fail, they often take the loudspeakers with them. And occasionally, if there is no one present when the failure occurs, the speakers catch fire.

An internal fault in the amplifier, which may be caused by the failure of a very minor part such as a 40 cent transistor, is often to blame. It effectively turns your low-distortion, high power amplifier into a very large battery. This very large battery is then able to deliver a great deal of power to the loudspeaker, causing the voice coil to become red-hot. If you are lucky, the voice coil will burn out before any more damage can be done. If you are not, the process can go a lot further.

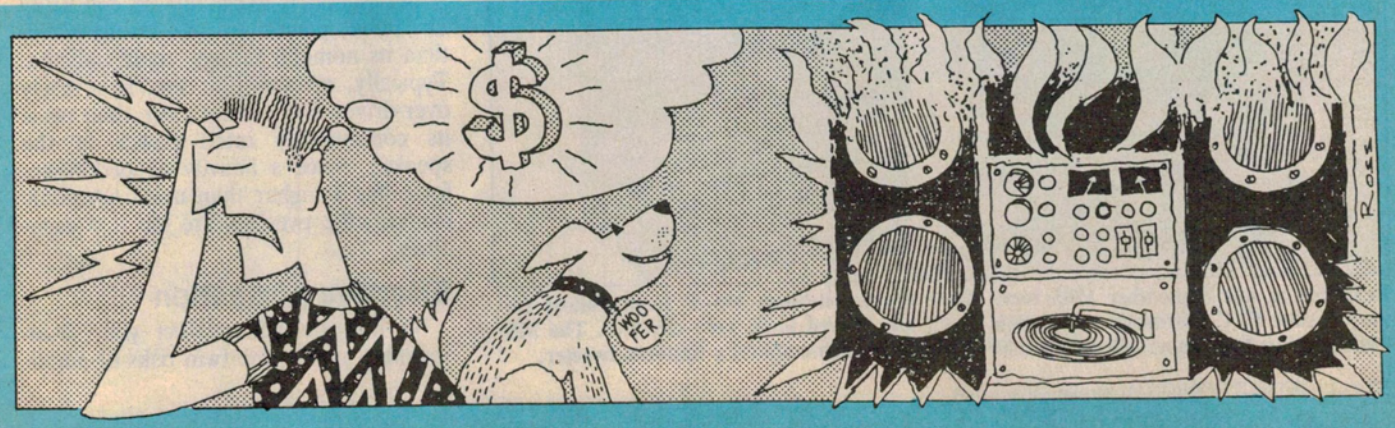
The red-hot voice coil sets the cone on fire. This is usually the woofer which has a large cone of paper or plastic. It can then set the grille cloth alight and the filling material behind the cone also starts to smoulder. This produces a lot of smoke.

Smoke damage

Our luckless reader said that the amount of smoke produced was incredible, filling the whole house. It was so bad that the whole inside of the house eventually had to be repainted. As you might expect, the burnt curtains weren't cheap to replace either, and cost the best part of a thousand dollars.

That all sounds bad enough but the list gets longer. All the carpets in the house had to be taken up, steam-cleaned and then relaid. And all the clothing had to be sent out to specialist dry cleaners to remove the dirt and smell of the fire.

Just imagine the disaster it would have been without contents insurance.



Loudspeaker protection

Now before you go and rip out your hifi system, let me reassure you. Such catastrophes don't happen very often. In fact, they happen very rarely. This was by far the worst case that I had ever heard of. And usually, when an amplifier does fail, someone is on hand to turn it off immediately, before things get out of hand.

The problem of failing amplifiers blowing loudspeakers really only arose about 10 or 12 years ago, when direct-coupled amplifiers started to become commonplace. Before that, most amplifiers were capacitively coupled to the loudspeakers, typically via a 1000μF electrolytic capacitor. This effectively stopped any DC voltage from getting to the loudspeaker(s) in the event of an amplifier fault.

Why not fuses?

