06 MAY 2015

Category: Advanced

Tags: antique phonograph society, brunswick, cabinet finishes, diaphragms, phonograph, records, shellac, sound box

The Origin & Many Uses of Shellac by R.J. Wakeman

The Origin & Many Uses of Shellac
By R.J. Wakeman

Recently as I was holding a copy of Amelita Galli-Curci's "Dov'e L'Indiana Bruna" from *Lakme* (Victor #74510), I marveled at what an amazing object this Victor Red Seal is. With the shiny black shellac and handsome red and gold label, the record appeals to the eye as well as to the ear. Concealed within the spiral grooves are the ringing tones of the famous diva–a captured moment in time. As an old piece of "software," to use a modern term, the record is made of finely ground rock, carbon black, and cotton floc held together in a shellac matrix.

Shellac phonograph records were produced in great quantities for fifty years–from the late 1890's to the late 1940's. Shellac finishes for fine wood furniture have been used for five hundred years or more. Shellac has also had many other uses over the years and is still used today.

What is shellac? Is there a real connection with an insect? Chemically, shellac is a high molecular weight resin containing small amounts of red dye and wax. Shellac resin can be a variable compound and is a complex mixture of aliphatic and alicyclic hydroxy acids and their polyesters. The major component of the aliphatic fraction is aleuritic acid; the major component of the alicyclic fraction is shellolic acid. In crystalline form shellac forms brittle, yellowish, semi-transparent sheets with the melting point between 239 – 248 degrees Fahrenheit. Shellac is 85 to 95% soluble in alcohol; it is insoluble in water unless the water contains dissolved alkalis or borax. (20) Shellac is the only known resin of animal origin.

Depending on the supply and demand, the price for crude shellac has been very volatile over the years. Before World War I the price hovered around 20 cents per pound, but war requirements escalated the price to 74 cents, dropping to 54 cents by May of 1917. Shellac was used for making munitions, insulating electric wires, and forming emery wheels. Despite this and general material shortages created during the war, U.S. phonograph companies made no big increase in the prices of their phonograph records.(33) The Henry W. Peabody and Company of New York City claimed to be the largest importer of shellac into the United States and to supply shellac for all the major record manufacturers.(35) However, the William Zinsser and Company of Somerset, New Jersey, claimed to be the world's largest shellac firm; they had been importing shellac since 1850.

An article in the December 1919 issue of the Talking Machine World stated there was a crisis in the supply of shellac coming from India.(34) The Kushmi crop for the fall season was only one quarter of normal. For 1919 of the total shellac exports from India, 44% went to the United States, 29% to the United Kingdom, 8% to Japan, and 5% to the Philippines.(36)) This crisis occurred just as the Brunswick-Balke-Collender Company was ready to announce and advertise new lateral-cut shellac records in January of 1920.

By January of 1921 the shellac production in India was near normal, but due to the general business slump the demand for shellac for phonograph records was down, resulting in falling prices.(38) At this time 85% of the shellac market in the United States was used by the phonograph industry. In 1921 it is estimated over 36 million pounds of shellac was exported from the port of Calcutta alone with nearly as much from all other Indian ports combined.

Today India and Thailand are the main producers of shellac. India produces 50% of the world's supply. Over 90% of Indian lac comes from the states of Bihar, Madhya, Pradesh, West Bengal, Maharashtra, and Orissa. This includes the regions from Bombay (Mumbai) in the west, through the central plains, to the north at Bihar, and to Calcutta in West Bengal and Orissa on the central east coast.

The collection, processing, and use of lac resins probably predates recorded history. It is one of the oldest known resins.(23) Greek and Roman writers were aware of it. In his encyclopedia of 77 AD, Pliny the Elder described the "amber" that came from India. The term "shellac" has Hindi and Persian origins and alludes to the number 100,000, referring to the vast number of tiny insects needed to infest a tree in order to produce the lac resin.(1) By the late 1400's European craftsmen were attracted to shellac as a finish for wood cabinets because of its gloss. The East India Company helped to introduce and distribute

shellac into Western Europe. Seventeenth century furniture makers used shellac because of its beauty, durability and ease of application. By the 1800's shellac was a standard protective finish.

Shellac Records

Emile Berliner's first disc records were pressed in celluloid (1894) followed by the use of vulcanized rubber (1895).(36) In 1896 Duranoid shellac records were developed and became the standard medium.(11) The formula used for making shellac records varied from firm to firm and from decade to decade; it was usually a company secret. The shellac component represented approximately five-eighths of the material used for the better quality records.(33) Essential components would include shellac, ground rock, carbon black, and cotton floc.

Record collectors have noticed the early shellac records pressed by the Gramophone Company in England tend to have smoother surfaces than most United States pressings, perhaps due to the fineness of the ground rock or to more and better quality shellac in the matrix. In the early years Britain controlled the supply of shellac coming from India and other parts of the Empire; the Gramophone Company had access to the best quality shellacs.

Several ground rock types were commonly used in the shellac matrix including limestone, rottenstone, barytes, slate, quartz, or pumice.(16) Usually only one or two rock types was used at a time. Limestone is calcium carbonate and is formed from the slow deposition of shells or corals in warm seas. Marble is finely crystalline limestone and is capable of being carved and polished. Rottenstone (also called tripoli) is the friable silicaceous material left after the calcium has been slowly dissolved from limestone by the action of water. Barytes (also called barite or heavy spar) is barium sulfate and can be found in large deposits often resembling marble. Slate is a soft dense rock that readily splits into thin layers; it is a form of shale. Quartz is silicon dioxide, the major component of sand. Pumice is powdered volcanic glass. China clay, kaolin, Fuller's earth and talc are not hard minerals but were sometimes used as fillers. China clay is hydrous aluminum silicate and has a "slippery" feel. Kaolin is white porcelain clay and is derived from the decomposition of aluminous minerals, especially feldspar. Fuller's earth is similar to potter's clay but less plastic. Talc is a magnesium-silica compound. Various iron oxide minerals were used in some formulae and were usually derived from limonite, hematite, or magnetite. The Keystone Minerals Company of 41 Union Square in New York City frequently advertised rottenstone; the company claimed to be the only manufacturer in the United States of rottenstone for use in phonograph records and that their product was used by practically every record manufacturer.

Figure 3. Advertisement from "Talking Machine World" March 1917, page 27

They also sold other minerals for use as fillers in phonograph records. For a time the Pathe Freres Phonograph Company used ground slate as part of its record matrix. (24)

Carbon black (also called lamp black) was used for black pigments. It is soot residues from the partial combustion of various materials, usually gas, oil, tar, or rosin; it forms dense black pigments. Some manufacturers used wood charcoal or the black organic dye, Nigrosin, as the source of black pigments. Shellac records were mostly black because it is easier to view the grooves. Reflected light from the record grooves can indicate sound quality. A fuzzy reflection may be due to rough walls

which can cause more surface noises. Worn records develop grooves in shades of non-reflective gray. Recording studios were usually equipped with a special microscope for detailed examination of the record grooves under a strong light. (7)

Finely desiccated cotton floc was used as a binder in the shellac matrix. The Claremont Waste Manufacturing Company of Claremont, New Hampshire, continually advertised cotton flocs for record manufacture; the company guaranteed uniform quality and offered free samples. Some manufacturers substituted asbestos, wood fiber, or animal fiber for the cotton floc. (28,29,32)

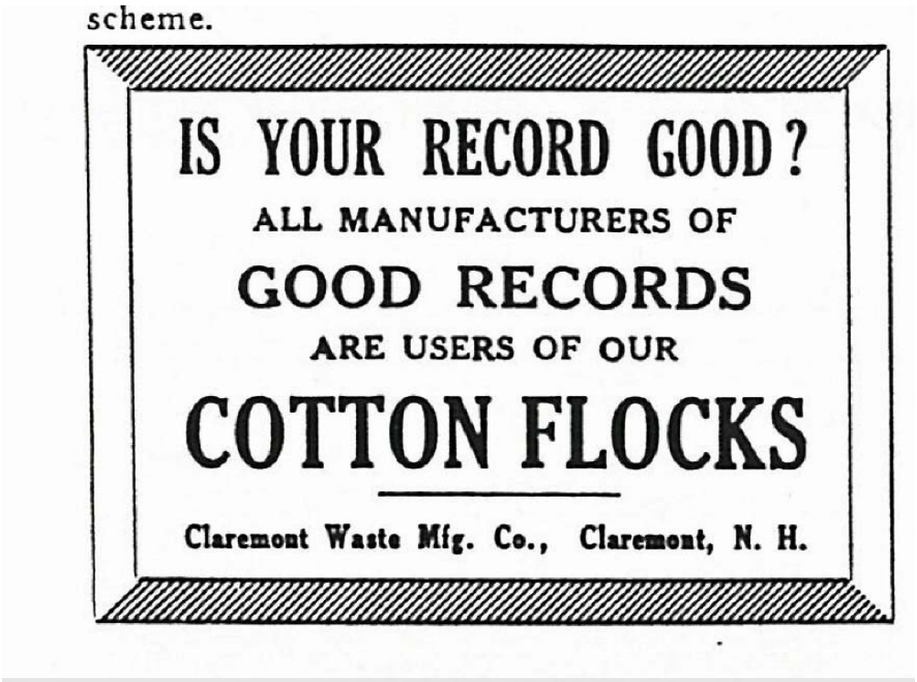


Figure 4. Advertisement from "Talking Machine World" September 1921, page 135

Advertisement from "Talking Machine World" September 1921, page 156

Abrasives were frequently added to the record matrix to help wear the point of the needle to conform to the shape of the record grooves. Crocus powder (iron oxide) was one; it is a mild abrasive also used to polish glass and metal.(9,28) Carborundum (silicon carbide) was another; it was also used to grind the outer edge of new records to form a trim, clean edge. (10,31,32) A harder abrasive was corundum (aluminum oxide) and called emery in the gray/black powder form.

Some organic compounds, such as naphthol, when included in the

shellac matrix could make the records stronger and less brittle.(10) Zein, a simple corn protein similar to gluten, was used in some formulae. Casein, a phosphoprotein found in milk and nuts, was sometimes included. Casein treated with alkali and hardened with formaldehyde forms a hard, insoluble plastic. Waxes were frequently added to the shellac matrix to aid in the stamper release. The firm, hard wax from the Candelilla plant (Euphorbia antisyphilitica) was the preferred wax; the plant is native to the south-western United States and Mexico. Ceresin wax, derived from ozocerite minerals, was also used as was Montan wax, a high melting wax derived from coal tars.

