WOOL GREASE

THE ECONOMICS OF RECOVERY AND UTILIZATION IN THE UNITED STATES

Marketing Research Report No. 89

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PREFACE

This report represents the first comprehensive study of wool grease recovery and use in the United States.

The Wool Advisory Committee, one of the industry advisory groups established under the Research and Marketing Act of 1946 to advise the Department on its research program, recommended in 1947 that one phase of the Department's wool research program be devoted to an economic appraisal of the scouring, recovery, refining, and distribution of wool grease and other byproducts of the wool manufacturing industry. This report is an outgrowth of the above recommendation and deals with the economic aspects of the production, distribution, and consumption of wool grease.

Many of the problems presented in this report are typical of those found in any industry dependent on a byproduct for its raw material. Although the wool grease industry is relatively small, it is important to many sectors of the economy. As a profitable byproduct, wool grease can be of greater significance to the wool industry than it is at present. The cost of processing wool can be reduced if a more efficient recovery of wool grease can be effected and if additional remunerative markets can be established or present markets expanded. Wool grease is of economic significance because it is widely used in many industries and is indispensable to a few. It has a military significance because the armed forces have been unable to find satisfactory substitutes for wool grease in some important uses.

In this report, the marketing channels and functions as well as the structure and characteristics of the wool grease industry are described and analyzed in some detail. Grease production by the wool scouring industry and the competitive situation of the product relative to other fats and oils made it necessary to discuss the economic and technical aspects of its production and consumption.

Several other objectives were attained by this study. The average per unit cost of scouring grease wool and recovering wool grease was developed for the industry for the first time. The present and potential production of wool grease in the United States has been estimated and compared to the uses and markets for wool grease (and of lanolin). The demand characteristics of the industries using wool grease have been ascertained in order to answer the principal query of the wool scourers: "Given a certain level of production of wool grease in the United States, at what price can it be sold?"

This study does not purport to answer all questions concerning wool grease. It is hoped, however, that its comprehensiveness will lead to a better understanding of the marketing pattern for wool grease and, consequently, will aid in the development of a more orderly distribution system and assist in opening new areas of use among potential users.

ACKNOWLEDGMENTS

The field work and analysis for this study were carried out under a Research and Marketing Act contract by the Lowell Technological Institute Research Foundation. The major portion of the work was done by Robert S. Raymond, formerly research associate of the Foundation, and now assistant professor, Pennsylvania State University, under the direction and supervision of Stuart L. Mandell, assistant professor, Lowell Technological Institute.

The basic research design for the study, technical supervision of the contract, and preparation of the manuscript for final publication were the responsibilities of Shelby A. Robert, Jr., and Philip B. Dwoskin of the Product Development Section, Market Development Branch, Agricultural Marketing Service. Others from the Department participating in the planning of this study were John T. Scanlan of the Eastern Utilization Research Branch, Agricultural Research Service; Harold P. Lundgren, Western Utilization Research Branch, Agricultural Research Service; and Richard J. Foote, Agricultural Marketing Service.

The United States Department of Agriculture and the Lowell Technological Institute Research Foundation appreciate the cooperation of many individuals and organizations without whose assistance the completion of this study would not have been possible. The sources of information and assistance in collecting the data presented in this report are too numerous to list individually. However, special appreciation is due to E. Henry Holm, I. W. Malmstrom, A. Wagner, and Frank Fanning, wool grease refiners, whose knowledge of and experience in the refining industry were generously given to the Research Foundation. For valuable technical assistance the Research Foundation is grateful to Philip N. Dwyer, chief chemist, O. L. King Company; T. N. Crowley and L. Ottey, American Chemical Paint Company; and Norman Newton, Abbott Worsted Company, Forage Village, Mass. Among those who read all or parts of this manuscript and contributed valuable advice and suggestions are Ruth Jackendoff, director of the Department of Economics and Statistics, and Giles Hopkins, technical director, The Wool Bureau, Inc., New York, N. Y.; Roland E. Derby, president, Textile Aniline and Chemical Company, Lawrence, Mass.; Harold Webber, textile consultant, Groton, Mass.; Elizabeth Richards, senior marketing analyst, Leo Burnett Company, Inc., Chicago, Ill.; T. N. Beckman, Ohio State University, Columbus, Ohio; and W. H. Day, University of Tulsa, Tulsa, Okla.

