Why do Audio Transformers Sound Different From Model to Model?

C. H. Preston

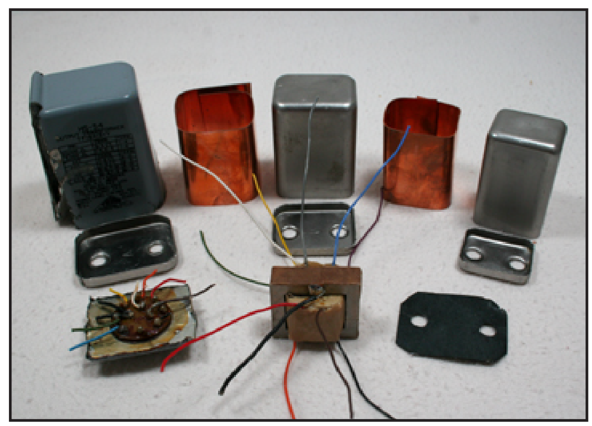
This is a very common question on the web. Usually it is asked on a forum that is moderated by someone in a business that sells or services related goods. Since it really isn't in the best interest to those involved to spill the 'secrets' that make transformers such a perceived black art, the question usually gets answered with: "well....it's pretty complicated, let's just say you get what you pay for" In other words, "don't worry your pretty little head and buy mine". When I first seriously started looking into audio transformers from a mechanical point of view there weren't many sources on the subject. The only book that could be found on the subject of audio transformers specifically was Wolpert's 'Audio Transformer Design Handbook' which really doesn't take a much of a hi-fi approach. The only way to see what was going on inside good audio transformers was to carefully dissect a variety of vintage units. Some of these came in as rewinds but for others I actually took apart working units. This is how I learned why transformers sound different and what good transformer practice is in general.

It may come as a surprise but transformers have been used in audio amplification from the very beginning of amplification itself. While the DeForest Audion was patented in 1906 and used in wireless applications, it wasn't until 1912 when DeForest was working for Federal Telegraph Company with the assistance of Herbert B. Van Etten, who had been assigned to DeForest to help with his experiments, that real amplification was achieved.[1] At first audio transformers were used between the radio receiver and the audion and a little later on they were used for stage coupling. We are now coming up on 100 years of using a technology that basically hasn't changed since it was introduced!

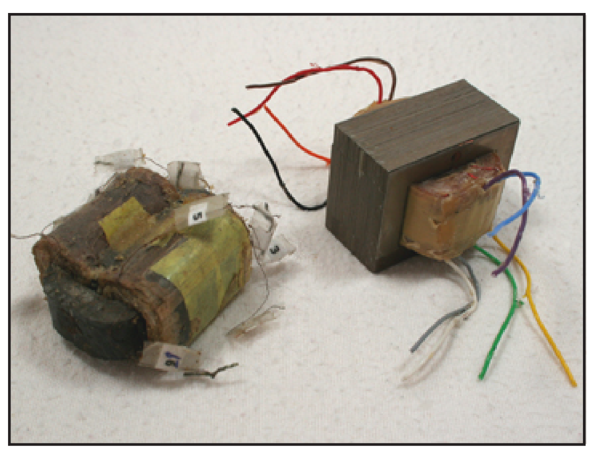
The basics of the transformer may not have changed much over the years but the details have. The mechanical action of the transformer can be fine tuned through careful choice of coil anatomy, materials, winding technique, etc. It might be interesting to note that in the last 50 years or so there hasn't been very

The manufacturer names mentioned in this article: Altec, Jensen, Lundahl, Peerless, WE and others, belong to their associated companies. The author has no affiliation.

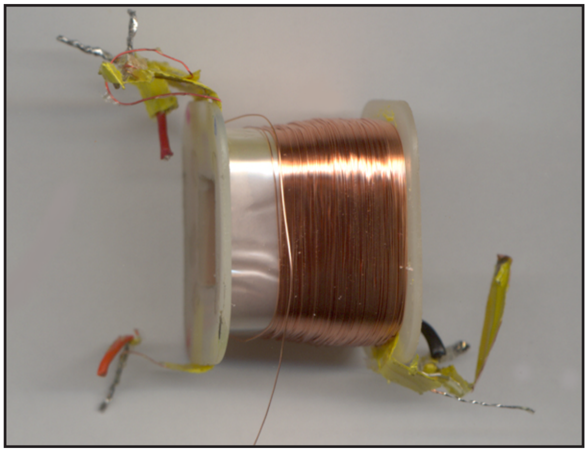
The Western Electric 111C



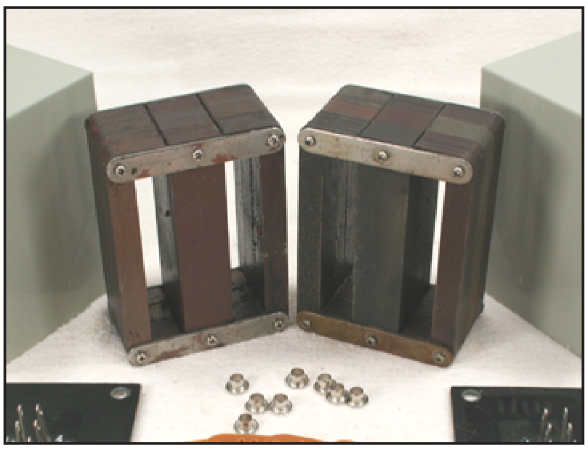
Here is a complete Triad HS-54. It has more shields than the HS-52 but has a smaller coil.



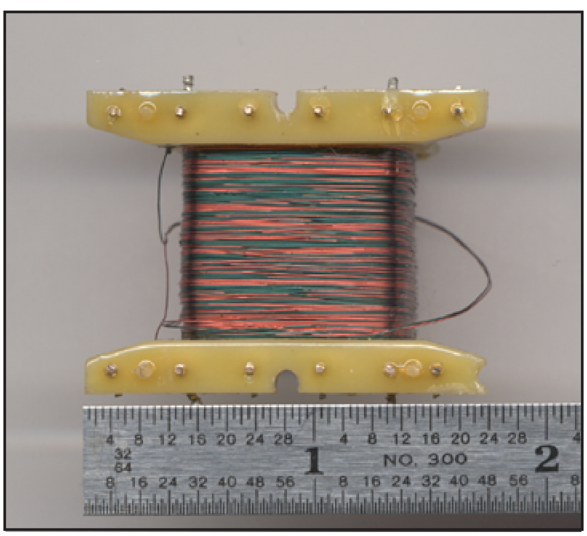
A comparison between a Langevin 129-A (Humbucking) and a Triad HS-52 (Shell Type). Both have similar specifications.



A shot of the proprietary winding system Jensen uses on their JT-16-B. This is one of the few newer winding techniques. It is briefly covered in Bill Whitlock's chapter in the 'Handbook for Sound Engineers'.



Cores from a Western Electric 171C Output Tran.