Records made from pure shellac would make them brittle and easily worn. Records made with too finely ground mineral fillers would also increase brittleness.(6) The mineral material—ground rock—needs to be of the right size to give strength and body to the record while maintaining the integrity of the pressed grooves.(16) In his article, “The Phonograph Needle” (*In the Groove*, Volume XVII, Issue #5, May 1992), Mr. George Copeland takes us into a record groove for a walk along the bottom. It is the abundant and close-fitting ground rock that mostly lines the walls and protects the grooves. It prevents the heavy needle from removing the shellac matrix, which holds the rock pieces in place. The rock will wear before the shellac wears. Poorly made records can have grooves with rough walls and protruding rock pieces. With laminated records the hard filler gives strength to the record, thus the rock for the shellac surfaces could be more finely ground, making smoother groove walls.(6) In early 78 rpm shellac records, the groove had an average width of 0.006 inches (0.015 centimeters) with a bottom radius of 0.0025 inches (0.0065 centimeters).(18) Due to the poor quality of the materials used to form the records, some dime store brands (Arto, Banner, Clover, Globe, Madison, Van Dyke, etc.) seem unduly brittle, wear more easily, and can have more surface noises.

These records can have a rough, unevenly-pressed appearance. It was a common practice by some record companies to grind returned and unsold discs and use this scrap material as part of the record matrix for pressing new records.(18)

There are numerous descriptions of the methods used for recording and pressing shellac records. (8,28,31,32,43). To mold shellac records, powdered shellac, ground stone, carbon black, and cotton floc were measured by a formula and mixed in a revolving drum or Banbury mixer.(16) The shellac needed to be finely ground for thorough mixing with and coverage of the other components. High quality orange shellac with low wax content and few impurities was the standard.(16) One

report states the shellac was ground to 80 mesh, the fillers to 200 mesh, and the coloring matter to less than 0.4 micron in size. The mixture was steam heated, causing the shellac to melt and form a thick dough which was then passed onto heated rollers and formed into a long roll. The roll was cut into sections (called “biscuits” in some factories) with adequate material to form a 10 or 12-inch record.(8,31) The usual number of pressings from a negative matrice (stamper) was around 1,000, but at times as many as 7,000 could be made. The first few pressings were usually discarded as the following pressings were of better quality. (24,31) Record labels were not usually glued in place, but were placed over center pins of the press just before the warm shellac mixture was formed into a record by the hydraulic press. The label was held permanently in place as the newly-formed record cooled and solidified.

Record pressing factories were usually messy and noisy with dust everywhere. There were cutters, conveyers, drills, furnaces, grinding mills, lathes, pressure pumps, revolving drums, steam boilers, steam pipes, water pipes and hydraulic presses. There were bags or bins of the various components along with packages of unused record labels and a pile or two of rejected discs. Rejected records were sometimes ground and used as the fill inside laminated discs. In early years many pressing plants had their own dynamo to generate electricity. Some factories used a magnetic separator to remove metallic particles from the tumbling dry ingredients.

The making of a phonograph record was a complex process. Any number of problems could occur from initial recording to pressing of the record. In early years there was no standardization of groove shape between different brands and even between recording sessions. While the groove for lateral-cut records was assumed to be “V” shaped, many were actually “U” shaped, a condition which could cause more surface noises.(43)

The per unit pressure at the point of the needle is very high.(6) If the weight of a reproducer and tone arm weighing 0.25 lb is focused at the point of a needle which occupies 1/3600 of a square inch, the pressure is equivalent to 900 lbs per square inch!(5) This is coupled with the dynamic action of the needle as it travels through the record grooves. Although having a reproducer with a compliant diaphragm mounted between two rings of soft gaskets can be essential, needle wear is most often determined by the components and quality of the materials used to make the record.(27) Since records were pressed by the thousands and were considered more or less disposable items, there was often no real concern by the average listener to avoid wear to a record. Concert and opera records, however, were usually considered family treasures and were protected and kept in albums or paper envelopes. When a shellac record is cracked it is easy to see, but a hairline crack is not. If a record “buzzes” when it is gently tapped, this indicates a small crack. Lamination cracks, common to the laminated Columbia discs, are not usually serious and are tolerated by most collectors. (14)

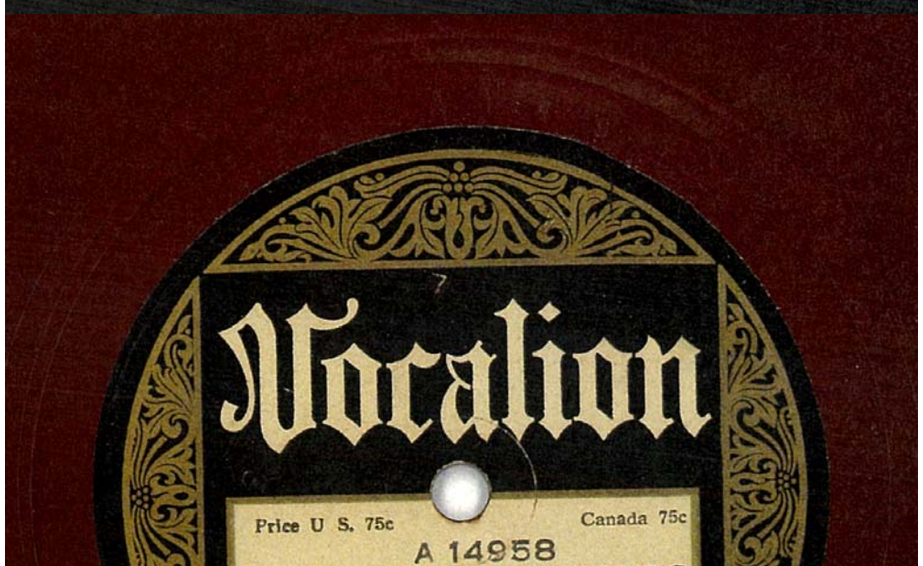
A single record cost approximately twenty cents to manufacture and it

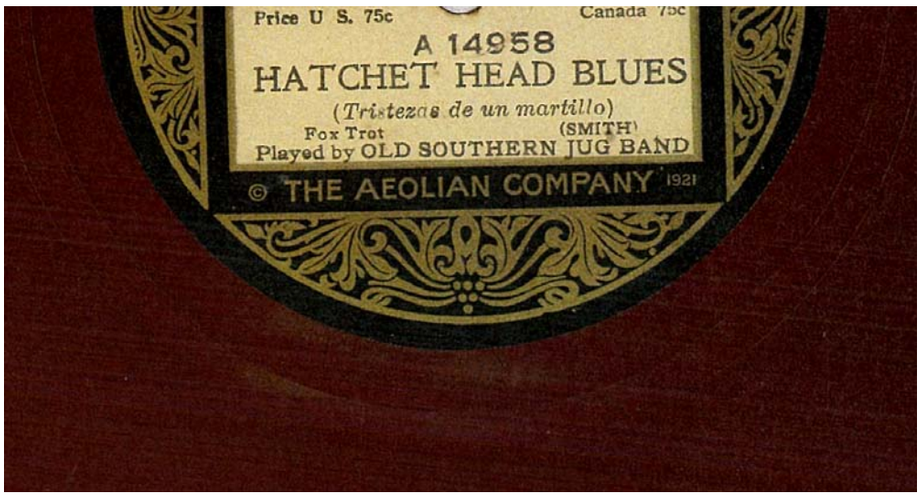
was estimated the sale of five thousand records effectively covered production costs. Sales above that figure were mostly profit.

Most shellac records were single sided until around 1904 when the Beka and Odeon companies in Germany began to regularly press double-sided records. In 1908-09 double-sided records became the standard for the major United States record companies. For prestige value, however, the Victor Talking Machine Company kept the concert and operatic Red Seal records single-sided until September of 1923. Despite depressed business conditions in early 1921, this was one of the best years for sales of phonograph records in the United States; retail sales reached $105.6 million.


PATHÉ FRÈRES PHONOGRAPH CO.
SAPPHIRE RECORD
TRADE MARK
REG. U.S. PAT. OFF.
GRAND PRIZE
PARIS 1900 HANOI 1902
MILAN 1906 LONDON 1908
NEW YORK
LONDON-PARIS
PAT. NOV. 25 1902
One Step
B
22367
OLD MAN JAZZ
(Quaw)
WEBB'S NOVELTY ENTERTAINERS
COPYRIGHT
Pathé


THE RECORD OF MERIT
OKEH
RECORD
1156-B
ONE STEP
OLE MISS
(Handy)
NEW ORLEANS JAZZ BAND
OTTO HEINEMAN PHONOGRAPH SUPPLY CO. INC. NEW YORK CITY.


Vocalion
Price U. S. 75c
Canada 75c
A 14958



On October 30, 1922, the Columbia Graphophone Company announced and advertised “New Process” records with three-ply construction and with “...the surface material so fine in texture that it virtually eliminates all record surface noises.”(39)

The body of the record was a hard mineral which on both sides was paper coated and covered by a layer of high grade shellac.(19) The new laminated records were widely proclaimed. Columbia dealers were provided with window posters in full color. A demonstration record featuring Columbia artist Ted Lewis was produced and sold for only 25 cents.(40) Many collectors consider the smoother surfaces of these records to be superior to that of the solid stock records. The laminated

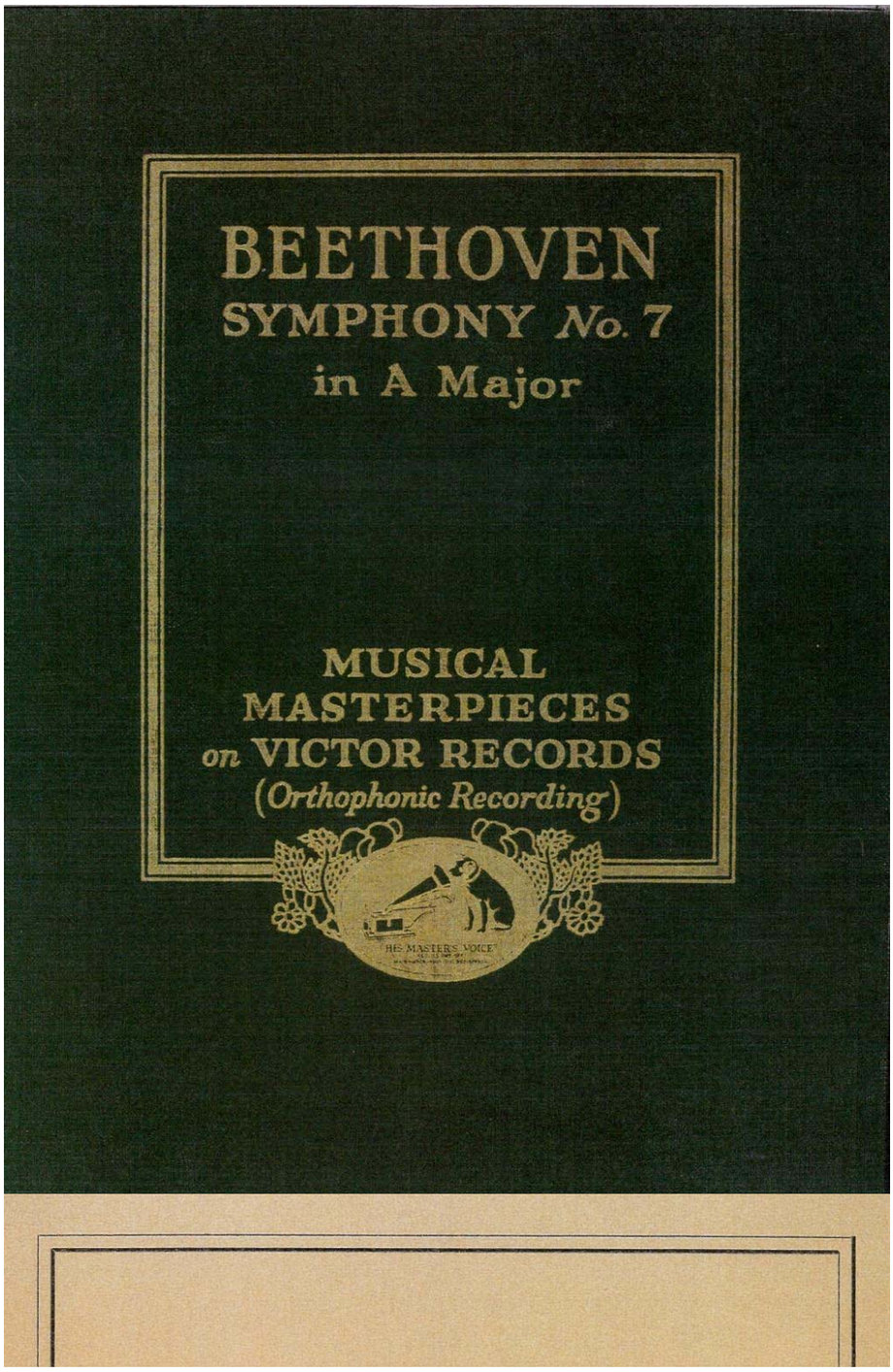
records were very successful when pressed from masters recorded by the new Western Electric recording process starting in mid-1925.(26) However, many collectors have noticed the smoother surface Columbia discs tend to wear more easily than solid records.

