Leather Facts

THIRD EDITION

A PICTURESQUE ACCOUNT OF
ONE OF NATURE'S MIRACLES

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THIRD EDITION

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Designed as educational material for student use, this comprehensive book should be of interest to inquisitive people of all ages. It deals with the fascinating story of leather, giving an insight into its origin and manufacture, as well as the reasons for its enduring quality and universal appeal.

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The First Tanner In America

Painted by Mort Kunstler *Commissioned by the American Cyanamid Co.*

CONTENTS

reduce the listed hazardous and toxic pollutants being discharged to waterways (rivers, lakes, or ocean) or to nearby publicly owned treatment works (P.O.T.W.) for liquid and solid wastes, or to the surrounding air. Included in this list of pollutants are:

1. Chrome
2. Sulfide
3. Mercury
4. Formaldehyde
5. Benzidene
6. pH
7. Total suspended solids
8. Biological Oxygen Demand (B.O.D.)
9. Oil and Grease
10. Volatile Organic Compounds (V.O.C.)
11. Etc.

These regulations have affected every phase of the leather making process from hide curing to leather finishing resulting in substantial increased costs of materials, equipment, labor, and overhead to meet the environmental demands/needs of this modern age. Most tanneries now have an environmental engineer with additional staff devoted to these issues, but the implementation still rests on the tanners shoulders. A very large percentage of tanneries that have ceased operations in the last twenty years have been due to these environmental challenges directly or indirectly.

On the positive side, the surviving tanneries have learned to make the necessary adjustments either through formula changes, more efficient formulas, recycling, better equipment and machinery, and if necessary building their own pretreatment plant without sacrificing quality or productive capacity. At the same time the technology of leather manufacturing continues to advance perhaps at even a faster rate.

Leather-dressing in Ancient Egypt, about 1550 B.C. The figure on the left is soaking the hide in a large jar; the one on the right is stretching and kneading a skin on a trestle to soften it. Bottom center: a skin is being cut with a knife with a crescent shaped blade. Top right: completed skin of an animal.

CHAPTER TWO

HIDES and SKINS *the tanners' raw material*

There is virtually no end to the variety of leathers which are commercially available today. This is due in great part to recent technological developments that have put new tools into the hands of the tanner. The tanner is a master craftsman who is constantly adapting these new technical advances toward creating new and exciting leathers.

But aside from the many different processing methods available to the tanner, there is another important factor that contributes to the variety of available leathers. We are referring to the tanners' raw material — hides and skins from all over the world. By convention, the tanner usually refers to the skin coverings of large animals (cows, steers, horses, buffaloes, etc.) as *hides*. Those of smaller animals (calves, sheep, goats, pigs, etc.) are called *skins*. However, both of these terms, as well as the word *pelt*, are often used interchangeably by the layman and we occasionally do so in the discussion which follows.

When you examine leathers made from different animal pelts, certain surface or *grain* characteristics are immediately noticeable. Thus, calfskin looks different than a pigskin; a pigskin possesses a different appearance than the skin of a sheep; and so on down the line. But the differences don't stop with the appearance alone. Beneath their surface we find that most hides and skins possess unique physical properties that are inherent to the particular animal or breed. Consequently, the type and source of raw material provides an excellent opportunity for the tanner to tailor-make leathers for specific purposes. Let us consider a few examples.

If a tanner wishes to make a luxurious, fine-grained upper leather for shoes, he quite likely will start with cowhide. Should it be a rugged sole leather that he wishes to produce, he'll probably select steerhide. Or if he wants to make a soft, drapey garment leather, he'll probably choose sheepskin.

Have you ever stopped to think of the leather goods you own and the number of different animals which they represent? You undoubtedly possess shoes made from cattlehide, calfskin, or kidskin; a cowhide handbag; or an ostrich leather wallet. Are your gloves sheepskin, deerskin, or pigskin?

Your belts, your slippers, etc. — all these things and many more were fashioned from an animal pelt with the characteristics best suited for the intended purpose.

Sources of Raw Material

There is scarcely a country of any size which does not produce hides or skins for conversion into leather. Some areas produce quantities in excess of the number that are tanned locally, and hence export their surplus. The reverse is of course also true. Since hides and skins are themselves by-products of the meat industry, it follows that the large meat producing areas also supply a large portion of the tanner's raw material. For example, the beef industry in the United States is one of the largest sources of cattle and steerhides for tanning in the world.

The source from which a tanner selects his raw material has a direct bearing on the resultant leather. Thus, there are many general types such as cattle and sheep that are prevalent throughout the world. But the many breeds within these types each produce a pelt of somewhat different nature. Much of this is related to the animals' environment — the climate of their land, the type of feed, etc. Imperfections in the hide such as scars, brands, manure damage, and any parasite damage also has an effect on the final product produced.

Let's take a look at some animal population and slaughter figures in Table A.

Table A
Population and Slaughter
World Cattle (selected countries only)
1992-93

	Population (million head)	Slaughter (million head)
Soviet Union	102	36
United States	101	35
Western Europe	87	32
Argentina	57	12
Eastern Europe	23	8
Brazil	129	29
Asia (esp.India)	390	39
Mexico	31	8
Canada	12	3
Columbia	16	4
Other (estimate)	102	29
WORLD TOTAL (selected countries only)	1050	227

Table A shows the United States near the top among world cattle producers.

Leather Production Statistics

Every year U. S. tanneries convert many millions of raw hides and skins into leather. Table B shows the production of some of the more important types: cattle, sheep and pig. These amounts represent the total of both domestic and imported pelts.

In addition, considerable quantities of other types of pelts are tanned in the U.S. These include the hides from horse, walrus, water buffalo, etc. along with skins from deer, goat, kangaroo, ostrich, seal, shark, crocodile, alligator and so on.

Leather—the product of American Tanneries — serves in turn as a raw material for the shoe and leather goods industries that provide jobs for approximately 85,000 people.

Table B
Animal Population, Slaughter and Leather Production
United States
1992-93

	Population (million head)	Slaughter (million head)	Leather Production (millions)
Cattle	101	33	14
Sheep	10	5	N/A
Pig	60	93	N/A

Table B indicates less than half of U.S. cattlehides are converted to leather domestically, most being exported for tanning. The reverse is true for sheepskin. Pigskins are used primarily as food but interest in leather production is increasing.

Leather tanning and finishing is a $2.3 billion industry in the United States, employing over 12,700 people in 330 establishments and accounting for $700 million in exports. About 110 plants are directly processing raw hides or skins into tanned leather. Tanning activities are concentrated in the Northeast, Midwest, Middle Atlantic States and California.

Some tanneries are relatively small companies often specializing in the manufacture of a particular kind of leather, while others employ several hundred people and produce a variety of leathers.

Curing of Hides and Skins

Food animals from vast herding and feeding ranges throughout the world are transported by the thousands to meat packers and processors. There the animals are slaughtered by humane methods that have been established by national health and agricultural authorities. These methods call for the rapid removal of the hide with skill and precision so as to protect the quality of both the meat and the skin covering. Carelessness in this operation can lead to inferior hides due to *slaughter cuts* in the pelt. Modern meat packing establishments continue to expend considerable effort to insure the best possible take-off methods. After the hide is removed it is sent to fleshing. This is a technical operation that rids the hides of excess flesh, fat, and muscle found on the inside (flesh side) of the hides.

Just as meat is perishable, so too are hides and skins. If not cleaned and treated to prevent putrefaction they begin to decompose and lose leather-making substance within hours after removal from the carcass. Since the location of the meat packer may be quite remote from the tanneries which will convert this raw material into leather, it is essential that hides and skins be well protected during the period of transit.

The protective treatment administered to the pelts is termed *curing*. It is not a tanning process but a treatment that provides an environment in which protein-destroying organisms cannot function. There are several methods by which hides and skins can be cured.

An old method, still practiced in some hot and dry climates, is to dry the skins. Bacteria which require moisture to live and reproduce, are thus either killed or made inactive. If required, further protection can be afforded by the addition of chemical anti-bacterial agents. To be effective, the drying process must be controlled. If it is too slow, decomposition can begin to occur; if too fast, there is the possibility of physical damage (breakage) to the intricate network of hide fibers.

The method more commonly used today employ salt (sodium chloride) as the principal curing agent. The salt can be applied in either of two ways, called *brine curing* or *wet salting*.

Brine curing is the faster method of salt treatment. The washed hides are placed in large vats called *raceways* to which is added a concentrated salt solution (brine). Mechanical means are provided to cause the hides to swim around in the brine, and complete penetration of the salt solution into the hide is accomplished in about twelve hours. Treated hides are removed from the brine-filled raceway, allowed to drain, dry salt is sprinkled on them and they are bundled for shipment.

Wet salting today is employed only by smaller meat packers, since it involves washing and salting the hides individually. This is accomplished by spreading out first one hide, hair side down, on a concrete floor. The *flesh* side is then sprinkled with a generous coating of granular salt. Then a second hide is placed hair down upon the first, and likewise treated with salt. This procedure is repeated until piles up to eight feet high are formed. The salted hides are left to lay for several days, during which time the salt granules dissolve in the skin moisture and thoroughly penetrate the hide.

Other curing methods that would eliminate the use of salt are currently under investigation. Currently a number of hides are being processed fresh after slaughter (not cured) in tanneries which are close to the processing plants.

Whichever curing method is practiced, it is important that it be done thoroughly, for only extremely fresh or well cured skins can produce high quality leather. Processors have come to appreciate the importance of this step to both themselves and the tanner and to this end a biological test, which can determine the quality of a hide cure, has been developed by chemists of the Tanners' Council of America.

CHAPTER THREE

HOW LEATHER IS MADE
a step-by-step description

The processing of hides and skins into leather is a fascinating procedure that requires the proper dovetailing of many chemical and mechanical operations. The nature of the process is such that it constantly tests the ingenuity of the tanner. Technically, tanning converts raw hides and skins into leather that (1) has thermal stability, (2) is soft and flexible, and (3) is non-putrescible. But as a practical matter, much more is involved.

Some leather-making operations can be described as preparatory: that is, putting the skin into the proper condition for a step in the process that is to follow. Others affect major changes in the properties or appearance of the skin.

All of the operations bear a certain relationship to each other. For instance, an experienced tanner recognizes that if he alters the method, chemical, temperature, time, etc. at one stage in the process, it will likely produce an effect requiring additional adjustments in some of the subsequent steps in the process.

There is no getting around the fact that this interdependence of one operation on another can cause production problems, and the tanner must therefore exercise strict control over his process at all times. On the other hand, the fact that he has so many variables to contend with opens up countless opportunities for him to tailor-make his product for specific end uses.

For the description of leather-making which follows, we have selected a typical process for converting cattlehides into shoe upper leather. This process represents a large percentage of the leather currently manufactured in this country. Also, it describes the essential operations that are common to the majority of commercial leathers.

1. The original recyclers — the tanner will take these hides (waste from the beef packer) and turn them into a timeless fashion. The following pages will tell you how.

The "PROCESS FLOW SHEET" below shows the various operations that are described in the text which follows. You are cordially invited to come along with us now to learn first hand how man converts a product of nature into one of the most useful and beautiful items of our world.

