Fig. 1: Humbucker with Stratocaster pickup size: Fender "Noiseless"

NO MORE INTERFERENCE

Cracking noises, hum, feedback... all are enemies of good tone. This article explains their causes and lists the best tricks to eliminate them

BY **HELMUTH LEMME**

We all are entitled to uphold some strange opinions, ones that go against what most people believe. My personal strange opinion is this: **an electric guitar or bass has to be absolutely quiet when it is not played.** But in reality, most of them produce unwanted noise all the time. This is annoying not only on stage; it is even more so in the studio where it can disturb recording.

But it does not have to be so. First we have to understand what kind of disturbances can happen in practice. There are several

different ones. Each of them requires specific approaches in order to get eliminated. Let's review them.

1. Magnetic Fields

The most common interference sources are alternating magnetic fields. They are produced by transformers present in amplifiers and other electronic devices, as well by the chokes of fluorescent lamps. Their fundamental frequency is 50 Hz in Europe, 60 Hz in America, accompanied by a lot of harmonics. If they pass through a single-coil pickup, they induce an AC voltage in the coil which sounds as the hum we hear though the amp. The strength of the hum depends on the distance from the amp and on the direction of the pickup axis with respect to the field lines. In a certain direction it is at maximum, perpendicular to this direction it is zero.

The simplest way of avoiding is to stay well away from the source of those magnetic fields. On stage this is usually possible, in the studio not always. Humbuckers, of course, succesfully tackle this problem. They contain two coils which work in phase for the tone signal but out of phase for the hum, so the hum is eliminated. There are a lot of humbuckers that have the same dimensions of standard single coils. The best ones practically have the same sound. For Stratocaster, Telecaster, or Jazz Bass there are many "noiseless" ones on the market (**Fig. 1,** on opposing page; note that it looks like a single coil but it has indeed two coils). Other popular single coils models also have hum-free alternatives now, such as the "P90" and "P94" models by Schaller (**Fig. 2**), brand new on the market.

There are some other sources of alternating magnetic fields which produce different frequencies: electric railways and tramways, a not unlikely situation here in Europe. The German railway uses AC with a frequency of 16.67 Hz. Against common belief, this deep frequency can indeed be heard by the human ear; it has a lot of overtones in the audible range which can be heard as a clattering noise—very annoying. Trams in Germany use 600 Volts DC (direct current) which is made of a rectified three-phases AC (alternate current), so it is overlayed by a 300 Hz AC component. I know it for a fact, since my home is very near to a high speed train line. No matter whether the train passes directly by or far away, the current always flows on the overhead cable. The *Freies Musikzentrum* in Munich, the music school where I hold my seminars on guitar electronics, is situated in a street with a tram, too. The 300 Hz tone with a lot of overtones at 600 Hz and higher can be heard through all single coil pickups. In both cases it is impossible to keep a longer distance. Only humbuckers help in such cases.

***Fig. 2*: No more hum: Schaller "S94"**

2. Electric Fields

This is physically a different phenomenon but is is annoying as well. Here the source are the electric cables present in all buildings, as well as fluorescent lamps (not the choke but the lamp itself). The field consists not only of the fundamental frequency of 50 or 60 Hz but of many overtones and spikes, especially if a light dimmer is in use. The electric alternating field is coupled capacitively into all electric parts of the guitar or bass: pickups, pots, switches, and cables. In this case, the strength of the hum does not depend on the direction of the instrument. The best weapon we have against this kind of interference is using a good shielding. **Fig. 3** (on the right) shows a cheap, unshielded Stratocaster body—a certain source of noise troubles.

Fig. 3: you get what you pay for—a cheap strat copy, no shielding at all.

A common method for shielding the cavities of guitars and basses is to use black conductive paint. This is very cheap but not very effective; the paint contains carbon powder which has a relatively high electric resistance, so it is not that conductive after all—at least not compared with the least resistant copper-containing paints. In any case, both have to be applied on in several layers, since only one layer will not suffice. A layer must be totally dry before the next one is applied. Some exclusive guitar manufacturers use silver-containing paint which shields very well: **Fig. 4** (on the right) shows the inside of an Alembic bass silver shielded.