Above is a coil from a line transformer used in Sony 3000 consoles. It is wound with 2 conductor litz wire and has very good performance.

many winding technique advances. Most modern advances in transformer design are in the area of materials. There are a couple of companies that have advanced the manufacture of transformers. Lundahl in the Sweden comes to mind. The Lundahl company has taken the techniques that were developed in the 50's and 60's for state of the art transformers, maximized them with current technology, and then automated them. Some of the early winding techniques were very time consuming during the period of their development and the units wound accordingly demanded a premium price. The only fairly 'new' winding technique that I have seen that is really different from what has been done before would be Jensen's proprietary system of carefully building up a wind starting from one end of a bobbin and building that end up while slowly winding back and forth towards the other end of the bobbin. The excellent Jensen JT-16 is wound this way. See top left photo. (for more info on this subject see the Handbook for Sound Engineers. Bill Whitlock's transformer chapter has a brief explanation of this technique).

Let's look at the variables that could effect the sound, or more accurately, how the coil and core can effect the signal:

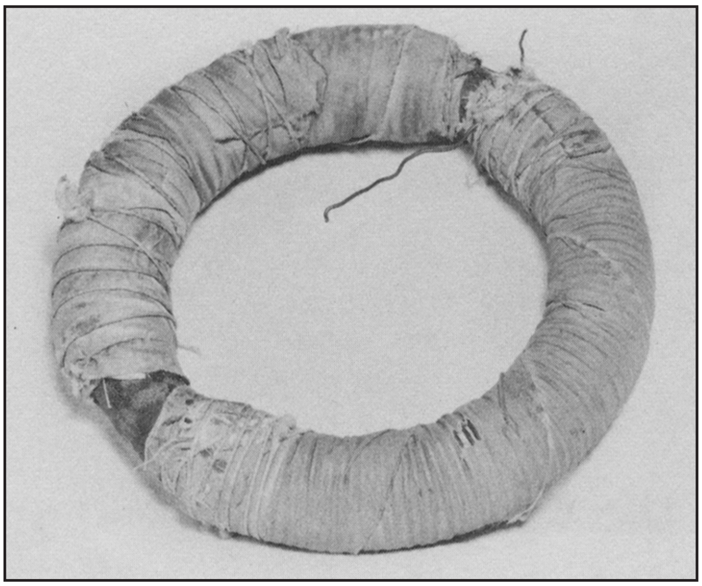
Anatomy
Core Material
Bobbin or Layer base
Winding Techniques
Wire (this includes the type of insulating material the wire is coated with)
Insulation
Inter winding shields
Shielding
Size

Anatomy

Once the specification for a subject unit is known the first decision to be made is what type of transformer anatomy will produce the best result within the usual manufacturing constraints. Manufacturing constraints meaning considerations like cost effectiveness, material availability, manufacturing capabilities, etc. For the most part these considerations all circle back to a price point for any given specification data.

Here are some examples of various topographies for transformer coils:

The first practical coils were toroid cores.[2] These are round, doughnut style cores that are sometimes cut through to provide an air gap. Here is a photo of the very first coil ever developed by Michael Faraday in 1831 (yes that is the correct date). This method of winding still produces the most efficient coils, however, the limitations on using toroids more in audio circuits is that high ratio input transformers require more winding precision than is normally associated with toroidal winders. Since the ratios on output transformers are lower we are starting to see more of those in the market place. The famous Western Electric 111C is an example of this type of coil. That particular coil has great specs even by today's standards..



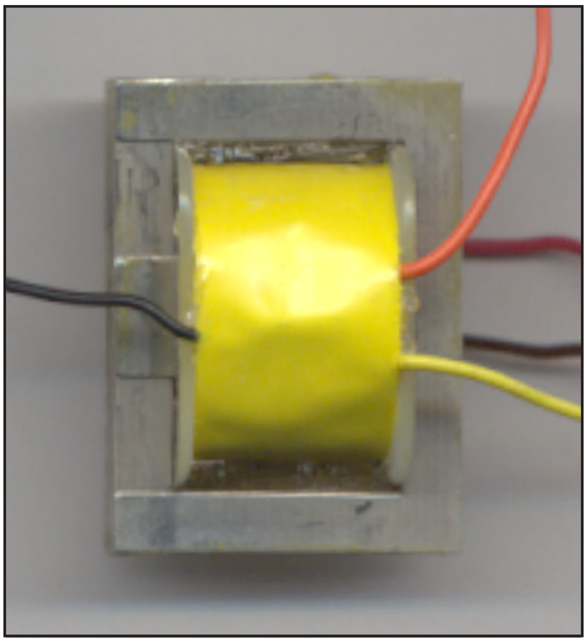
This is the coil that stared it all. Developed by Michael Faraday in 1831. This coil is the basis of all induction based apparatus conceived since. The WE 111C below is just an improved version but is essentially the same as are the toroid line and output transformers manufactured today. Faraday was a lateral thinker and the fingerprints of his ideas are all over our modern world. For more information on Faraday I highly recommend "Michael Faraday", the biography by, L. Pearce Williams. This book is detailed and well written. A blowup of the Faraday notebook page with the explanation of the coil to the left is provided at the end of this paper.

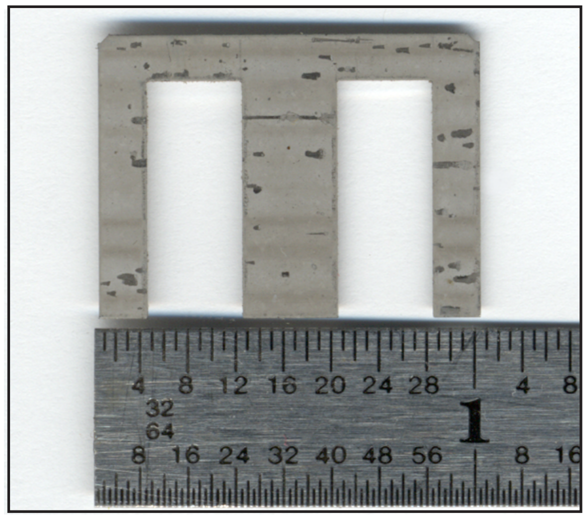
Here is the famous Western Electric 111C coil. This thing is a piece of engineering genius. It is wound on a HUGE tape wound core. The winding techniques were state of the art using what is referred to as the 'two section reverse' method of winding. This winding technique produces a low capacitance, high Q coil. Because these coils were to be used in very remote and sometimes very harsh conditions, they were built like tanks. While these transformers were specified to 15K the response actually extends considerably past that figure.

For a complete detailed dissection of a 111C please see my Audio Transformer Design DVD's at VintageWindins.com.