PROCESS FLOW SHEET

- **WET OPERATIONS**
  1. RECEIVING and STORAGE OF RAW HIDES
  2. SOAKING
  3. UNHAIRING
  4. BATING
  5. PICKLING
  6. TANNING
  7. WRINGING and SORTING
  8. TRIMMING and SIDING
  9. SPLITTING and SHAVING
  10. RETANNING, COLORING, FATLIQUORING
  11. SETTING OUT
- **DRY OPERATIONS**
  12. DRYING
  13. CONDITIONING
  14. STAKING
  15. BUFFING
  16. FINISHING
  17. PLATING
  18. GRADING
  19. MEASURING

1 RECEIVING AND STORAGE OF RAW HIDES

(Objective: Preparation of hides for processing.) The first step in getting hides ready for processing takes place in the tanner's *hide house*, a large storage area that is kept cool and well ventilated. It is here that the tanner receives and stores hides which have been shipped to him from meat packers. Most hides arrive in a cured state, described in the previous section, although a few tanneries work with fresh stock that is shipped within hours of being removed from the animal and immediately put into production to prevent putrefaction. Trucks or freight cars deliver about 1000 hides at a time — a quantity weighing about 50,000 pounds.

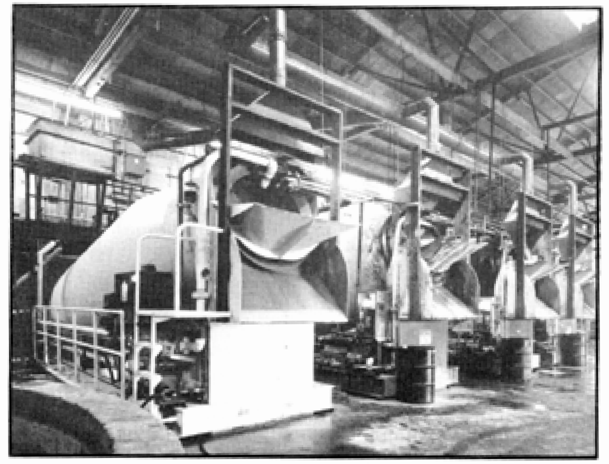
In the hide house the hides are sorted for thickness then weighed into packs. Each pack is identified as to size, weight, type of skin and any other information that will be helpful to later processing. Each pack, consisting of 100-700 hides, depending on the type of equipment available, travels through the tannery as a unit or batch.

2 SOAKING

(Objective: Restore lost moisture to the hides.) As a result of the curing process the hides will have lost a good deal of their natural moisture. The tanner must now restore the moisture in the hide so the chemical treatments that are to follow can fulfill their purpose. This is done by soaking the hides in water to which chemical wetting agents (similar to household detergents) and disinfectants are usually added.

Soaking is accomplished in a number of vessels: tanning drums, hide mixers or paddle vats (Figure 2). The purpose of these vessels is to move the hides around in the soak liquor so they will flex and gradually absorb water. They will become softer and cleaner as a result. From 8 to 20 hours, depending on the thickness of the hides, is required for proper soaking.

At the completion of the soak, the hides are washed by introduction of fresh water to the vessel while continually discharging the overflow. This washing removes excess salt, dirt, and blood from the hides.



2. Mixers loaded with hides for soaking and unhairing operations.

3 UNHAIRING

(Objective: Removal of hair, epidermis, and certain soluble proteins.) The hides are now ready to have the hair removed. This is primarily a chemical process, although mechanical unhairing equipmment has been used by some tanners in order to save the hair for other usable products.

The chemicals, or depilatory agents, actually have a threefold purpose. They must: (1) destroy the hair or attack the hair root so that it will come free from the hide; (2) loosen the epidermis, a hard outer layer covering the grain; and (3) remove certain soluble skin proteins that lie within the hide substance. At the same time, these chemicals must have little or no effect on the desirable *collagen* (leather making fibers) of the hide.

The most commonly used system of hair removal employs calcium hydroxide (hydrated lime) and sodium sulfide. These chemicals are added to the vessel containing the hides in water. The concentration of these materials, the water temperature and the amount of agitation (paddling or turning) all have a direct bearing on the rate at which the unhairing proceeds. For example, higher concentrations and temperatures used in the *hair burn* can result in the hair being dissolved and removed in only a few hours. However, if the hair is to be saved for its commercial value, a longer procedure using weaker concentrations is used. This *hair save* process usually runs from two to four days and destroys only the hair root, leaving the hair itself free to be recovered mechanically. It is then washed, dried, and sold for various uses such as felt.

The lime and sulfide chemicals used in unhairing produce a strongly alkaline solution (high pH). The hide fibers under such conditions acquire a considerable affinity for water, which causes them to absorb a large amount of moisture and swell. An unhaired skin after lime-sulfide treatment swells to about twice its normal thickness, a condition the tanner calls *alkaline swelling*.

4 BATING

(Objective: Removal of residual unhairing chemicals and non-leather making substances.) At this point, the hides are free of hair, swollen and moderately clean. The alkaline materials used in the unhairing are still present in relatively large amounts, and now that they have performed their function they must be removed. In addition, there are still some non-leather making constituents in the grain and throughout the thickness of the hide: removal of these is necessary to improve the appearance and resiliency of the resultant leather. Bating accomplishes these objectives.

The first phase of the bating process, termed *deliming*, eliminates the lime and alkaline chemicals present. The excess of these is removed by washing the hides in large cylindrical drums (Figure 3). The drums have hollow axles and rotate at a rate of about 8 revolutions per minute. On one side of the drum there is a mixing tank in which chemicals that are to be added may be prepared. A pipe leads from this tank into the drum through one of the hollow axles. Through the other axle a water pipe is inserted. Whenever the process calls for washing the hides, a perforated door is fastened into the place normally occupied by a solid door. As the drum rotates, water is introduced through the water pipe and the effluent discharges through the perforated door.

The vast network of collagen fibers in a skin tend to hold onto the last portions of lime. To speed up the deliming operation, additional chemicals are employed at this point. Salts like ammonium sulphate or ammonium chloride are added to neutralize or convert the residual lime into soluble compounds which later can be washed free of the system. As this process takes place, some of the excessive alkaline swelling begins to disappear, and the skins start to return to a more normal thickness.

The deliming chemicals also perform another useful function. They adjust the acid-alkaline conditions (pH) to the point for receiving the *bate*. Bates are enzymes similar to those found in the digestive systems of animals.

The second phase of this process commences with the addition of the bate itself. It attacks and destroys most of the remaining undesirable constituents of the hide. Some of these substances, such as hair roots and pigments, are in the outer (grain) portion of the hide. Their removal creates a softer, less harsh feeling to the grain surface and gives it a cleaner appearance. Also attacked are glue-like protein substances that are located

3. Drums used for bating, pickling, tanning, retanning, coloring, and fatliquoring operations.

between the leather-making fibers. If allowed to remain they would tend to cement the fibers together to the point of making the resultant leather hard and *tinny*.

As was the case in unhairing, the amount of bating material, the temperature, and the length of time are critical to the extent to which bating takes place. Commercial processes vary in time from a few hours to overnight, depending upon the nature of the hides being handled. Modern bates are actually mixtures of chemical deliming agents and various enzymes, permitting both phases of this overall process to be conducted simultaneously.

When the bating chemicals have completed their job, the hides are washed thoroughly to rid them of all the substances which this operation has loosened or dissolved.

5 PICKLING

(Objective: Transform the hides into an acid environment for tanning.) We are now approaching the time for performing the actual tannage. The previous steps have removed all the undesirable constituents (flesh, hair, non-leather making substances) from the hides. One final preparatory step remains, called *pickling*.

Pickling places the hides in an acid (low pH) environment ready to accept the tanning materials. This step is necessary because the chrome tanning agents that are to follow are not soluble under alkaline conditions. Thus, if they were added to non-pickled hides, they would precipitate from solution and therefore not effect a tannage. Any of a number of different acids can be used for this purpose, sulfuric acid is the most common.

The pickling process first calls for the addition of common salt, or brine, to the system. If acid were added alone, a condition called *acid swelling* would soon develop, similar in many respects to the alkaline swollen state of limed hides, except that it causes irreversible damage. Tanning a hide in this condition would produce very undesirable leather. The purpose of the common salt (many other chemical salts will function similarly) is to attract and *tie-up* the excess moisture that would otherwise cause the fibers to swell.

Pickling, then, is the process of adding salt and acid to hides. It is frequently done in the same drum immediately following the bating procedure. It takes only a few hours for the salt and acid to penetrate completely.

The pickling operation is a preserving technique in its own right, and hides and skins can be kept in this state for extended periods of time without fear of deterioration. Though not common practice in our country, this procedure is used extensively on certain skins, notably sheepskins, in other areas of the world where it is desired to complete all of the pretannage operations at the point of slaughter and then export the pelts for tanning.

6 TANNING

(Objective: Conversion of the hides into a stable, non-putrescible material.) The next step in our operation is the tannage itself. The primary function of any tanning agent is to convert the raw collagen fibers of the hide into a stable product which is no longer susceptible to putrefaction or rotting. In addition, these materials significantly improve many of the properties of the substance: for example, its dimensional stability, abrasion resistance, resistance to chemicals and to heat, the ability to flex innumerable times without breaking, the ability to endure repeated cycles of wetting and drying, etc.

The actual chemistry involved in tanning is quite complex and beyond the scope of this book. As with so many things in this world about us, man first discovered certain practical methods of achieving something that satisfied his needs without actually knowing many of the whys and wherefores. So it was with tanning, the oldest known manufacturing process, practical methods preceded knowledge of why many of these chemical processes worked. Recent times have changed much of this and leather chemists have simplified much of the complex mechanism that is involved in tanning. This in turn has led to the development of new tanning materials and methods designed to impart specific properties into today's leathers.

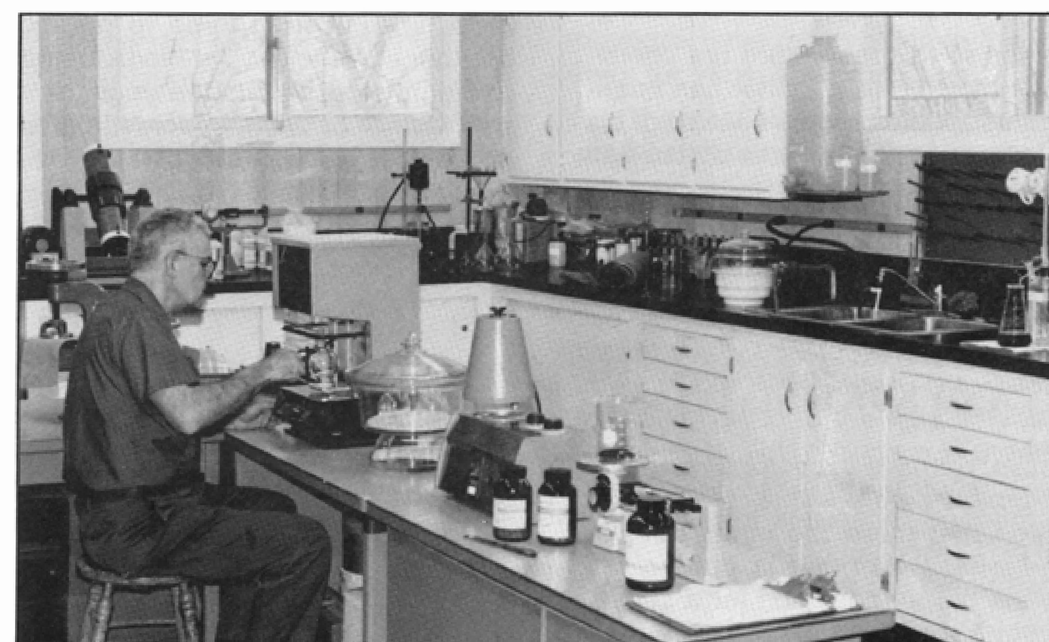
The tanning method which ranks foremost today is the one called *chrome tanning*. It finds favor chiefly for two reasons: (1) it can be accomplished in a much shorter time (4-6 hours) than prior classical methods, and (2) it produces a leather that combines to best advantage most of the chemical and physical properties sought in the majority of leather uses.