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WOOL GREASE: THE ECONOMICS OF RECOVERY AND UTILIZATION IN THE UNITED STATES

by

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SUMMARY AND CONCLUSIONS

The findings of this study indicate that an increase in the annual level of production of wool grease from around 10 or 12 million pounds to a minimum of 20 million pounds would help to stabilize the supply and price in the industry. A steady demand is believed to be already available to absorb the added production without unreasonably low prices. At the same time, improvements in waste disposal which could be obtained efficiently with larger production would contribute to the abatement of stream pollution.

An increased supply of wool grease will not solve all of the industry's problems nor will fluctuations in supply (and consequent fluctuations in price) be completely eliminated. But the same fluctuations around a higher mean annual production would have substantially less serious effects. Reductions below an already low level of wool grease production in the United States can cause severe financial loss to industrial users, who experience not only price increases but actual physical shortages. When average annual production is high, all users can meet their absolute needs, and the margin for adjustment by users is much greater than when production is low. There is also reason to believe that price fluctuations would be less at a higher production level, since enough wool grease would then be available so that the needs of marginal users could be met with only minor changes in the market price.

With respect to the future market outlook for this product, the many uses for the alcohol portion of the wool grease ester and many possibilities for use of the acidic fractions are of great potential importance. However, it is also an important fact that, even when the price of wool grease has been competitive with prices of other animal and vegetable fats and oils, the uncertainty of the wool grease supply has persuaded many firms to seek less satisfactory but more plentiful substitutes.

1/ Prepared under contract for the Market Development Branch of the Agricultural Marketing Service.

It appears that wool grease producers could profitably increase their production and contribute to greater dependability of supply by (1) investing in additional grease-recovery equipment, (2) adopting longer-run price policies with a view to building markets, and (3) cooperating with refiners in a research program to find improved recovery methods.

With the wool scouring industry concentrated in the Northeastern part of the United States, the problem of stream pollution from wool scouring operations has become increasingly important. Although there is no immediate prospect that all apparel wool scourers will be required to treat their scouring waste before discharge into streams, eventually some form of treatment is likely to prove necessary.

The following possibilities are pointed out to wool scourers as the result of an analysis based on the assumptions that, for mills scouring at least 3 million pounds of apparel wool annually, wool grease recovery by centrifuge is economically sound, and that, for smaller scourers, waste water treatment is as justifiable an expense as the usual payment for treatment of intake water.

(1) All apparel wool scourers not now recovering grease should reexamine the technical and economic possibilities of grease recovery for their mills.

(2) Wool scourers collectively might undertake or encourage research to develop a practical method of solvent scouring. The consensus in the industry is that aqueous scouring offers serious disadvantages not inherent in the solvent method. The ideal method should combine efficient, low-cost scouring with abatement of stream pollution and maximum recovery of grease.

(3) The smaller wool scouring establishments can decrease their costs for both scouring and waste treatment by centralizing such activities. Where technically and geographically feasible, cooperation by these mills might include one or both of the following operations:

(a) As cost studies in this industry indicate, lowest costs for scouring can be achieved by large-scale, three-shift operation, centralized scouring enterprises. These might be set up near the ports of Boston, New York, and Philadelphia. The success of these enterprises as commission scourers to small mills would depend upon their management's technical knowledge as much as upon their ability to reduce costs.

(b) There are several areas where a number of small scouring establishments are located within a 5-mile radius on one waterway or its branches. It might be economical for these adjacent plants to pipe their waste to a single recovery plant. If an acid-cracking system of grease recovery were used, larger mills might find a greater net return by delivering their effluent via pipeline than by centrifuging it themselves.

Some people in the industry have suggested subsidies to marginal producers to increase the production of wool grease. This might be applicable during wartime if wool grease were considered a strategic material important for its use in leather, cordage, rust preventives, and lubricants. Others in the industry suggested accelerated rates of depreciation on recovery equipment as a method that might also increase production.

