SPOT PICKUP

From Experimental Musical Instruments

The Spot Pickup from Experimental Musical Instruments is an electromagnetic musical instrument pickup. Electromagnetic pickups are most commonly used in electric guitars, but they can be used equally well in any instrument in which the vibrating element is made of steel or other ferrous metal. Thus, this pickup can be used for instruments using steel strings, as well as mbira- or kalimba-like instruments with iron or steel tines, xylophone-like instruments with steel bars or tubes, and many others types. It can also be used with non-steel instruments (for instance, wooden xylophone bars) if a steel plaque such as a washer is attached to the vibrating body where the pickup can sense it.

Guitar pickups are made in a bar shape suitable for the six strings of a guitar. Our Spot Pickup is designed for other sorts of applications, where a guitar pickup won't fill the bill. They're particularly suitable for instruments in which the sounding elements are too broad or too widely spaced for bar-shaped pickups to be practical. In such cases, you can place one Spot Pickup under each sounding element.

The Spot Pickups are provided with copper shielding to minimize unwanted noise. The hum level from a single Spot Pickup is considerably less than that of a typical guitar pickup. In installations with many spot pickups, the hum level may increase. To reduce the hum level further in multi-pickup installations, the Spot Pickups can be used in humbucking pairs. Each pickup is marked with a white or a black dot. By using an equal or near-equal number of each in your installation, you'll be getting the noise-reducing benefits of the humbucking design.

In signal strength, the Spot Pickup is comparable to an average guitar pickup.

The impedance of a Spot Pickup installation depends on how many pickups are connected in series in the installation. Typically it will fall in the nominal high-impedance range, meaning that you can plug the output from one or more Spot Pickups into a standard musical instrument input. This includes electric guitar amp inputs, as well as high impedance mixer or PA inputs, keyboard amps, powered speakers and acoustic guitar amps.

As for appearance – well, it's true that our Spot Pickups are not the loveliest of things to look at. Instead of putting the effort into making the Spot Pickup slick-looking, we've taken an approach that keeps it affordable, compact and sturdy.

Dimensions: 1 1/8" high x 5/8" wide x 7/8" long.

Resistance: 600 Ohms per pickup.

Impedance: Depends on the number of pickups joined in series, but typically in the nominal high impedance range, comparable to a standard guitar pickup.

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INSTALLATION INFORMATION
and Wiring Diagrams

What kinds of instruments can I use the Spot Pickup on?

You can use the spot pickup to capture the sound of any vibrating body made of ferrous metal – that is, steel or iron. That includes

instruments with steel strings

kalimbas, mbiras or sansas with steel tine

free bar instruments (i.e., xylophone-type instruments) using steel tubes or bars

tuning-fork instruments using steel forks

plus many more steel-based instruments.

In addition, you can use it on many non-steel instruments (for instance, wooden xylophones) by affixing a steel plaque such as a washer on the vibrating body where the pickup can sense it. See further notes on this near the end of this document.

Typically you'll use Spot Pickups in either of two types of applications:

Instruments with just one or two sounding element (e.g., a one-string zither or diddley bow)

Instruments having many sounding elements that are too broad or too widely spaced for a guitar-style bar pickup. In such cases you would use multiple Spot Pickups, with one for each of the sounding elements.

How many Spot Pickups can I use together at once?

You can use as many Spot Pickups on a single instrument as you want or need. Very large numbers of pickups, however, may call for a more complex installation. Read the next section for more on this, and the section after that for a set of simple guidelines on numbers and wiring approaches.

How do I decide how to wire the pickups?

There are three typical approaches to wiring multiple spot pickups: series, series/parallel, and buffered series. Which you choose depends on how many pickups you're using and what kind of sound you want. The accompanying wiring diagrams show graphically how each approach works. A discussion of these three approaches follows. (A fourth possible approach, parallel wiring, is not recommended.)

Series: A simple series connection is the easiest connection for multiple pickup installations, and it is recommended for most installations of up to about 12 pickups. It can be suitable for larger numbers as well, but as the number connected in series increases, two things happen: 1) The high frequency response diminishes, yielding a less bright, warmer tone. (Whether you consider this desirable or not depends on the preferred tone of instrument in question and on your individual taste.) 2) The signal strength from each individual

pickup diminishes.

