THE JOHN ARTHUR WILSON MEMORIAL LECTURER FOR 1970

DR. JOSEPH NAGHSKI

The Eleventh John Arthur Wilson Memorial Lecture was presented on June 23, 1970, during the Annual Meeting of the American Leather Chemists Association held at Lake Placid, New York, by Dr. Joseph Naghski, Chief of the Hides and Leather Laboratory of the Eastern Marketing and Nutrition Research Division, Agricultural Research Service, U. S. Department of Agriculture. He was introduced by Dr. Robert Stubbings, Institute of Leather Technology, Milwaukee School of Engineering.

"Our speaker for today's John Arthur Wilson Memorial Lecture is known, of course, to all of us. He has worked with the industry for about 15 years as Chief of the Hides and Leather Laboratory of the Eastern Marketing and Nutrition Division of the Agricultural Research Service, United States Department of Agriculture.

"I think it's quite important to our organization and to our industry that we participate with Dr. Naghski and with this laboratory in every way we can, because it represents the only large-scale basic research arm available to us, except our own laboratory in Cincinnati, and I sincerely believe that we need all the help we can get in our business in improving our technology, and that we had better utilize any source of information that we can.

"Dr. Naghski's section of the USDA spends about $600,000 a year on research in hides and leather, and anything we can do to encourage research in those areas which are going to be beneficial to us, we certainly should do; and I'm sure anything Joe can do to find out from us what's needed, he's going to do.

"His laboratory, during the time he's directed it, has, as you well know, done some things that have done us a great deal of good. Early glutaraldehyde studies came from that laboratory and have proved quite useful in our industry in terms of improving the consumer product. Many other things have been done there, many of which you have used yourselves.

"He's also done a lot of things on the personal side for us, which often we forget. He's been with the ALCA-ASTM Joint Committee on Leather that meets twice a year and works in between trying to set up test methods and standards for our industry.

"During that time, he served as chairman of that committee; he now is serving as its secretary, and a quite thankless job that can be at times.

"For these things I think we all owe Joe a debt of gratitude, on top of which, I'm most interested in hearing Joe's feelings about what he's going to talk to us about today in his lecture, "Leather to Meet the Needs of the Consumer."

"I'd like to present to you Dr. Joseph Naghski."

LEATHER TO MEET THE NEEDS OF THE CONSUMER

JOSEPH NAGHSKI

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It is indeed a pleasure to be here today to present the John Arthur Wilson Memorial Lecture. It was in 1955, when I undertook the responsibility for the guidance of the Department's research program on hides and leather, that I became familiar with the work of John Arthur Wilson. Later, when I had the privilege of visiting your tanneries, I appreciated the thoroughness with which he treated the chemistry and structure of hide and the technology of leather-making.

This is the eleventh in the series of lectures initiated to commemorate his accomplishments.

During this past decade many changes have taken place. For the first time the supremacy of leather as a shoe upper material was challenged by substitutes. As if to flout Dr. Wilson's own words, the technologists found ways to produce products whose properties approached those of leather. In the preface to the 1941 volume, "Modern Practice in Leather Manufacture," Wilson wrote, "The value of leather in service lies only in its properties, and what the tanner has to sell is essentially only the properties of his leathers. He should, therefore, learn to know his leather by its properties and to offer it only in terms of the suitability of its properties for any service that it may offer." (1)

This statement is as true today as it was when John Arthur Wilson wrote it. Leather still has to be offered in terms of the suitability of its properties for the service expected. Possibly we may expect greater service from it. But if we do, then it becomes a challenge to our technology to accentuate the existing properties or to create new ones. To do this it is necessary to identify the source from which leather derives its properties. Many of these exist in the raw material and it becomes only a matter of conversion or preservation. Greater familiarity with the characteristics of the raw material would be helpful in defining and predicting leather's properties. Such an evaluation can be approached from several directions.

Since leather is utilized as a three-dimensional nonwoven fabric, the composition of a hide needs to be studied in terms that can be interpreted within this framework. Thus it has proved fruitful to study the distribution of components

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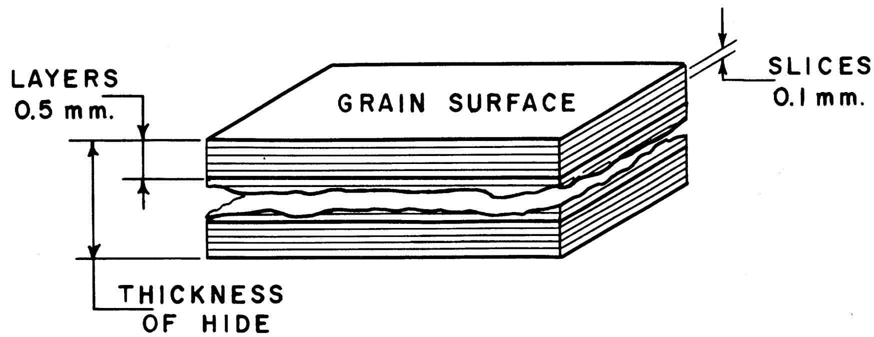

FIGURE 1.—Details of stratigraphic slicing method (from Mellon *et al.* (2)).

with stratigraphic layers (2–4). The piece of hide is cut so that layers 0.1 mm. thick and of equal volume are obtained and then each layer is analyzed separately, as shown in Figure 1. Such investigations have demonstrated that the components of fresh skin are not evenly distributed through the thickness. Figure 2 shows that when the dry weight was determined, there was only about half as much dry matter in the layers within the region of the grain (first three to four layers) as in the corium. The distribution of nitrogen (Figure 3), which is a measure of the protein content, shows that there is only half as much protein within the

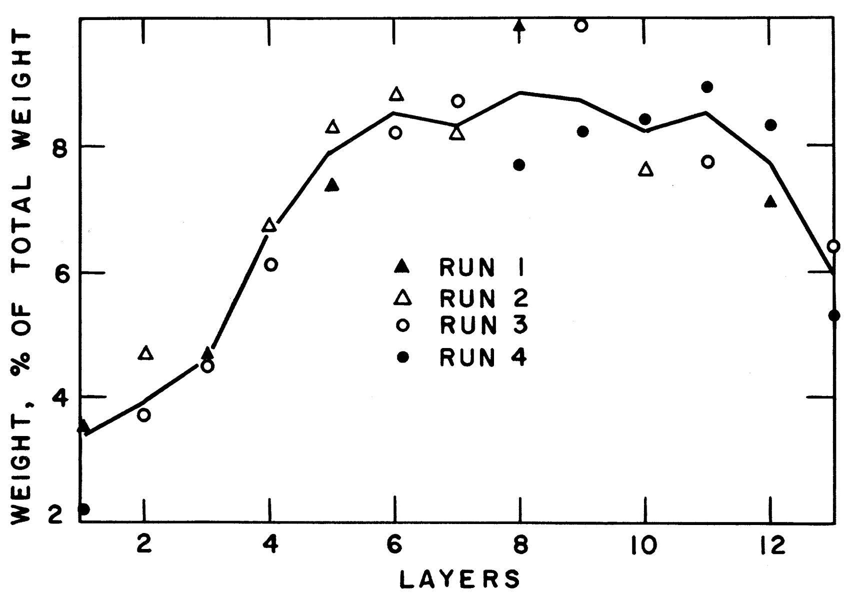

FIGURE 2.—Layerwise distribution of dry matter as percent of total dry weight: median line and extreme points of four different runs. Dry matter represents the residue after acetone dehydration of slices and removal of solvent (from Mellon *et al.* (2)).