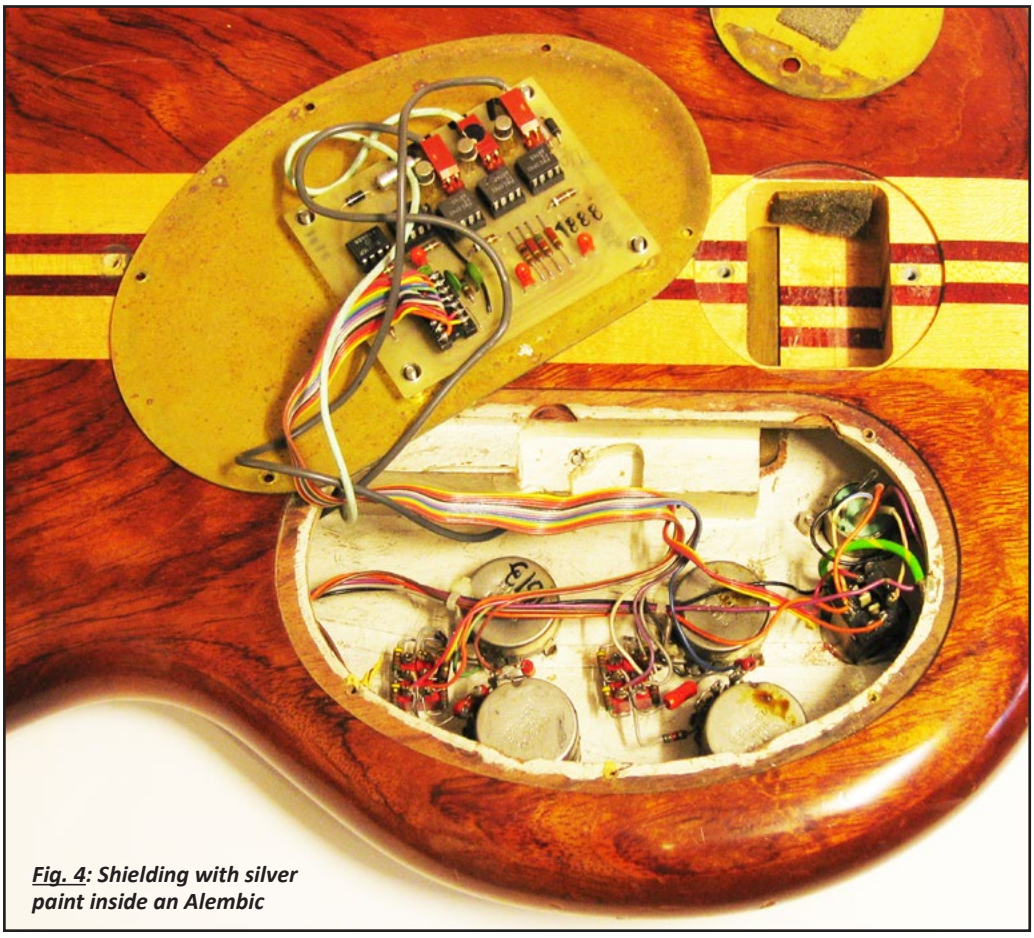
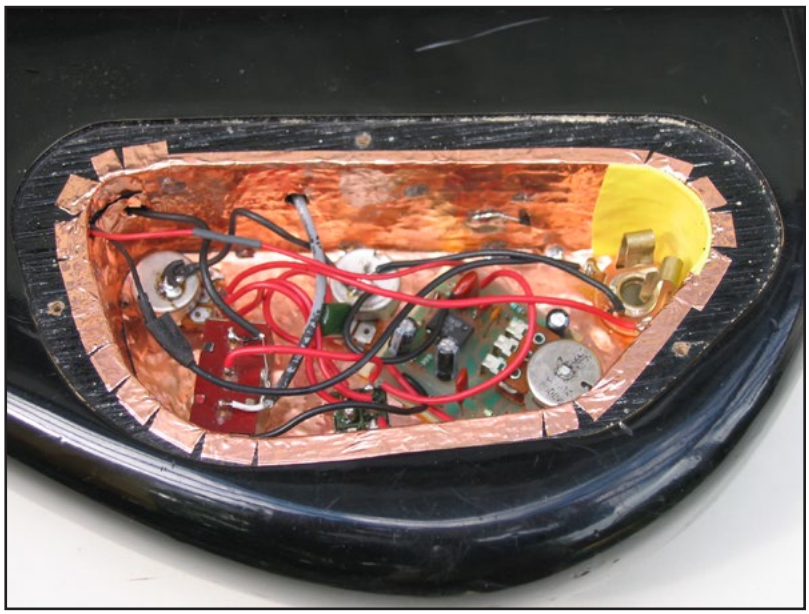