A suggestion from one segment of the industry was that a trade association might be formed by the wool grease refiners to (1) promote the use of wool grease, lanolin, and derivatives, (2) act as spokesman for the industry, (3) promote research on uses, (4) set up trade standards, (5) collect data from all sources and make it available in one place, and (6) exchange general information among members.

In any event, the suggestion was made that the refiners collectively undertake or encourage research on the technical aspects of wool grease uses. Both private and public research facilities could be called on for this work. Research is presently under way at the Regional Laboratories of the U. S. Department of Agriculture on expanded utilization of wool grease and improved methods of scouring and grease recovery. Such research, if successful, could assist in stabilizing the wool grease industry, expanding present uses and developing the many potential uses for wool grease and its components, and abating the problem of stream pollution.

INTRODUCTION

This is a report on the first comprehensive survey of the economic aspects of the production, distribution, and consumption of wool grease in the United States. The recurring shortages of this material and the attendant repercussions make such a survey important not only to producers, refiners, and industrial users, but also to potential and marginal wool grease producers and ultimate consumers. A better understanding of the marketing pattern for wool grease can aid in the development of a more orderly distribution system and consequently open new areas of use among potential users.

Statement of Purpose

The ultimate purpose of this study was to make an economic appraisal of wool grease as a byproduct of the wool industry. As a profitable byproduct, wool grease can be of greater significance to the wool industry than at present. The cost of processing wool can be reduced if a more efficient recovery of wool grease can be effected and if additional remunerative markets can be established or present markets expanded.

In order to fulfill this purpose the study was designed to collect data on the cost of scouring wool and producing grease as a byproduct, to estimate the present and potential production in the United States, to investigate the present and potential uses and markets for wool grease based on its physical and chemical properties, and to report on the structure and characteristics of those industries that produce, distribute, and consume it. This analysis will also yield an estimate of the prices that can be obtained throughout the wool grease industry at given levels of production.

This study touches upon several larger pertinent problems than wool grease production, and on many other areas of industrial activity. Among these larger problems are stream pollution, national defense, and wool consumption. The waste from the scouring of grease wool is a powerful pollutant to the streams in the northeastern part of the United States. The situation has disturbed public health officials whose duty it is to supply cities with potable water, manufacturers whose water supply must be pretreated at increased expense, and many groups and individuals who use the waterways for sport and recreation. The problem of national defense is involved because, for some purposes, the military forces can find no good or close substitutes for wool grease and lanolin. For example, the Army has found wool grease indispensable for retan leather in combat boots; the Navy has found no satisfactory substitute for it in cordage; and the Air Force uses large quantities of technical lanolin in rust-preventives to protect aircraft engines and parts. The matter of wool consumption involves not only the producers of wool in the United States, but also the processors of wool who are faced with the problems occasioned by the extensive introduction of synthetic substitutes.

Scope and Method of Study

This study involved all wool grease refiners, nearly all grease wool scourers in the United States, and a cross section of the industrial users. Questionnaires were mailed to all of the wool scourers, with a covering letter explaining the purpose of the project and inviting them to participate in it. A follow-up letter was mailed to non-respondents; where practicable, a personal interview was obtained to explain the project in greater detail. 2/

Information from the refiners was obtained by personal interviews and by letter. Their number and location made this the most practical and economical method. Information was obtained from industrial users by questionnaire, telephone, letter, and, where practicable, by personal interview. As this study was begun in the latter half of 1952, all cost data are necessarily for the preceding calendar year, 1951.

Definition of Terms

The following six terms are used hereafter as defined below.

Wool grease	The greasy material in wool secreted by the sebaceous glands of the sheep.
Lanolin 3/	The material refined from wool grease known as technical lanolin, U.S.P. lanolin, or cosmetic lanolin.
Apparel wool	Wool finer than grade 40's.

2/ Lowell Technological Institute, where this study was made, is located in the center of the apparel wool scouring area.