Tanning is done in the same large drums that were previously described (Figure 3). It can be executed in the same drum as was used for bating and pickling, as soon as the latter operation is complete. If, however, the hides have been removed after pickling for storage or to sort for quality, they are put back into a drum along with brine. Brine rather than water is used to *float* the hides in order to guard against the possibility of acid swelling, as discussed under PICKLING. The proper amount of chrome tanning agent is then measured out, placed in the mixing tank, and introduced into the revolving drum.

Considerable attention is given to the preparation of the chrome tanning agent prior to its use. The chemical state of the material, as well as the conditions inside the drum, must be such as to permit good penetration throughout the thickness of the hide. For example, if the affinity of the tanning agent for the protein fibers is made too great, too much of it will *fix* on the skin surfaces, with insufficient amounts in the internal sections. Poorly tanned, non-uniform leather is bound to result.

To prepare a chrome tanning agent with the correct properties, the tanner takes a chromium salt, such as sodium bichromate, and reacts it with sugar-like substances plus sulfuric acid. This procedure *reduces* the chromium salt to a substance chemically known as basic *chromium sulfate* — or popularly called simply *chrome*. The operation is performed in large reaction vessels that are equipped to control the rate of reaction, important to the final properties of the materials. A tanner usually makes up about a week's requirement of chrome at a time and draws from it as required, or purchases a 'prepared' chrome from a chemical supplier.

Chrome imparts a blue-green color to the hides (called 'blue' state) and this property is made use of in assessing the extent to



4. A portion of the quality control laboratory in a modern tannery.

which penetration has been achieved. When it is deemed adequate, the pH conditions of the system are slowly raised to increase the fixation of chrome with the skin protein. This is done by adding a mild alkaline substance such as sodium bicarbonate (baking soda); it reduces the acidity and increases the affinity of the protein for the chrome. The entire tannage takes 4 to 6 hours to complete, depending upon the thickness of the hides. The tanned hides are then dumped into large boxes which fit underneath each drum. They have holes in them to permit the excess solution to drain away from the skins.

Due to environmental considerations, greater process efficiency is required. Through recycling and increased fixation the utilization of chrome has been raised to as high as 90+%.

The rate at which tanning proceeds is followed by determining the *shrinkage temperature* of the hides. Tanning materials impart increased heat resistance to leather. If an untanned piece of hide is heated in water, it will shrink in size quite noticeably when the water temperature reaches about 140°F. The shrinkage temperature increases measurably as tanning proceeds and when fully chrome tanned leather can withstand a temperature of 212°F (boiling) without shrinking.

In addition to this test, there are chemical methods by which the tanner can quantitatively measure the chrome content of his leather. It can be seen from the discussion above that the modern tanner relies heavily on his laboratory facilities (Figure 4) to insure production of quality leather.

7 WRINGING AND SORTING

(Objective: Remove excess moisture and sort for thickness before splitting.) We have already seen that there are many tannery operations whose purpose is putting the hides into the proper condition for a subsequent step in the process. Such is the case of the next step, termed *wringing*; it removes excess moisture from the stock so that it can be properly handled on the splitting machine which follows. The drain box containing the tanned hides is moved with a fork truck to the wringer. As the name suggests, this machine is two large rolls which squeeze out the excess moisture as the hides are fed through. It works on the same principle as a clothes wringer with a helical spreading cylinder keeping the hides against the feed roll preventing wrinkles.

This action also compresses the leather to something less than its natural thickness, but because of the inherent resiliency of the fibers, they soon spring back to normal.

8 TRIMMING AND SIDING

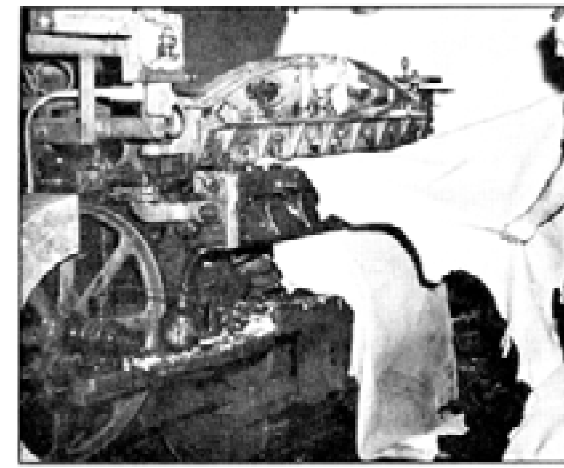
(Objective: Preparation of hides for splitting and shaving.) The trimming and siding operation is done on a moving conveyor belt that has a circular blade at one end (Figure 5). The hide is placed on the conveyor and the heads, long shanks and other perimeter areas are trimmed off with a hand knife. These *offal* areas do not make good leather and if left on would interfere with tannery equipment.

As a further aid to easier handling, the hides are cut from head to tail along the backbone by the circular blade to make a left and right side. This is the origin of the term *side leather* or in other words leather that is processed as two sides rather than one whole hide. As used hereafter, the word hide actually means half-hide, or side.

5. The "siding" or cutting in half of a cattlehide.

9 SPLITTING AND SHAVING

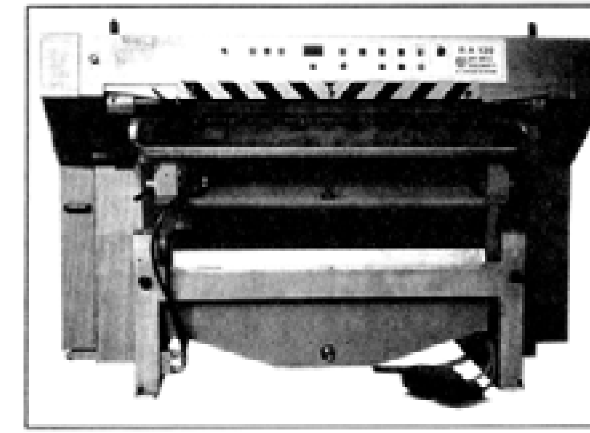
(Objective: Adjust the thickness to that required for the end use.) The thickness of all hides and skins can vary quite a bit. Some of this is related to the age of the animal, but even on any given hide there will be thickness variations between different parts of the skin. Since this variability, if not eliminated, could cause problems for the manufacturers of leather goods, and because various end uses require different thicknesses, it is now necessary to correct for this with the *splitting machine* (Figure 6).



6. Splitting side leather to uniform thickness. The bottom or flesh layer is termed a "split."

The hides are fed through the machine with the *grain* side up, yielding a grain portion of uniform thickness. The underneath or flesh layer that is cut off is called a *split*. Usually there is a fairly large area of the split which still possesses enough thickness to warrant further processing. Though a split no longer has any grain, it is still a valuable raw material for making sueded types of leather. A tanner may process his own splits or sell them *in the blue* (that is, chrome tanned only) to other tanners who specialize in making such leathers. For the purposes of this discussion, we are now concerned from this point on only with the grain portion after the splitting operation.

Our next operation is *shaving* (Figure 7).



7. Shaving machine used to level overall hide thickness.

The shaving machine, which has helical shaped cutting blades similar to the previously described fleshing machine, is used to level the overall hide thickness to exact specifications and open the fiber structure to better receive subsequent chemical processing. Thickness is measured by a gauge in *ounces* or millimeters, with one ounce equal to 1/64 inch.

PROCESS AND EQUIPMENT CHANGES IN THE 90's

As we proceed into the 90's a number of changes have taken place in the lower tannery for various reasons.

The most obvious changes have been the physical separation of the tannery into lower tannery (SOAKING through TANNING and possibly SPLITTING and SHAVING) and the upper tannery (COLORING through FINISHING and SHIPPING). The location of these two tanneries are also geographically separated usually by several hundred miles even in excess of 1000 miles. The lower tannery is located close to the hide source (slaughter houses). This change was gradual beginning in the late 60's but today (90's) most tanneries are separated undoubtedly hastened by E. P. A. regulations. This has led to several variations on the same theme:

A. Separated Tanneries — Same Management

B. Separated Tanneries — Different Management
   1. Both managements historically in the tanning business
   2. Meat packers participating in lower tannery manufacturing

Other changes which have taken place in the last 30 years are:

A. Manufacture of fresh hides — eliminating the use of salt and other preservatives.

B. Larger vessels — the larger the hide supply source leads to larger facilities and larger vessels specifically drums (built to process in excess of 30,000 lbs. of hides).

C. "Feed-through" wringing machine which is now standard equipment in almost every lower tannery, wringing whole hides for splitting then siding for shaving.

D. Computerized automation — designed to more accurately control the leather making process. Automation can be in various degrees:
   1. Strictly monitoring the process
   2. Automatic water delivery, chemical feeding, and drum operating control.
   3. Automatic chemical weighing and delivery system.

Some lower tanneries are operating with system 1 & 2 with at least one tannery utilizing all three areas of automation.

The benefits of process automation are laying the foundation for the tannery of the future with capabilities of implementing the latest technologies available.

10 RETANNING, COLORING, FATLIQUORING

The hides are now put back into drums (Figure 3) to perform three operations listed below. Although each of these has a vastly different purpose, the tanner considers them as a unit because they follow one another without interruption, requiring a total time of 4-6 hours.

RETANNING

(Objective: Impart special end-use properties with other tanning chemicals.) The retanning operation gives the tanner an opportunity to combine the desirable properties of more than one tanning agent in his leather. It is in effect a second tannage. There is a large family of materials which can be employed for this purpose, the more common ones being vegetable extracts, syntans, and mineral compounds.

Vegetable extracts are derived from trees and shrubs by the application of heat and water to ground up leaves, twigs, bark or wood. They are among the oldest tanning materials known. The names of some of the more common ones are quebracho, wattle, sumac, and chestnut. These substances add solidity and body to chrome leather and help to minimize variations in the character of the leather that may still exist between different parts of the hide.

Syntans are man-made chemicals, developed within the past 60 years, that impart a variety of properties to chrome tanned leather. They are used extensively in the manufacture of softer side leathers which have become recently popular. They also find use in making white or very pastel shades, since most of them have a pronounced bleaching effect on the blue-green chrome color of the original tannage and have a 'leveling' and uniforming effect on the color imparted to the leather by aniline type dyes.

Mineral retanning agents most often used are basic chromium sulfate and basic zirconium sulfate. Again these materials are used because of specific properties they impart to the leather, such as softness from chrome and a 'white' color from zirconium.

The retanning step generally takes much less time to execute than did the original chrome tannage. First of all, the skins are washed and neutralized with mildly alkaline or acid chemicals to adjust both the temperature and pH of the system to the best levels for the particular retan material selected. The chosen material is then introduced into the revolving drum and combines with the leather usually within 1 or 2 hours. Often, combinations of vegetable, synthetic and mineral retanning agents are used.