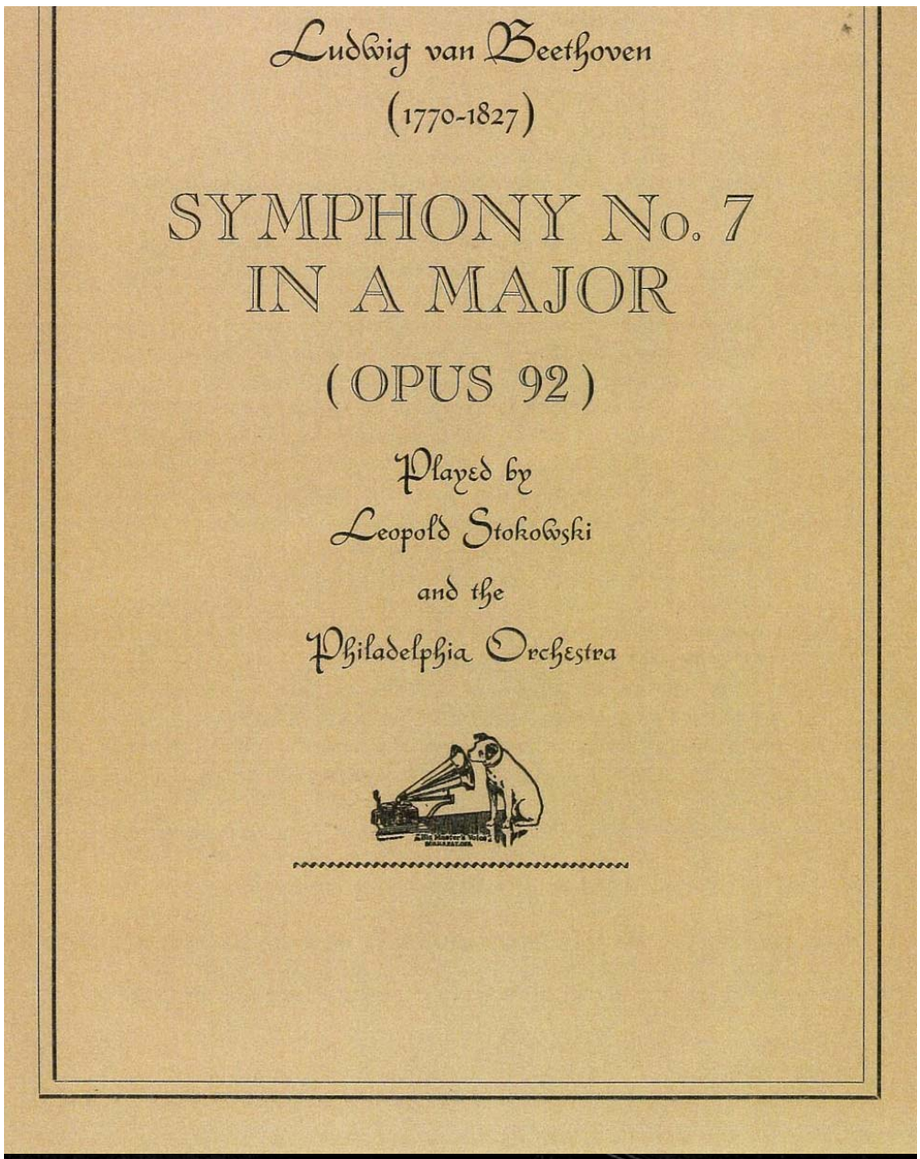
Electrically recorded records had been developed by the Western Electric Company in the late 1910's. The new method utilized an electronic microphone, a radio amplifier (with vacuum tube amplification), and a horseshoe magnet recording head. In early 1925 Western Electric licensed patent rights for the new electrical recording method to the Victor Talking Machine Company and the Columbia Phonograph Company. The new electrically recorded records had not only more volume but much expanded fidelity. With the acoustic recording method it was difficult to capture sound waves below 250 cycles—just under middle "C" on the piano. The new Western Electric recorders were designed to operate over a range of frequencies from 30 to 5,500 cycles. Processes driven by vacuum tube amplifiers have many times the force of the sound energy collected by horns. The new electrically recorded 78 rpm shellac records were first issued around May of 1925, although new much-improved mechanical and the first all-electric phonograph models designed to play the new records did not appear on the market until late 1925. The Brunswick-Balke-Collender Company also introduced electrically recorded records by using the light-ray recording method which had been developed by the General Electric Company for recording sound on film. With the introduction of electrically recorded records the standard V-shaped record groove of 3 mils bottom diameter became more or less universal for most companies recording and pressing lateral-cut 78 rpm shellac records.

To indicate that records had been recorded by a new process, each new Victor record had a small "VE" (Victor Electronic) pressed into the

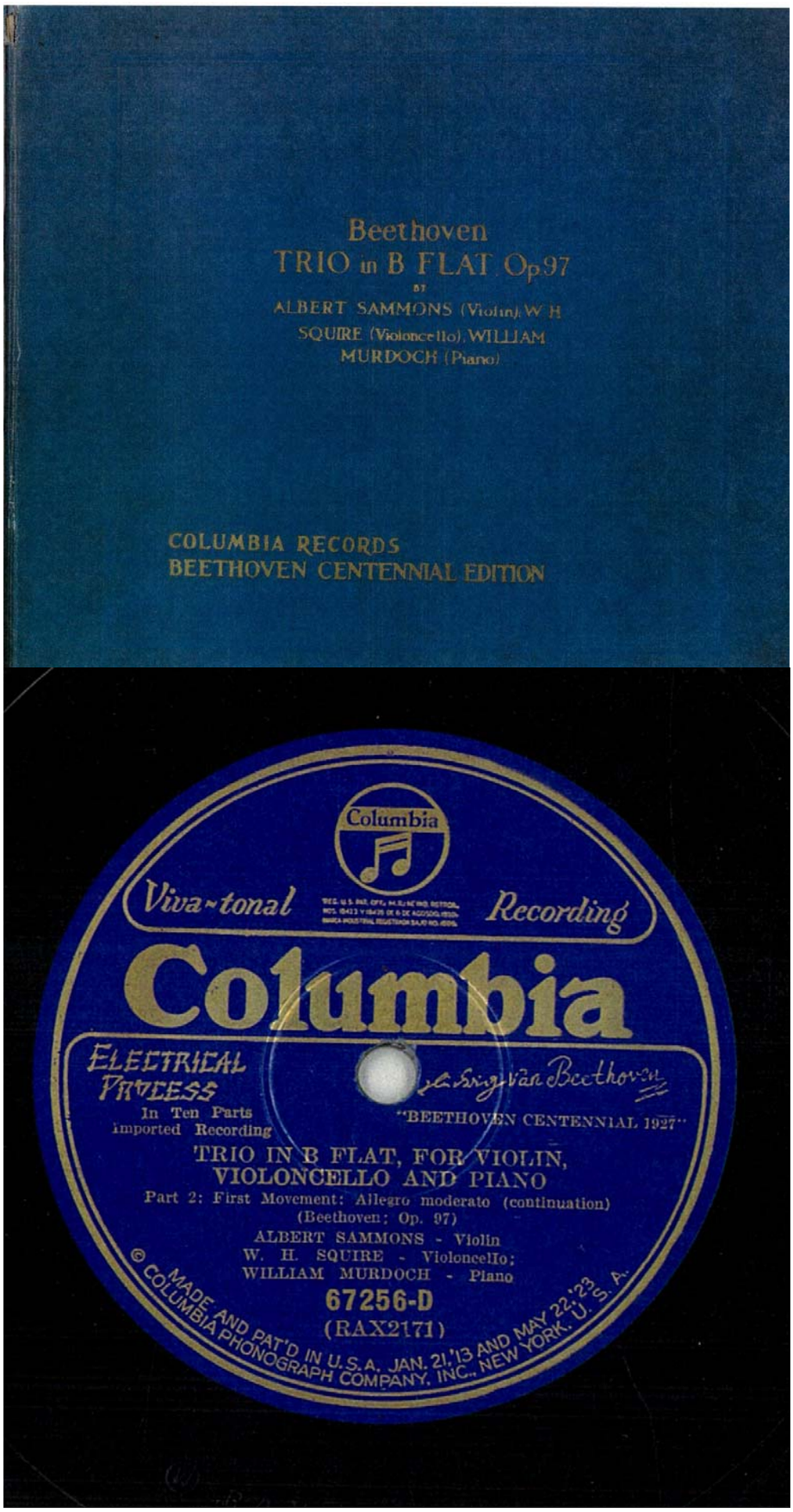
shellac between the inner record grooves and the record label. The new Victor records also had the last inner groove as an eccentric circle to activate the shut-off mechanism of the new Orthophonic Victrolas. Somewhat similarly, the new Columbia records had a “WE” within a circle pressed into the shellac to indicate the use of the new Western Electric recording method.

With the advent of electrically recorded records it was possible to adequately record full symphonic orchestras; it was no longer necessary to crowd a small orchestra around a recording horn. For the first time an orchestra sounded like an orchestra. Orchestral works were on 12-inch records and came in handsome record albums, most containing three to six records. Victor began to release classical album sets starting with album M-1 and continued the “M” series well into four digits before the demise of shellac records in the late 1940’s. Leopold Stokowski, principal conductor of the Philadelphia Orchestra, worked extensively with Victor’s engineers to develop the best methods for microphone placement, seating arrangements, sound reflectors, etc. A new type of record collector appeared—the listener primarily interested in the symphonies, concertos, complete operas, and chamber music of the great masters.