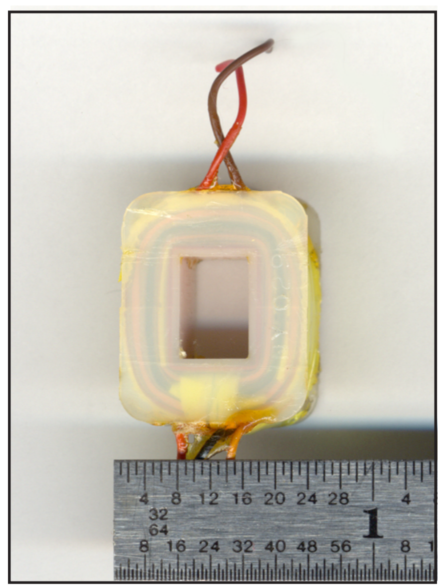
Shell style transformer coils:

The traditional IE core produces what is also called a 'shell' type of transformer. These are probably the most common audio type transformer. Examples of this type included many Jensen units (JT-115K, JT-16, more), the venerable Peerless K-241-D is in this category as well. The various techniques used to wind this type of transformers has been perfected over many years of manufacture and very good transformers have, and are still being produced this way today. During the 40's it was noted that there is a build up of gauss in the areas of the core where the laminations butt.[3] It was determined that it was better engineering practice to place the lamination butts closer to the center of the coil away from the coil ends. EE core laminations come in a variety of butt configurations but their use is usually to move the gauss buildup away from the ends of the coil. (continued page 7)

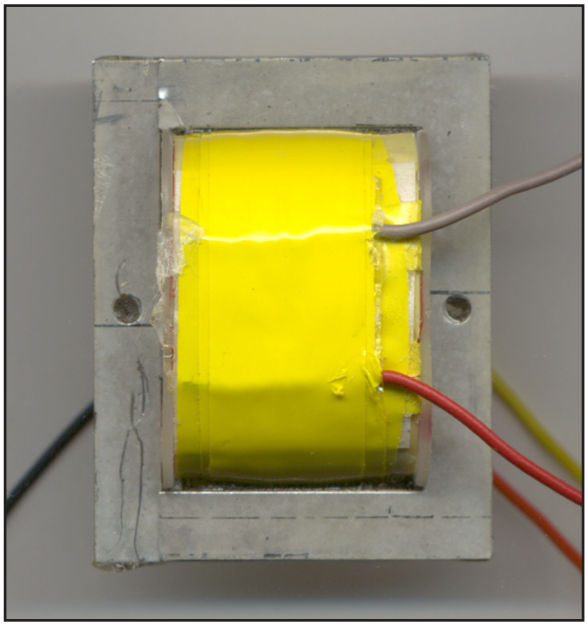




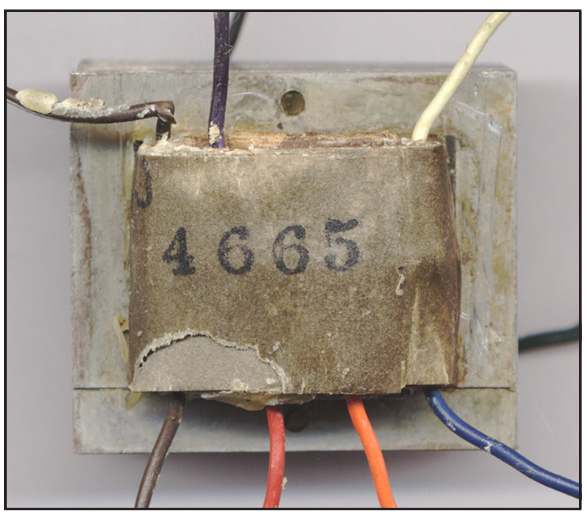
This is a group of scans of a Jensen JT-K-115-E. This transformer has been around since the 70's and I'll let you know a piece of information that you will most likely not find anywhere else. Not ALL 115's were made the same! I have dissected earlier JE-115's, that were most likely made by Reichenbach during his years with Jensen, and found that the secondaries on the earlier units were wound similarly to the Peerless K-241-D utilizing "pied" side by side windings! The earlier 115 models didn't have the inter-layer insulation like the Peerless models and there were some other shortcuts but essentially the earlier 115's were very similar in build to the Peerless input models. The Sony 3000 recording consoles had the earlier pie wound 115's. You heard it here first! Both the early and later units sound similar and the transformers are similar in size to a Peerless 4722 (completely different winding technique).

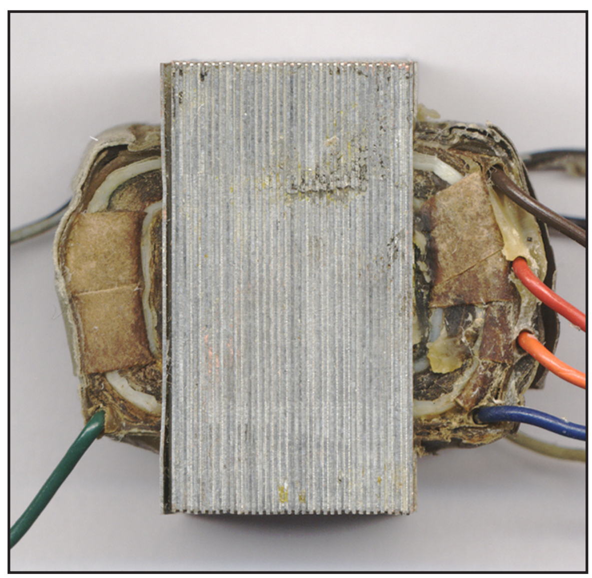


Shell style transformer continued:



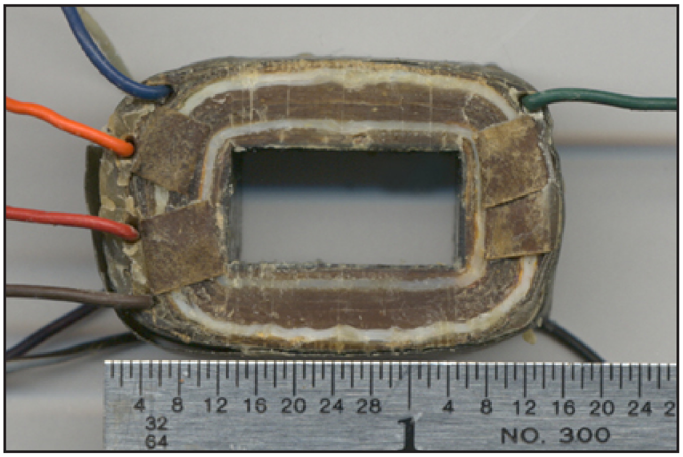
Above are a couple scans of a Jensen JT-16-B input transformer. The 16-B is a low ratio step up transformer and it is one of the best sounding audio transformers currently on the market. The core is quite large and beefy compared to most modern offerings and, as mentioned earlier, uses the Jensen proprietary build-up type winding technique on the secondary. (see page 2 for more details). Jensen recommends using a loading resistor across the secondary for optimal performance. John Hardy uses these in his mic preamps and the units in my Sony console sound great. Note: the discoloring on the core in the photo is due to the heat needed to melt the potting substance between the lams. That is not how the lams looked at the time of manufacture. There are other engineering details inside these transformers but since they are still being manufactured I'll have to leave those notes in my notebook. Suffice to say that imho these are great units and the price from Jensen is a deal.