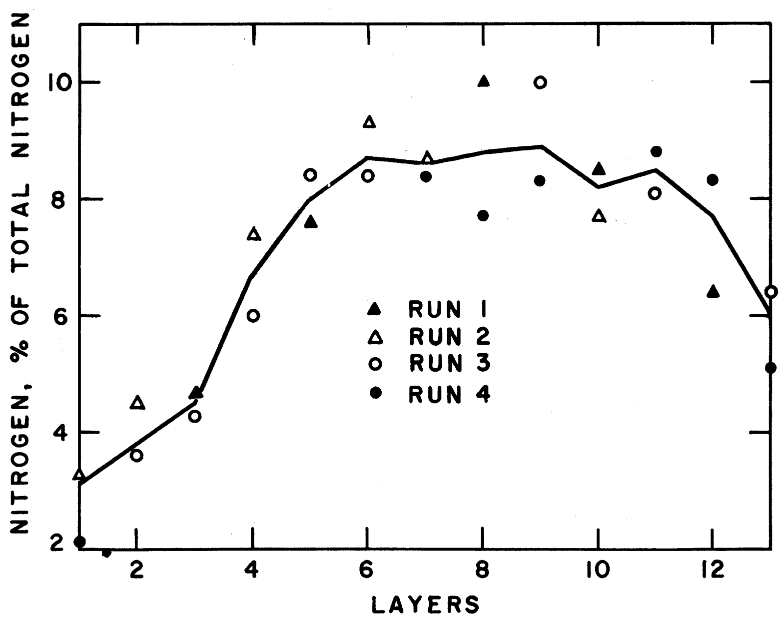

FIGURE 3.—Layerwise distribution of nitrogen as percent of total nitrogen: median line and extreme points of four different runs (from Mellon *et al.* (2)).

grain region as in the corium. The curves for the distribution of dry weight and protein are practically superimposable. This implies that the bulk of the dry matter is protein. If we had plotted the hydroxyproline, which is an index of collagen, the curve would have been the same. Space does not permit me to go into that detail.

Bitcover and Mellon (3) found that the lipids are also stratified, but in a different pattern. The hide was cut into only five layers of approximately the same thickness. Data in Table I show that the grain region is high in lipids, as

TABLE I

YIELD OF CRUDE LIPIDS FROM STEERHIDE LAYERS*

Layer	Dry Wt. (gm.)	Lipid Extracted		
		(gm.)	(% of Dry Wt.)	(% of Total)
1	25	1.88	7.5	43
2	15	0.28	1.8	6
3	29	0.12	0.4	3
4	34	0.32	0.9	7
5	23	1.78	7.6	41
Total	126	4.38	3.5	100

*Based on data from Bitcover and Mellon (3).

would be expected because of secretion from the sebaceous glands. The corium is relatively free of lipids but the flesh layer is exceptionally rich in them.

Another component of hide which may play a significant role is the fibrous protein elastin. Figure 4 shows that it is highly concentrated in the grain region, with only a slight amount in the corium. Elastin because of its elastic nature gives tone to the skin and this may be reflected in the character of the grain in leather.

The question comes to mind regarding the substances that bind the water in the grain region and thus acount for the volume (current evidence points to

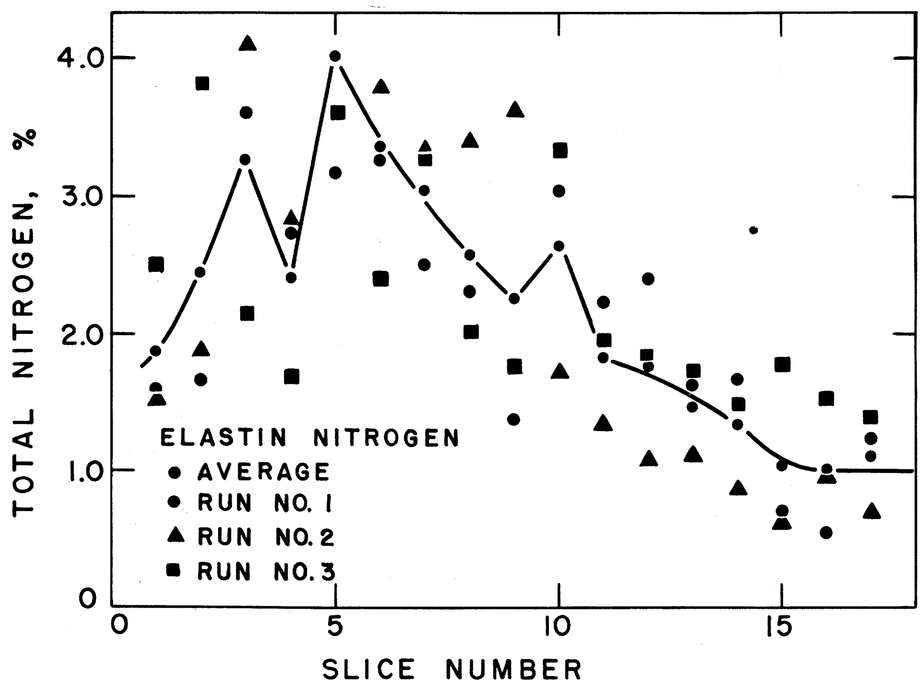

FIGURE 4.—Layerwise distribution of elastin nitrogen plotted as percent of total nitrogen. The solid line is the average value for the three runs (from Mellon and Korn (4)).

carbohydrate-type substances). Figure 5 shows the distribution of the tissue carbohydrates, also known as mucopolysaccharides or ground substance. These are concentrated in the grain and are characterized by their water-binding power. These jellylike materials of high moisture content (ground substance and cellular tissue) which fill the spaces between the fibers are removed by the pretanning processes, and as a consequence the grain layer of the resulting leather will have a more open structure than that of the corium. The open structural arrangement of the fibers gives leather many of its unique properties. It gives leather its ability to transmit water vapor and its high resistance to flexural fatigue. However, this