Another crisis occurred when the June-July 1926 shellac crop in India was low, causing shortages and rising prices in 1927.(22) March 20 to 26, 1927 marked the hundredth anniversary of the death of Ludwig von Beethoven. Several phonograph companies used this opportunity to celebrate the event by releasing new recordings of Beethoven's symphonies.



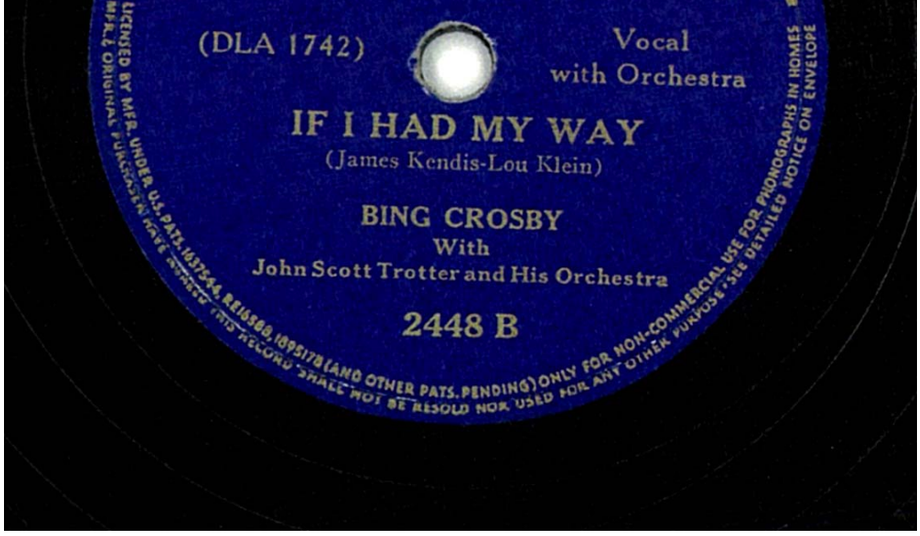
With the stock market crash in October, 1929. and the national economy rapidly in decline, the phonograph and records industry was hit as if a garden in full bloom had been struck by an Arctic blast,(12) 1931 and 1932 were doleful years for phonographs and records in the United States. In 1932 only six million records were sold; six percent of the total record sales in 1927. Radio, however, continued to prosper. Radio entertainment was reaching a high professional level and it was free at a time of massive unemployment and diminishing wages. It was no longer necessary to buy the latest dance records; they were played almost continually on the air waves. In these hard times the public even developed an anti-phonograph sentiment. Still, the major record companies struggled for survival. Victor and Columbia maintained their name brands at seventy-five cents for popular records, but introduced

the less expensive subsidiary Bluebird and Okeh brands, which sold for thirty-five cents. The American Record Corporation kept their Brunswick flagship label at seventy-five cents but sold the Melotone, Perfect, and Vocalion brands for twenty-five cents. Despite economic conditions, the asking price for most 12-inch classical records was maintained at two dollars.

In December, 1928, the first radio transcriptions were used for radio broadcasting. Early transcriptions were standard electrically-recorded 12-inch shellac discs played at 78 rpm. By the 1930's transcriptions were recorded at 33 1/3 rpm, which gave a longer playing time and recorded discs were increased in size to as large as sixteen inches in diameter.

The shellac-based discs were soon replaced with smoother and less-noisy vinyl transcriptions played with a semi-permanent jewel stylus mounted at the end of a long tone arm.(21)

In September, 1934, a new record company made its debut on the American market, Decca Records. In England, the Decca Record Company, Ltd., decided to establish an American branch. The policy of the new company was that good records need not be expensive; the plan was to offer the biggest personalities in popular music at thirty-five cents a record or three for a dollar.

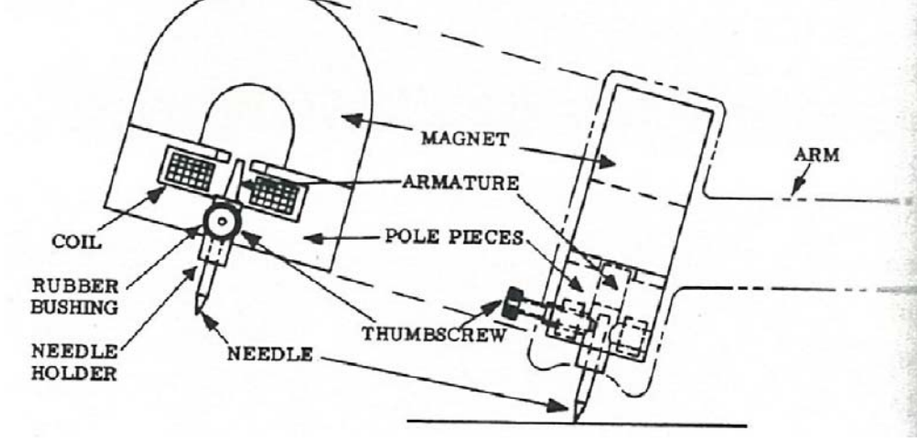


Decca also planned to undercut competition for the jukebox business by offering records for only twenty-one cents each. With a jukebox in every bar, drug store, and malt shop, a large percentage of record sales went for jukebox use; by 1936 this amounted to forty percent of all records produced in the United States.(30) During the 1930's RCA Victor used a tiny "z" in the run-off area of some records to indicate the use of high quality shellac. These records have noticeably smoother record surfaces.(13)

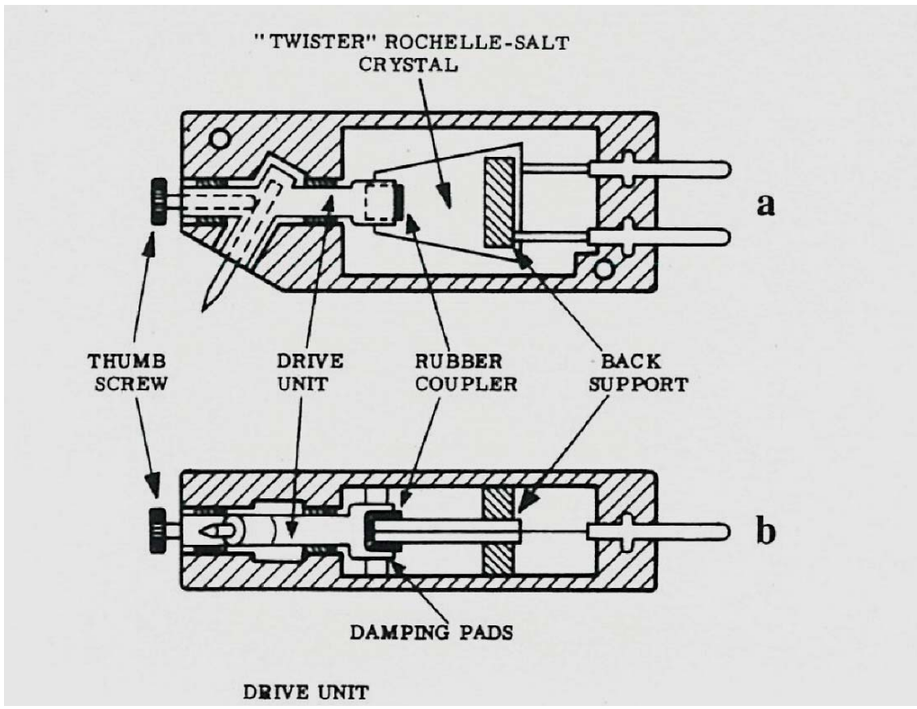
Needle Wear

To start a lively conversation among a group of collectors, just mention steel needle types. Everyone has a favorite type or brand. When a needle enters the groove of a 78 rpm shellac record the needle point should quickly abrade to fit the record groove. The needle should be good quality steel and not leave chunks of metal in the groove or wear unevenly. Poor quality needles often do not have uniformly sized points.(6) The final step in the manufacture of steel needles was to place a large number of needles in a small rotating barrel with a fine abrasive powder until the desired polish and point size were attained. (18) The ideal needle should have a gradual taper from the needle chuck to the tip of the point; some medium volume needles have this shape. Soft volume needles have a gradual taper but are a straight shaft for most of the length of the needle. Loud volume needles are thick and usually have an abrupt taper at the point. The best sound and least record wear occur when most of the flexibility of the needle shaft is at or near the point of the needle.(6) As the needle travels through the record grooves it gradually forms a flat area. As the flat area grows larger it can begin to act as a cutting edge and damage the record grooves. Use a steel needle to play only one or two sides of a 78 rpm shellac record; it then needs to be changed. Packets or tins of old but unused needles are still good to use. To determine if a steel needle has been used, manually rotate the point of the needle in a strong light, observing the tip at various angles. If the needle is used (and not rusted) the flat area will flash light into your eyes.

All-electric phonographs (with an electric turntable, vacuum tube amplifier, and electronic speaker) first appeared on the market in late 1925; they utilized a heavy horseshoe magnet pickup that still required changeable steel needles.

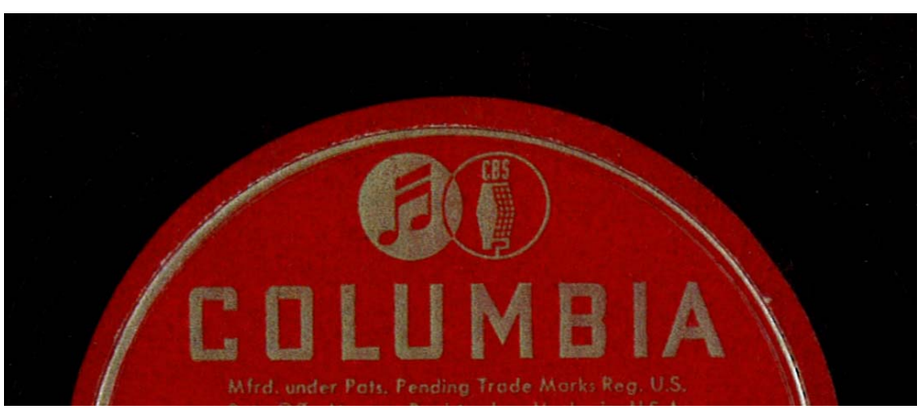


Unfortunately the heavy pickups also accelerated record wear.(18) In the 1930's light-weight crystal pickups were developed. Rochelle salt crystals (potassium-sodium tartrate), which have an asymmetric crystal structure, produce an electric potential when pressure is applied to the crystal—called the piezoelectric effect. The electric potentials produced are almost in direct ratio to the changes in pressure, thus a needle or stylus can be mounted onto the crystal and the electronic impulses generated sent to a radio amplifier.