COLORING

(Objective: Color with aniline derived, water soluble dyes.) The natural beauty of leather is made even more striking by the wide variety of shades which the modern tanner is capable of producing. The dyeing of leather is an art in its own right, as there are several factors to contend with which are not present in the coloring of most other substances.

One such item is nature's own built-in variability among hides that takes the form of different pigmentation and other grain characteristics. Of course, all products of nature have varying degrees of non-uniformity. But in the processing of such things as cotton fibers into textiles, cellulose fibers into papers, etc., the raw materials are generally mixed and blended during the early stages of processing, producing a homogenous base on which to apply the coloring matter. The tanner cannot blend or rearrange his leather fibers, and it is therefore essential that he tan and retan his leather in such a uniform manner as to minimize any factors that could lead to uneven dyeing. We should make note of the fact, however, that a very slight shade variation actually enhances the overall coloring effect, and is something no synthetic product can easily duplicate.

A second important consideration which the leather colorist must take into account is termed *penetration*. As the name suggests, it refers to the depth to which the coloring matter penetrates into the leather. Dyes differ widely in their ability to penetrate. Since it is only rarely that a particular color can be produced with a single dye (usually blends of two, three, or more are required), the tanner must select combinations that will work well together, that is, penetrate and exhaust from the coloring solution at as nearly the same rate as possible.

Coloring is accomplished with aniline-type dyes which are derived primarily from petroleum. They are dissolved in very hot water and added through the hollow axle in the rotating drum as soon as the retanning step is completed. The dyes combine with the hide fibers to form an insoluble compound which becomes part of the hide itself. The rate at which dyes exhaust from the color liquor onto the leather influences the resulting shade, degree of penetration, etc. The faster the exhaustion rate, the greater will be the amount of surface color at the sacrifice of penetration. Here again, the tanner makes use of pH control in order to regulate the affinity of the dyes for the leather fibers.

There are hundreds of dyes and auxiliary products available to today's tanner. They possess widely differing properties, but by careful selection and application, the tanner can produce a myriad of appealing shades with good resistance to fading, perspiration, bleed, and the effects of dry cleaning and washing. The most commonly used dyes and their chief characteristics are:

ACID DYES (penetrate readily, make bright and lively shades)

METALLIZED DYES (level dyeing, for subdued pastel shades)

DIRECT DYES (surface dyeing, produce deep shades)

BASIC DYES (surface dyeing, make very brilliant shades)

FATLIQUORING

(Objective: Lubricate the fibers for flexibility and softness.) Several of the preceding operations have a bearing on how firm or soft a leather will be. *Fatliquoring*, however, has the most pronounced effect on this characteristic and is the last of the *wet* chemical operations to which the leather will be subjected. It is a process by which the fibers are lubricated so that after drying they will be capable of sliding over one another. In addition to regulating the pliability of the leather, the fatliquor contributes greatly to its tensile strength.

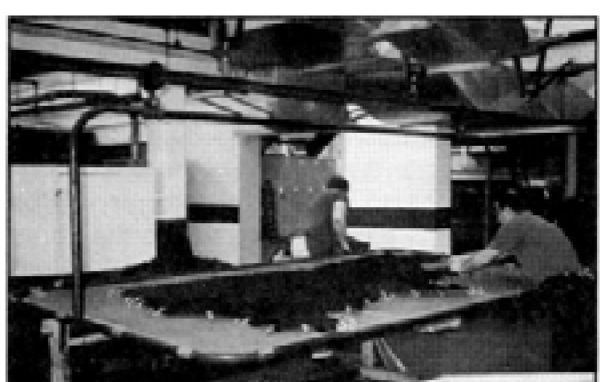
The basic ingredients in fatliquors consist of oil and related fatty substances which represent products from animal, vegetable, and mineral sources. As one would suspect, these oily substances are not soluble in water. They can be made to react, however, with certain chemicals that impart water solubility to them. Another approach that is also used is to add a class of chemicals known as *emulsifiers*, which, although they do not react chemically with the oily substances, do permit them to be dispersed in water to form a stable emulsion.

After the hides are colored, they are washed to eliminate residue dye, excess acid, etc., and to adjust the temperature to that required for the fatliquor system — usually about 125°F. The fatliquor is dispersed in hot water and added to the rotating drum; about one hour is required for exhaustion.

The tanner, by the selection of the type and amount of fatliquor, can produce, from the same basic tannage, side leather that ranges from the firmness of shoe and boot leather to the softness and suppleness of today's casual shoe and garment leathers.

11 SETTING OUT

(Objective: Smooth the grain and remove excess moisture.) Having now passed through all of the wet chemical operations to which they must be subjected, the hides are approaching the time when they must be dried out. The next step, termed *setting out*, puts them into the proper condition for drying.



8. Toggling wet skins on metal frames before sliding into drying oven.

It is a multi-purpose operation, which smooths and stretches the hide, while compressing and squeezing out excess moisture.

The type of machine used is much like a fleshing machine (Figure 7) except that the blades on the cylinder are shaped so as not to produce any cutting action. Considerable pressure is applied to the rolls to aid in smoothing down the grain.

As a result of this operation, the leather fibers assume a relatively compressed state — a condition which will be maintained during the subsequent drying. The hide at this stage contains about 60% moisture.

12 DRYING

(Objective: Removal of all but equilibrium moisture.) Leather drying can be accomplished by four different methods. The method that is chosen will have a bearing on the final characteristics of the leather.

The simplest method, *hanging*, is performed by draping the hide over a horizontal shaft and letting it dry as you would clothes on a line. In order to speed up the process, the hung hides are usually passed through a large drying oven by means of a conveyor system. It is important that drying temperatures be kept moderately low (below 130°F) in order to minimize shrinkage.

Toggling is another method (Figure 8). Hides are kept in a stretched position by means of clips called *toggles*. Generally, two operators work as a team, fastening toggles to the perimeter of the hide, stretching it and attaching the toggle (which has a small hook on the underneath side), to a perforated frame. The frame is then turned over and a second hide is attached in a similar fashion to the other side. Finally, the operators slide the frame into channels in the drying oven.

The third method in use today for drying side upper, garment, split and other specialty leathers is called *pasting*. And as the name suggests, the hides are actually pasted onto large surfaces called *plates*, about 6x11 feet in size. The plates may be made of porcelainized steel, stainless steel or even glass, and they are attached to a continuously moving mono-rail. The plates first pass through equipment that scrubs them clean and wipes them dry. Then a spray gun, moving up and down automatically, sprays the paste solution uniformly over the surface. The paste is generally a starch-like material specially formulated to provide good adhesion of a heavy wet hide and hold it in place during the drying process, but it must allow the hide to be 'stripped' or peeled from the plate easily once it is dry. Also any paste left on the hide must be easily washable from leathers that are to be made in 'full grains'.

The operators place the leather grain-side against the plate, stretching and smoothing it out with a dull bladed instrument called a 'slicker'. The pasted skin is transported by the mono-rail into a drying oven where controlled temperatures (120-170°F) and humidities (40%RH) are maintained. Hides are stripped from the plates and stacked as the plates come from the dryer. Paste drying gives the tanner more *yield*, that is, more square feet of leather per hide than any other type of drying. Drying times for these three methods vary from 4-7 hours. Regardless of which drying method is used, it is important that the leather not be over-dried. Normal leather, dry to the touch, still contains 10-12% moisture.

The fourth, newest, and most popular, drying method is called *vacuum drying* (Figure 9). In the vacuum dryer, the wet hide is smoothed onto a heated stainless steel plate, then covered by a perforated steel plate which is covered by a felt or cloth. A vacuum is pulled which extracts water vapor from the leather. Care must be taken that tanning materials not chemically bound are not pulled out with the water. Vacuum drying can be performed in a very short time, 3-8 minutes usually. It is also used as an auxiliary drying method to remove limited amounts of moisture at specific points in the drying process.

9. Wet sides are slicked out on a vacuum dryer for drying.

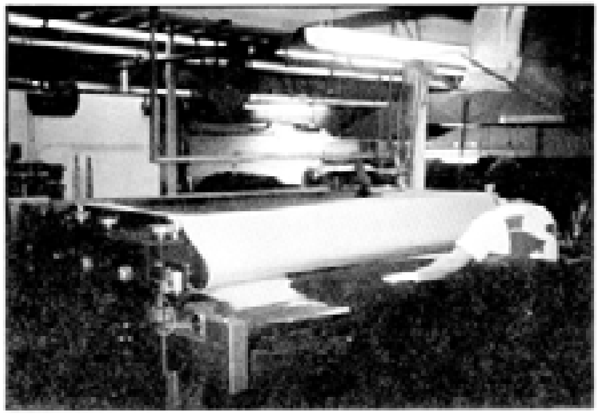
13 CONDITIONING

(Objective: Introduction of controlled amounts of moisture.) At this stage, the leather could be used as is for some applications. In general, however, the drying operation renders the hides too hard and unworkable for most shoe upper construction. The shoe manufacturer requires varying degrees of softness — or *temper*, as the tanner calls it — depending on whether he is making a man's hand sewn moccasin (the loafer) or the equally soft, supple cold weather boot for women's wear.

The *conditioning* of leather, sometimes called *wetting back*, is the first step in adjusting for the final temper. It consists of applying a fine mist of water to the leather surfaces as the hides pass on a conveyor between several shower-like nozzles. The water is distributed by capillary action through the thickness of the skin. Each hide is then piled on top of the other on a portable table. A watertight cover is wrapped over the load and the leather is left to *mull* overnight to permit uniform distribution of the moisture. The moisture content of the leather is thus raised to about 25% throughout. It will act as a temporary lubricant to protect the fibers during staking.

14 STAKING & DRY MILLING

(Objective: Mechanically soften the leather.) Leather is *staked* to make it pliable. In combination with the correct fatliquoring



10. A staking machine used to mechanically flex and soften leather.

treatment, as described in section 10, staking governs the final firmness or softness of the leather. Most staking is done today on automatic machines (Figure 10). Leather is carried by conveyor belts between a very large number of rapidly oscillating, overlapping fingers or pins. The pins pound into the piece of leather from both above and below hundreds of times as it passes through the machine, stretching and flexing the leather in every direction. The mechanical stresses that staking imposes on the leather are very great, and illustrate the inherent strength of leather. This high production 'through-feed' machine is capable of staking up to 300 large sides per hour and more than 500 smaller skins.

The moisture added during the conditioning operation facilitates the flexing of the leather fibers. Following staking, this excess moisture is removed by one of the previously described drying methods, *airing off*.

Another type of mechanical softening is called 'dry milling'. This method is used generally on lighter weights, particularly garment leathers, and may be used in conjunction with staking. It consists of throwing the previously dried leather into a large dry drum and tumbling it for a time (½ - 8 hours) until the softness and grain pattern desired are obtained.

15 BUFFING

(Objective: Smooth the grain surface by mechanical sanding.) Some skins have natural healed scratches or parasitic damage in the grain of the leather. Such blemishes attest to the genuineness of leather and are generally not detrimental to its use. To improve its final appearance, however, it is frequently desirable to minimize such a condition by lightly *buffing* the grain surface of the leather.