The following chart shows roughly how these factors play out:

Number of pickups in series	Tone Quality	Signal Strength from each pickup
1- 4	Bright; crystalline	Excellent
5-8	Bright	Good
9-12	Moderately bright	Fairly good
13-16	Noticeably less high end	Fairly good
17-20	More mid-rangy	Weaker, but still functional
20-30	Little high end	Functional, but degraded signal-to-noise ratio
30-40	Little high end	Signal-to-noise problems likely
Over 40	It'll work, but with compromised tone quality and signal-to-noise ratio.	

Series/Parallel: This approach may be the way to go if your installation calls for a large number of pickups but you don't want the high-end loss that comes with large numbers connected in series. A series/parallel connection consists of two or more groups of pickups which are connected in series within the group. These groups are then connected in parallel. (See the accompanying diagrams.) For instance: if your installation calls for 16 pickups, but you want to retain the brighter tone quality of smaller numbers connected in series, you can wire as follows.

Group A: 8 pickups, wired in series

Group B: 8 pickups, wired in series

Outputs from groups A and B joined in parallel.

Parallel wiring reduces signal strength. In this example, the resulting signal strength will be significantly less than that of either of the groups of 8 alone, and it will be slightly less than the 16 pickups all wired in series.

You can create more than two groups. For instance, in a fifteen-pickup installation you could have three groups of five. Be aware, though, that the more parallel groups you have, the greater will be the reduction in signal strength.

Buffered Series: For installations calling for many pickups, this is the most effective way to go, and for installations with a particularly large number of pickups it may be the only way to go. But it's also the most expensive and, depending on how you handle it, the most complex. The idea here is that you can get around the problems of high-frequency loss or signal strength loss by having two or more groups of pickups that are electrically isolated, or "buffered," one group from the other. Buffering is achieved by sending each group to its own pre-amp before mixing the signals. You can do this either by plugging each group into its own input on a mixer, or (for those with electronics know-how) by incorporating an op-amp into the output circuit for each group. The mixer option is bulkier and potentially more costly, but it's actually is not a bad choice given how compact and affordable many small mixers have become these days. (For instance, there's a very small 4-in mixer by Eurorack available at the time of this writing for only $50 from Musiciansfriend.com.) And using a mixer offers the added bonus of a high degree of control over

balance, tone and other processing.

As an example of buffered wiring, an installation calling for forty pickups might take the following form:

Group A: 10 pickups connected in series, output sent to mixer input 1.

Group B: 10 pickups connected in series, output sent to mixer input 2.

Group C: 10 pickups connected in series, output sent to mixer input 3.

Group D: 10 pickups connected in series, output sent to mixer input 4.

Alternatively, the outputs from groups A-D could each be sent to their own op-amps and then joined in parallel.

Recommendations:

To summarize and simplify the above information, here are some recommendations based on the number of pickups you want in your installation:

12 or fewer pickups:

Keep it simple. Wire them in series.

Exception for 6 – 12 pickups: if you really want a bright sound (lots of high end), wire them in two groups, series/parallel, as described above.

13 - 20 pickups:

Simplest approach: wire them in series. There will be some high-frequency loss, which may or may not give you a sound you prefer. The signal strength from each pickup will be somewhat less than you'd get with a smaller number of pickups.

If you want more high end: Wire them in two groups, series/parallel. This will give you more high end, but the signal strength will be slightly little less than it would be with a series connection.

If you want the best signal strength, signal-to-noise ratio, and high-frequency response, go with a buffered series installation as described above: wire the pickups in two or more groups, wiring in series within each group. Send the output from each group to its own mixer input or op-amp. The more subgroups (meaning fewer pickups in each group), the better the results will be.

21 – 30 pickups:

Wiring in series is possible, but the high-frequency loss will be pretty noticeable. Signal strength will be less than in an installation with fewer pickups, and as a result the signal-to-noise ratio won't be as good.

Wiring in two or more series/parallel groups will help preserve the high end. The overall signal strength will be less and there will be a corresponding reduction in the signal-to-noise ratio.

For the best signal strength, signal-to-noise ratio, and high-frequency response, go with a buffered series installation as described above: wire the pickups in two or more groups, wiring in series within each group. Send each group to its own mixer input or op-amp. The more

subgroups (meaning fewer pickups in each group), the better the results will be.

Over 30 pickups:

Wiring in series is possible, but not recommended due to loss of signal strength and poorer signal-to-noise ratio, as well as high frequency loss.

Wiring in two groups series/parallel will help preserve the high-frequency response, but there will still be loss of overall signal strength and a corresponding reduction in the signal-to-noise ratio.

For best results, go with a buffered series installation as described above: wire the pickups in two or more groups, wiring in series within the groups. Send each group to its own mixer input or op-amp. The more subgroups (meaning fewer pickups in each group), the better the results will be.