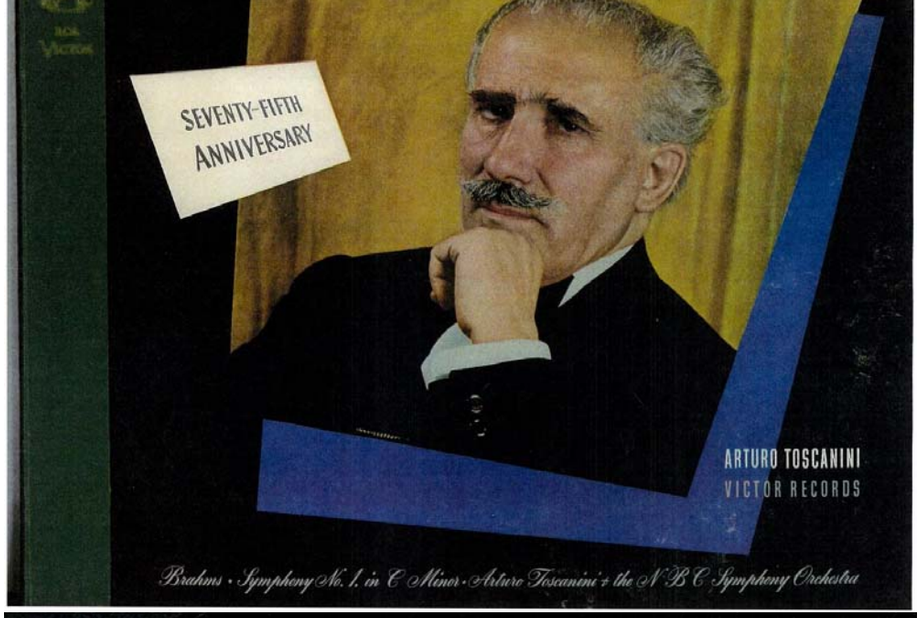
RCA Victor introduced the first crystal pickup phonograph models in 1936. In addition to being light weight, the crystals were inexpensive and convenient to install. They also permitted the use of semi-permanent sapphire and diamond styli and softer shellac records. Layers of thin quartz crystals can produce similar electric potentials. Later certain ceramics formed with metallic oxides were developed to have greatly improved piezoelectric properties.

In December, 1938 the Columbia Broadcasting System (CBS) purchased the American Record Corporation. This sale provided CBS with recording, pressing, and distributing facilities second only to RCA Victor.

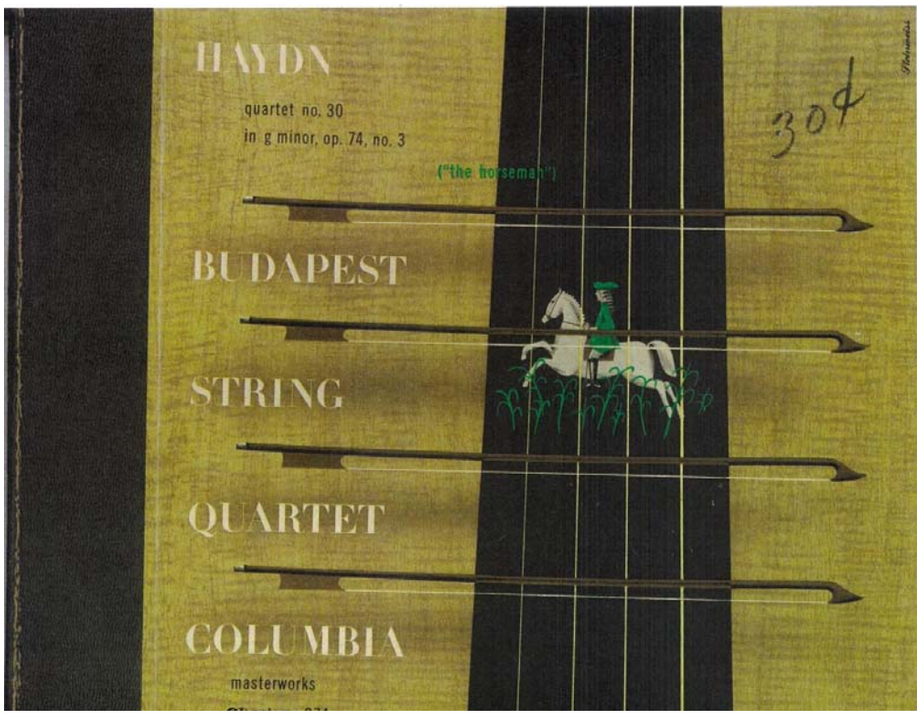


CBS formed the Columbia Recording Corporation and re-introduced 10-inch Columbia records (dormant since 1936) and at fifty cents a record for popular tunes, it soon became a major brand with the familiar red label. Columbia discontinued the Brunswick and Vocalion labels in 1940. In August 1940, without advance notice, Columbia reduced the price of 12-inch classical records to one dollar; RCA Victor had no recourse but to do the same.

This made 12-inch classical records available at a popular price. It was possible to purchase classical record albums in two forms. With the proliferation of home phonographs with an automatic record changing mechanism, albums could be purchased with the record sides arranged in series so that a stack of records could be set in place and automatically played; it was not necessary to turn the record stack over until the last record had played.



This contrasted with older phonographs which required each record to be manually turned over for sides 1 and 2 on the first record, sides 3 and 4, on the second record, etc.



With the production of around 130 million records in 1941, the sale of phonograph records in the United States finally exceeded the 1921 sales record.(30)

With the advent of World War II, the supplies of new shellac coming from India, Malaya, and the East Indies were completely stopped. Shellac was placed under government control in the United States as it was considered a strategic material.(16) In April, 1942, the War Production Board ordered the U.S. record industry to reduce the amount of shellac used by seventy percent, limit record production to 1940 levels, and keep record prices to those listed in December, 1941. Shellac drives were held with two to three cents offered for each record. To stretch supplies some record manufacturers ground old and unsold records from the factories and dealers' stocks; the ground material was mixed with new shellac for pressing records. The use of re-cycled material resulted in poor quality records with increased surface noise. With center-filled laminated records, Columbia was better able to save supplies of new shellac for record surfaces.(26) However, one popular phonograph brand with a unique record changing mechanism would sometimes delaminate the Columbia discs when changing records. (18) It was a common belief by the public that records were made of hard rubber and many records were included in the scrap rubber drives held during the war.

On behalf of the members of the American Federation of Musicians, union president, James C. Petrillo, ordered all musicians to cease recording until the record companies agreed to pay royalties to the union on each record sold. The ban became effective July 31, 1942. In

the fall of 1943 Decca was the first major record company to settle with the union; Victor and Columbia signed a year later.

During World War II in Britain to distinguish Allied and German submarines, the English Decca Record Company developed much-improved sound recording with extended frequency range from microphone devices on sonar buoys in the English Channel and North Sea. After the war Decca produced recordings which extended the frequency range to 14,000 Herz, almost the limit of human hearing. The new Decca records were announced in July, 1945, and became the “ffrr” records—full frequency recording range. The new discs could provide overtones previously reduced or eliminated on discs. In late 1946 imports of Decca’s “ffrr” records reached the United States.(12)

For the first post-war high quality, very expensive, (and very heavy) 1946 Capehart radio/phonograph (Panamuse N Series—Farnsworth Television and Radio Corporation), Capehart advertised “…new standards of dependability and excellence, particularly as concerns the tuner-amplifier-speaker combination, established in the many military applications of communication equipment.” With 22 vacuum tubes, the radio featured AM, FM, and short wave. A light-weight crystal pickup was used for playing records. The complicated (and amazing to watch) record changing mechanism was capable of playing records recorded in series or by alternate sides. During this time some companies produced shellac records with a sharp or “knife” edge, which could cause problems with some brands of record changing mechanisms.

The lack of shellac during World War II helped to stimulate research for an alternate medium for pressing records, such as ethyl cellulose and polyvinyl compounds.(26) The government sponsored V-Discs made between 1943 and 1949 were made of a Vinylite-Formvar matrix.

After the war shellac was combined with other resins to form softer and less brittle 78 rpm records.(16) Shellac was reduced in the matrix to form 15 to 30% of the mix.(16) Vulcanite (also called ebonite), a hard rubber, was sometimes included in the mix, as were Vinsol (a pine tree resin) and Manila gum (16).

Manila gum is a resin derived from the Kauri tree (Agathis australis), native to New Zealand. In 1946 RCA Victor optionally released 12-inch Red Seal 78 rpm records in transparent cherry-red vinyl. The new vinyl records, however, were more expensive and were more susceptible to heat damage.(18)

In June of 1948 Columbia Records introduced the first successful long-playing records. Developed by recording engineer Peter Goldmark, the new microgroove records were pressed in non-breakable vinylite. The new 33 1/3 rpm records could play for twenty-three minutes per side; the slow speed of the inner grooves was compensated by an electronic equalization system.

The new vinylite records held 224 to 300 grooves per inch, which compared to an average of 85 grooves per inch on 78 rpm shellac records. The new records were nearly ideal for longer classical works. With the hope of accomplishing a successful change-over to the new

system, Columbia offered to share the new system with RCA Victor. However, the following year RCA Victor introduced the small 45 rpm microgroove records, also pressed in vinylite. For a year there was a battle of the speeds, but in 1950 Victor also began to produce 33 1/3 rpm microgroove records for the longer classical works while the smaller 45 rpm records proved more ideal for popular music. The new vinylite microgroove records marked the end of the 78 rpm shellac records.(12)

Other Uses of Shellac

The Edison Diamond Disc and Amberola reproducers made between 1912 and 1930 used a shellac-based diaphragm to vibrate and generate

sound from the stylus bar and linkage. For the standard Diamond Disc diaphragms Edison used seven to nine layers of rice paper impregnated with shellac. For the Edisonic reproducers, eleven layers of rice paper were used. Most Amberola reproducers are found with four rice paper layers. The rice paper is not the same as the white paper made from edible rice and used for Oriental art, but the firm, tissue thin paper made from the pith of the rice paper shrub—Tetrapanax papyriferus.

In this time before the development of modern plastics, there were not many choices; celluloid, cork, fiber, glass, gutta-percha, mica, rubber, thin metal, or thin wood could be used to form diaphragms. Gutta-percha is a tree resin with properties between a hard lac and a soft rubber; it is collected from the trunks of several species of the Payenia and Pelaquium trees, which are native to Malaya. Gutta-percha was used extensively for insulating wires; similar to rubber, it can be vulcanized. Gutta-percha was molded to form diaphragms for the Cheney and Crystola reproducers,

Does shellac harden with time? Are old 78 rpm shellac records now harder and thus more brittle than when they were new? If the Edison reproducer diaphragms are a valid indicator, shellac does harden with time. Listening to the Edison Diamond Disc records it is obvious there is more “sound” recorded into the records than is being recovered by the original reproducers, even when new soft rubber gaskets had been installed on both sides of the diaphragm. How to make the old shellac diaphragms more compliant? Some collectors attempt to use Vaseline or oil treatments. In recent years some collectors have experimented forming diaphragms with more modern plastic materials, including Styrofoam.