Fig. 4: Shielding with silver paint inside an Alembic

***Fig. 5*: Shielding with copper foil, later installed in an Aria bass**
(all photos in this article by H. Lemme).



But metal foil is superior by far. Copper tape (**Fig. 5,** on the left) is the best option; it can be soldered easily, but it is relatively expensive. Aluminum has the same good shielding effect and is cheap, but it cannot be soldered. It can only be contacted by the pots and switches in order to put the shielding to electrical ground level. It is fundamental that all kinds of shieldings have good contact to the ground potential of the guitar wiring: the cases of the pots and the outer contact of the jack, otherwise they are useless.

A common problem, easy to avoid: a short circuit between the "hot" jack contact and the shielding, in the neighbourhood of the output jack. Some isolating tape will help.

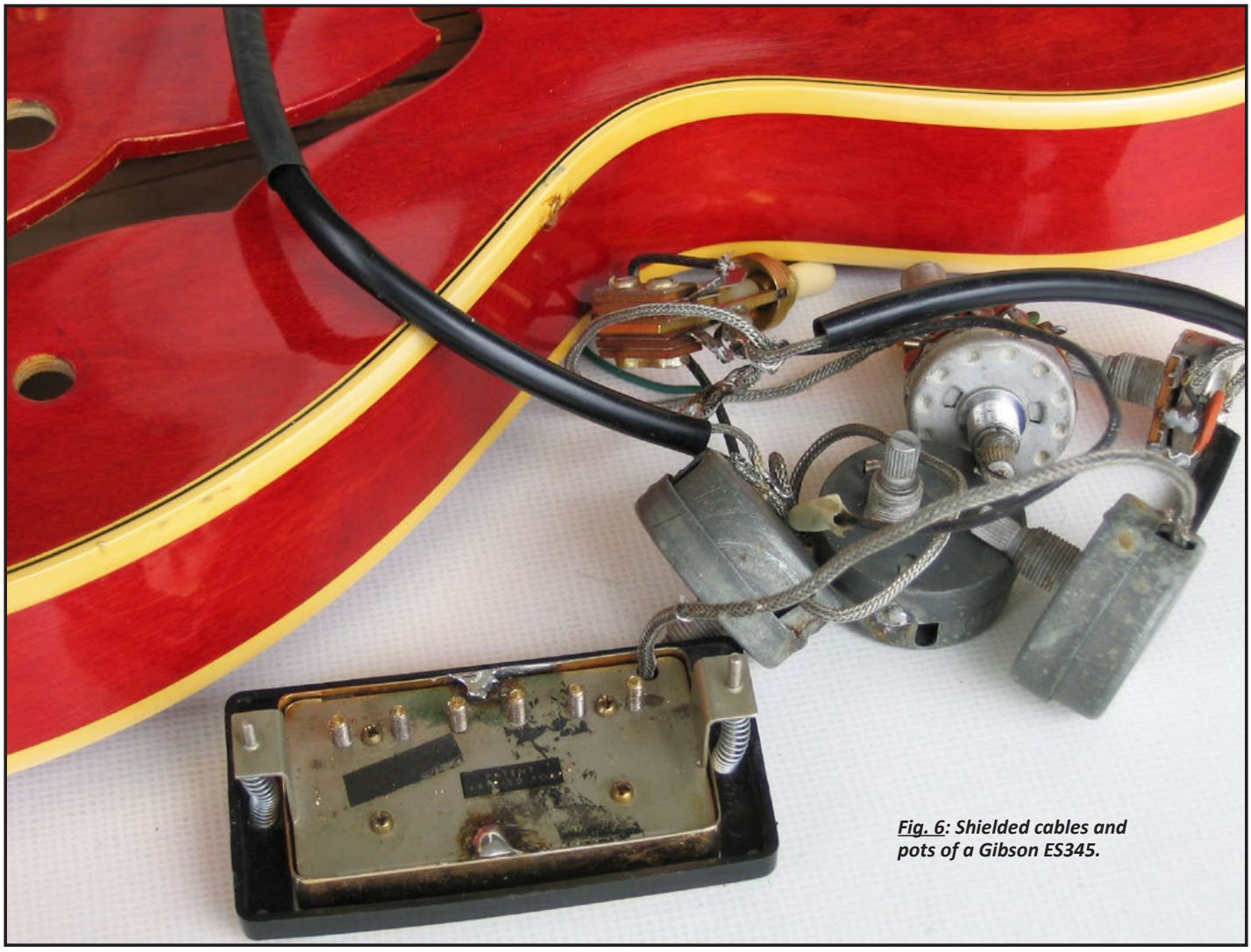


***Fig. 6*: Shielded cables and pots of a Gibson ES345.**

Fig. 7: Metal cover over the pots in a Les Paul.

In the case of arch-top and semiacoustic guitars it is not possible to shield the inside. Here all wires have to be shielded, instead (see in **Fig. 6**, below). Here even the pots have shielding cases around. This is not absolutely necessary, though, as the pot contacts are not very sensitive to interference; grounding the pot itself will suffice. Furthermore, it is an extremely tricky job to install these shielded pots into the guitar again.

Gibson Les Pauls have an inner metal cover inside the cavity (**Fig. 7,** above) and a metal plate in which the pots are mounted. This works well, so that a shielding of the walls of the cavity is not necessary.

Pickup covers:

Fig. 8 (on the right) shows an opened Fender Jazzmaster. The bottom of the cavity has been covered with brass sheets, which are connected to the circuit's ground by wires. The pickguard is shielded on the inner side by another metallic sheet (**Fig. 9,** opposing page, top). But all these kinds of shieldings are rather useless as long as the pickups are still open. They are much more sensitive to electric AC fields than the rest of the controls. Humbuckers will not help here. The only resource that works is a metal shielding around the coils, connected to ground—a pickup cover. The Gibson humbucker was the first pickup with complete shielding.

Granted, the metal cover has some disadvantages, too. First, it attenuates the treble frequencies. It dampens the resonance of the pickup because of eddy currents (which are spureous electric currents induced within

Fig. 8: Fender Jazzmaster with its cavities covered with brass sheets.

Fig. 9: Fender Jazzmaster pickguard with a metal sheet underneath - rather useless as the pickups of this model come totally unshielded.

conductors by any changing magnetic fields in the vicinity) acting like a short-circuit winding on a transformer. Many musicians say that they prefer the sound without cover, so most replecement humbuckers do not have one.

The amount of damping caused by the cover depends on its material and on its thickness. Brass (an alloy of copper and zinc) dampens more than the so called German silver (alloy of copper, zinc, and nickel). And of course, a thick cover dampens more than a thin one. In **Fig. 10** (below) shows a Gretsch pickup made in China. It has a brass cover of 1 mm thickness (which is a lot!) and it dampens the treble so extremely that the sound is totally dull. The best solution is implemented in another Gretsch pickup, the Filtertron humbucker. It has a H-shaped opening in the top (**Fig. 11,** below), so no eddy currents occur, and the shielding is good nevertheless. Here it does not matter wheather it is of brass or German silver.

Fig. 10: Chinese Gretsch pickup of inferior quality with 1 mm brass cover—it sounds dull.

Fig. 11. Gretsch "Filtertron" humbucker with good shielding—no treble loss by eddy currents.