With the advent of direct-coupled amplifiers, many designers recognised the inherent risks to the speakers and incorporated relay protection circuits. The problem with fuses is that, whether they are placed in series with the amplifier supply lines or the speaker outputs, they must have sufficient rating to allow the amplifier to deliver full power. If this criterion is met, as it must be if fuses are not to blow prematurely, there is little protection for the speakers in the event of an amplifier fault.

Consider the case of the current Playmaster Sixty-Sixty which is typical as far as this argument is concerned. It delivers up to 105 watts into an 8Ω loudspeaker on musical transients and over 150 watts into a 4Ω loudspeaker under the same conditions.

To do that reliably, each power amplifier is fitted with 5A fuses in the positive and negative supply lines. Now what happens if the amplifier develops a fault whereby the output is latched up to the positive or negative supply rail! This means that the full 50V rail is applied to the loudspeaker although it is likely to droop somewhat, to say 40 volts or so. With the typical voice coil DC resistance of around 6Ω, the current flowing will be approaching seven amps and so the fuses are likely to hold forever. But with this current flowing, the voice coil power dissipation will be up around 280 watts!

No wonder the voice coil gets red-hot.

This is why relay protection circuits have become standard in most but by no means all high fidelity amplifiers. And there are lots of older direct-coupled amplifiers which don't have this protection.

The relay protection circuit which has been a feature of Playmaster amplifiers is fairly typical of commercial practice but has one refinement. The relay is arranged to not merely disconnect the amplifier but also to short the loudspeakers out. The significance of this is that when the heavy fault current flows through the loudspeaker voice coil, an arc will be drawn across the opening contacts of the relay and the arc is likely to maintain itself rather than voluntarily extinguish.

By arranging the relay to short the loudspeaker, the arc is effectively taken to the 0V line of the amplifier. This then blows the abovementioned fuses (and possibly also the output transistors) but then no further damage occurs.

The foregoing demonstrates just how intractable a large hifi amplifier can be when it develops a fault and why relay protection is so worthwhile. The bill for repairs to loudspeakers is usually much more than that for the amplifier.

The compact disc risk

But even if it has relay protection your amplifier can still destroy your loudspeakers. We had a recent call from a reader who had just completed the Playmaster Series 200. He was delighted with the amplifier but reported that he had just blown his tweeters with the first playing of the 1812 Overture on Telarc compact disc.

A number of loudspeaker distributors we have spoken to have stated that this particular compact disc ought to be banned — it is so dangerous. People whack the disc on the player, wind up the volume and sit back to enjoy the lashings of sound. Then the cannons let go and there really are wisps of smoke coming from the speakers. Or the tweeters are open-circuit.

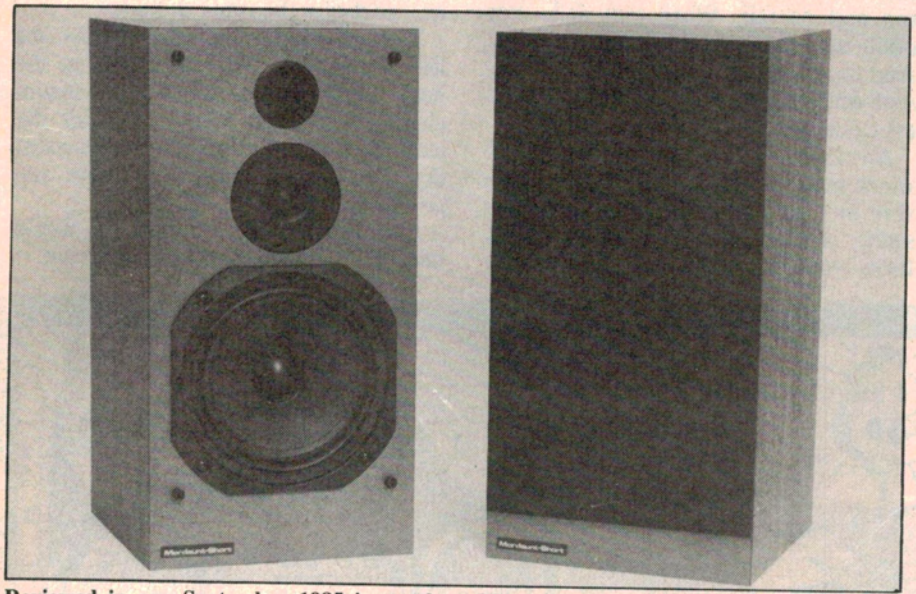
Another scenario in which compact discs can blow speakers is where the user merely advances the volume control too far before the music starts. You can be lulled into doing this by the extreme silence from the compact disc player.