Shellac as a wood finish is the most familiar use of the product. Until around 1925 most phonograph cabinets were finished with either several layers of hand-rubbed shellac or with one or two coats of shellac followed by one or more coats of varnish. Despite the development of modern synthetic varnishes, shellac finishes still have special advantages. It is soluble in alcohol, a relatively harmless and convenient-to-handle solvent. Shellac sinks into the wood, forming a firm bond that will never peel.(16) It dries quickly and needs no curing time; it can be repaired as it will re-dissolve in alcohol. Shellac is used to form French polishes, perhaps the most beautiful finish. Shellac resists ultraviolet degradation and is tough enough to use for floors, dance halls, and bowling alleys. Shellac can seal and cover waxes and many other finishes; no sealing or topcoat layers are required. Shellac retains some elasticity; it will dent but not crack under hammer blows.(16) When restoring a phonograph cabinet it is possible to briefly dissolve the original shellac finish, but this re-amalgamation process is not easy and it is best to have experience with this method.(13)

Shellac quality is graded by the color and wax content. Colors vary from colorless “blond” to yellow, orange, and reddish-brown garnet. Natural wax in the dried shellac film make it more resistant to water but leaves a slightly dull finish. For wood finishing, de-waxed and de-colored shellac is preferable as an undercoat and as a top dressing and can be applied

by brush or by spraying. Once dried, the coating can be smoothed with sandpaper, pumice, or 0000 grade steel wool before applying the next coat.

Shellac does have disadvantages; it is not totally waterproof and the white water rings that form around drinking glasses or the potted Geranium are a common problem. Shellac tends to scratch more easily than other finishes and it can become malleable at 150 degrees Fahrenheit. Solid shellac can be purchased in all grades and with and without wax; it has an indefinite shelf life if kept cool and dry. In contrast, liquid shellac solutions have a shelf life of a few months. Shellac solutions are acidic and with time the shellac becomes gummy and when applied to a surface will not dry to a hard finish. It is best not to apply shellac in humid conditions. Liquid shellac comes in various grades and with designations such as “4 lb cut shellac,” indicating four pounds of resin were used per gallon of solvent. Denatured alcohol (ethanol with 5% methanol) is a common solvent for practically all work.(16) For floors the shellac is usually diluted to no heavier than 2 or 3 lb cut. For thin coatings on furniture 1 or 2 lb cut is preferred. It is best to discard old cans of shellac and purchase new cans. Also, flake shellac can be dissolved as needed. Liquid shellac containing white pigments is commonly used as a primer for other finishes.

Flake shellac is no longer available in most paint and hardware stores, but can be found in woodworking shops and some hobby stores. It is also available from a number of companies listed under “flake shellac” on the internet. The William Zinsser & Company is one–still located in New Jersey. It is even possible to purchase stick lac and button lac. These firms also sell special colored sticks to repair bad scratches and damaged areas on a shellac finished cabinet. The sticks are variously termed “burn-in” or “touch-up” sticks. At one time Sears, Roebuck & Company sold a series of colored Craftsman repair pens, called glue sticks. In the early years stick shellac was available in tints to match any shade; the sticks were four inches long and a half inch square. The end of the stick could be heated with a soldering iron and the melted shellac dripped into the scratched or damaged cabinet surface. Once cooled the area could be carefully sanded to match the even surface.(37) Today various types and brands of shellac sticks are advertised on the internet as well as felt tip markers that can hide nicks and scratches; several shades are available. If a water spot is not too deep on a shellac finished cabinet, it can be removed by rubbing the area with an alcohol dampened rag.

Varnish by the old traditional meaning and now often termed heirloom varnish, is shellac boiled with linseed oil. The resulting varnish dries harder and is water, alcohol, and oil proof, making it nearly ideal as a furniture finish.(15) Linseed oil is flax seed oil from the flax plant (Linum usitatissimum), used to make linen cloth. Varnish qualities vary greatly depending on the relative amounts of linseed oil used in the mix. Spar varnish is mostly linseed oil and has the characteristic of never drying to a hard finish, thus it is used for outdoor work such as on boats. For fine furniture the shine of the finish can be progressively higher depending on the final rubbing with 0000, 00000, or 000000 grade steel wool.(15)

It is ironic that the success of shellac led to the synthetic resin industry. Leo Baekeland developed phenolic resins while searching a substitute for shellac. He introduced Bakelite in 1909 and began commercial production in 1911. Bakelite is a hard, insoluble resin that can be colored, machined or molded; it is produced by the reaction of phenol (a highly toxic compound) and formaldehyde under heat and pressure and with an alkaline catalyst. Bakelite is a much harder compound than solidified shellac. Thomas Edison used Condensite, a form of Bakelite, for the surfaces of his Diamond Disc records.

Around 1925 many phonograph companies discontinued using shellac and varnish and began to finish phonograph cabinets with fine satin lacquer, a nitrocellulose derivative also called pyroxylin. In 1923 Du Pont (E. I. du Pont de Nemours and Company) developed fast-drying nitrocellulose based lacquers which were dissolved in volatile solvents, usually with an acetone or toluene base. The lacquer could be colorless or contain pigments; it was usually applied as fine sprays, usually in a closed room. If the lacquer contained pigments, it was possible to use beech, holly, maple, pine, spruce, and other woods that would not normally take a stain. It was possible to spray over these woods with layers of dark lacquer and have them blend with the larger areas on the cabinet; this permitted the production of very beautiful cabinets. The lacquer formula could also be varied to impart hardness, gloss, or imperviousness to water.

Nitrocellulose lacquers are not the same as the lacquers used in the Orient. Oriental lacquers are derived from the sap of several trees, including the sumac tree, Rhus vernicifera. Lacquer work in the Orient is a highly developed art form; it is not unusual for fine crafted objects to be given as many as forty coats of lacquer.

Today hardware and paint stores present a bewildering array of cans of modern synthetic varnishes for different uses—spar, wiping, bar-top, wood, floor, interior, exterior, etc. All have as their base a vegetable oil, usually linseed oil, soybean oil, or tung oil. Tung oil is the preferred oil, but is expensive. Tung oil is derived from the tung tree, Aleurites fordii, and is native to China and Japan; the oil is extracted from the poisonous fruit. Modern varnishes are made by chemically combining an oil with a modifying resin. The ratio of the oil to the resin is called the oil length; it determines the flexibility of the dried film. Varnishes with 60 to 75% oil are called long-oil and are used for exterior work. Most wood finishes contain 45 to 60% oil and are called medium-oil finishes; they form a hard semi-flexible protective film. Short-oil varnishes contain less than 45% oil and usually require heat to cure; they are often mixed with pigments for painting stoves, refrigerators, metal furniture, etc. Polyurethane (toluene diisocynate) is one modifying resin. Alkyd (phthalic anhydride) is another; it is preferred for hardwood floors. Styrene and vinyl toluene are included in fast drying varnishes. Phenolic resins are also used, although these are slow to dry and tend to yellow with time. Synthetic finishes better withstand moisture.

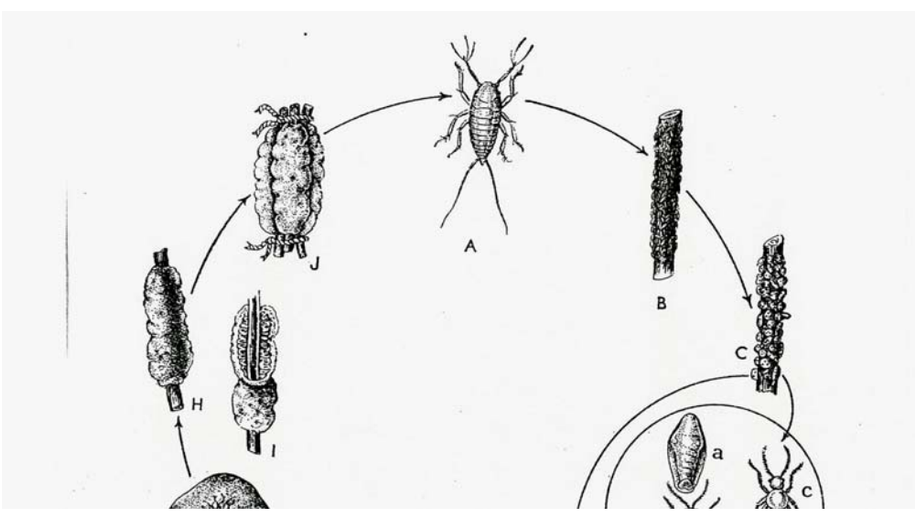
When restoring a phonograph cabinet it is tempting to use one of the modern synthetic varnishes; they have a fine long-lasting finish but lack

the aged patina of the original layered shellac or shellac/varnish. Nor do they have the shine of the lacquer finishes applied to cabinets in the late 1920's. Most collectors can immediately identify a cabinet that has been refinished. The "rule of thumb" still seems to be if you can live with a cabinet as it is, it is best un-refinished. Refinishing a cabinet usually reduces its value. It is sometimes amazing how much of the original finish can be brought out by a thorough cleaning and polishing. Although there are other good references, many collectors follow the cabinet cleaning and polishing methods described in the book, *The Furniture Doctor*, by George Grotz .(15). The book also describes how to determine if a cabinet has been finished with shellac, varnish, or lacquer. The author also describes how to repair or remove old finishes and to prepare the cabinet for a new finish. He also describes how to apply new shellac finishes; it helps to have had experience restoring old wood furniture.

Shellac is non-toxic when dry and is approved as a food coating for fruit glaze, vitamin tablets, and candy (including M & M's and Reese's Pieces). Shellac coatings are used for time-release pharmaceuticals. A small amount of powdered shellac is blown onto coffee beans as they are tumbling in the roaster; it helps prevent flavor loss.(23) Shellac can be mixed with many products, such as printing inks, gasket cements, leather dressings, cosmetics, hair sprays, polishes, sealants, laminated products, wax Crayons, wallpaper, photographic supplies and even fireworks. It is safe to use on toys. Shellac is used to give body and firmness to a number of items—such as felt hats. Shellac coatings are used when silvering mirrors. Playing cards are coated with shellac; it provides the shine and the hard "snap." Shellac has arc-resistant qualities for high voltages; it is still used as an electric insulator when combined with mica, asbestos, or other materials. Shellac combined with ground or powdered mica is called micanite. In the 19th century shellac was mixed with wood flour or powdered minerals and molded into shapes by heat and pressure to form picture frames, medallions, dresser sets, brooches, etc. The Union Case picture frames are the most familiar form; they were used to hold the early daguerrotypes and ambrotypes.

The Insect

Kerria lacca (formerly Laccifer lacca), the scale insect that produces shellac, lives on trees in the East Indies, Malaya, and India. The life cycle takes about six months and consists of the egg, larva, pupa, and adult stages.