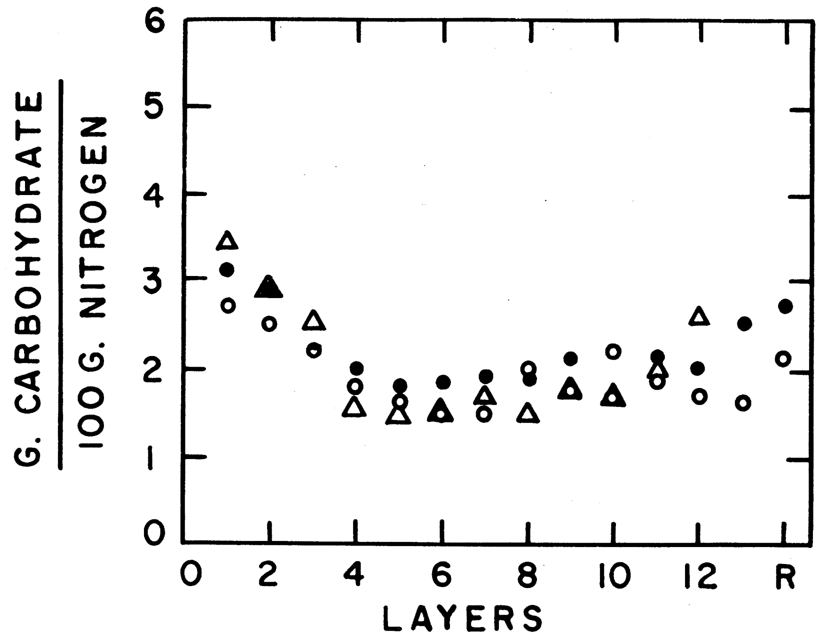

FIGURE 5.—Carbohydrate content related to the nitrogen content of serial layers of cattlehides: ● and ○ a steer, △ a ten-year-old cow. R is the flesh side residue (from Mellon *et al.* (5)).

should also be of great interest to the tanner. He can take advantage of the porous nature to control and modify the texture and other properties of leather by introducing polymers and other chemical modifiers.

Mieth Maeser, when he addressed this group in 1963 on the subject, "An Engineer Looks at Leather," summarized the properties of leather as follows: "Upper leather has many properties and characteristics which can be used to advantage in shoemaking, and properties which are important in wear. The capacity of leather to be either stretched or compressed into its own voids without altering its surface appearance; its ability to be skived and scarfed without losing its strength; its ability to be stitched close to unturned or unbound edges; the fact that its raw edges do not fray and tear in wear; its lack of notch sensitivity; its great fatigue resistance; its multiple-layer, fibrous structure and rich, fine, porous grain; its beauty and texture which cause a person to enjoy stroking it with his hand or rubbing it against his face; its ability to be wet and then dried with no loss in character, its moldability and its capacity to be shrunk and set permanently in its lasted shape are all good shoemaking and shoewearing properties." (6)

This is an impressive list of properties. Unfortunately the individual variability of each hide is passed on to the leather. The range in tensile strength can vary from weak (defective) to exceptionally strong. This can be further complicated by weakness of the grain surface which can result in cracking during shoemaking operations. Predicting the properties of leather is difficult, since the test specimen reflects only a statistical relationship to the unit. Published statements of shoe manufacturers indicate that uniformity is the most preferred property of the new substitute materials.

In 1966, when this group met at Atlantic City, we had a dialogue with shoe manufacturers (7). They complained that non-uniformity of thickness and color, even within lots, was a big problem. Just a few months ago, at the meeting of the ALCA-ASTM Joint Committee on Leather, this same complaint was heard again (8). Are we purposely ignoring our customers' complaints? Is the problem too difficult to solve? Is this an area for research? I am posing these questions because I do not think that we have the luxury of time to continue ignoring our customers.

Defects are the biggest source of non-uniformity in leather. Some of these are inherent in the live animal, while others are a result of the environment. For example, veininess (a costly defect in glazed calfskin leather) was found to be a manifestation of the void space surrounding blood vessels (9). Figure 6a shows such a blood vessel in a cross section of calfskin leather. Figure 7 shows what happens when the surrounding fiber bundles are pushed into the voids by mechanical treatments; indentations appear on the surfaces of the leather which are characterized by differences in glossiness of the finish. These observations suggested that the defect could be corrected if the void spaces could be filled. Some progress toward alleviating the condition has been made by application of zirconium or by resin impregnation. The results of retanning with zirconium are shown in Figure 6b.

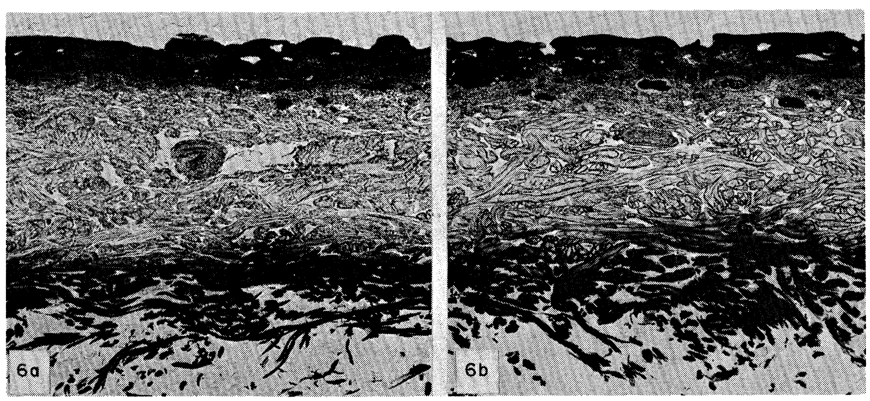

FIGURE 6.—Cross sections of veiny calfskin leather from matched side experiment. a: control side with normal chrome tannage, b: experimental side retanned with zirconium (from Everett *et al.* (9)).

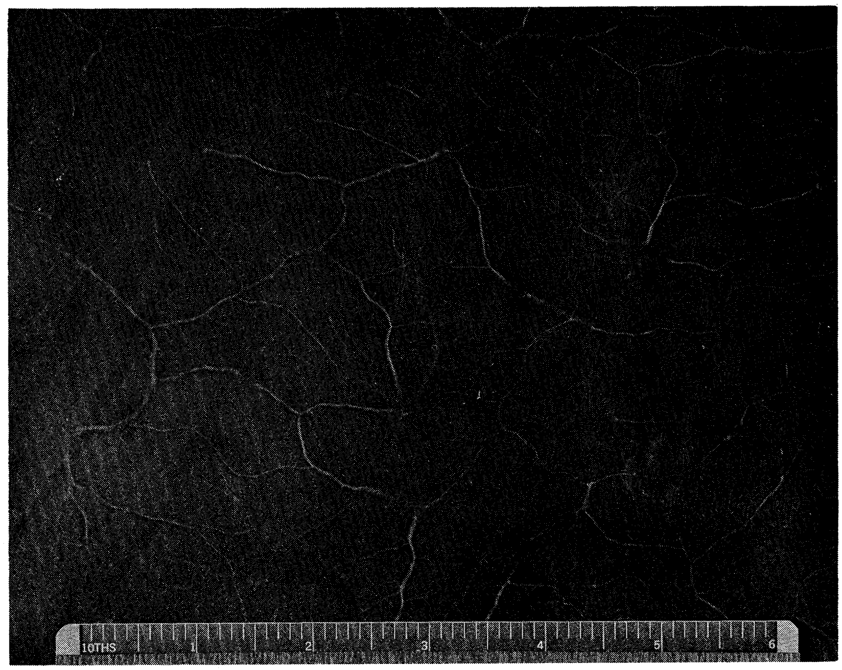

FIGURE 7.—Surface view of the grain surface of veiny glazed calfskin leather (from Everett *et al.* (9)).