(There is yet another disadvantage to pickup covers: microphony, discussed in section 3, below).

String grounding is the subject of lenghty discussions. Should the strings of a guitar or bass be grounded or not? In most instruments that is precisely the case. People say that this is necessary to prevent hum. The truth is: When the player touches the strings his whole body is grounded, acting as a shield, at least on the rear side of the instrument. So in many cases the hum vanishes or is attenuated. But this is clearly not a good method. If an instrument is re-

ally perfectly shielded, like the ES345 of **Fig. 6** or the Les Paul of **Fig. 7**, then it makes no difference whether the body of the player is grounded or not, and in this case string grounding is not necessary. Additionally, a good shielding has also the vital effect of protecting the player against electrical shocks: if the strings are not grounded, they cannot act as a path to ground for an electrical discharge coming (for example) from a faulty microphone touching the lips of the player, and from there through the rest of his/her body. If the strings are ***not*** grounded (which is what we recommend), that current will not be able to circulate—provided that there are no other paths to ground.

Guitar cables can be sensitive to hum interference. This is the case if the shielding is not tight. Cheap cables often have a wound shielding of a few thin wires laid side by side, only. These cables are very flexible but when they are bent the shielding often moves and becomes loose. High quality cables have a tighter, braided shiedling; they are a bit stiffer but the shielding will conserve its shape. If the guitar or bass has an active circuit the cable is less critical. In this case the output impedance is very low, and interference coming from outside will not do much harm, even if rather inferior cables are used.

3. Microphony

Pickups are not only sensitive to the string vibrations but also to airborne sound vibrations. When the amp is set to a high volume level, acoustic *feedback* occurs—that horrible squeak that sometimes won't end even when the strings are stopped. In most cases it is caused by the top of the pickup cover that vibrates and works like the membrane of a microphone. How can we prevent this? By using waxed pickups, or by waxing them ourselves,