This is why the new Playmaster Sixty-Sixty has an index mark on the volume control to show where clipping occurs with the maximum CD output signal of 2 volts RMS. We predict that this will become a common feature on amplifiers in the future so that there will be less likelihood of people subjecting their loudspeakers to severe over-drive.

The problem with an over-driven amplifier is that it is capable of delivering far more power to the loudspeakers than its nominal ratings would indicate. Typically, an amplifier that is severely over-driven will deliver more than twice its continuously rated power to the speaker. Since a heavily clipped waveform has a higher than usual harmonic content, the tweeters are the first casualties.

Effective protection

So how do you protect your loudspeakers against the twin risks of ampli-



Reviewed in our September 1985 issue, these Mordaunt-Short MS-30 loudspeakers employ Positec PTC thermistor protection which has proved to be very effective. The MS-30s have now been superseded by the MS-35 model which employs a titanium tweeter.

fier faults and CD over-drive? Until now, there has been no truly effective answer. A number of loudspeaker systems are available with inbuilt protection systems but these have usually been only on the more expensive systems. Usually, the protection has been based on relays. For the reasons outlined above, these are more or less effective against amplifier DC faults but less effective against straight over-drive.

One British loudspeaker manufacturer has come up with the answer. Mordaunt-Short has Positec. Last year, in the September issue of *Electronics Australia* we reviewed the Mordaunt-Short MS-10 and MS-30 loudspeakers. Apart from their good sound qualities we were particularly impressed with their Positec protection system.

We gave the Mordaunt-Shorts a torture test which included connecting them directly across a 30V high-current supply. No problems at all. The current immediately rose to about six amps which almost as quickly was knocked back to less than an amp. Neat.

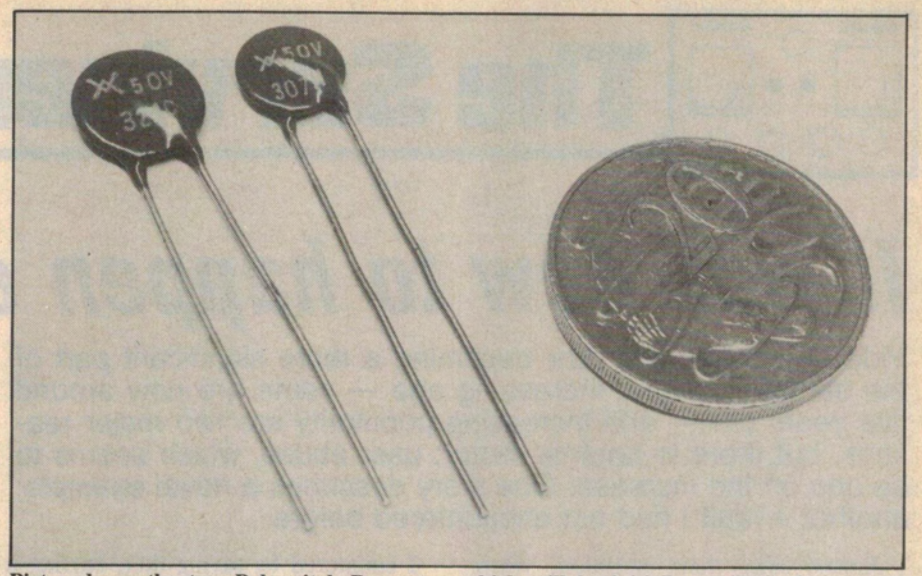
At the time we determined that the Positec system was based on positive temperature coefficient (PTC) thermistors. These are connected in series with the woofer and tweeter and normally present a very low value of series resistance, ie, less than 1Ω. However, once their designated current rating is exceeded, they suddenly go very high in resistance, so that the damaging current is reduced to a negligible value which can't cause any damage.