Another prominent defect is known in the trade as pulpy butts. This defect proved to be characterized by a vertical arrangement of the fibers. "Vertical fiber" consists of an abnormal arrangement of corium fiber bundles, in a direction nearly vertical to the grain surface. Upper leathers made from the defective hides can usually be recognized by their characteristic pulpy texture and inferior strength. The basic cause has not been determined, but the defect is also known to occur in Australia (10), Argentina, and Great Britain. Thus the problem is not unique to domestic hides.

Recent studies at our Laboratory and at the Tanners' Council Laboratory indicate that the defect is not caused by poor curing or tanning but is inherent to the hide (11–13). The fibers in the affected area are loosely woven and perpendicular to the hide surface, rather than tightly woven and parallel to the hide surface, as they should be. This accounts for the lack of tensile strength. Such hides often have a high fat content. Usually the weakness occurs in only a small area of the hide. Thick, heavy Hereford hides have the defect more often than hides from other breeds — a fact that suggests a genetically induced fault. This does not preclude the role of environment and nutrition.

Modern feeding practices have done much to control the development of the animal. Figure 8 shows two animals of the same age. The one on the right was

FIGURE 8.—Beef Ration Comparison. The Brown Swiss-Hereford steer on the right was on a 1929-type feeding program; it weighed 655 lbs. at 15 months of age. The steer on the left received a modern all-concentrate 1969 ration and was fed in confinement; it weighed 1306 lbs. at 15 months. This demonstration trial was conducted by researchers at Doughboy Industries, Inc., New Richmond, Wisconsin (14) (photo courtesy of Feedstuffs and Mr. Harold Ronnenberg, Doughboy Feeds).

raised on a diet normally fed in 1929, while the one on the left was fed the greatly improved formulation of 1969. Animal husbandry has made tremendous changes over the past 40 years; yet we do not know for certain how these changes have affected our raw material.

Three years ago, Dr. Bowes of the British Leather Manufacturers Research Association addressed us in this room on the effect of feeding practices on the character of hide and skin collagen (15). She concluded that "cattle hides reach the relatively steady adult state with respect to composition and properties at about 18 months. Only hides from intensively fed animals slaughtered at 15 months or less are likely to differ appreciably from traditional hides in their leather-making properties."

Feeding is only one of the factors that can influence hide character; changes in animal type may be even more profound. During recent years there has been a severe decrease in numbers of dairy-type cattle and a tremendous increase in the population of beef types. This has been reflected in the type of hides available to the tanners. Mrs. Tancous told us yesterday that she found a significant difference in temper of leather made from spready or plump hides (16).

During previous studies (17, 18), Mrs. Tancous measured the tensile strength of leather made from over a thousand Hereford steerhides. Figure 9 shows the wide variation in tensile strength of the 2139 sides of shoe upper leather. The bulk of the leather has adequate strength for shoe construction. However, the small percentage of sides with strengths below 2000 pounds per square inch can be expected to give problems in the lasting room. Presently, we are directing research toward developing a selective test so that the hide producing weak leather can be removed from the production line. If this can be accomplished, the tanner will be in a better position to give the shoe manufacturer a better product and thus insure satisfaction for the consumer.

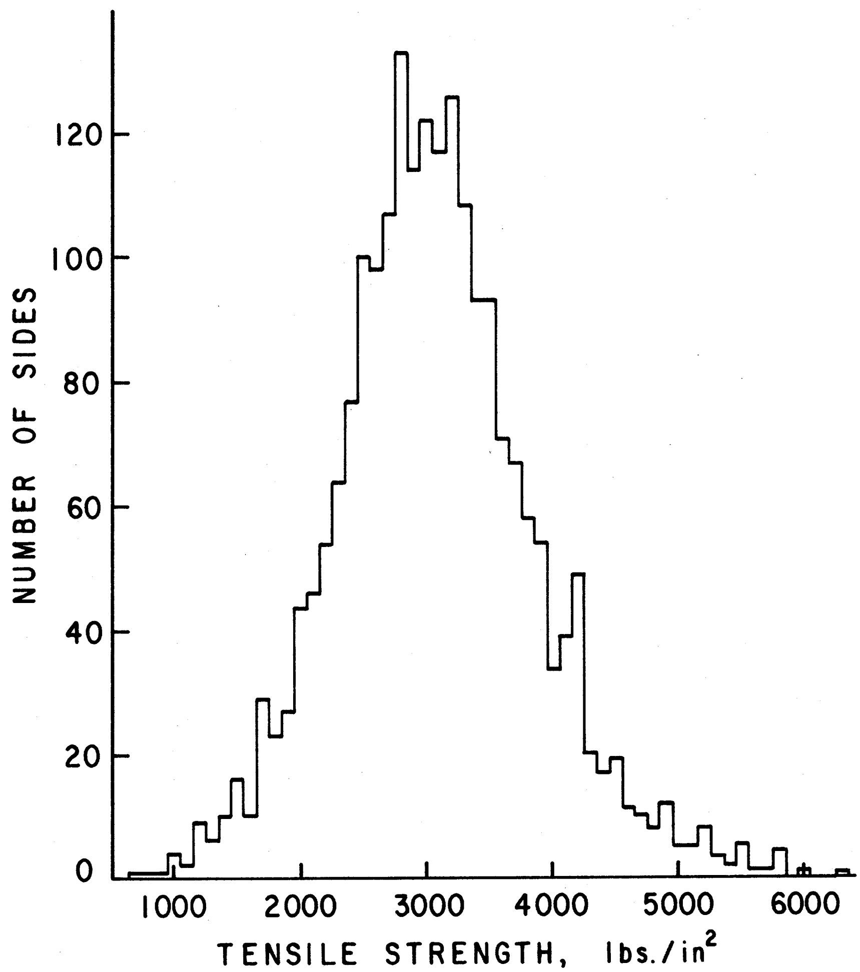

FIGURE 9.—Histogram showing the tensile strength distribution of 2139 sides of shoe upper leather made from Hereford steer hides. Data courtesy of J. J. Tancous.

Some of the non-uniformity in leather is also the result of blemishes on the grain surface. Barbed wire and briar scratches may never be eliminated. However, losses of leather due to firebranding may be minimized through use of freezebranding (19). The cause of cockle in sheepskin, unknown several years ago, has been identified as the sheep ked (20). Eradication of the ked should be a simple matter, provided we can supply the incentive for the application of known treatments. Demodectic mange, on the other hand, presents a different