With installations involving large numbers of pickups, hum is always a potential problem. Be sure to install the Spot Pickups in humbucking pairs, and try to ensure that all the connections and terminals are well shielded. These topics are discussed further below.

A suggestion: For multi-pickup installations, you may wish to try out alternative wiring configurations before making the wiring permanent. You can do this easily using alligator-clip leads. These are short sections of hook-up wire with spring-mounted alligator clips on each end. They're very easy to attach to and unattach from the Spot Pickups without any risk of damage. American Science and Surplus (sciplus.com) usually has a good deal for buying in quantity. Important: keep in mind that these unshielded leads will pick up a huge amount of hum that won't be present in your final, shielded installation. Thus, your final set up will have much less noise and a much better signal-to-noise ratio than this temporary hook-up.

By setting up your entire string of pickups temporarily this way, you can then test the response of any one pickup in the chain and get a pretty good idea of what your signal strength and tone quality will be. After trying one configuration, you can then reconfigure to try alternatives, compare, and decide which wiring configuration is best.

What About Shielding?

All electromagnetic pickups can pick up unwanted hum from surrounding electromagnetic fields – a problem that is worse in some environments than others. Our Spot Pickups are copper-shielded to minimize the problem. If, in addition, you use the Spot Pickups in humbucking pairs as described below, then hum arising from the pickups should be minimal. But in an installation with many pickups, hum can still arise from unshielded wires and terminals connecting the pickups. You can minimize this problem by using shielded wire for all connections. (Shielded wire is cable that has an insulated center wire which serves as the conductor for the "hot" lead, plus a braided wire conductor surrounding the center wire. This braided conductor serves as both the shield and the conductor for the ground connection.) The accompanying diagrams show how to make the connections.

Another approach is to enclose the circuitry, as much as possible, in metal conduit or other housing. Any metal housing that suits the particulars of your installation will do. Just be sure to make a connection between the conduit or metal housing and the wire leading to the ground connection. Also, be sure that the grounded housing doese not contact any hot leads or the copper coverings of any of the pickups.

What is humbucking? How can I take advantage of it with the Spot Pickups?

"Humbucking" is the term used for a clever system for noise reduction in magnetic pickups. It involves wiring two pickups and orienting their magnets in such a way that, when their signals are

combined, unwanted hum from surrounding electromagnetic radiation is cancelled out, but the musical signal is not cancelled. In a typical humbucking electric guitar pickup, there are actually two pickup coils set up this way within a single housing. With our Spot Pickups, the same effect is achieved with pairs of separate pickups. In any installation using multiple Spot Pickups, you can take advantage of this effect.

Each Spot Pickup comes with one of two markings: a white dot, or a black dot. If you order multiple Spot Pickups, we will send an equal number of each (or as close to equal as we can get, if you order an odd number). You'll then combine the signals for equal or near-equal numbers of white-dot and black-dot pickups in your installation. The accompanying wiring diagrams provide the wiring details.

How should the Spot Pickups be positioned?

The top of the Spot Pickup should be pointing toward the sound source, as close as possible without touching when the sound source vibrates.

You'll often have some choice as to where along the vibrating body to locate the pickup. The two main considerations are:

1) Where is the vibrating body most vibrationally active? Placing the pickup near the most active point will give a stronger signal, but in some cases this may yield a signal that comes across as too peaky (too sharp in the attack; too rapid in the decay).

2) Where along the vibrating body yields the nicest tone quality? Some points will yield more of the fundamental, yielding a subjectively purer or warmer tone. Others bring out more overtones, for a brighter effect. For some sounding bodies, the natural overtones are inharmonic. Inharmonics may add a piquancy that you like, or they may make the tone seem clangy or muddy or incoherent. Accordingly, you may try to place the pickup at a location that de-emphasizes them.

Here are specifics for a few instrument types.

Free bars (e.g., the sounding elements in a set of metal bars, tubes or rods mounted marimba-style): These are most active at the ends and at the center. They are less active nearer the mounting points (typically about a fifth of the bar-length from the end). Placing the pickup under the center or under one end will give you the strongest signal but it may come across as too peaky. Positioning closer to the mounting points will yield a signal that's weaker in the initial hit but will show smoother attack and sustain.