3/ The term lanolin (Latin - lana - wool) originated in a patent specification in 1882 issued to two German inventors, Braun and Liebreich.

Carpet wool — Wool not finer than grade 40's, which if imported into the United States for specified uses would enter duty free.

Scourer — An establishment scouring grease wool on a commercial basis. The study does not include scourers of waste wool, nor those who specialize in the scouring of mohair, alpaca, vicuna, camel, or other hair or fibers.

Refiner — A lanolin manufacturer who distributes both wool grease and lanolin.

General Characteristics of Wool Grease and Lanolin

Wool grease is known and referred to as wool fat, lanolin, lanoline, neutral wool grease, and degras, and by various other terms. Chemically, wool grease is a wax rather than a fat since it contains no ester of glycerol. The true waxes have long-chain monohydric alcohols in place of the glycerol. Wool grease is, therefore, an ester 4/ of higher fatty acids 5/ with higher fatty alcohols (sterols, triterpene, and normal aliphatic alcohols), some free fatty acids and alcohols, and various impurities from the fleece and from the chemicals used in scouring and recovering the grease.

Physically, it is a soft, greasy substance, almost odorless, varying from a deep brown to an ivory color, according to its purity. Unlike true fats such as tallow, butter, and lard, wool grease (also lanolin) does not become oxidized more than enough to form a surface film that acts as a protective coating, nor does it become rancid by exposure to air or during long periods in storage. It is unlike other waxes, such as carnauba or ouricouny which harden in air and take a high, durable polish.

It is unique among the waxes for the absence of hydrocarbons, usually present in appreciable quantities in other waxes; for the high proportion of cholesterol (30 to 40 percent of the unsaponifiable part); and for alcohols 6/ and acids not known to occur in

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4/ Chemically it is a compound formed by combination of an organic acid with an alcohol.

5/ At least 30 different acids are present (see Weitkamp, item (56) in Literature Cited, page 158).

6/ Many of its unique qualities as a surface active agent, such as emolliency, emulsifying power, its tenacity as a surface film, and its ability to increase viscosity or to act as a plasticizer, are attributed to the alcohol portion.

any other compounds. Its outstanding property, however, is its ability to form very stable emulsions of the water-in-oil type. It is self-emulsifying, and when added to other oils, even in small amounts of 5 to 10 percent, it enables them to absorb many times their own weight in water. This property enables water-soluble medicaments mixed with lanolin to be held in contact with the skin until they can be absorbed.

WOOL GREASE SUPPLY IN THE UNITED STATES

Many of the current and potential industrial uses for wool grease are limited by the quantity produced, the uncertainty and fluctuations in its supply, and the methods of recovering it from the wool washing waters. Many of the problems of the wool grease industry and most of the limitations on the use of wool grease are due to its status as a byproduct of the wool scouring industry.

General Supply Situation

The supply of wool grease available for consumption in the United States is derived from two sources, as shown in figure 1. The principal one is the grease produced as a byproduct by 38 scourers of apparel wool that recover the wool grease from their scouring liquors. The other and secondary source is imports.

Centrifuged grease that is suitable for refining into lanolin is produced by 35 domestic scourers. The other 3 scourers recovered, by the acid cracking method, approximately 20 percent of the grease produced in the United States in 1951. Grease from this process is darker in color, has a strong odor, and has a much higher free fatty acid content. It can be desulphurized with sodium sulphite at a cost of approximately 1 cent a pound. Wool grease obtained by this process was sold under ceiling prices of the former Office of Price Stabilization (OPS) at approximately 15 cents a pound in contrast to 20 cents a pound for centrifuged grease. Acid-cracked grease is used for leather stuffing, drawing compounds, fur dressing, and cordage, where the fatty acid content is not critical.