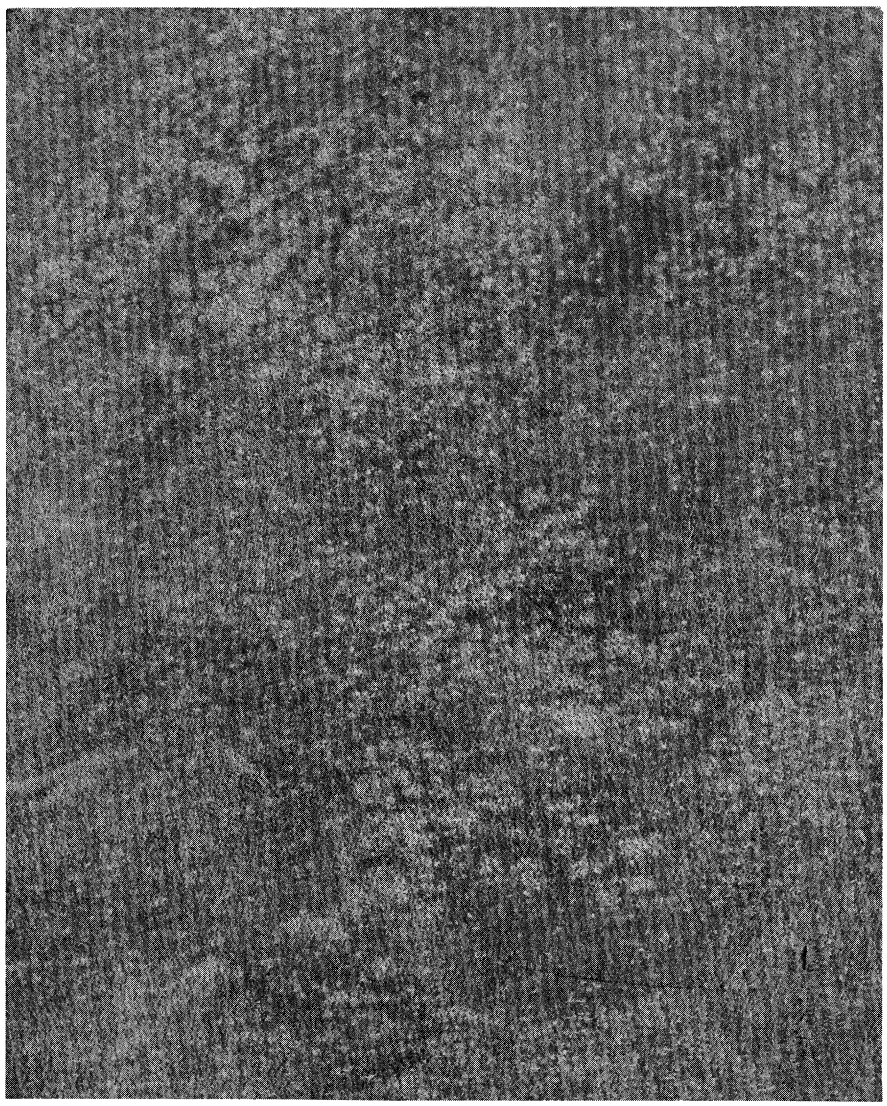

FIGURE 10.—Photograph of shoe upper cattlehide leather affected with "white spot."

problem. The cause is known, but no means for control are available. So its destructiveness continues to spread, possibly aggravated through the more intimate contact between animals in feedlots.

Figure 10 shows a photograph of the surface of shoe upper leather affected with a defect that, for lack of a better name, we call white spot. It is characterized by small areas where the enamel of the hide has been destroyed. I am certain that all of you have encountered it in your production. It is not due to any fault in curing, for it appears on beamed fresh hides. Evidently it happens on the live animal. But what causes it is still a mystery and we do not seem to have any leads.

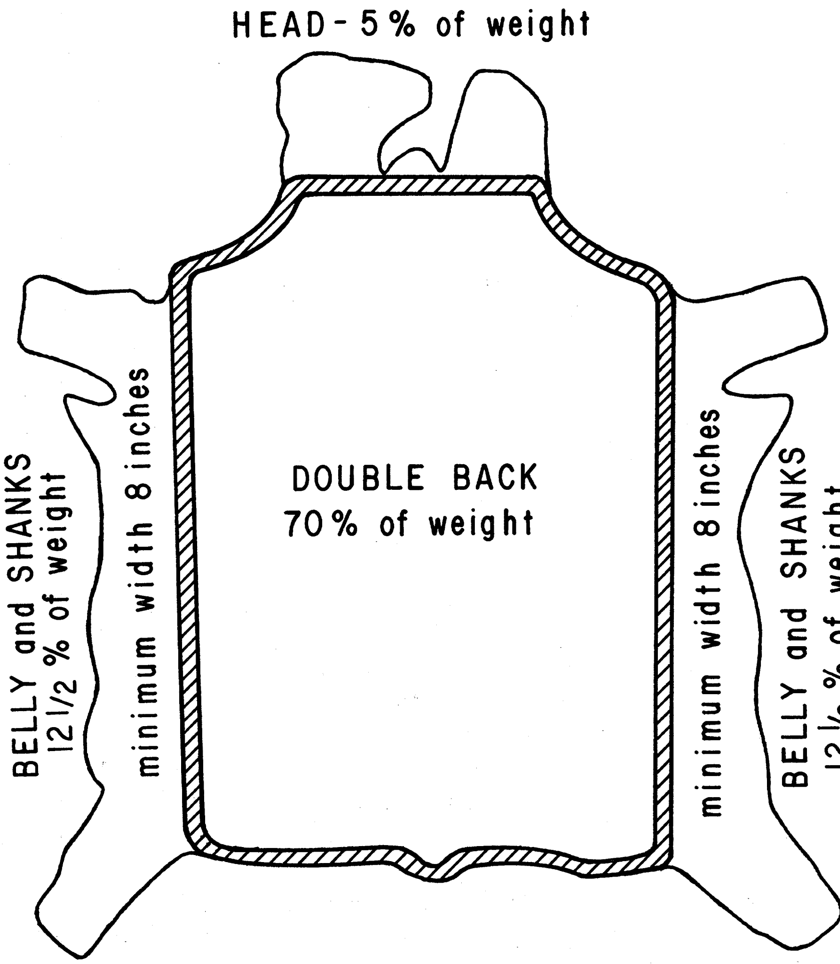

FIGURE 11.—A proposed scheme for segmenting a cattlehide to produce a regular shape (after Thompson and Poats (21)).

Segmentation of Hides

Probably the greatest potential for improving the quality and uniformity of leather lies in segmentation of hides. The use of rectangular shaped rawstock, as indicated in Figure 11, offers the possibility of gaining economic advantages from development of through-put equipment, savings in processing chemicals, and improvement of over-all tannery efficiency. However, the idea to square off cattlehides by removing the less desirable leathermaking areas is not finding ready acceptance. Although economic evaluations indicate that a tanner would be money ahead to throw away the trimmings, there is a great psychological reluctance to discard material that costs 12 to 18 cents per pound (21). The segmentation of cattlehides has the potential of making about 100 million pounds of dry weight collagen available annually. Alternative markets for this raw material would do much to improve the economics of hide utilization and leather processing.

Possibly this approach is no longer timely. The chemical industry has made available a wide variety of fillers, impregnants, and finishes than can change the characteristics of leather. Tanners can now choose those treatments which impart the desired improvements, such as scuff resistance, character of break, and water resistance. Care has to be exercised that these achievements of uniformity are not attained at the sacrifice of the esthetic qualities of leather. For example, too heavy a layer of finish will conceal the appearance of leather and make it look very much like the substitutes which compete with it. A further ineffectiveness of current materials is that defects are concealed rather than corrected and will often break out during shoe processing operations.