Free bars in their simplest form produce inharmonic overtones which you may wish to de-emphasize. (More sophisticated free bars, such as orchestral marimbas and vibes, have their bars specially shaped to bring the overtones into harmonic alignment.) Placing the pickup under the center will bring out the fundamental most strongly. Placing it under the one end will also pick up a strong fundamental, but with more of the upper partials. Placing it nearer one of the mounting points will reduce the strength of the fundamental.

Kalimba, mbira or sansa tines are most active at the end. However, with longer kalimba times, the excursion is so large that placing the pickup under the very end of the tine may be problematic – it's too easy for the tine, when plucked hard, to inadvertently hit the pickup; or, if the pickup is far enough away to avoid that, then it may be too far away from the tine when it's vibrating less actively. In such cases it's better to place the pickup a little more toward the base of the tine, where it doesn't oscillate to such extremes immediately after the pluck. This

will yield a smoother and more even tone.

As with free bars, kalimba tines are inharmonic unless specifically re-shaped (which is rarely done with these instruments). One overtone in particular is often quite prominent and potentially distracting. You can reduce the presence of this overtone by locating the pickup about a fifth of the tine-length from the end.

Plucked Strings are most vibrationally active near the center, but with a pickup located under the center of the string you run into the problem described above for kalimba tines due to the large excursion of the string when plucked hard. Also, placing at the center yields a tone that may seem a little dull. The closer to one end you locate the pickup, the brighter the tone will be. But as you get quite close to one end, you'll find signal strength dropping off.

Bowed Strings will be much like plucked strings, with this added note: While plucked strings vibrate in all directions, bowed strings only vibrate side-to-side, in keeping with the bowing direction. A pickup placed under the string as the bow moves horizontally above it will pick up only a very weak signal due to the direction of vibration. If the pickup is oriented so that it points at the string from the side, the signal will be strong. This orientation isn't possible with bar-shaped pickups on violin-like instruments, but it is possible with spot pickups on one-or two-string fiddles.

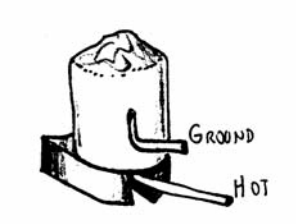
A few more notes on specific instrument types

Non-Steel Instruments: Electro-magnetic pickups such as the Spot Pickup are made to respond to the vibration of a ferrous metal such as steel. But can the pickups be used for instruments in which the vibrating body is not made of steel? In many cases you can use the Spot Pickup on such instruments by adding affixing a steel plaque to the vibrating body, and positioning the Spot Pickup to respond to the movement of the plaque. The easiest thing to use for the steel plaque is a steel washer, held in place by glue or by steel screw. This works well with wooden marimbas, xylophones, tongue drums and the like. The resulting tone quality will often be more appealing than the tone you'd get from a piezo pickup attached to the same sounding element. There is a possibility that the added weight of the plaque will throw off the tuning of the bar or tongue. This is not a problem if the original tuning is done with the plaques already in place. In cases where the plaques are added later, detuning effects are minimal for reasonably heavy sounding elements such as most marimba bars. If they are noticeable, some retuning of the bar can be done.

Free bar instruments with or without air resonators: Vibraphones, marimbas and similar instruments are normally provided with an air-resonance tube below each bar which serves to enrich the tone by strengthening the lower frequencies, especially in the lower ranges. This is done because, even though those low frequencies are present in the vibrating bar, they don't transmit to the surrounding air very effectively without the aid of the resonator. A pickup such as the Spot Pickup will not pick up the air resonance from the resonator, but it will do something that may be better: It fully picks up those low frequencies at their point of origin in the bar. So while your Spot Pickup will miss the air resonance tone on an instrument with resonators, it solves the problem that made the resonators necessary in the first place, by capturing a full-spectrum tone including the lower frequencies at full strength. In fact, if you're designing such an instrument from scratch and you'll be using Spot Pickups, you can make the design far simpler and more compact by skipping the resonators entirely.

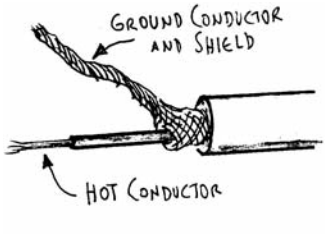
WIRING OPTIONS FOR SPOT PICKUPS

(be sure to review the attached text as well)



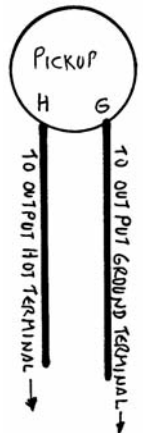
Ground and Hot Terminals on the Spot Pickup

The ground connection on the Spot Pickups is the shorter upper terminal. Hot is the lower, longer one. When soldering to the ground termnal, it's recommended that you do not use more heat than is needed, and attach something that can act as a heat sink, such as an alligator clip, between the solder point and the body of the pickup.