Removing the current allows the thermistor to resume its very low resistance value and normal speaker performance is restored.

As such, these PTC thermistors are far more effective than fuse or relay protection and have the virtue of extreme simplicity. That is the story as we perceived it last year and that is where it would have remained except that these thermistors are now available in Australia.

The devices in question are made by Raychem Corporation of the USA and are referred to as Polyswitch Protectors. Instead of being based on barium-titanate, as many thermistors are, these new devices are based on conductive polymers. They look like ceramic disc capacitors (coated in blue) but act like resettable solid-state circuit breakers.

The new PTC thermistors are composed of crystalline polyolefin or fluoropolymer matrices in which carbon black particles are dispersed. At normal temperatures, the carbon black particles form chains in the polymer, giving it a very low resistivity. Typical resistivity is one ohm-cm at 20° Celsius and is determined by the type of conductive particles as well as by the volume ratio of conductive particles to polymer.



Pictured are the two Polyswitch Protectors which will be initially available from parts stockists. They are the RDE 050 and RDE 115A.

Small variations in the particle-to-polymer volume ratio produce very large changes in resistivity. And the volume of the crystalline polymer changes abrubtly at temperatures near the polmer melting pot. The melting pot temperature is around 120° Celsius.

So what happens when the operating current of the Polyswitch is exceeded is that the interior of the device partially melts, which suddenly increases the volume and disrupts the chains of conductive particles. This increases the resistance drastically and reduces the current.

The device stays in this state while the current is maintained because its temperature is elevated. Once the current is removed, the conductive particle chains re-establish themselves almost immediately, so that the low resistance value is restored.

Other applications

As such, Polyswitch Protectors have much wider applications than for loudspeaker protection. They are available in a large range of current and voltage ratings to protect all sorts of devices which need resettable overload protection.

For the purpose of loudspeaker protection though, they are ideal. Their normal resistance is so low that their effect on speaker performance is negligible. And, with correct device selection, they give virtually foolproof loudspeaker protection.

An indication of this is the service record of Mordaunt-Short loudspeakers in Australia. With many hundreds of Positec protected speakers sold, Concept Audio, the distributors have not had to replace a single tweeter or woofer. That is a remarkable record.

We have been able to arrange for two of these Polyswitch devices to be made available immediately in Australia. They are the RDE 050A and RDE 115A. These are 50V devices with ratings of 0.5 and 1.15 amps respectively. Their respective nominal resistances are around 0.4Ω and 0.12Ω.

The RDE 050A is suitable for protecttion of tweeters in systems with music power ratings up to 100 watts while the RDE 115A will protect midrange drivers and woofers up to around the same rating.

Installation is simply a matter of soldering the respective thermistors in series with the woofer and tweeter. For the cost of a few dollars per device, it's simple and elegant.

As far as hobbyists are concerned, these Polyswitch Protectors should shortly be available from parts stockists such as Jaycar Electronics and Dick Smith Electronics. Dealer enquiries should be directed to S.F.I. Australia, PO Box 50, Dyers Crossing 2429. Phone (065) 50-2254.

Acknowledgements

We thank Trevor Wilson of North Shore Hifi for his assistance in the sourcing of material for this article. Mordaunt-Short loudspeakers are distributed in Australia by Concept Audio Pty Ltd, 98 Old Pittwater Road, Brookvale, NSW 2100. Phone (02) 938-3700.