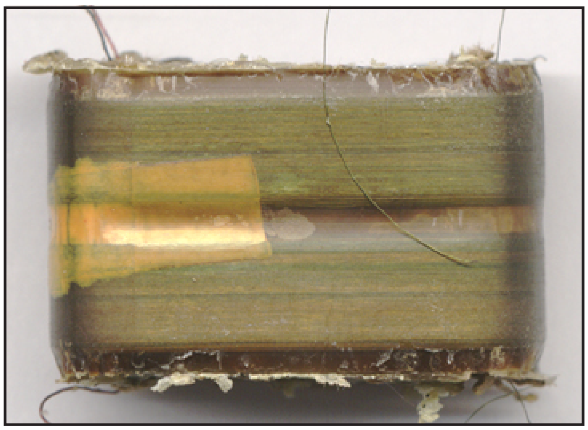




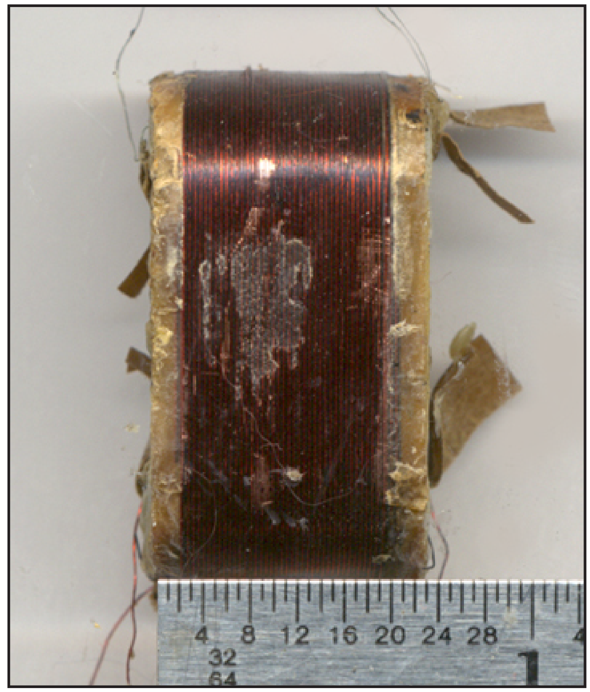
Here is a group of scans of one of the best engineered high ratio input transformers ever produced. This model and it's variations, the K-241-D and 4629, are without question exceptional sounding and very well built transformers. Some design features were Teflon wraps between the primaries and secondaries, pied windings on the secondaries, parallel bifilar windings on the primary, three shields, and a HUGE core that appears to have some of the laminations receiving a slightly different annealing process than other lams. These are layer wound coils and inter-layer insulation is used between each layer. They were manufactured on long arbors with a dozen or so coils per arbor. The coils are then cut from the arbor, the leads fished out of the ends and the coils finished with insulated wire leads. On the next page are some more scans and photos of the 4665/K241-D coils and a size comparison with a Langevin coil.

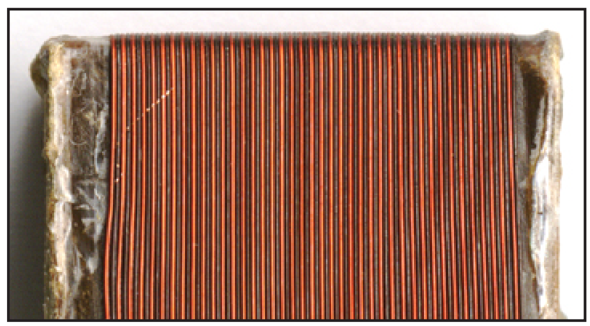
Shell style transformer continued:

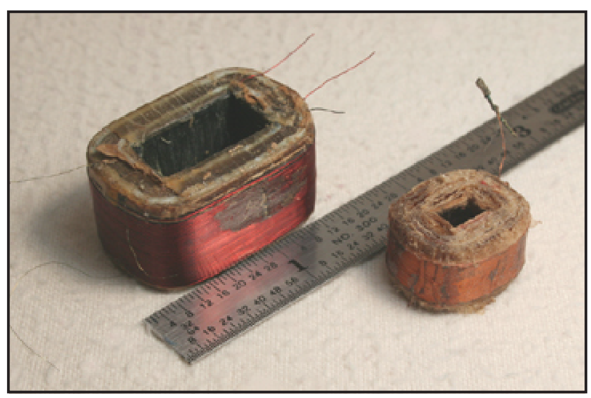




The scan at the top left and right shows the size of a Peerless 4665 coil. The Teflon insulation between the windings can clearly be seen in the photo. If you look at the scan at the top right you will see that the primary winding is bifilar and a closeup of that winding is under it. This bifilar layer is not litz wire. It is two separate side by side windings laid perfectly next to each other while being wound at the same time. The lower left photo shows the pied secondary. Other details include very thin insulation used between each and every layer. Wire over wire winding as layers progresses to reduce capacitance between adjacent conductors. Layer by layer buildup with margins instead of using a bobbin. It's details like these that are very time consuming and have been all but lost in todays manufacturing process. Do you have to do all of these things to make a great sounding audio transformer? The answer is it's not that simple and different manufacturing and design techniques can deliver relatively little perceived audible differentiation from one well made model to another.



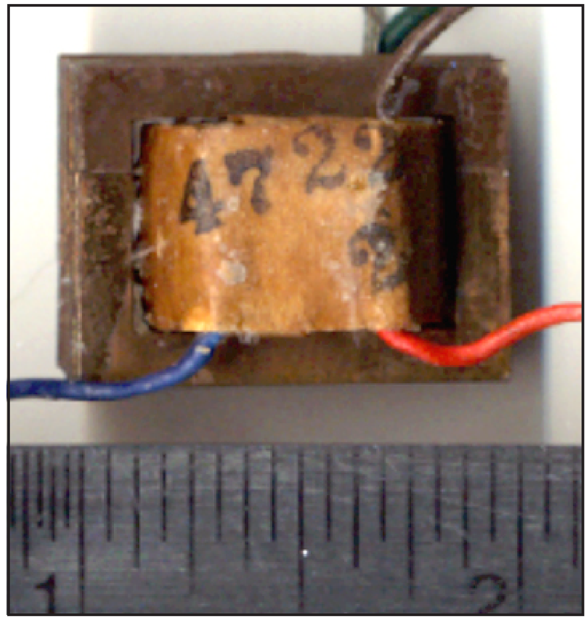


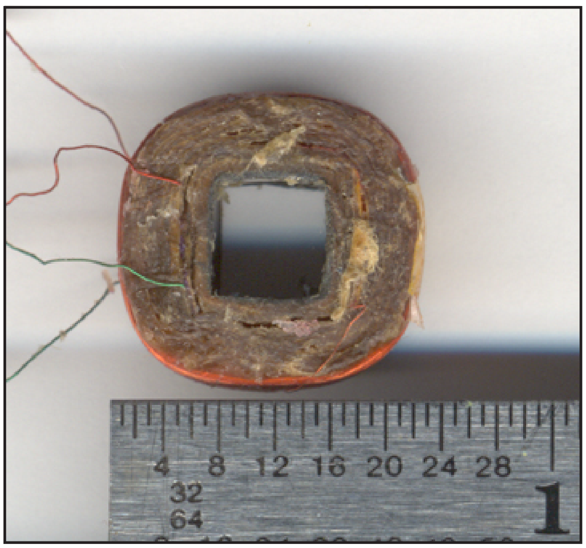


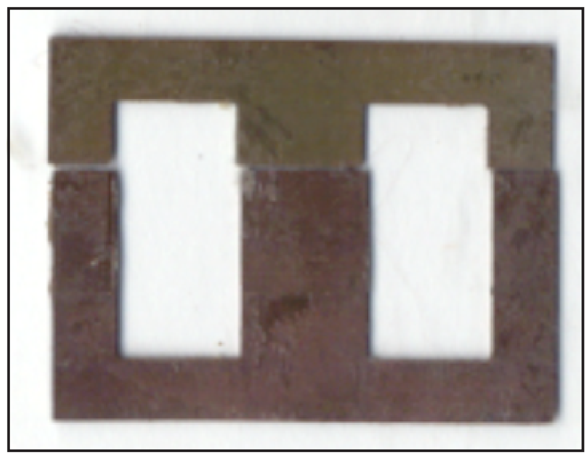
Above is a photo of a 4665 coil compared to the coil from a Langevin TF-132 -B (input from a 5116-B tube preamp). The Langevin coil is smaller but the precision build is similar. The specs are very similar between the two.