The buffing machine (Figure 11) uses a sanding cylinder covered with a special abrasive material similar to sandpaper. Other types of machines utilize a rotating belt of abrasive paper in much the same fashion as beltsanders used in sanding wood. Various controls on the equipment regulate the extent to which the abrasive material cuts into the grain.

The light sanding leaves a clean, smooth surface ready for the subsequent finishing operation. Any leathers which are not so buffed are called *full grain*. If leather is to be used in an unlined shoe, it is desirable to have a smooth, fine nap adjacent to the foot, in which case buffing may also be performed on the flesh side of the leather as well.

After the hides are buffed, it is necessary to remove the *dust* created by this operation. Several methods are employed, including the use of rotary brushes, jets of compressed air, and vacuuming techniques. Modern buffing machines frequently incorporate such equipment in tandem with the buffer, making the entire procedure a one-step operation.

11. Smoothing the grain surface of side leather on a buffing machine.

16 FINISHING

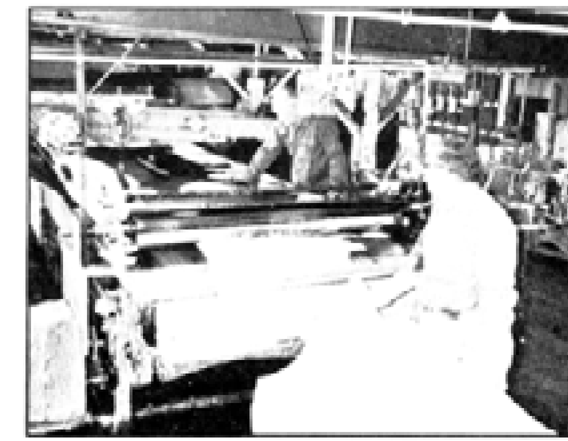
(Objective: Application of film-forming materials to the grain to provide abrasion and stain resistance and enhance color.) So far we have been dealing with the chemical and mechanical operations which have converted the hides into a stable material — one with strength, flexibility and smoothness. The *finishing* department in a tannery is the area where an alert and creative mind now adds the final touches to enhance the natural beauty of the product, while further improving its serviceability. It is here that many imaginative effects are produced by varied applications of coloring matter compounded with different film-forming materials.

The finishing system employed is dictated by the nature of the hides and their use. Thus, full grain leathers which possess superior grain characteristics generally receive light applications of transparent coating materials containing subtle amounts of coloring matter, e.g. aniline dyes, or dyes and solvents alone as in today's 'naked' leathers. As a result, all of the inherent beauty of the grain shows through, while the surface is protected against abuse and shaded to the desired color effect. This is analogous to the natural finishing of fine furniture, and leathers so finished are in demand for quality footwear and garments that feature individuality, depth, and rich aesthetic appeal.

Where a more opaque coloring effect is desired, selected pigments are added to the finish composition. Such finishes possess greater *covering power*, in the same fashion as paint compared to shellac. This type of finish serves to upgrade hides of coarser grain. These leathers are used for work shoes and the like.

From an appearance standpoint, the two finish systems described above represent the extremes which are obtainable; there are many variations that lie between these which produce additional effects.

In recent years the vast chemical industry has given birth to a number of new coating substances, and the tanner has been quick to adapt many of these to his leathers. No longer is he restricted to casein, shellac, albumin, wax, linseed oil — materials of yesteryear. Today more sophisticated film-forming substances, materials such as acrylate, vinyl and butadiene polymers, nitrocellulose, polyurethanes and the like, are used as leather coatings. This has resulted in leathers with marked improvements in resistance to abrasion and staining — leathers which hold their true colors indefinitely and are easy to care for.

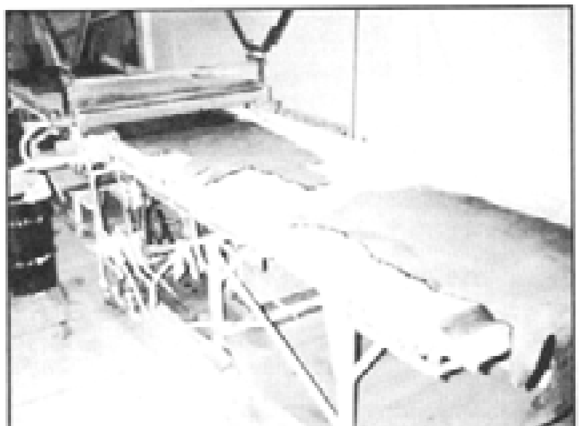


12. The application of coating materials on a seasoning machine.

A good example of product improvement is the case of patent leather. Only a few short years ago the best coating system available for this perennial favorite was a mixture of varnish like substances that sometimes cracked or peeled in use. Today, polyurethanes and related chemicals are used to produce surface coatings on patent leather that withstand the most severe wearing conditions, while retaining their high lustre for the life of the shoe.

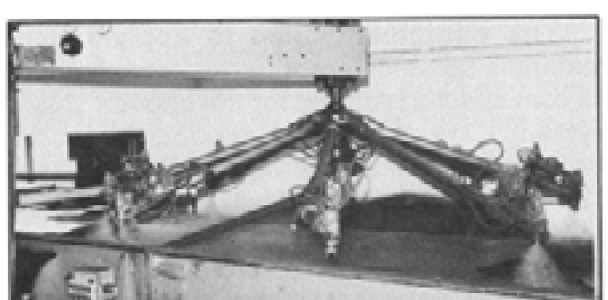
The equipment used to apply finish materials takes different forms, each having its own special features for the chosen finish system. One of the conventional methods makes use of the *seasoning machine*. (Figure 12). The finish is pumped into a trough where it is picked up by a rotating fluted roll. A rotary brush transfers the finish from this roll and deposits it onto the leather which passes beneath on a *bolster*. Finally, mechanized *swabs* work the coating material into the grain and smooth it out.

A *flow coating* machine (Figure 13) is especially adapted to depositing a heavy coat of finish. Two types of machines are in use. In both cases the finish is pumped into a reservoir, or *head*, which is placed above the conveyor that transports the leather. In one type the finish flows down in a thin unbroken sheet from a narrow slit in the bottom of the head. The other type is designed so that the finish is made to overflow from the head like a waterfall.

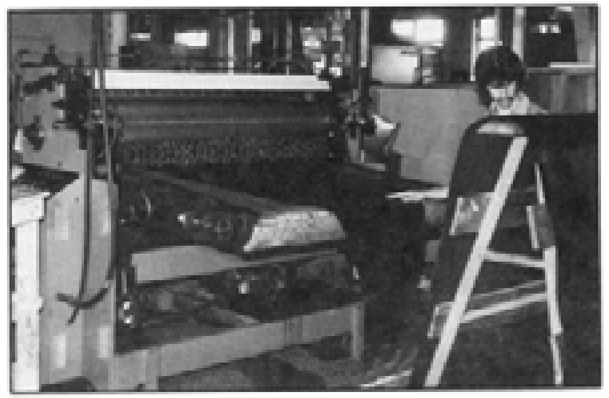


13. A flow-coating machine laying down a film of finish onto the leather surface.

Another widely used method is the *rotary spray* (Figure 14). In this instance, several spray guns are mounted on a unit which revolves continuously over the conveyorized leather. Spray equipment lends itself well to the application of light coats of finish. In addition, unique patterns and multi-tone effects can be obtained by varying the atomization of the spray, the angle of the guns, their speed, etc. A fourth method of applying finishes is *roll coating* (Figure 15). Most often used to apply a solvent lacquer top coating, the finish is transferred directly from a rubber coated or knurled steel roll to the leather surface — depending on the design of the coating machine. By using etched or engraved transfer rolls, the leather surface may also receive a distinctive pattern, as in rotogravure printing.



14. Coating materials being applied by rotary spray guns.



15. Application of coating material with a roll coating machine. Photo courtesy Dr. T. Thorstensen.

The leather, with its wet coat of finish, must now be dried to evaporate the water or solvents contained therein, and cause coating materials to coalesce into a durable, protective film — one that becomes an integral part of the leather. Various types of dryers are used, one of the most common being in the form of a long tunnel. Steam heated air or infra-red heating units expedite the drying.

It should be mentioned that, as is the case with most all coating systems regardless of what the substrate may be, only seldom is it possible to produce maximum results with a single application of material. Leather finishing is no exception, and usually several coats of finish are applied (with intermediate drying) to achieve the desired properties. The final coat, applied by spraying, flow coating, or roll coating is specifically formulated to seal the bottom coats and develop the required lustre — glossy or matte, as the case may be. In some of the high performance specialty boot and sports leathers, applications of oils or waterproofing materials are required. These materials are most often applied by either the seasoning machine or flow coater methods.

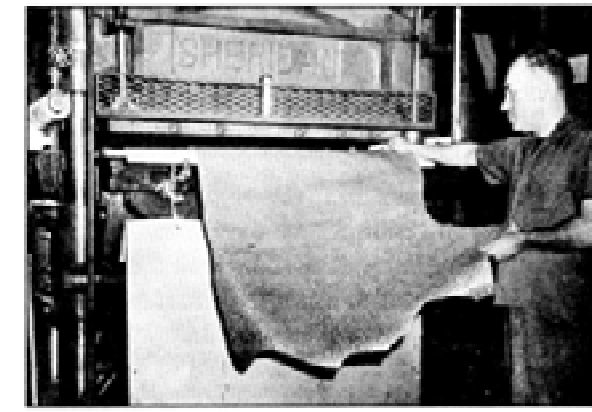
17 PLATING

(Objective: Smooth the finished grain surface or produce varied grain textures.) The final processing step to influence the appearance and feel of the leather is called *plating*. The effect produced is similar to what you would expect from running a hot iron back and forth over the leather, using tremendous pressure. It smooths the surface of the coating materials just applied, while affixing them firmly into the grain.

Finishing and plating steps are carried out in conjunction with one another over four or five days. For example, it is common practice to apply a few coats of finish, plate, apply another finish coat, plate again, etc.

The plating and embossing operations are carried out in presses capable of developing extremely high pressures — up to 300 tons per square inch. On one type of machine the mirror smooth plating surface is steam heated to about 225°F. Leather is fed into the press and the press is closed for a second or two. It is then opened and the operation repeated until all parts of the hide have been plated. A more modern smooth plating machine irons the leather by a mirror-finish stainless steel cylinder as it passes through the machine (Figure 16). These high production 'through-feed' presses utilize electrically heated oil to maintain the desired temperature, which may go above 250°F on the cylinder.

16. A mirror-smooth, hot roller irons flat the leather surface.



17. An embossing machine used to produce a variety of grain effects on side leather.

A related operation is performed by the *embossing* machine (Figure 17). A specially engraved plate is used to produce a particular pattern as for example a 'boarded grain'. It is possible to emboss any number of fashionable textured effects into the leather surface this way, including the simulation of another animal's grain characteristics. This demonstrates still another of leather's many attributes — its ability to accept and permanently retain a printed pattern.

18 GRADING

(Objective: Determine the quality of the finished product.) We have seen that the process of leather manufacturing is a carefully integrated system of unit operations, requiring close supervision. The final *grading* of the leather will ascertain the effectiveness of the tanners' quality controls.

Leather is graded for temper, uniformity of color and thickness, and the extent of any defects which appear on its surface. Higher quality leather naturally commands the highest price and is ultimately cut into the finest shoes.