Chemical Modification

Leather has always possessed a degree of superiority over substitute materials in terms of strength, comfort, and resistance to wear. This led to the coining of the phrase, "Nothing takes the place of leather." This may have been unfortunate, for it gave the industry a sense of security that was not justified, and blinded it to the pernicious erosion of the markets by substitutes. Thus it was not long before leather joined the ranks of the other natural fibers, silk, cotton, and wool, a victim to the onslaught of substitutes spawned by the sophisticated technology of chemists and chemical engineers.

Properties of natural materials are widely variable and it was thought that little could be done to alter them. Modern technology has changed all this and we have now within our grasp sufficient knowledge to modify not only the structure but also the chemical and physical properties.

What are the prospects for leather to mantain its dominant position? I think they are good. However, I must hasten to say that it will not just happen. A concerted effort of research must be brought to bear to bolster the weak points. Here we can learn from the other commodities. Cotton and wool have been able to reverse the trend to a degree through modifying the properties of the natural product. This modification was directed at the correction of the weaknesses.

In 1957 I had the privilege of hearing Dr. Speakman address the Fifth Congress of the International Union of Leather Chemists Societies on the subject, "The Reactivity of Keratin" (22). He reviewed the chemistry of wool and related how improvements in the properties had resulted from chemical interactions. He exhorted his listeners to accept the challenge of substitutes and to undertake investigations of the chemical reactivity of collagen as a means of developing improved leathers. At that time our research program on chemical modification was well on its way and preliminary results were appearing in our *Journal* (23).

Out of these basic studies on the chemical modification of hides and hide proteins have emerged some completely new tanning agents. Dialdehyde starch proved effective in shortening the time necessary to tan sole leather; however, the current high cost has deterred its commercial adoption (24). Glutaraldehyde, on the other hand, is finding a growing application for the production of garment leathers with increased mellowness and for the production of shoe lining and shoe upper leathers where resistance to deterioration from perspiration and chemicals is an essential property.

Research at our Laboratory and by others has clearly demonstrated the versatile tanning action of glutaraldehyde and the desirable properties it imparts to leather. These studies led to the development of processes for making improved leather using glutaraldehyde alone, simultaneously in the same tan bath with chrome and as a retannage after chrome. Such versatility, coupled with its commercial availability at reasonable cost, soon led to its commercial use in tanning by the leather industry in the U. S.

Perspiration-Resistant Leathers

An outstanding property that glutaraldehyde imparts to leather is resistance to deterioration from perspiration. This is true whether glutaraldehyde is used as the only tanning agent or whether it is used in combination with chrome or vegetable tans. Glutaraldehyde is much superior to formaldehyde and glyoxal in conferring perspiration resistance, as is evidenced by the stability of the leather to an accelerated perspiration test (Figure 12).

The notable resistance to perspiration of this leather has led to new applications. It has caught on in work shoe leather, and field tests have substantiated laboratory tests. Work shoes made with leather tanned with glutaraldehyde alone or in combination with chrome have given excellent service to workers in dairy barns, paper mills, cement plants, and gasoline stations, where perspiration, alkali, and alkaline cleansing agents rapidly deteriorate leather. Glutaraldehyde-chrome combination leathers are now available in work shoes at the retail level.

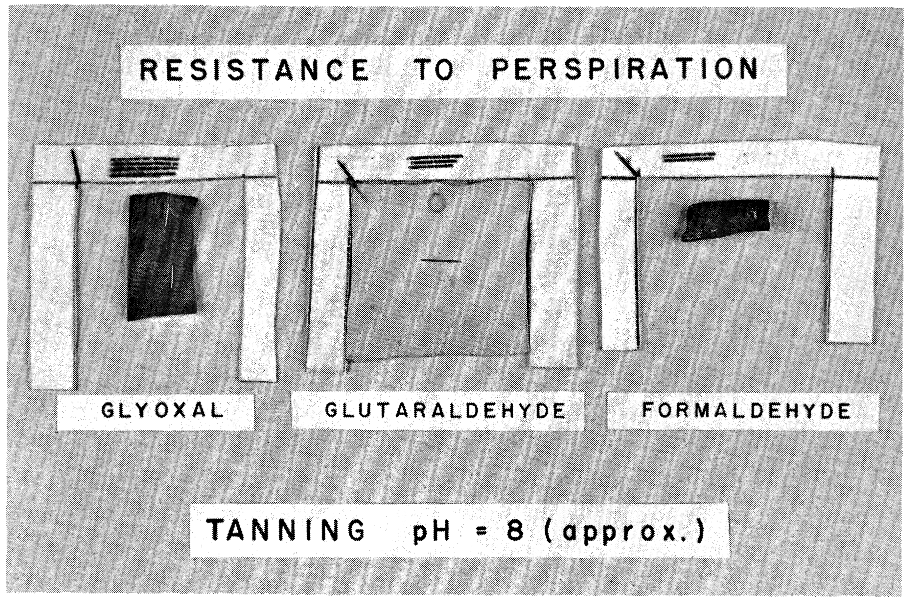

FIGURE 12.—Photograph of test specimens of sheepskin leathers tanned with glyoxal, glutaraldehyde, and formaldehyde after being subjected to a perspiration test (from Filachione *et al.* (25)).

More recently, glutaraldehyde is finding application as a retannage for white shoe upper leathers to give them greater perspiration resistance.

Deterioration of leather by perspiration is not necessarily restricted to footwear. I suppose that most of you wear wrist watches, but I am safe in saying that less than ten percent have leather straps. The short life of leather wrist watch straps has enabled substitutes to capture the bulk of this market. Since I personally enjoy the comfort of leather, I decided to test the efficacy of glutaraldehyde in prolonging the life of wrist watch straps. I procured a dozen straps fabricated from calfskin, and retanned half of these by tumbling in a solution of glutaraldehyde. Upon drying, the straps showed only a little dulling of the finish. During my first wear test I found that the treated straps lasted about three times longer than the untreated. However, my statistician friends told me that the test was not valid because I did not wear both straps simultaneousy. Therefore I repeated the experiment. This time I wore two watches, and to compensate for righthandedness the watches were switched to the other wrist each morning. The results of this test are shown in Figure 13. The test was terminated after 18 months because the stitching holding the buckle on the treated strap broke, although the leather was still serviceable. However, during this period the leather in two of the untreated straps failed from deterioration and the second replacement also shows severe cracking. Thus retannage with glutaraldehyde prolonged the life of these wrist watch straps by at least threefold. As a consumer I am