Shell style transformer continued:

How about the Peerless/Altec 4722? It is tiny compared to the K-241-D. It uses EE cores and the laminations seem to have two variations (core photo lower right). It's coil is small and it's construction is simply a layer wound secondary, wound over several layers of the primary. There is no interleaving of the different windings at all. There is very thin inter-layer insulation between layers. This transformer has a pretty good reputation among audio professionals in the know but the build quality is nothing like the earlier Peerless models. It is also limited in it's loading connections. The scan at the lower right shows the differing laminations. I'm not sure if the alloy is different or just the heat treatment but it is clear that there are two different lamination types. The scan below is the 4722 coil. They were also multi-wound on an arbor and cut into individual coils.



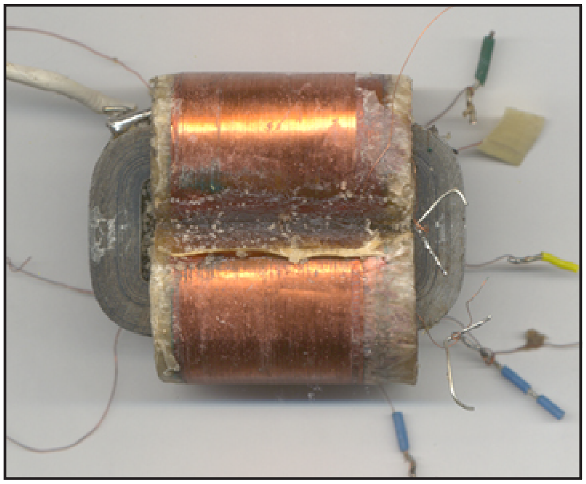


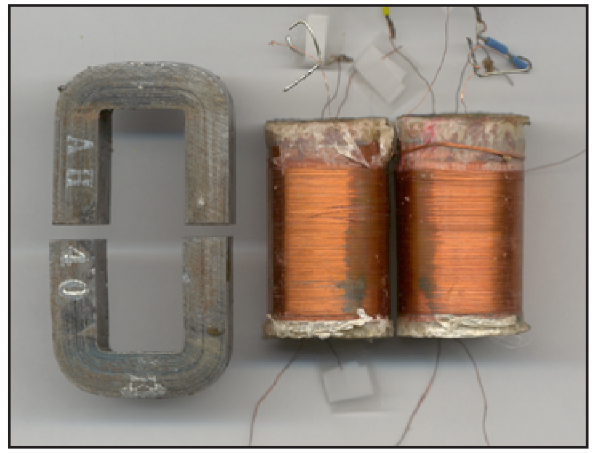


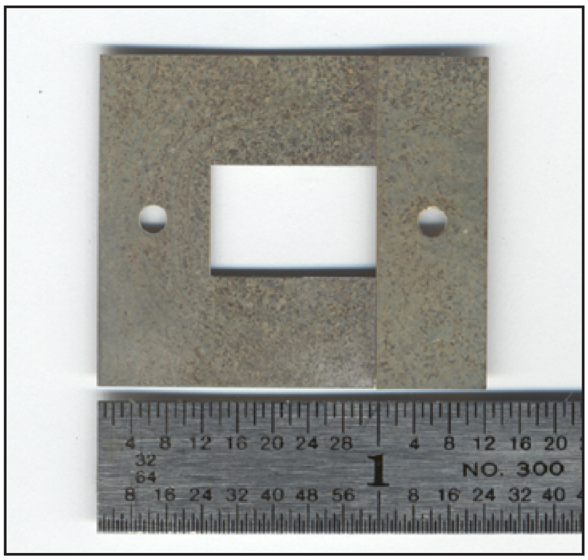
Semi-toroid style transformers:

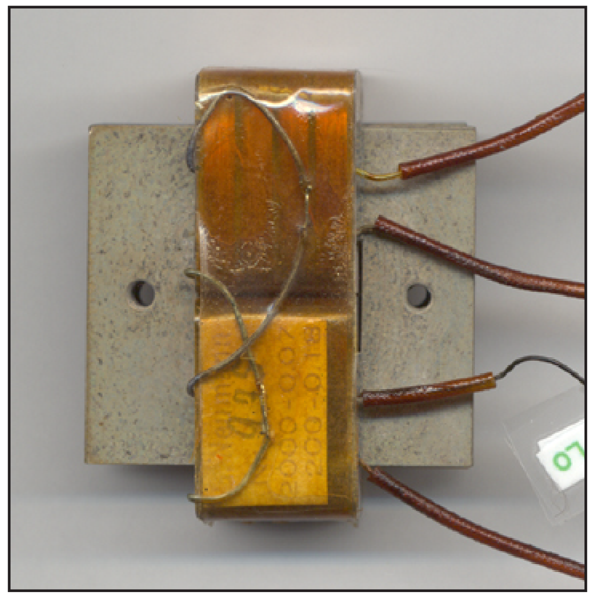
The basic shell structure is used on countless models from most all audio transformer manufacturers past and present. The exterior look to all of them is similar so let's move on to semi-toroidal construction. The semi-toroid is quite common. They can be made using wound tape cores (cut "C" core), or UI laminations. Often semi-toroids are wound as fully balanced transformers. The coils are split up into two windings that are wound on opposite legs of a O core, C core or tape wound core. Examples of this type of winding are many of the humbucking Lundahl audio transformers, German tube mic transformers (many other tube mic transformers), and many tube preamps & line amps from the late 50's, they all used this type of topography. The Langevin 5000 tube amplification series makes use of shell type input transformers and semi-toroidal balanced output transformers. (continued page 9)

Semi-toroid style transformers continued:









At the top of the page is the coil from a Langevin 129-A tube output transformer. The 129-A was used in the 5116-B preamp output. This was a monster to reverse engineer and is an exceptional transformer. The core is a cut "C" core and the model number can be plainly seen stamped on it. This AH-40 core is in fact listed in the 1950's Arnold Engineering catalogs and is made of Selectron silicon steel. The cut core is squeezed together with a band clamp. This unit is made similarly to earlier Western Electric transformers and is very high quality. The coils are identical layer wound halves and were multi-wound at the same time on a long arbor and cut into individual coils. The lower two scans are of a Neumann BV-11 tube mic output transformer (M-49, M-50). It is essentially the same as the BV-8 (U-47) transformer but has a different ratio. Notice the windings are "section wound" where each winding is broken up into separate sections of the bobbins (more later). There is no inter-layer insulation on these, just insulation between windings. We have here two very different transformers sharing the same style of construction but two very different engineering protocols. Altec, Western Electric, Peerless, UTC, McIntosh, and dozens, if not hundreds of other manufacturers offered semi toroids that were used as input, interstage, and output transformers. This style of winding is usually noted in catalogs on the spec sheets. They have the benefit of being fully humbucking.