Shielded Cable

It's recommended that you use shielded wire wherever possible in hooking up the spot pickups.



Wiring for a Single Spot Pickup

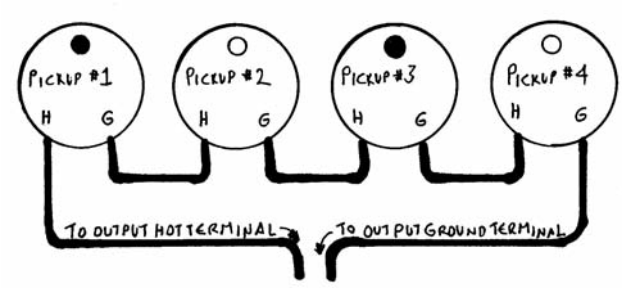
With a single pickup all you need to do is use a shielded wire to connect the hot terminal on the pickup to the hot terminal on the output, and ground terminal on the pickup to ground terminal on the output. The output could be an audio jack or plug, or other routing of your choosing. (A diagram for wiring to a volume control appears on the back of this sheet.)

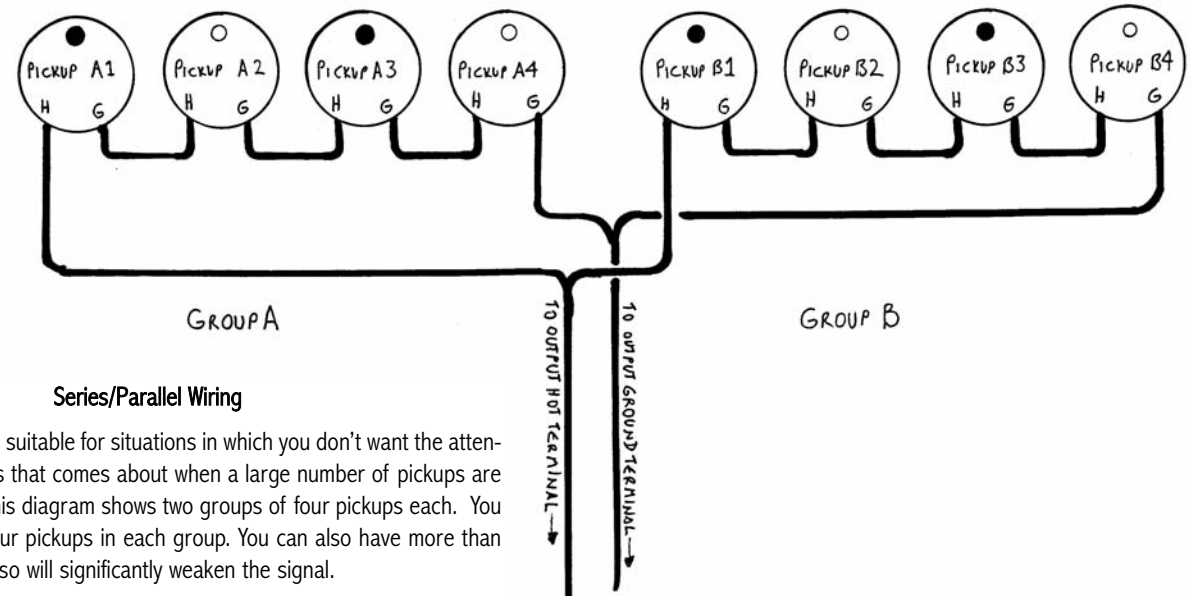
Wiring for Humbucking: Black Dots and White Dots

Each Spot Pickup is marked with either a white dot or a black dot. To take advantage of the humbucking (noise-cancelling) effect in multi-pickup installations, you should use an equal or near-equal number of white-dot and black-dot pickups. The diagrams on these pages indicate the alternation of white and black dots pickups.