19 MEASURING

(Objective: Determine the area of each side.) When a side leather tanner purchases his raw material, the price he pays is based on the weight of the cured hides. Interestingly enough, he sells the resultant leather on the basis of its area. Since the hides are irregular in shape, a special type of machine is used (Figure 18).

By the use of photoelectric cells and built-in computers, the square footage is measured for each individual hide. The hide is passed over the sensing device by a conveyor while an adding machine automatically tallies the footage. The number of square feet is then stamped on the flesh side for each individual piece.

The graded and measured sides are now rolled into bundles of from four to six sides, wrapped in a protective paper cover, secured and labeled. Leather for export is generally placed in wooden boxes for added protection.

And now, after four weeks of painstaking care, the tanner is at last ready to ship his elegant product — leather — into the anxiously awaiting hands of the shoe manufacturer, who will convert it into the most fashionable and durable footwear of our times. The next chapter in this booklet will give an insight into the reason why leather is such a highly prized fabricating material for shoes and countless other items.

18. Determining the area of leather on a measuring machine.
Photo courtesy Dr. T. Thorstensen

CHAPTER FOUR

PHYSICAL PROPERTIES OF LEATHER
its unique and valuable qualities

As beautiful and appealing as leather is, it could never have achieved the commercial importance that it holds today as the result of these attributes alone. What is it about this product of nature that has caused man for centuries to use it for clothing, for convenience items, and in all kinds of occupational pursuits? Obviously, any material that is so versatile in its applications must possess a wide variety of functional properties.

The physical properties to be discussed in this section apply to leather generally, regardless of the type of skin from which it is made. However, through the years, leather made from certain skin origins has been shown to excel in one respect or another, making it appropriate to match specific skin types to various end use items. Table C shows a few of the more common applications that certain kinds of hides and skins are generally used for.

In categorizing leather as a fabricating substance, it is classed as a *flexible sheet material*. Other substances that fall within this broad description include textiles, paper, sheet rubber, certain plastics, and the like. As we delve into the reasons why leather maintains such a prominent position as a flexible sheet material, we will occasionally refer to the photomicrograph (Figure 19) which show a magnified cross section of leather. The uppermost layer is the grain (from which the hair grew), while the bottom portion is the flesh side. The center section is termed the

19. A photomicrograph of a leather cross-section, illustrating its complex fibrous structure. Actual thickness: one-sixteenth of an inch.

corium. Most of leather's valuable assets are directly related to this structure — a structure that took nature the lifetime of some animal to create and the knowledgeable hand of a tanner to permanently preserve.

Tensile Strength
Very High For A Flexible Sheet Material

The strength of any material is of course an important factor in determining the end uses for which the substance will be suitable. What do we mean by *strength* and how is it determined? Actually, there are several different measures of a material's strength. Probably the most universally used measurement, however, is the one called *tensile strength* which Webster defines as *the greatest longitudinal stress a substance can bear without tearing apart.*

It is customary to express tensile strength in terms of pounds per square inch of cross-sectional area, abbreviated *psi*. For example, a rope with a cross-sectional area of 1/2 square inch, capable of withstanding a pull of 700 pounds before breaking, is said to have a tensile strength of 700 divided by 1/2 — or 1400 psi.

If we examine the photomicrograph of a leather section, as shown in Figure 19, we can see that leather's unique physical structure is responsible for this and many of its other attributes.

Note the many small bundles of fibers, all intricately interwoven and twisted around each other. These bundles are built up from smaller fibrous units in a manner somewhat like that used in making a multi-strand steel cable from many small wires. If we could take a still close look, with the help of an electron microscope, we'd find the basic leather molecules (collagen) to be quite long and possessing a helical shape — much like that of a coil spring.

Thus, nature has created leather's physical structure by building up millions of coil-like molecules into tiny fibrous strands, twisting the strands together into bundles of fibers, and finally interweaving the fiber bundles about themselves in a three-dimensional manner. The intricate fiber network so produced forms an untold number of interlocks within the substance which result in leather's very high tensile strength.

Adequate tensile strength is very important to the shoe manufacturer. His machines must be able to stretch and pull leather down tightly onto the shoe *last* without breaking it. In a like manner, the glove manufacturer's leather must withstand the tugging and pulling that accompanies the formation of his product. In a variety of end uses, leather straps and belts must be capable of resisting considerable stress without breaking.

Leather's excellent tensile strength permits it to meet these requirements with room to spare, as each tiny fiber joins in to accept its share of the load.

TABLE C
LEATHER USES RELATED TO TYPES OF HIDES AND SKINS

SKIN ORIGIN	END USE APPLICATION
Cow and Steer	Shoe and boot uppers, soles, insoles, linings; patent leather; garments; work gloves; waist belts; luggage and cases; upholstery; transmission belting; sporting goods; packings
Calf	Shoe uppers; slippers; handbags and billfolds; hat sweatbands; bookbindings
Sheep and Lamb	Grain and suede garments; shoe linings; slippers; dress and work gloves; hat sweatbands; bookbindings; novelties
Goat and Kid	Shoe uppers, linings; dress gloves; garments; handbags
Pig	Shoe suede uppers; dress and work gloves; billfolds; fancy leather goods
Deer	Dress gloves; moccasins; garments
Horse	Shoe uppers; straps; sporting goods.
Reptile	Shoe uppers; handbags; fancy leather goods

Tear Strength
Exceptionally Good For A Sheet Material

Of all the properties of leather, its ability to withstand tearing forces is probably the one most taken for granted. Most flexible sheet materials don't begin to exhibit the same resistance to tearing that leather does.

Another look at the photomicrograph in Figure 19 will help us to explain leather's high tear resistance. The fibers, interwoven and locked as they are, form a moderately random, three dimensional design. Because they are not oriented in any fixed directional pattern, there is no easy path for a tear to follow. This is the failing of many other sheet materials, in that, because of their directional make-up there is frequently a path of *least resistance* which a tear, once started, can follow.

For this reason, we find leather fabricators cutting and stitching leather into shoes, handbags, luggage, straps, and countless other articles without the need of turning over a hem. There also are many instances where stitching around a punched hole or a slit is not required because of this excellent tear resistance. This inherent property of leather helps to build exceptionally long life into the products that are made from it.

Elongation
Can Be Varied Over A Wide Range To Fit End Use

As the name suggests, elongation refers to a substance's ability to lengthen, or stretch, when stress is applied to it. It is commonly expressed as the percent increase in original length when the stress applied equals the material's tensile strength. Stated another way, elongation tells us the maximum extent to which the material can be stretched without breaking.

It should be borne in mind that the amount of elongation that occurs during service is naturally dependent on the amount of stress being applied to the article. Since in most leather applications the stresses are far below leather's high tensile strength, it follows that only rarely will a leather be called upon to stretch to its maximum capacity. Thus, a leather having an elongation of 50% is capable of stretching this amount if the need arises, but under normal conditions is more apt to be subjected to elongations of perhaps 15 to 25%.

One of the reasons that leather finds its way into so many different types of products is because the tanner can control this characteristic over a wide range by regulation of his tanning and fatliquoring procedures. Elongations as low as 15% or as high as 60% are possible. Let's consider some applications that cover this wide range.

A good example of a low elongation requirement is that of flat transmission belting leather. Good dimensional stability here is a must because the belting is used on pulleys that are fixed distances apart, and too much stretching would cause a belt to slip and fail as an efficient drive connector. Slip it will, however, if the load conditions become excessive, thereby supplying a built-in safety factor for the entire drive mechanism — a feature that no rigid type of drive connector can provide. Leather sold for this purpose is prestretched under stress to insure low elongation.

Very high elongation values are required of leathers that are to be used in making gloves. Here, freedom of hand and finger movement is essential for manual dexterity. Because of the stretchy nature of glove leather, only a moderate number of glove sizes are required to fit the entire populace.

Finally, moderate elongations (about 20 to 30%) are found in the leathers used for the upper portions of shoes. Some variation exists between different parts of a hide, a factor that experienced shoe cutters take into consideration when selecting the portions for the vamp, quarters, and other shoe parts. The elongation characteristics which a shoe upper material possesses are a determining factor in the fit, comfort, appearance and wear life of any shoe.

Thus, the material must stretch enough to conform to the foot and any of its deformities such as corns, bunions, etc. At the same time, it should resist stretching beyond a certain point, else the shoe will lose its shape and fail to give proper support. Nor should the stretching character change appreciably at low humidities over a fairly wide temperature range. If it does, the shoe will not maintain a close fit all year round; it may be tight in the winter and loose in the summer.

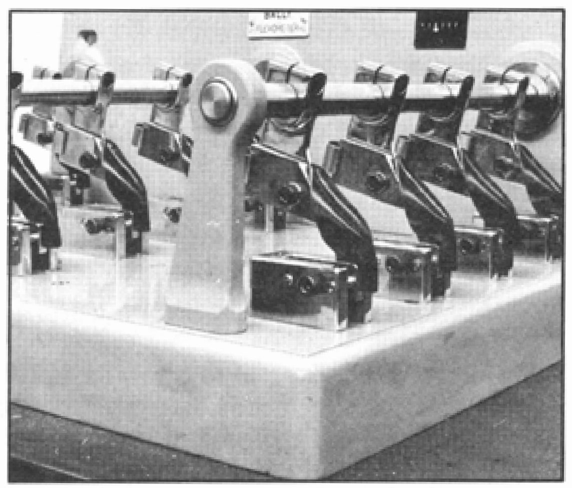
Leather is unsurpassed in satisfactorily meeting all these requirements.

Flexibility

Excellent Over A Wide Temperature And Moisture Range

The unique matrix of fibers of which leather is composed allows it to flex freely without damage under all the normal temperature conditions encountered in everyday life. Since nearly all types of leather are used under conditions of flexing, we recognize this as one of leather's natural rather than special properties.

Here again, we find that the relatively random fiber configuration which nature has built into leather helps in two ways to provide high resistance to flexural failure. First of all, it doesn't matter which way the leather is flexed — top to bottom, side to side, grain out, grain in — there are no weak links that are going to give way and cause failure. And secondly, as it is flexed its structure can be likened to millions of little hinges that are moving back and forth, each taking its share of the load, and doing so in a manner that causes a minimum of fiber breakage. This accounts for leather's remarkable endurance — its ability to take thousands of flexings without failure. Figure 20 shows an instrument for testing the flexibility of leather samples.



20. Leather's endurance to thousands of flexings is determined on test instruments such as this.

As is the case with many materials, exposure to undue amounts of heat will produce damage in leather that is generally reflected in greater stiffness and brittleness. The resistance of leather to the effects of heat is largely determined by the type of tannage. Mineral tannages, such as chromium and zirconium, produce greater thermal stability in leather than do most organic tannages.

Examples of leather's performance under extreme conditions of cold, of heat, and of moisture are numerous. Leather boots and clothing, leather shoe bindings, and dogsled harnesses are widely used in the Arctic and Antarctic regions. Leather's long flexural life under extreme dry heat conditions prompted it to be used as the fan belts in Army tank engines during the extensive desert campaigns of World War II. And what do you suppose was the only suitable material found for pads in the recoil mechanism of big guns during the war — yes, again leather!

Its performance under wet conditions is amply illustrated by the many uses found for leather diaphragms, packings, and seals in various liquid pumping systems. In all its many applications it is noted for its lasting flexibility.