Core metals and alloys:

This is perhaps the least understood part of the black art of transformer design. Far too many web discussions are reduced to what amounts to voodoo regarding vintage magnetic materials. I get many inquiries regarding alloy contents of cores from vintage transformers. Believe it or not most earlier alloy compositions are still available, most probably in an "improved" form. Since transformers are still used in many other manufacturing processes the technology in the manufacture of the magnetic materials has improved over time. In some cases this simply means that the alloy compositions are purer than in the past, in other cases the metal's properties have been altered drastically. Many alloy compositions have been made to be more 'square' in the last 30 years or so. The term 'square' refers to the appearance of the alloy's BH curve which has a squarish shape to it. The geometry of the curve shows the magnetic characteristics of the sample. Squarish looking curves indicate that the core saturation points are rather abrupt with very little change in reactance right up to the point of saturation. Cores of this sort are especially good for tuned transformers, filter coils, transformers for magnetic amplifiers. [4]

To cloud things up a bit more there are things that occur in the manufacture of the core metals that considerably changes the BH curve (magnetic characteristics) of a given alloy. The part of the manufacturing process that has the most effect on an alloy's magnetic qualities is annealing. This is the most difficult subject in transformer manufacturing to find practical information on. The reason for that is that most of the information regarding heat treatment of soft metals resides in textbooks dealing with electrical metals and not in transformer design books. Annealing is a process by which transformer core metal is precision reheated after stamping. This aligns the molecules in the metal effectively increasing conductivity. This increase is directional. For instance, a standard E lamination conducts slightly better along it's long side compared to the shorter top, middle, and bottom legs. This is why a wound tape core can be a more efficient core than an UI core. Proper core metal annealing can make a transformer that works wonderfully in it's designed circuit while improper core annealing can make the same transformer unusable. The downside to the annealing process is that batch to batch, year to year, the properties of the final material may not match it's listed curves, which is a fact that is stressed in many early transformer text books. At VintageWindings.com[5] there are a series of papers posted which drive home the importance of heat treatment of soft metals by the engineers who wrote the book, Bell Labs. In the Bell Lab papers the authors were generous giving many details of the numerous differing heat treatment methods and their effect on the alloy's final magnetic characteristics. Another excellent detail that is covered in the early Bell work is the technique(s) of creating small quantities of different alloy combinations in the laboratory using an Ajax Northrup induction furnace. In many of the Bell papers it is stressed that annealing has more to do with the final BH characteristics than does the exact alloy composition. One last note on soft metals annealing is that the high nickel metals are usually annealed in a hydrogen atmosphere, sometimes for a day. If one wants to actually expand the horizons of audio transformer practice, understanding heat treatment and the ability to create and process alloys is the way to it. The Bell people developed the paradigm.

Another thing that changes the characteristics of a transformer core material is the air gap. The air gap can be cut into the core or it can be the distributed air gap that naturally occurs when stacking laminations. The introduction of the air gap is that it essentially increases the effective length of the magnetic path. The effect of the air gap on an alloy's BH curve can be explored further in McLymann's 'Transformer and Inductor Design Handbook' p38 2nd Ed. There you will find some comparison BH curves between cut and uncut cores. Suffice to say here that there is a very close relationship between the air gap (or lack of) and the magnetic characteristics of a subject core sample.

Annealing, the heat is on:

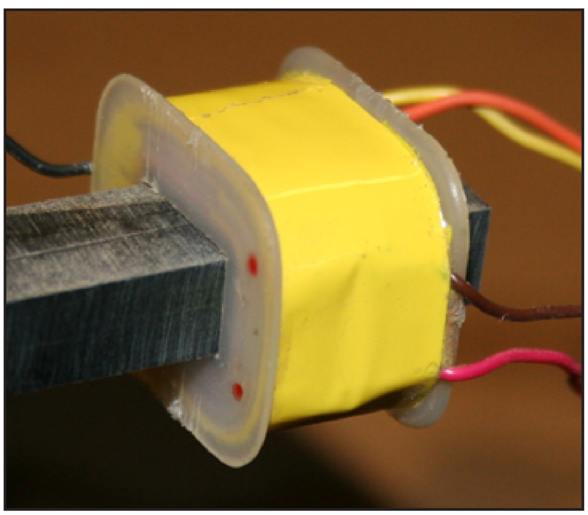
The heat treatment and or inclusion of an air gap in a transformer core can have more effect on the final sound of an audio transformer than using certain different alloys. When trying to develop a modern alternative to a vintage unit it may be a better idea to try to match the BH curve of one of the currently available lamination types and tweak via heat treatment that to the BH curve of the original core material. That is basically the approach that the folks at Cine Mag did on their U-47 transformer replacement. Through careful design and the selection of available core options they essentially used two different core alloys, stacked alternately, at a ratio that brought them to a match of the BH characteristics of the original U-47 core. The use of multiple alloy laminations was originally used by Peerless and some current manufacturers have been using the technique. At first I thought that this was kind of a lame way to remake a U-47 transformer. After rethinking the idea I like it. In reality, even if one was to commission the smelting of a specific alloy, the final product would probably still not sound exactly the same. There are just too many other factors involved and to nail all of them just like the original is next to impossible. I have measured many multiple transformer models and found considerably different measurements between examples, even from close manufacturing batches. One could go as far as special ordering a particular alloy, annealed to a specification but the expense of that effort, when plotted against the current market for audio transformers makes that option very dicey. Alloy experimentation is little simpler with a manufacturing process like Lundahl's where the tape core material is actually wound through finished coils, requiring no special lamination stamping or re-annealing.

What type of core material produces the the 'best sound'? Well, again it's not that simple. First, very low level signals, like from a moving coil or microphone, usually benefit from hi nickel alloys with their high initial permeability. Signals a little further down the line, like an output transformer, usually have core with less nickel, like Radiometal, Mu metal or Selectron. Early transformers used silicon or Selectron core material. When higher Ni content alloys came along at the end of the 20's engineers were quick to start using them because the size and therefore the cost of manufacture could be reduced. A measurable improvement in specs was achieved by the implementation of newer and better core materials and some of the best semi-modern transformers were produced from the higher ni content alloys. The catch here is that the most valuable transformers tend to be the older Western Electric transformers that mainly used earlier Armco iron/silicon cores. There is an excellent book on this subject, unfortunately it's only written in Japanese but it is called 'Output transformers of the World' from the authors of Stereo Sound Magazine. This book contains dozens of listening tests of various output transformers, old and new. Do the older transformers sound good enough to justify their huge price tag? There is no question that newer alloys can produce transformers with better specifications and smaller in size to boot. The earlier alloys (silicon and Selectron are still around) had a couple of characteristics that might be appealing to the human ear. For one thing, in general, they hold on to a magnetic charge longer than newer alloys, and, although these metals were originally classed as 'square' metals, their BH curves are no where near as square as some metals today. The way the older alloys saturated was softer and less abrupt. The older alloy cores were slower to charge and slower to release that charge to make room for the next transient. I think that it may be the softer sound that is produced from these shortcomings that audiophiles, especially from Asia, find appealing.