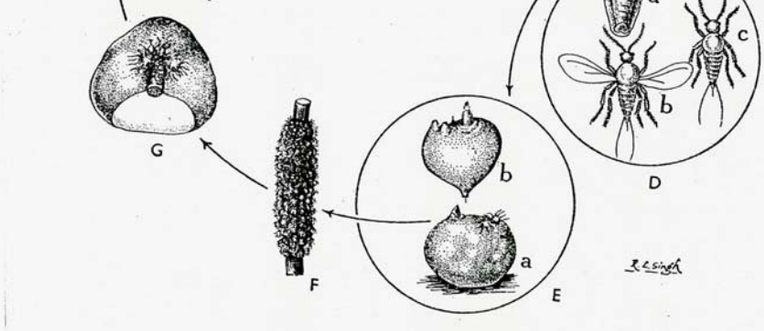


Figure 2. Life cycle of *Kerria lacca*:

A. newly emerged larva.
B. early larval development on a young shoot of host plant.
C. developing male and female lac cells on the shoot.
D. male scale. a. male lac cell; b, winged male; c, wingless male.
E. female scale. a. female lac cell; b. female scale after removing lac cell.
F. expanding female cells after fertilization.
G. female scale at maturity; ready to lay her eggs.
H. stem covered with maturing female lac cells.
I. the same with part of encrustation removed to reveal individual female cells.
J. sticks of broodlac tied together for inoculating fresh host plants.

(after Kapur, 1954)

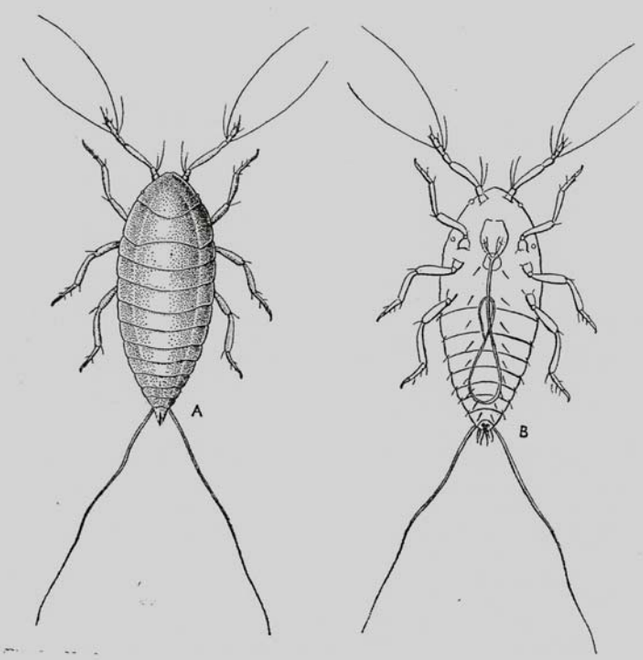
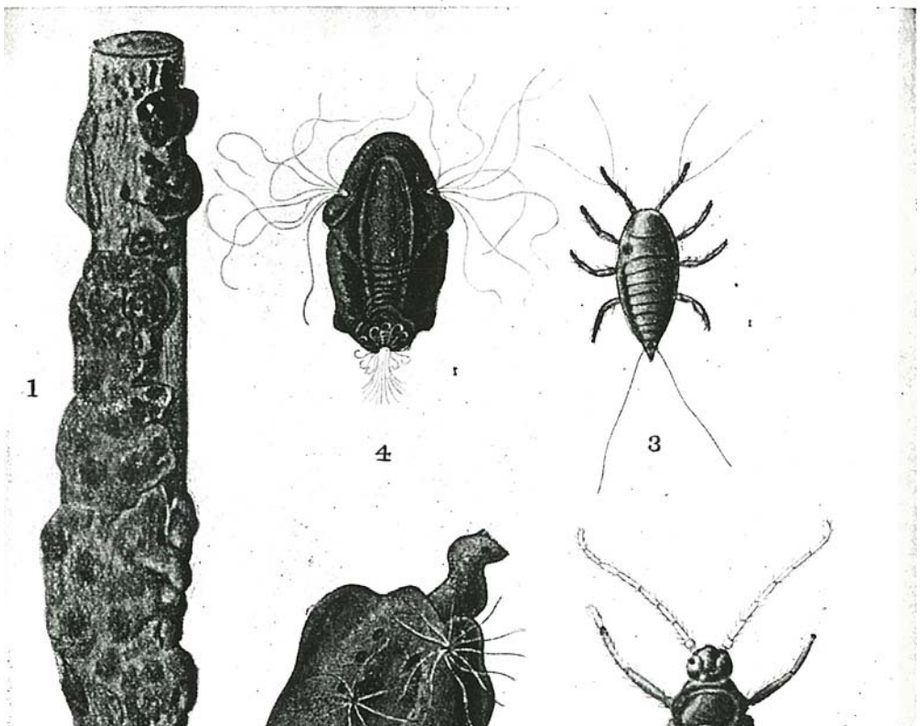
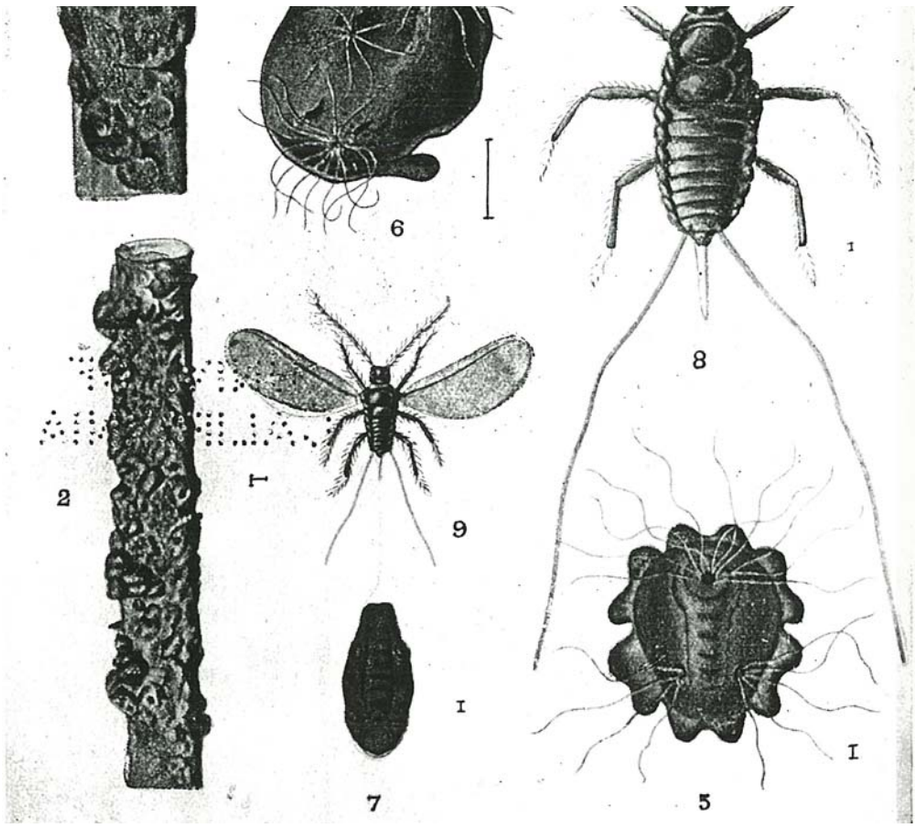


Figure 1. Newly emerged larva of *Kerria lacca*: A, dorsal view. B, Ventral view (note long proboscis, a flexible tube for penetrating into the young host host tree branch. (after Imms and Chatterji, 1915)





The young scale finds a suitable place on a succulent twig or branch, inserts its long proboscis into the stem, and gradually secretes a resinous lac that covers and protects the insect from predators. Specialized glands just below the dorsal cuticle of the scale produce the lac which is emptied to the exterior via a series of connecting ducts and pore openings in the cuticle. The lac hardens with exposure to air. It is a different compound from the chitin exoskeleton produced by most insects. The lac scale insects also produce waxy secretions and, similar to aphids, they can excrete excess amino acids and carbohydrates from the plant sap as honeydew.

Thousands of these scale insects side-by-side can secrete enough resinous material to completely cover stems. The encrusted stems are known as stick lac. The largest yields of lac are obtained by harvesting infested stems while the scales are still alive, usually in June and November. Due to the various dialects in India, different names are given to the harvested crops of stick lac. There are two main crops, Bysaki (a combination of the Baisakhi, Katki, and Jethwi crops) and Kushmi (often spelled Kusmi). The highest quality lac is harvested during the Kushmi months in the late fall. It is estimated 300,000 of the scale insects are needed to produce just one kilogram (2.2 lbs) of crude shellac.

Collecting the stick lac is a cottage industry in parts of India and provides a means of subsistence for thousands of natives.(16,22,23) Although the process varies in different localities, typically the branches are collected and taken to a primitive factory where they are dried and scraped to remove the lac resin. The resin is ground in large crude mortars and forms a granular lac called seed lac. About two pounds of stick lac can yield a pound of seed lac. The seed lac is sieved to remove sand and dirt and washed to remove dye and insect parts. The lac is dried and packed into a long cotton bag and heated over a charcoal fire. The bag is slowly twisted and as the lac gradually melts it filters through the bag onto a large ceramic jar or stone. A skilled worker,

called a bhiwaya, stretches the warm lac into a thin transparent sheet which is dried and broken into flakes, a crude form of the commercial shellac. In some places the melted lac is allowed to drip into puddles where it hardens into a form called button lac. Shellac processed by these methods contains 2 to 5% natural wax. Lac qualities vary depending on the host plant and area collected. The quality can even vary from year to year.

The modern method to process stick lac dissolves the lac in alcohol or an aqueous alkaline solution (such as sodium carbonate) where the dissolved lac can be more easily filtered to remove impurities.(16) This method can also be used to remove wax residues. The dissolved lac can also be passed through activated charcoal filters to remove most of the natural yellow to red colors. It can be further treated with chlorine to bleach the lac and produce nearly colorless shellac. The solution is heated to remove solvents and the shellac is stretched and pressed in rollers before drying. Shellac is not waterproof and can be damaged by seawater contamination during the long voyage from India. Shellac is usually shipped as flakes or button lac and often in a refrigerated container to prevent damage and melting due to heat. The better grades of shellac are shipped in wood cases lined with cloth while most are shipped in double burlap bags.(16)

In India to prepare for a new crop, branches of stick lac (called brood lac) are tied onto host trees with new branch growth. Each female scale can lay 200 to 500 eggs (sometimes as many as 1000) which hatch into larvae. The larvae are red and vary in size from 0.35 to 0.6 millimeter (less than 1/32 of an inch). As the larvae crawl out of the mother shells and begin to swarm the tree branches take on a pink to reddish hue. The news of the swarm spreads fast and an army of workers moves and distributes the brood lac onto trees with strong young branches. The larvae settle onto various parts of the branch, insert their long proboscis into the tree’s phloem tissues, and begin to exude the resinous layers that eventually form a hard shell with small anal and respiratory openings. It takes about eight weeks for the scale insects to become sexually mature. The male scales undergo a complete metamorphosis; they pass through a pseudo-larval stage, lose their proboscis, and develop antennae, legs, and a single pair of wings. The males then emerge from their shells and either walk or fly to the females, fertilizing them. They then die.