Puncture Resistance

Provides Safety Features in End Use Items

If asked to rate the relative puncture resistance of steel, concrete, hard wood, and leather, most people would put leather on the bottom of the list. This is indeed the case if the comparison is made between pieces of the same thickness. It is not the case, interestingly enough, if the comparison is based on the flexibility of the above materials. This is due to the fact that to attain leather's flexibility, the non-leather items would have to be shaved so thin as to afford little resistance to puncture.

Certain materials related to the textile, rubber, and plastic fields are capable of being manufactured with good flexural characteristics. But they consistently fail to offer the same puncture resistance as leather. The fact of the matter is that it is difficult to manufacture a material that is both flexible and tough to puncture.

The reason that leather is a particularly good material in this respect is again directly related to its unique physical structure — the random weaving together of countless thousands of fibers. Ask any woman who has ever sewn a button onto a leather coat, or perhaps made a leather dress, about leather's puncture resistance. She will be quick to testify that it takes a considerably greater effort to push a needle through leather than it does most textiles. Leather's irregular fiber pattern resists penetration by sharp, knife-like objects, and thus contributes an important added feature to many end use items.

For example, a person is a good deal safer in a pair of shoes having leather soles than ones made of a synthetic material. Rusty nails or broken glass can puncture through the latter with far greater ease than through a sturdy leather sole. Leather work gloves offer far greater puncture protection than those made of textiles or rubberized fabrics. And in addition to its safety features, leather's good puncture resistance contributes to the long and enduring life of most all leather goods.

Capacity To Absorb And Transmit Moisture

Aids The Shoemaking Process And Makes For Good Foot Comfort

Most leathers are hydrophilic by nature; that is, they possess a certain affinity for moisture. Leather will absorb liquid water, it will pick up moisture from the humid air, and it will wick away water from any damp material it comes in contact with. This inherent property of leather translates itself into several valuable features.

When leather absorbs moisture, some of it fills the voids between the fiber bundles. A portion of the moisture, however, is directly absorbed by the fibers themselves, lubricating them internally, and allowing them to stretch and slide past one another with greater ease. As the water content increases, from dry to about 40%, strength and elongation values also increase — a property that is exhibited by very few other substances. Shoe manufacturers take advantage of this attribute by dampening upper leathers prior to the molding *(lasting)* step in their process.

The reaction of leather to water plays an important part in both the breaking in and wearing of shoes. When a shoe is worn, the enclosed foot starts to become moist from perspiration. A leather shoe will pick up this moisture either from the moist air inside the shoe or by absorbing it from the damp stocking. This absorption of water has a number of important consequences.

For one thing, leather's thermal conductivity (the capacity to transmit heat) increases as it becomes damp. Depending upon the conditions under which a shoe is being worn, this can be either a good or bad characteristic. For example, if the leather becomes very wet in cold weather, its increased thermal conductivity will permit heat to escape from the feet, with the latter becoming colder. If the condition persists, actual physical damage such as chilblains may result. Fortunately, shoes are seldom worn for prolonged periods under such adverse conditions without added protection against both moisture and loss of heat.

A far more general problem related to foot comfort is that of keeping the feet dry and cool during warm weather, or in heated homes, schools, offices, and factories. Here leather's affinity for water is of great importance in keeping feet from becoming excessively wet and hot. The shoe leather will absorb perspiration at hot enclosed places (the toe and bottom areas in particular) and by a wicking action, transmit it throughout the whole upper portion. This distributes the moisture over a wider area where it can dry off more rapidly into the air. The evaporation that ensues will cool the shoe and thereby increase the loss of heat from the wearer's foot. Greater foot comfort is the result.

There are still other aspects of the comfort story that are related to this characteristic. During the course of a day or when activity increases, a person's feet tend to become slightly larger (the size declines, of course, during nighttime rest). A leather shoe keeps pace with this change, since as the leather picks up foot moisture it swells and the shoe becomes slightly larger inside. This serves to decrease the pressure between the foot and the shoe. The leather also becomes more pliable and easier to stretch, permitting it to more readily shape itself around any portion of the foot that it is pressing upon it.

Thus, all of these factors connected with leather's hydrophilic nature work hand in hand to make the shoe fit the foot and increase our comfort.

Breathing And Insulating Qualities

Contribute To Year-Round Comfort

Leather garments have become increasingly popular over the years, for no other material affords such universal comfort, regardless of the season. Whether you are spending a summer evening on the patio or tramping through a cold winter's snowstorm, a leather jacket helps to maintain the air next to your body at a comfortable temperature. How can a single material act in what seems to be such a contrary manner?

The secret is leather's ability to combine *breathing* and insulating properties, while at the same time adapting itself to the needs of a particular situation. For example, if outside temperatures are warm, the body will begin to generate more heat than is needed and start to perspire. If a leather garment is being worn, it has sufficient porosity and moisture transmitting properties to enable the moisture on the skin to evaporate. This in turn produces a cooling effect that continuously works toward preventing an undue buildup of heat.

During the winter season, the body seldom generates enough heat to create much perspiration. There being no moisture to remove, the cooling effect mentioned above does not come into play. To the contrary, we now have a situation where the millions of tiny voids, or air spaces, that exist within the matrix of leather fibers provide insulation. They curb the passage of heat away from the body and thus permit a comfortable temperature between the body and leather clothing to be attained.

Leather's dense fiber structure also acts to keep sharp winds from penetrating, providing windproof features that are unique for a material which is so flexible and relatively light in weight.

Lasting And Molding Ability

Retains Its Properties Even After Permanent Deformation Into New Shapes

When a flexible sheet material is forced into an unnatural shape over a mold, it is extremely important that it permanently retain the shape into which it has been deformed. This is one of the important aspects of shoemaking. Leather is forced to conform to the shape of a *last*, which is an idealized mold of an average human foot. After all the operations which transform the leather into a shoe have been completed, the shoe must be removed from the last. The leather, of course, is expected to remain in the shape it took on the last — not only on its way to the shoe store, but for as long as it will be worn.

Reflect a moment upon the unusual combination of requirements that are placed on the leather in a pair of shoes; good strength, permanent flexibility, breathability, etc. — and now still another, the ability to mold into a new shape, then hold it. We can thus begin to appreciate the complexity of the material and the fortuitous combination of properties it possesses.

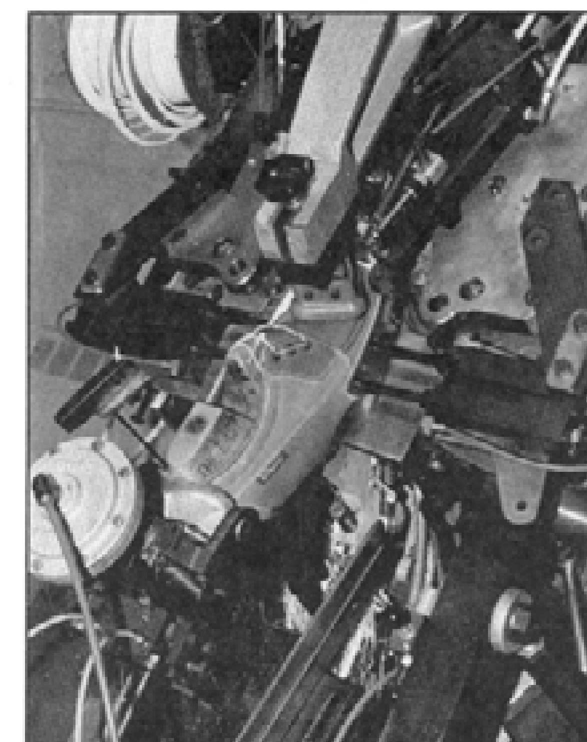
How does leather mold or *set*? Why does it conform to a last? These are not questions that can be simply answered, and a detailed discussion is beyond the scope of this book. It has to do with the complex organic chemistry of collagen, the protein substance of which leather is made, and the physical properties of collagen fibers.

Nonetheless, we can get a good idea of the reasons behind leather's ability to last and to mold by recalling some of its other properties that we've been discussing. First, its flexibility and elasticity allow it to be formed into an irregular complex shape without rupturing. If held in this shape for an extended period of time it will tend to remain in that new shape. The molding operation can be made easier if the leather is first dampened, under which conditions the fibers can slip by one another and readjust their location more readily. In the subsequent redrying, the fibers will remain in their new configuration.

This phenomenon can be sped up by the judicious application of heat; first moist heat to plasticize the fibers, then dry heat to set them. Properly done, an effect is achieved whereby the leather is permanently deformed into the desired shape, but not otherwise changed. The basis for all shoemaking hinges on some adaptation of this principle. Figure 21 illustrates the lasting of a shoe.

Leather's ability to mold when damp has also led to its widespread use in packings, gaskets and the like. Many of these are intricately shaped articles that may range in size from a fraction of an inch to a foot or more in diameter.

A.



B.

21. Shoemaking machines used to (A) stitch together upper parts and (B) mold the leather to shape on a "last."

Summary
Leather's Combination of Properties Make it Unique

There are many instances where one or two specific properties of leather make it ideal for a specialized use. But it is impossible to single out any one of leather's many attributes as being the most important, for its greatest virtue has to be the unparalleled combination of physical properties that it possesses. When you couple this with its beauty and aesthetic value, it is truly a unique substance. It is not surprising, then, that no other flexible sheet material can be cut and fabricated into such a large variety of consumer and industrial goods.

In this age when more and more emphasis is placed on our well-being, it is important not to lose sight of the following fact; that whenever an application calls for the selection of a material which is to be in close contact with the body (shoes, gloves, garments, hat sweatbands, etc.), leather combines to best advantage all of the desirable properties that promote good health. Medical authorities have long recognized this fact. For example, in his book entitled 'WALK AND BE HAPPY'*, Dr. Benjamin Kauth — a Director of the American Foot Care Institute — states:

"As for materials that are best for health, leather is superior to anything you can put on a foot. Podiatrists recommend leather because it is itself skin, allowing the active foot to breathe and pass off perspiration rapidly. It molds readily to the shape of the foot. It is resilient and yet firm enough to offer support.

"As you step out, the leather shoe bends and stretches to accommodate your foot. When you stand or sit, the leather upper returns to its original shape. Easy and flexible under your foot, the leather sole is tough. Because of its resilient, fibrous structure, the leather sole absorbs punishment without passing on tiring shockwaves to your feet.

"Between the millions of tiny fibers that make up the leather are microscopic pores that let fresh air into the shoe and perspiration out. This exchange of air and moisture through leather uppers and soles keeps your shoes healthfully dry and your feet comfortably insulated in any weather.

"When you go shopping for a pair of shoes, therefore, make certain they do not just look like leather, but actually are made of leather. Check new shoes carefully before buying because in recent years substitute materials, have been developed which at first glance look like leather."

**Published by John Day Company, New York, NY*

Shown here are some of the different uses and styles that today's market is requesting from the leather industry.