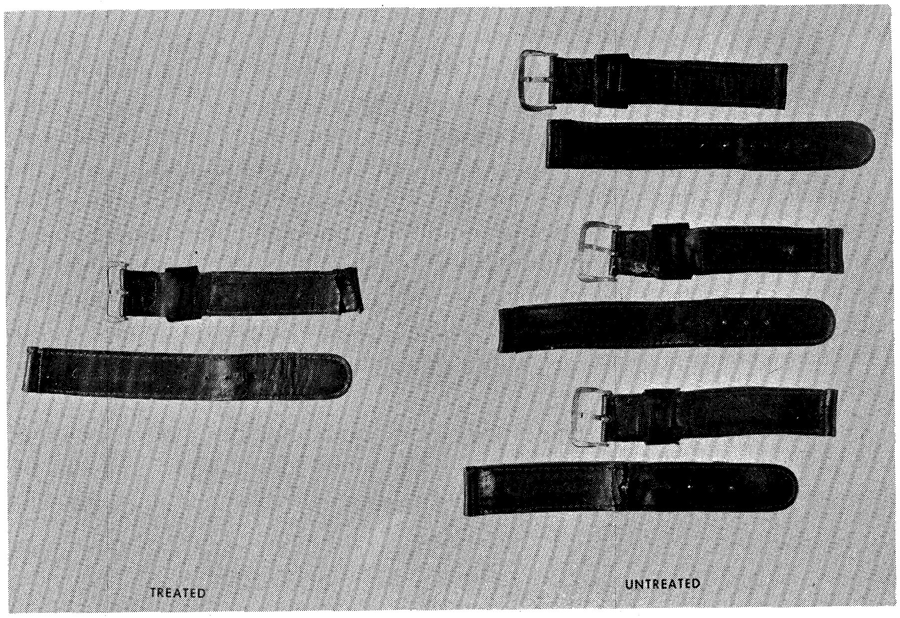

FIGURE 13.—Effect of glutaraldehyde on the serviceability of calfskin leather wrist watch straps. The test was terminated after 18 months of continuous wear when the stitching broke on the treated strap, although the leather was still serviceable. During this interval the untreated straps were replaced twice when the leather had deteriorated from the effects of perspiration to point of failure. Even the second replacement showed severe cracking.

disappointed with the short life of currently available straps, but I could be satisfied with 18 months of service. It would be interesting to learn whether the consumer would respond to an offer of a superior watch strap or is it too late to turn back the clock?

Natural products have a way of improving in appearance and beauty with use and age. When an article is used with care, and not abused, it develops a patina that is highly prized. Unfortunately, articles in everyday usage show the ravages of wear that often borders on abuse. Maintaining the appearance of leather articles under such conditions can be a problem.

The consumer is always faced with the problem of cleaning leather articles. This is probably the one area where substitutes have an advantage over leather. However, as a result of recent innovations this gap is closing. Finishes are available on shoes that retain their shine longer, and improvements are being made as newer products are adapted to this purpose.

Improvements in Garment Leathers

The incompatibility of tanned collagen with water has been a major weakness of leather. Repeated wetting and drying deteriorates leather rapidly. This weakness has not only kept leather from developing in certain markets but has actually been responsible for inroads by substitutes. An example of this has been the loss of markets for lambskin paint rollers with the advent of water-based paints. Research demonstrated that, by stabilizing the structure through cross-linking with glutaraldehyde, shearlings were made resistant to deterioration from water and alkalis (26). Such shearlings proved to be launderable (27) and their effectiveness as medical bedpads was established (28). In spite of the superior properties of lambskin pads, the substitutes still outsell because of initial price advantage and aggressive merchandising. Since the patient cannot readily distinguish between these, he is rarely aware that he is not getting the most efficacious product. Thus the consumer is denied the benefits because he is not in a position to demand the best.

The property of launderability and perspiration resistance was incorporated into golf gloves (29). Laundering chrome-tanned glove leather reduces the shrinkage temperature. Table II, Column 2, shows the extent of this drop with

TABLE II

EFFECT OF LAUNDERING ON THE SHRINKAGE TEMPERATURE OF CABRETTA GLOVE LEATHER[a]

Wash Cycles[b]	Shrink Temperature (°C.)	
	Chrome	Chrome-Glutaraldehyde
0	87[c]	88
1	74 (70)	84
2	71 (64)	80
3	63 (64)	78
4	53 (64)	77

[a]Unpublished data of M. L. Fein and S. J. Viola, Eastern Regional Research Laboratory, USDA.

[b]Wash Test: 50°C. (120°F.); 0.5% soap solution; 0.5 hrs. (specimens air-dried between cycles) (30).

[c]Response of a typical chrome-tanned glove leather. Values in parentheses represent a better grade.

each washing cycle for typical production of glove leather. A better grade of glove leather gave the figures in parenthesis. Leather that contained glutaraldehyde dropped to some extent but did not reach the low levels of leathers containing only chrome. This development has been in effect several years but the consumer still cannot purchase these articles readily.

There is some question about the desirability of launderability in leather garments, especially those of complicated construction. Lining materials must also be launderable; otherwise the garment will lose shape or colors will run and bleed. Accessories must be rustproofed to prevent staining. These requirements may present an obstacle that the manufacturer may not be able to overcome economically.

On the other hand, drycleanability presents problems of its own. The most commonly used solvents (perchloroethylene and stoddard) strip the oils and some of the dye from the leather. This means that, after a leather garment is cleaned, it has to be treated with special lubricants to restore the suppleness to its original condition and with dyes to reproduce the original shades. Some of the new synthetic lubricating agents show greater substantivity to the hide protein in the presence of drycleaning solvents than the products based on natural oils (31). Reactive dyes are now available which resist bleeding or extraction with solvents (32). The range of colors and shades is still limited but I am sure that this can be expanded if a demand develops. Treatments with chemicals based on fluorocarbons have proved useful in imparting water repellency and oil, stain, and soil resistance.

Sole Leather

Over the last fifteen years more than half of the market for sole leather was lost to substitutes, so that now only about 17 percent of shoes are made with leather soles. The main criterion that has been extensively promoted is the better wearing properties of substitutes. However, we should not overlook the inherent savings to the shoe manufacturer as a motivation for the use of substitutes. The question arises — Is this to the best advantage of the customer? If a sole is supposed to contribute to the support of the foot under varying conditions of wear, then the substitutes do not fulfill this need. Data developed by Witnauer and Palm (33) illustrate the isometric nature of the flexibility curve of leather with temperature (Figure 14), while substitutes become stiff when cold and soft when warm. Thus a shoe built with substitute materials can feel overly stiff in the winter and not give enough support in the summer. Actually the change can occur even during a day, depending on atmospheric conditions. In spite of this decided advantage, I am not aware that the leather industry has emphasized this property for promoting their product.

Prospectus

I cannot help but wonder what the situation would be today if the scientists working with leather had the same support and resources at their disposal as those working on substitute products. There is no question that the consumers of leather constitute a much sought after market. In recent years this market has been invaded by numerous products that feature some desirable properties. The extent to which leather will be displaced by these products will depend on their acceptance by the consumer. There is much watchful waiting to determine whether the properties that are featured are the ones that the consumer prizes above others that may be available in another product.