Great transformers can be made from older or new alloys. A very good paper on the evolution of magnetic metals can be found here. [6]

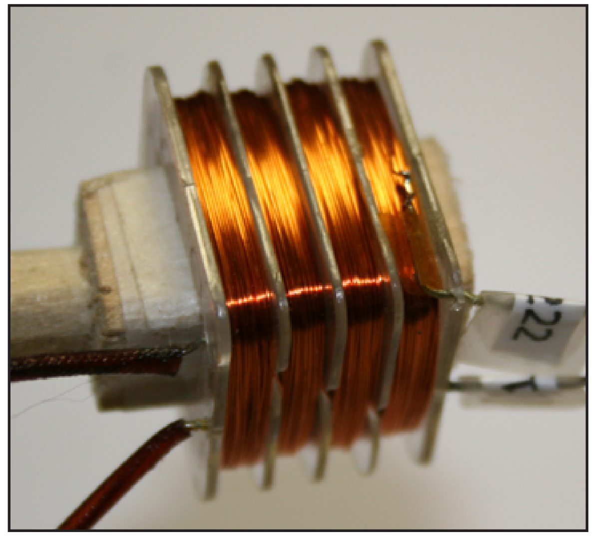
Bobbin or Layer....or both

Modern transformers tend to be wound on bobbins. An exception to this is many Lundahl units which are layer wound. If you delve into the textbooks it is *generally* understood that layer winding can produce technically better results. Lundahl wrote a great paper on this subject and it is available here.[7] Some transformer coils are layer wound on a bobbin. Generally, it is easier to wind a bobbin coil but it is very hard to achieve good specs when winding high ratio input transformers on a bobbin. Some very conspicuous exceptions are some of the earlier WE transformers. However, later WE units and the early Altec input trannies were layer wound. You can wind a fairly good bobbin coil on a homemade winder but it would take a very good homemade winder to wind a layer wound coil as very accurate transverse movement is essential.



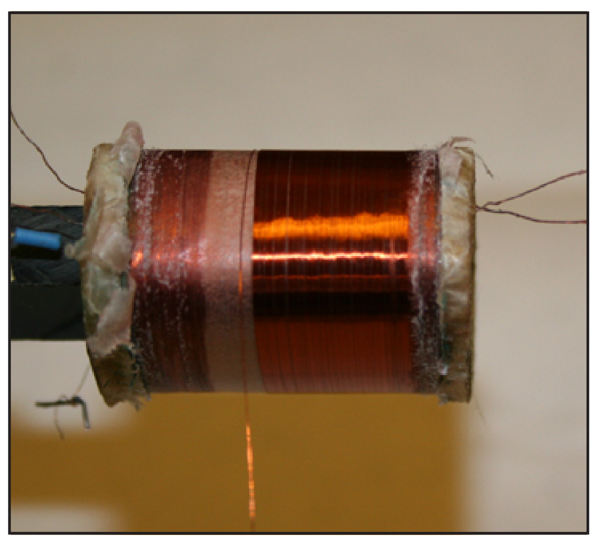
This is Jensen 115-E bobbin. The windings are layered but no insulation was used between layers of the same windings, There are at least two different versions of this transformer. Earlier versions have slightly different winding counts and a "pie" wound secondary. It's a very good bang for the buck transformer.

In Neumann tube mic transformers the compartments are simply used to separate parts of the same winding. Jensen also does some interleaving between the primary and secondary in some of their coils.



This is a photo of a coil from a Neumann BV-11. It shows the compartments in this style of bobbin. The number of winds in each compartment for the corresponding winding is specified in the build sheet data but the actual fill is quite random.

Bobbin winding can be improved by including partitions or compartments in the bobbin for splitting the coils up. In textbooks the divisions are usually used to split up the primary and secondary into smaller parts, these winding section parts are then alternated in the compartments to reduce capacitance. The effect of this is similar to interleaving layers in a layer wound coil.



Here is a beautifully precision layer wound coil from a Langevin 129-B output transformer. The insulation between layers of the same winding is very thin as can be seen in the photo.

Winding techniques continued:

Here is a comparison of the coil form for the Langevin 129-B bobbin from the photo on the previous page, compared to a coil from a Lundahl input transformer. They are almost identical in construction. Only the materials and winding counts differ from each other. Lundahl has miniaturized and automated this process very nicely.

Occasionally, if the primary or secondary doesn't have very many winds, and the design might be improved by interleaving the side of the coil that has more winds, the winding with the least winds is wound in it's entirety in layers between interleaved parts of the larger side. The smaller windings are then wired in parallel. So the geometry might look like this: 1/4 pri, full sec, 1/4 pri, full sec, 1/4 pri, full sec, 1/4 pri. the primaries are then wired in series (or broken out to terminals) and the secondaries are wired in parallel. This technique allows the benefits of interleaving for coils that may be impractical to interleave otherwise. It is a technique used by at least two manufacturers today.

Interleaving can be used in bobbin or layer winding. It is the practice of breaking the various coils up into parts (often done at tap points) and sandwiching the partial layers, alternating between the primary and secondary coil parts. So you might have a coil with geometry that looks like this: 1/4 pri, 1/3 sec, 1/4 pri, 1/3 sec, 1/4 pri, 1/3 sec, 1/4 pri. Information regarding interleaving is covered in most transformer texts so I won't elaborate further here. Since these winding techniques all evolved to generally reduce the stray capacities and losses affecting the final product they all have a direct bearing the final sound. Layer winding generally requires more skill and materials than bobbin winding. The more interleaved layers, the more connections, and more to go wrong during the winding process. Hence a higher price tag.

Wire:

Most wire for transformers have traditionally used copper wire. Some new more esoteric companies market transformers with silver wire. While silver wire has about 8% less resistance than a similar piece of copper wire, manufacturers in the past have found that the improvement was not great enough to justify the expense. If an 8% decrease in resistance equaled an 8% improvement in the perceived sound of the final product perhaps we would see more silver wired units. That is not the case. The 'improvement' sound wise when using silver wire was non existent in my experiments, your mileage may vary but the use of silver wire is mostly a marketing tool...

The insulation used on the wire does make some difference in the final sound. Since transformers share some of the same anatomy characteristics as a common capacitor, the type of di-electric insulation that is coating the wire helps determine the amount of stray capacities introduced in the winding. The newer poly type insulations are di-electrically superior to the older enameled wire, and the enameled wire was di-electrically superior to the cloth covered wire of the early transformers. The irony here is that some of the early WE transformers that used plain silicon cores and silk covered wire are currently fetching automobile prices in the marketplace. Do they really sound that much better than the new 'improved' types? Preferred sound is in the ears and mind of the listener. If specifications don't

Wire continued:

lie the improved materials made better transformers. Some wire insulation coatings not only provide di-electric insulation but they also are formulated to sort of evaporate when touched by a soldering iron so they do not have to be stripped when soldering connections. This is especially useful when working with very small gauge wire like the type associated with high ratio transformers. The original winding sheets for many Neumann transformers specified solderable wire.

Old wire or new wire? Electrical copper is very pure. Wire that was manufactured before most manufacturing moved to Asia is generally excellent wire. Wire coming from Asia today can be excellent but it can also be inferior so beware. Some audiophiles swear that the older the wire, the better the sound, but I don't subscribe to that. The manufacturing process for purifying copper got better over the years so I do not believe that early wire was sent from the gods. Most electrical copper today has recycled old copper in it anyway.