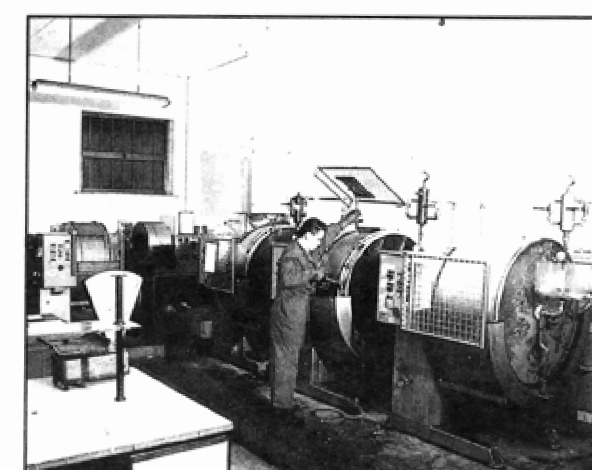
Earlier we discussed leather's ability to mold and the fact that leather shoes will conform to the shape of the wearer's feet. This feature takes on particular significance when we realize that no two persons have feet that are shaped exactly alike, any more than there are people with identical fingerprints. Shoe manufacturers do their utmost to provide us with a comfortable fit by supplying a large number of different sizes. But cost and mass production techniques make it impossible to furnish everyone with customized fashioned footwear right out of the shoe box. When we buy shoes, therefore, we accept the standard shoe size which comes closest to meeting our individual requirements.

For example, suppose your *exact* shoe size is 9 3/4 B while that of your neighbor is 10 1/8 A. If the two of you went into a shoe store together and each purchased the same style shoe, it would not be surprising to find you both leaving with a size 10 B. During the *breaking in* period, the shoe material must adjust itself to compensate for size variations and any other foot abnormalities.

Shoes made of leather are known for their ability to perform this function readily. In fact, if in a few days you tried on your neighbor's shoes, you would find that they were quite uncomfortable in spite of the fact you both bought the same size.

Every leather shoe, then, will deform slightly as required during the first few times worn — and then hold its new, customed-shaped form indefinitely thereafter. On the other hand, synthetic shoe materials generally have such a persistent *memory* that, although they may yield temporarily, they constantly attempt to revert back to the standard size they were in back at the shoe store. Under such circumstances it is impossible to achieve true foot comfort.

On the preceding pages we have described leather's unique physical properties and shown how they translate themselves into important consumer values. As illustrated in Figure 22 the tanner is dedicated through constant research to keep leather in the forefront as the flexible sheet material most prized for a wide variety of applications. It is little wonder that no other single material has enjoyed such long and varied use dictated by its performance capabilities.



22. Experimental pilot plant facilities transform the leather chemist's findings into full-scale production methods, creating a constant flow of new leathers.

CHAPTER FIVE

LEATHER GLOSSARY

definitions of common industry terms

On the following pages there is a glossary of common terms used by the tanner and leather product industries to identify leather. The number of such terms is considerable and is a natural consequence of these facts:

1. HIDES and SKINS: There is a great variety of hides and skins throughout the world for conversion into leather.

2. TANNING PROCESSES: The tanner has at his disposal a wide choice of processes for producing many different types of leathers.

3. LEATHER GOODS: Leather is used in an endless number of consumer goods and for many industrial applications.

Oftentimes a combination of terms is used to describe leather or leather items. Thus, you may own a pair of shoes that have *uppers* made from *calfskin* that was *chrome tanned*. "Leather Uppers" — "Calfskin Upper Leather" — "Chrome Tanned Uppers" — "Chrome Tanned Calfskin Uppers" — all these are bonafide descriptions. The more common terms follow, and are divided into the three categories mentioned above.

TERMS RELATED TO HIDES AND SKINS

ALLIGATOR	Alligator, crocodile, and related types.
BOVINE	A cow, ox, or closely related animal.
BUCKSKIN	Deer, and elk skins, having the outer grain removed.
BULLHIDE	Hide from a male bovine, capable of reproduction.
CABRETTA	A hair-type sheepskin; specifically those from Brazil.
CALFSKIN	Skin from a young bovine, male or female.
CAPESKIN	From a sheep raised in South Africa.
CARPINCHO	A water rodent native to South America; like pigskin.
CATTLEHIDE	General term for hides before tanning from a bovine of any breed or sex, but usually mature; includes bullhide, steerhide, cowhide, and sometimes kipskins.
CORDOVAN	From a section of horsehide called the shell.
COWHIDE	Hide from a mature female bovine that has produced a calf.
DEERSKIN	Deer and elk skins having the grain intact.
DOESKIN	From sheep or lambskins, usually with the grain removed.
FLESHER	The underneath (flesh side) layer of a sheepskin which has been split off. Used to make chamois.
GOATSKIN	Skin from a mature goat.
HAIR SHEEP	Sheep from several species whose 'wool' is hair-like.
HEIFER	A female bovine, under three years of age, that has not produced a calf.
HIDE	The whole pelt from large animals (cattle, horse, etc.).
HORSEHIDE	Hide from a horse or colt.
KANGAROO	From the Australian kangaroo or wallaby.
KIDSKIN	Skin from a kid, or young goat.
KIPSKIN	Skin from a bovine, male or female, intermediate in size between a calf and a mature animal.
LAMBSKIN	Skin from a lamb, or young sheep.
LIZARD	Any of a great number of the lizard family.
MOCHA	Middle-east hair sheep, usually with the grain removed.
OSTRICH	From the two-legged animal native to North Africa.
PECCARY	From a wild boar native to Central & South America; like pigskin.
PELT	An untanned hide or skin with the hair on.
PIGSKIN	Skin from pigs and hogs.
RAWSTOCK	General term for hides or skins that a tanner has received in a preserved state, preparatory to tanning; a tanner's inventory of raw material.
SHARKSKIN	From certain of the shark species.
SHEARLINGS	Wooled sheep and lambskins, tanned with the wool intact.
SHEEPSKIN	Skin from a mature sheep.
SKIN	The pelt from small animals (calf, sheep, goat, etc.).
SKIVER	The thin grain layer split from a sheepskin.
SNAKE	Any of a number of the snake species.
STEERHIDE	Hide from a mature male bovine, incapable of reproduction, having been raised for beef.
WALRUS	Skin from a walrus; also, sometimes sealskin.
WATER BUFFALO	Flat-horned buffalo, primarily from the tropics.

CORDOVAN	From a section of horsehide called the shell.
COWHIDE	Hide from a mature female bovine that has produced a calf.
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TERMS RELATED TO TANNING PROCESS

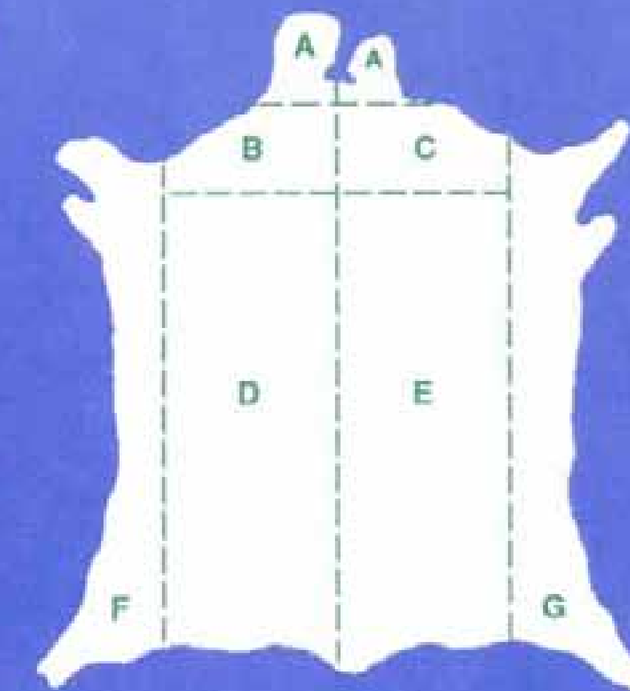
ANALINE FINISH	Full grain leather which has been colored with dyestuffs rather than pigments. Usually topped with a protein, resin, or lacquer protective coating; can also be waxed.
BARK TANNED	See 'VEGETABLE TANNED'.
BOARDED	A grain effect produced by folding a skin grain against grain and mechanically rolling the two surfaces back and forth against each other.
BUFFED	Leather which has been smoothed or sueded by mechanical sanding.
CHROME TANNED	Leathers which have been tanned with soluble chromium salts, primarily basic chromium sulfate. Currently the most widely used tannage in the U.S.A.
COMBINATION TANNED	Leathers tanned with more than one tanning agent. For example, initially chrome-tanned followed by a second tannage (called RETAN) with vegetable materials.
EMBOSSED	A mechanical process of permanently imprinting a great variety of unique grain effects into the leather surface. Done under considerable heat and pressure.
FULL GRAIN	Grain leather in which only the hair has been removed. Usually carries either an analine or glazed finish.
GLAZED FINISH	Similar to an analine finish except that the leather surface is polished to a high lustre by the action of glass or steel rollers under tremendous pressure.
GRAIN LEATHER	Hides and skins which have been processed with the grain, or outer surface, dressed for end use.
IMITATION	A variety of materials which have been made to resemble genuine leather. The great bulk of these are rubber or plastic coated fabrics. It is unlawful to use terms connoting leather to describe imitations.
LEATHER	The pelt of an animal which has been transformed by tanning into a non-putrescible, useful material.
MINERAL TANNED	Leathers which have been tanned by any of several mineral substances, notably the salts of chromium, aluminum, and zirconium.
OIL TANNED	Leathers tanned with certain fish oils. Produces a very soft, pliable leather such as chamois.

GLOVE	Sheep, pig, deer, and kidskin that has been tanned to produce a soft, stretchy leather for dress gloves. Also, cattlehide splits, sheepskin, and others that are tanned for garden and work gloves.
HANDBAG	Any of a variety of leathers used for women's handbags.
HARNESS	Vegetable tanned cattlehide leather finished for harness and saddlery use.
HAT	Vegetable tanned calf or sheepskin leather used for hat sweatbands.
INSOLE	A shoe leather used for the inner sole which the foot rests upon. Usually from cattlehide.
LINING	A shoe leather used for lining the inside portions. Made from all kinds of hides and skins, either grain or suede finished.
NOVELTY	Any of a variety of leathers, frequently vegetable tanned, used for billfolds and small leather goods.
OUTSOLE	A shoe leather used for the outer soles. From vegetable tanned cattlehide, often quite thick.
PATENT	A shoe leather, heavily finished to give a highly lustrous, baked-enamel type appearance, used for shoe uppers. Generally from cattlehide.
SHOE	General term including all upper, lining, and sole leathers.
SLIPPER	Cowhide and sheepskin leathers, usually chrome tanned, used for slipper uppers.
SOLE	See 'INSOLE' and 'OUTSOLE'.
STRAP	See 'BAG, CASE, & STRAP'.
SWEATBAND	See 'HAT'.
UPHOLSTERY	Large cattlehide, split thin, and tanned for use as furniture and automobile seat coverings.
UPPER	A shoe leather used for the upper portions. Predominantly from cattlehide and calfskins, although a great variety of skins are used. Usually combination tanned.

THE SUBDIVISIONS OF A HIDE

In the processing of most hides from large animals, it is customary to cut them into two or more smaller sections for easier handling. The nomenclature of the various parts is shown below.

HEAD	A
SHOULDER	B or C
BEND	D or E
BELLY	F or G
SIDE	A+B+D+F or A+C+E+G
CROP	A+B+D or A+C+E
BACK	B+D or C+E
CROUPON	D+E



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The New England Tanners Club wishes to dedicate this book to all Past Presidents of The N.E.T.C. as well as to Mr. Richard N. "Dick" Jones, Chairman of the first Leather Facts Committee, for his many contributions to this publication and the Club, always done characteristically quietly and thoroughly.

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