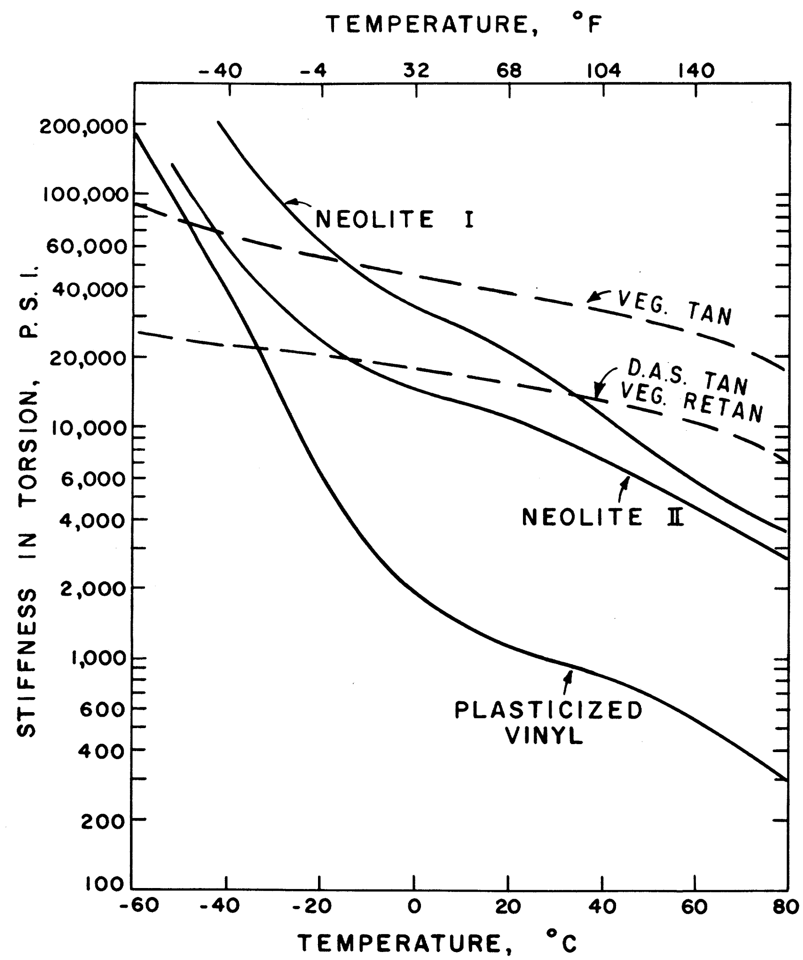

FIGURE 14.—Effect of temperature on the stiffness of leather and substitute soling materials (from Witnauer and Palm (33)).

George Bernard Shaw said, "You see things and you say why. But I dream things and say why not." I would like to paraphrase this and say, "Let us produce for the consumer the best piece of leather that money can buy — why not?"

It has also been said that mankind has one foot in the Stone Age, the other in space. This statement not only summarizes our present position but also concerns our future. It recognizes that we are astride a period of change. In the physical sciences we have aspired to the stars, and if we continue to do so — we shall have them. I have confidence in the capabilities of science and research and hope that you share that confidence with me. I hope that you share it strongly enough to be willing to contribute your time and the energy necessary to define the objectives and to build the aspirations.

I, therefore, charge you, as members of this Association, to renew your efforts in defining and characterizing the properties of leather. In doing that, keep in mind that you must meet the demands of two types of consumers, each with a specific set of requirements. On the one hand, you have to meet the demands of the shoe manufacturers, while you maintain the satisfaction of the public. The first looks at leather as a construction material and some of the requirements may be contrary to the best advantage of the public. Thus, judicious compromises must be reached, whereby the requirements for each consumer are retained to the best degree.

Dr. George Philips, while addressing the Tanners' Council of America in 1960 on the subject of "Natural vs. Synthetic," said that "the tide of battle is always shifting, because technology works for natural products as well as for synthetics." He asserted that the real problem for most industries is to define the issues. This must begin with the most objective appraisal of technical advantages and disadvantages and these cannot be guessed or assumed. For example, Dr. Philips pointed to the contrast of the memory factor in plastics as against the conforming quality of leather as a question of the highest importance. He asked how human toes would feel in the absence of the accommodation provided by leather.

Comfort is a very elusive property, when it comes to definition and measurement. It is composed of a number of variables and means different things to different persons. In 1966 Bradley discussed the properties of shoe leathers and their measurements (34). He dealt with seven: 1) pore volume, 2) pore size, 3) pore and fiber orientation, 4) specific surface, 5) water diffusion, 6) plasto-elasticity, and 7) thermal insulation and transpiration. He showed how the absorption and transpiration of water depend to a great degree on the porous structure of leather and how they affect the sensation of comfort — "protecting the wearer from external cold on the one hand, and, on the other hand, assisting the cooling of the overheated foot by transpiration." He related the plasto-elastic properties to the ability of leather to conform not only to irregularities of the foot but also to diurnal changes in volume. However, we still do not understand how these seven factors — there may be more — interact or how they relate specifically to structure of the leather.

During my recent trip to India, I was able to visit the Central Leather Research Institute. The Department of Agriculture supports a number of research projects at this Institute and one of these deals with the identification and measurement of properties of leather that contribute to comfort. The results of an experiment where a vapor barrier was introduced between the foot and the leather shoe were related to me. After a short period of activity, the temperature at the foot surface rose to 41.5°C. This was not only 7.5° above the ambient temperature of 34°C. but also 4.5° above the physiological temperature of the body. The wearer complained of discomfort and burning sensations of the foot. It is hoped that such psychometric evaluations will some day enable us to enumerate the factors that contribute to the comfort properties of leather and to specify their limits for various conditions of service.

Recently Grief (35) reported that finish had a significant effect on comfort by modifying the water permeation and transmission properties of leather. He predicted that measurement of these properties will be required in the future to provide data on the performance potential of shoe upper materials.

The public buys shoes and other leather goods without any real knowledge of the properties of the materials used in them. Neither is the consumer aware of the properties that contribute to serviceability and he is rarely in a position to demand what he wants, let alone know what he needs. Names, trademarks, and price are associated in the mind of the customer with certain quality standards and over-all acceptability. Part of the problem is that we do not always know how to measure or specify the requirements. The ALCA Liaison Committee on Research conducted several brain-storming sessions with the objective of preparing a list of properties for leather with specifications. The list has not yet been prepared — not because no one was willing to do it, but because the information is not available.

Following Dr. Wilson's lead, leather chemists have devoted much time to characterizing leather's properties and in developing test procedures for their evaluation. Even now the process continues. The ALCA-ASTM Joint Committee on Leather has been active in developing methods for measuring the characteristics of leather. Newer shoemaking processes impose strenuous demands on shoemaking materials and the subcommittees are exploring test procedures that will predict the performance of leather in meeting these requirements.

Recently Redwood (36) reviewed the demands made on leather by new processes for the manufacturer of footwear and other goods. Many of these operations, mulling, heat setting, vulcanizing, and direct molding, subject leather's to more heat than in the past. The move to the use of cements, vulcanizing, or direct molding for sole attachment involves a shift away from one of leathers superior properties — stitch tear strength. This move has created a host of specialized requirements which often create problems for both the tanner and the shoe manufacturer.

The rapid pace of today's innovations also becomes a source of problems. A tanner may adopt a new polymeric finish before it has been fully evaluated. A shoe manufacturer may use the same leather in a new process without realizing that it may no longer be compatible. This calls not only for close communications between tanners and shoe manufacturers, but also for the creation of meaningful screening procedures. We must realize that we no longer stand or work alone. We are a triumvirate — the tanner, the shoe manufacturer, and the consumer have much to gain from the liaison. The ALCA is in a position for leadership and it must accept the challenge. If it discharges this responsibility faithfully, leather will continue to be the supreme product.

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