Insulation Materials

The first the insulation wrappings between layers or windings in a transformer were made from paper or sometimes even cloth on very early units. Later, paper impregnated with wax and other substances were employed. During the 50's and 60's some companies started using acetate type paper in between layers and used heavier paper for separating the windings and covering inter winding shields. Newer transformers usually use some form of poly tape and poly wraps. When Peerless wanted to place a serious di-electric separation between the primaries and secondaries of the famous input transformers of the 50's, they used sheets of Teflon with many wraps between the various windings (a paper on these transformers available at VintageWindings.com). Again, because all of these wrappings have varying degrees of di-electric properties, they all affect the distributed capacities and therefore the sound of the final unit. There is no 'best way' approach here and sometimes compromises are made because of manufacturing capabilities, price point or material availability.

Inter-Winding Shields

Many transformers use copper shields between the primary(s) and secondary(s). This is usually done to reduce the interaction of the pri and sec due to proximity to each other in a coil. The shields are usually a thin piece of copper sheet wrapped once around the coil with a littler overlap. They are attached to a ground when the unit is installed. While these inter winding shields may or may not effect the sound directly they have an effect on noise in the unit which can be argued into a sound benefit. As far as their inclusion into a product, they are another stage of assembly, more connections, more materials, more cost in the final unit. Sometimes they are absolutely necessary to a design, other times they should not have been used. Many web discussions dissolve to chaos discussing this topic.

Case Shielding

While shielding the case really doesn't effect the perceived sound of a transformer it can keep other exterior extraneous noise producing EMI from entering a transformer in a circuit. Once again this could be argued into being a sound advantage. In the vacuum tube era these shields were critical and many transformers of the day had three or more shields surrounding the coil. Vacuum tube equipment is notorious for having huge, noisy power supplies and rectifiers that were often placed in the same racks as the gear they were powering. Those racks were often next to a radio transmitter so there so there were multiple sources for extraneous noise in early broadcasting chains. Today much of the relatively low frequency rectifier noise and very powerful power supply noise is gone but it has been replaced with much higher frequency interference from our digital world. Most transformer manufacturers today include one mu metal can shield and most engineers consider this adequate shielding on a modern transformer. You get around 30db in noise reduction per shield. There is a great Western Electric booklet on shielding audio transformers during the 40's available at my web site VintageWindings.com.[5]

The industry standard three case shield usually consisted of a large exterior case, many times it was made of mu metal but sometimes it was just plain steel. Inside of that case was a copper sleeve and a third mu metal case surrounded the coil and was nestled in the first two cans (See the Handbook for Sound Engineers for more info). Some companies used more than three shields so shielding was a very real concern back in the day.

You may notice that modern transformer cans look different from the square cans of yesteryear. That is because in the 50's it was realized that the abrupt 90º bends in transformer shield cases were leakage points for EMF. It was found that drawn cases with rounded corners were more effective at keeping stray EMF from entering or exiting the coil. Mu metal also losses much of it's shielding properties after it is worked and has to be re-annealed after working to bring it back to it's full shielding potential. (Note: this also occurs when magnetic transformer laminations are accidentally bent, they lose some of their permeability and have to be re-annealed to reacquire their original specifications.)

Size

I left this one until last because it is one of the more controversial subjects involving transformers. This is where I think that modern transformer manufacturers miss a potential market place. There are many audio people, myself included, who think a transformer should be as large as practical. Large to the point of overkill. There are some very good engineer's who feel the same way, Rein Narma (Fairchild 670) spoke of the advantages of large transformers in an AES interview. One of the reasons that some people talk of the big fat 'tubey' low end of some tube audio units is that smaller transformers saturate at low frequencies and have negatively affected the public's perception of tube powered low end. When using large transformers that comfortably exceed power handling needs of the subject unit, the sound passing through the transformer sounds decidedly free of constraints. The sound just seems to sit in the middle of a big open space. This notion is obviously subjective, but there are many subjects who feel this way. Today, due to the availability of high Ni alloys and such, transformer size is considerably reduced from what it was even in the 60's. If you look at the actual power handling on the specification sheets for these small newer designs you'll notice that the power handling capabilities are in keeping with their earlier larger counterparts, regardless, these new materials will saturate with enough input and the sound gets ugly fast. When it comes to manufacturing, size almost always succumbs to cost and if a smaller unit will work to spec. (officially) the management will always opt for cheaper production option.

Conclusion:

In the final analysis, the reputation of the 'sound' of a good transformer can develop over time due to it's use in a circuit that happens to be a well engineered, good sounding circuit. It may be the proper use of brand X transformer in brand Y's circuit and a magical audio tool, Z appeared. All of the for mentioned winding techniques and materials directly effect the performance of an audio transformer in a given application. There are other design factors like a transformer's natural resonance, etc. that also have to be taken into consideration but a detailed explanation those details requires another text.

References:

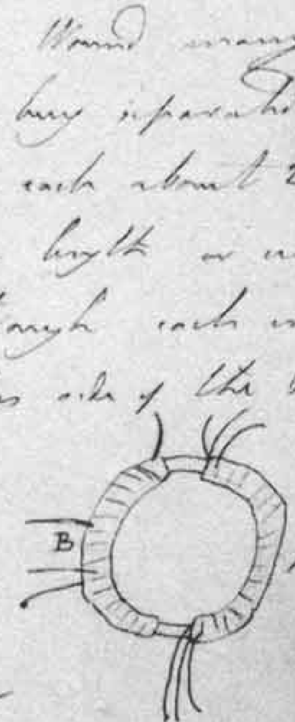
1. 'Saga of the Vacuum Tube' by Gerald Tyne p.113 This book is required reading.
2. Many early inductors were simply a rod of steel with wire wrapped around it. Toroids were the first practical coils utilizing the principles of induction. The use of toroids exploded with the expansion of Western Electric and the Bell System where hundreds of thousands of coils were put into service. For more info please refer to 'A History of Engineering and Science in the Bell System' by the Bell staff. It's another great book.
3. 'Journal of the Society of Motion Picture Engineers' Sept. 1944 Vol 43 #3 'High Quality Communication and Power Transformers' by E. B. Harrison (Altec corp.) This is an excellent paper and is available on Vol 1 of my Audio Transformer & Design DVD series available at VintageWindings.com.
4. A good explanation of BH curves resides in a publication by the Allegheny Ludlum Co. from 1947 called 'Magnetic Materials'. This is a really cool art deco pub and it's available on my Audio Transformer Design & Construction DVD Volume 2 at VintageWindings.com.
5. http://www.VintageWindings.com/tech swag/Bell Labs Papers.html
6. http://www.sowter.co.uk/pdf/GAVS.pdf
7. http://www.lundahl.se/pdfovrigt/design_philosophies.pdf

Vintage Windings®

Aug 29th 1831

Expts. on the production of Electricity from Magnetism &c &c

Have had an iron ring made (soft iron), iron round and 7/8 inches thick & ring 6 inches in external diameter. Wound many coils of copper wire round one half the coils being separated by twine & calico — there were 3 lengths of wire each about 24 feet long and they could be connected as one length or used as separate lengths. By trial with a trough each was insulated from the other. Will call this side of the ring A. On the other side but separated by an interval was wound wire in two pieces together amounting to about 60 feet in length the direction being as with the former coils this side call B.



Charged a battery of 10 pr. plates 4 inches square. Made the coil on B side one coil and connected its extremities by a copper wire passing to a distance and just over a magnetic needle (3 feet from iron ring). Then connected the ends of one of the pieces on A side with battery. Immediately a sensible effect on needle. It oscillated & settled at last in original position. On breaking connection of A side with Battery again a disturbance of the needle