Wiring in Series

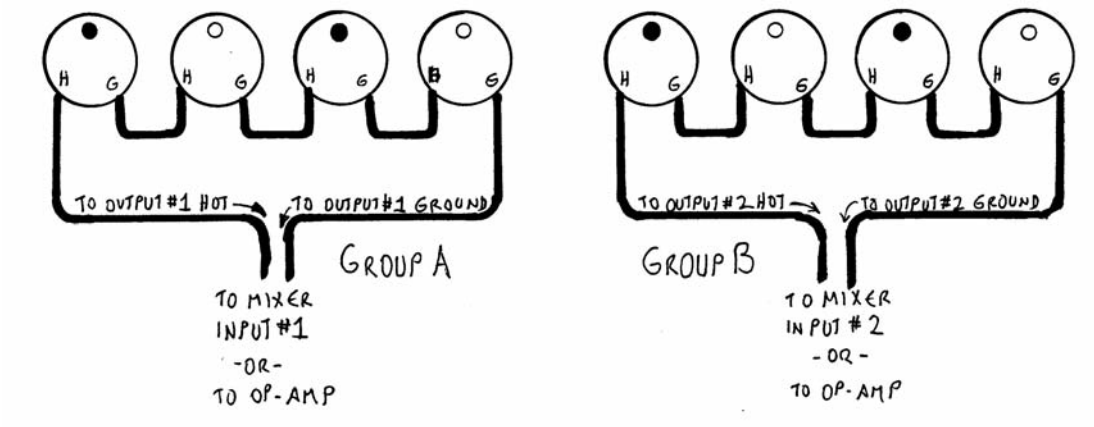
Simple series wiring is the easiest option for multi-pickup installations, although some drawbacks appear when the number of pickups is very large. Four pickups are shown here, but the series can be extened to include many more. Notice the alternation between black-dot pickups and white-dot pickups. The ideal is to have equal numbers of each marking, but if your installation calls for an odd number of pickups you can have one more of one than the other.





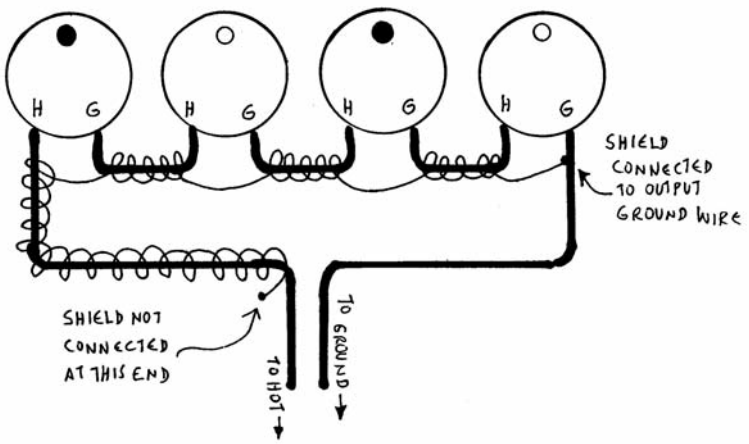
Series/Parallel Wiring

Series/Parallel wiring is suitable for situations in which you don't want the attenuation high frequencies that comes about when a large number of pickups are connected in series. This diagram shows two groups of four pickups each. You can have more than four pickups in each group. You can also have more than two groups, but doing so will significantly weaken the signal.



Buffered Series Wiring

In installations with a very large number of pickups, buffered series wiring will be best to mitigate the loss of signal strength and the attenuation of high frequencies that comes with large numbers of pickups connected in series. In buffered series wiring, two or more sub-groups are each sent to their own mixer inputs or to separate op-amps built into the circuitry. Four pickups are shown in each group here, but that number could be larger. Two groups are shown, but you can have as many groups as you wish (or as your mixer allows). The fewer pickups within each group, the better the signal strength and high frequency response.



Using Shielded Cable in Series Hookups

The information in this box may be applied to the wirings described in the three previous boxes. Installations with lots of exposed wiring will tend to pick up a lot of background noise from the environment. The exposed wires should be shielded to minimize this. This diagram shows the use of shielded cable in a series connection. The bold lines show the main circuit. The curly lines around them represent the braided over-wrap in shielded cable, and how it should be connected from one cable segment to another, without ever contacting the hot lead or any of the pickup housings.

An alternate to the use of shielded cable in the inter-pickup connections is to enclose all the wiring, to the extent possible, in an encasement or housing that provides shielding.

Connecting to a Volume Control

This diagram shows the connections of inserting a volume contol into the circuit. A suitable volume control for the Spot Pickups would be a 250k Ohm audio-taper potentiometer. (You needn't worry about wattage rating in this application -- even the lowest wattage ratings will be sufficient.) These are commonly used in electric guitars and are available at electronics stores. Notice the two ground connections that are soldered directly to the housing of the pot. These connections will require greater heat from the soldering iron than other connections called for on this page.