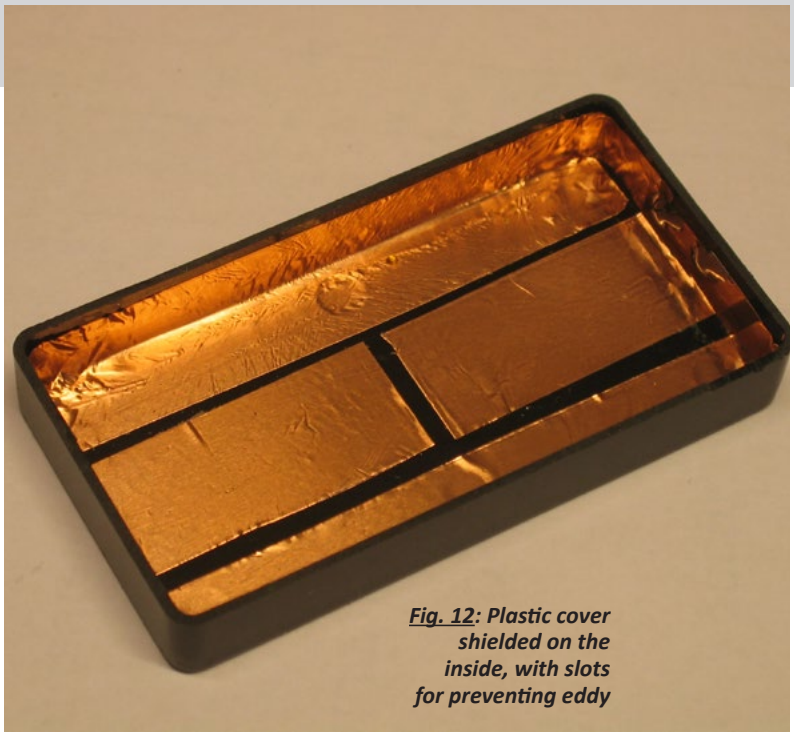


Fig. 12: Plastic cover shielded on the inside, with slots for preventing eddy

To wax a pickup, follow these steps. In the case of a Gibson pickup, for example, remove the cover using a strong soldering iron (in the order of 100 Watts). Close the holes of the cover from the outside with adhesive tape. Drive the pole screws inside so that their heads are below the top of the bobbin. Turn the cover upside down and put the pickup next to it. Place both under an infrared lamp or a strong incandescent lamp to heat them up. Put a piece of wax into the cover (ca. 2 cm^3) and wait until it is molten. Then press the pickup into the cover; be careful of placing the bobbins as they were originally, that is, with the screws to the side of the cover with the holes. Hold the pressure until the wax cools down (you can put a weight on top). Then strip the tape off, remove the wax from the screws (with some turpentine, for example) and unscrew them again so they protrude through the holes as they were before. Finally, solder the cover on the baseplate.

A loose coil can be another generator of microphony. Waxing won't work here: the wax will not penetrate totally inside the winding. For that, the waxing must be done in a vacuum, a procedure that only well-

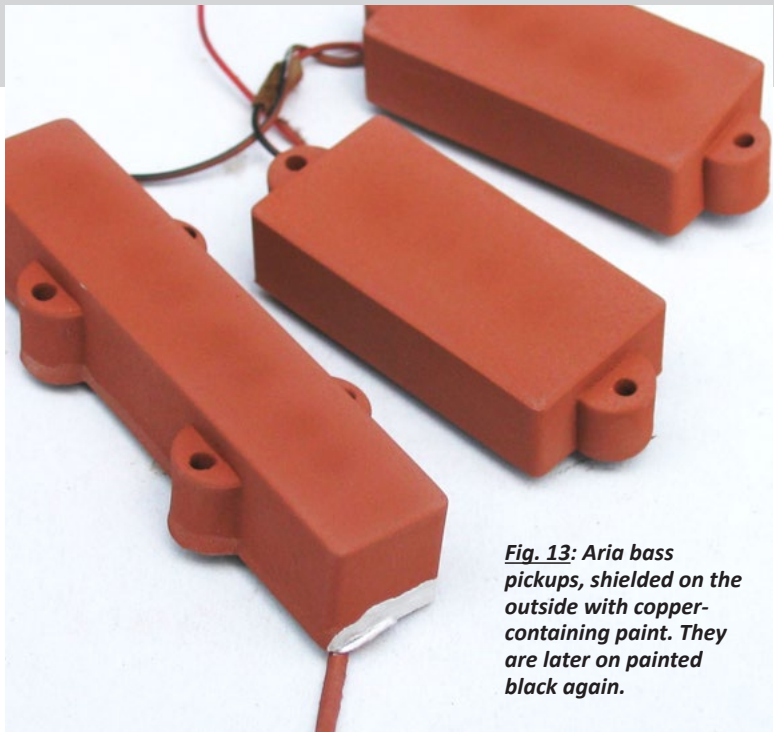


Fig. 13: Aria bass pickups, shielded on the outside with copper-containing paint. They are later on painted black again.

equipped manufacturers can afford. A good alternative is to apply thin superglue (cyan acrylate) which penetrates well within the wires of the coils.

There are other tricks to create a well-shielded, non-microphonic pickup. First: remove the metal cover and use a plastic cover shielded in the inside with adhesive copper foil. To prevent eddy currents, the foil should have an H-shape, like the cover of a Gretsch humbucker (**Fig. 12,** opposing page).

Some plastic pickup covers cannot be removed, though (e.g. the bass pickups shown in **Fig. 13** of an old Aria bass) because the covers were tightly glued on. Here the solution was to spray them on the outside with copper containing paint. After complete curing of the paint (three layers of it) a thin wire was fixed with silver glue. To end, the pickups were sprayed black. Now they look as they did before.

Electrostatic charge causes cracking noise when the pickguard is touched. It can be eliminated by shielding it with metal foil on the back side, and grounding it.

Cables can be microphonic, too. Inferior quality ones cause a rumbling noise when they are moved or stepped on. The underlying physical effect is called "triboelectricity", which can only be avoided with the use of active wiring in the instrument. If this is not wanted, the cable must be replaced by a good one.