Female scales remain attached to the stem; they molt three times and retain mouth parts but do not develop wings or eyes. In adult form rudimentary antennae and legs develop but they are immobile shell-like organisms with little resemblance to most insects. They are little more than egg producers in the shape of small reddish spheres inside a thick lac covering. As the eggs develop the females increase in size and the lac resin is secreted at a faster rate forming thick continuous hard shells. After about fourteen weeks the females lay their eggs. When the eggs hatch the larvae emerge and begin the cycle again. The female ovaries contain a crimson fluid called lac dye and is similar to the cochineal dye produced by Coccus insects. Some lac fluid is collected and used to dye silk.

Kerria lacca is not host specific and can be found on numerous species of trees and shrubs from many different plant families. However, the scale is most commonly found on a dozen species and for commercial purposes it thrives best on the Banyon, Ber, Ghont, Khair, Kusum, Palas, and Pipal trees. There is little organized cultivation of the lac scale, but there are some plantations of trees for lac production. Most tree hosts are found in forests, along streams or growing along roadsides and rice field embankments. Many of the trees, such as the Ber (Zizyphus jujuba), tolerate annual pruning and will produce a number of vigorous succulent branches each year. The Ber tree can be pollardized, a method of pruning where the cut will produce thick clusters of new shoots. The Ber tree grows well in poor soil.(22) Amazingly, no trees are permanently damaged from the annual pruning and infestation with the scale insects. The Ghont tree, (Zizyphus xylopyra) is a scale host mainly in the central provinces; it is commonly found and grows to be a large shrub or small tree.

The famous Banyan tree (Ficus bengalensis) is a soft wood tree of the fig family.

It sends down long and strong aerial roots from the larger stems of the tree. With time these roots become trunks, thus increasing the size of the tree. Some Banyan trees are so large they become local landmarks. There is a legend that Alexander the Great once camped his entire army under just one Banyan tree. The Pipal tree (Ficus religiosa) is closely related to the Banyan and can also grow to be a tree with large girth. Banyan and Pipal trees are considered sacred by Buddhists, however both are common pest trees as the seed can readily germinate on roofs, walls, and even on other trees.(3) The Kusum tree (Schleichera trijuga), which yields the superior lac, is slow growing and cannot be pollard. It is also slow to recover and is not used as a host tree every year. It is found growing in forests and along streams. The Kusum wood is very hard and can be used to form mortars, pestles, rollers, screws, etc. A commercial oil is also extracted from the Kusum seed. The Palas tree (Butea frondosa) does not usually require annual pruning; it is a soft wood

legume with large leathery leaves that can be used as plates and as a paper substitute. The Khair tree (Acacia Catechu) is another tree legume; it is fast growing and serves as a winter brood host.

Most entomologists place the scale insects in the Homoptera insect order, which includes aphids, cicadas, leafhoppers, mealybugs, psyllids, spittlebugs, and white flies.(2) Unlike beetles, which have chewing mouth parts, the Homoptera are characterized by piercing-sucking mouth parts to extract nutrients from a host plant. All Homoptera are plant feeders. Aphids, whiteflies, and some leafhoppers are serious pests and are capable of transmitting plant viruses. The large leafhopper called the Glassy Winged Sharpshooter can transmit the fastidious bacteria which causes the dread Pierce's Disease of grapevines. A scale insect can settle onto the stem of a perennial plant, tap into the food supply in the phloem tissue of the stem, and remain in place for the rest of its life with a secure source of energy.

Scale insects can be found in the United States. The San Jose scale found on fruit trees and lilac bushes is the most familiar. Some scale insects are similar in appearance to the bark and are difficult to see. Individual scale insects do little harm but in large numbers they can remove vital plant nutrients and stunt or kill branches or entire plants. Scale species that produce a soft leathery covering instead of a hard shell retain legs and can move throughout their life. Some scale insects produce only wax. Some have the wax as a powdery layer while others produce a continuous filamentous wax that appears to be a cottony mass on the stem. Merely touching the "cotton" can cause it to collapse. Mealybugs are a similar type of insect but without a shell covering. Scale insects do have pest problems, mainly from the larvae of several moth species and from tiny parasitic wasps.

The scale insect, Dactylopius coccus, lives on cactus plants in Mexico and Central America. The brilliant red dye known as cochineal can be extracted from these insects and a lively industry and trade in this product was developed in the 1600's. However, cochineal is carcinogenic and has been replaced with aniline dyes.

Finale

Considering the multiple uses and large volume of shellac used today as well as during the era of shellac records, it is amazing there have been adequate supplies of stick lac as well as adequate numbers of trees to serve as the scale hosts. We are indebted to these crusty little insects for giving us many hours of listening pleasure.

Although only 3 or 4 Kerria species produce the commercial lac, there are some 7,340 species of scale insects. Most are serious plant pests and difficult to control. Scale life cycles can be amazingly complex with vestigal structures and incomplete stages, leading one entomologist to wonder if these creatures are, "...not of this earth!" Considerable research is done with the scale insects: HTTP://WWW.SEL.BARC.USDA.GOV/SCALENET/SCALENET.HTM.

References

1. Berendsahn, Roy. 2002. *Shellac Revisited (In Praise of an Unsinkable*

Product). Internet webpage.

2. Borror, Donald J., and Dwight M. Delong. 1960. *An Introduction To The Study of Insects.* Holt, Rinehart, and Winston, New York.

3. Brandis, Deitrich, Bishen Singh, and Mahendra Pal Singh. 1972. *The Forest Flora of North-West and Central India.* Dehra Dun

4. Canby, Edward T. 1952. *Home Book of Recorded Music and Sound Reproduction.* Prentice Hall, Inc., New York.

5. Condon and Company, Inc. 1919. "Uniform Needles" *The Talking Machine World.* Advertisement, p.21.

6. Copeland, George A. 1992. "The Phonograph Needle" *In The Groove*, XVII 5:4-6.

7. Copeland, Peter. 1990. "Playback" *The Hillandale News* 173:26.

8. Electronic and Musical Industries. 1938. "Writing In Sound" Reprinted in *The Talking Machine Review* 45:988-997.

9. Emerson, Victor H. 1905 *Sound-Record and Sound-Record Tablet.* United States Patent Office. Patent #838,968. December 18, 1906.

10. English, John C. 1905 *Composition of Sound-Records and Other Objects.* United States Patent Office. Patent #948314. February 10, 1910.

11. Fabrizio, Timothy C., and George F. Paul 1997 *The Talking Machine, An Illustrated Compendium.* Schiffer Publishing, Ltd., Atglen, Pennsylvania.

12. Gelatt, Roland 1965 The Fabulous Phonograph

13. Goon, Timothy. 1990. "Restoring Shellac and Varnish Finishes" *In The Groove*, XV 7:5.

14. Gracyk, Tim. 2002. "Assessing the Condition of Old 78 RPM Discs" Internet webpage.

15. Grotz, George. 1962. *The Furniture Doctor*. Doubleday, Garden City, New York.

16. Hicks, Edward. 1961 *Shellac Its Origins and Applications*. Chemical Publishing Company, New York.

17. Hunter, James H. 1938. *Phonograph Record*. United States Patent Office. Patent #2,284,091. May 26, 1942.

18. Isom, Warren Rex. "The High Fidelity Phonograph Transducer" *Journal of the Audio Engineering Society* Volume 25. No. 10, 11; October-November 1977.

19. Maxfield, J.P. 1926 Phonograph *Encyclopedia Britannica*, 13th Edition. Reprinted in the *New Amberola Graphic*, #79, 1992 p.13.

20. Merck and Company, Inc. 1997. "Shellac" The Merck Index. Whitehouse Station, New Jersey.

21. McClary, Thomas Calvert. "Electrical Transcription for Broadcast Purposes" *Radio News*. January 1932 pp.564-565, 619-620.

22. Misra, Rai Bahadur. 1929. *The Cultivation of Lac In the Plains of India*. Bulletin by the Agricultural Research Institute. Pusa, India.

23. Mukhopadhyay, B., and M.S. Muthana. 1961. *A Monograph on Lac*. Indian Lac Research Institute. Nakum Ranchi, Bihar, India.

24. North London Phonograph and Gramophone Society. “75 Years Ago” *The Hillandale News* 165:13.

25. Peters, Michael T. 1988. *Insects and Human Society*. Van Nostrand Reihhold, New York.

26. Read, Oliver, and Welch, Walter L. 1976. *From Tin Foil To Stereo*. H.W. Sams, Indianapolis, Indiana.

27. Rogers, W.S. 1931. *The Gramophone Handbook*. Pitman Press.

28. Royal Society. 1908. “The Gramophone and the Mechanical Recording and Reproduction of Musical Sounds” Reprinted in *The Talking Machine Review* 42:824-826.

29. Sanders, Joseph. 1904. *Composition of Matter for Sound-Record Tablets.* United States Patent Office. Patent #787,001. April 11, 1905.

30. Sanjek, Russell, & Sanjek, David. *The American Popular Music Business In The 20th Century* 1991.

31. Seymour, Henry. 1987. “How Gramophone Records Are Made” *The Hillandale News* 158:270-274.

32. Seymour, Henry. 1918. “How Disc Records Were Made in 1918” The Reproduction of Sound. *Antique Phonograph Monthly* 1,9: 3.

33. *Talking Machine World*, 15 May 1917 p. 64.

34. *Talking Machine World*, 15 December 1919 p. 42.

35. *Talking Machine World*, 15 April 1920 p. 69.

36. *Talking Machine World*, 15 July 1920 p. 10.

37. *Talking Machine World*, 15 November 1920 p. 73.

38. *Talking Machine World*, 15 January 1921 p. 92.

39. *Talking Machine World*, 15 November 1922 pp. 17, 42.

40. *Talking Machine World*, 15 December 1923 p. 35.

41. *Talking Machine World*, 15 July 1927 p. 104.

42. Tuddenham, Adrian, and Peter Copeland 1988 “Record Processing for Improved Sound” *Hillandale News* No. 162 pp35-39.

43. Willey, D. A. 1904. “Making a Talking Machine” *The Technical World*. Reprinted in *The New Amberola Graphic* 86:7-8.

ABOUT US

We are a worldwide society of 1000+ members who share a passion for the preservation of antique phonographs,

CONTACT US

The Antique Phonograph Society

SOCIAL

gramophones and records. We encourage, promote, publish and present research on the history of sound recording and reproduction, including the machines that create and preserve these wonderful voices and sounds. To that end, our Society maintains informative articles on its website which are open to the public, as well as an exhaustive online searchable archive of over 20,000 pages of phonograph and record research material available to members. We publish a full-color quarterly journal called The Antique Phonograph. The APS also sponsors an annual antique phonograph/record Expo and banquet, to which all are welcome.

P.O. Box 169
Victorville CA 92393
United States of America
Email us at:
info@antiquephono.org

Join the Conversation on Facebook