The domestic production of wool grease is closely governed by the consumption of apparel wool in the United States, as shown by figure 2. This relationship is shown by a statistical correlation of $r = 0.749$, 7/ indicating by the square of that number that

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7/ Formula is $r = \dfrac{\Sigma(XY)}{\sqrt{\Sigma(X^2)}\sqrt{\Sigma(Y^2)}} = \dfrac{11631275}{\sqrt{446540}\sqrt{537795827}} = .749$

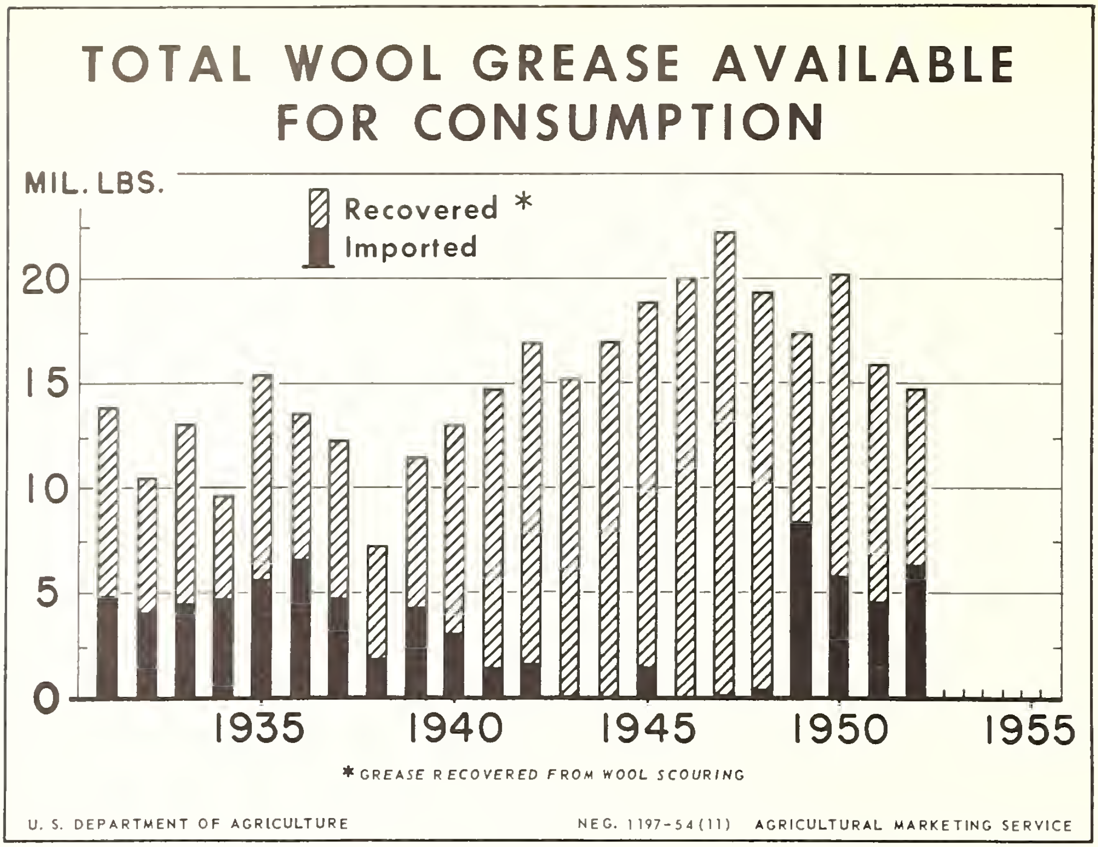


Figure 1

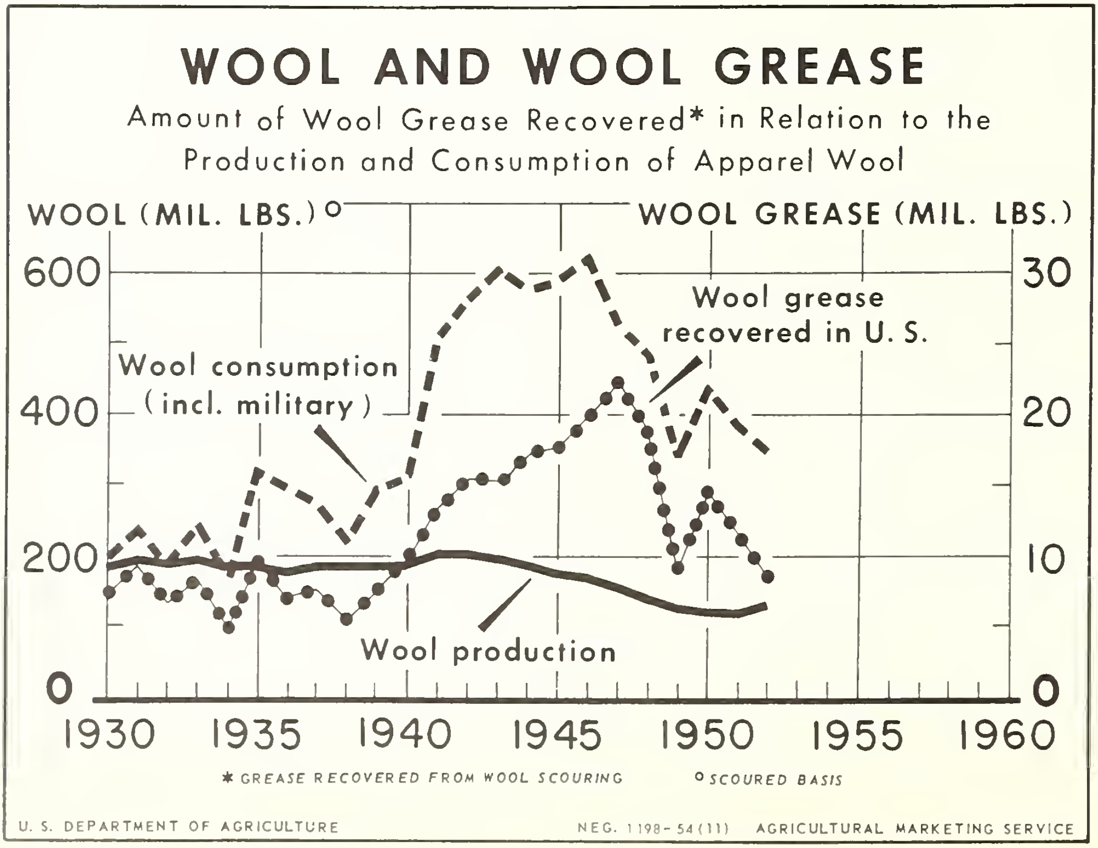


Figure 2

approximately 56 percent of the variations in wool grease production may be accounted for by variations in mill consumption of apparel wool. The other 44 percent may be due to variations in the grease content of wool from year to year, incompleteness of census data on wool grease production, and the variations in use of grease recovery equipment. The low point in apparel wool consumption and grease recovery since 1930 came in 1934 when only 381 million pounds of grease wool were scoured. The high point was during World War II (1943) when 1,134 million pounds of grease wool were scoured in the United States (31). 8/ A part of the increase in grease recovered in the United States during the war was due to the installation of centrifugal recovery equipment.

The other source of wool grease is imports. Nearly all of this foreign supply contains more than 2 percent free fatty acid, as shown in figure 3. Very little of this type of grease is refined in the United States. It supplies the demand for cruder forms of wool grease as that for leather stuffing, fur dressing, belt dressing, and drawing compounds. It plays a marginal role in United States consumption and is imported in varying amounts to bridge the gap between domestic production and total demand.

The largest foreign supplier of wool grease to this country since 1935 has been the United Kingdom. Most of this material has a high free fatty acid content, and it is not economically suitable for refining into lanolin.

Factors Affecting the Supply of Wool Grease

Many factors affect the supply of wool grease. The chief one is the quantity of apparel wool scoured in the United States, as shown by the correlation between mill consumption of raw wool and domestic production of wool grease. In addition, at a given level of wool consumption, the volume of grease recovery may be expanded through technological developments, 9/ legal pressure on scourers to abate stream pollution, and economic self-interest when the price of wool grease rises considerably above its cost of production for a year or more.

8/ Underscored figures in parentheses refer to Literature Cited, page 153.

9/ Such as the froth flotation process for grease recovery recently developed in Australia by the Commonwealth Scientific and Industrial Research Organization.

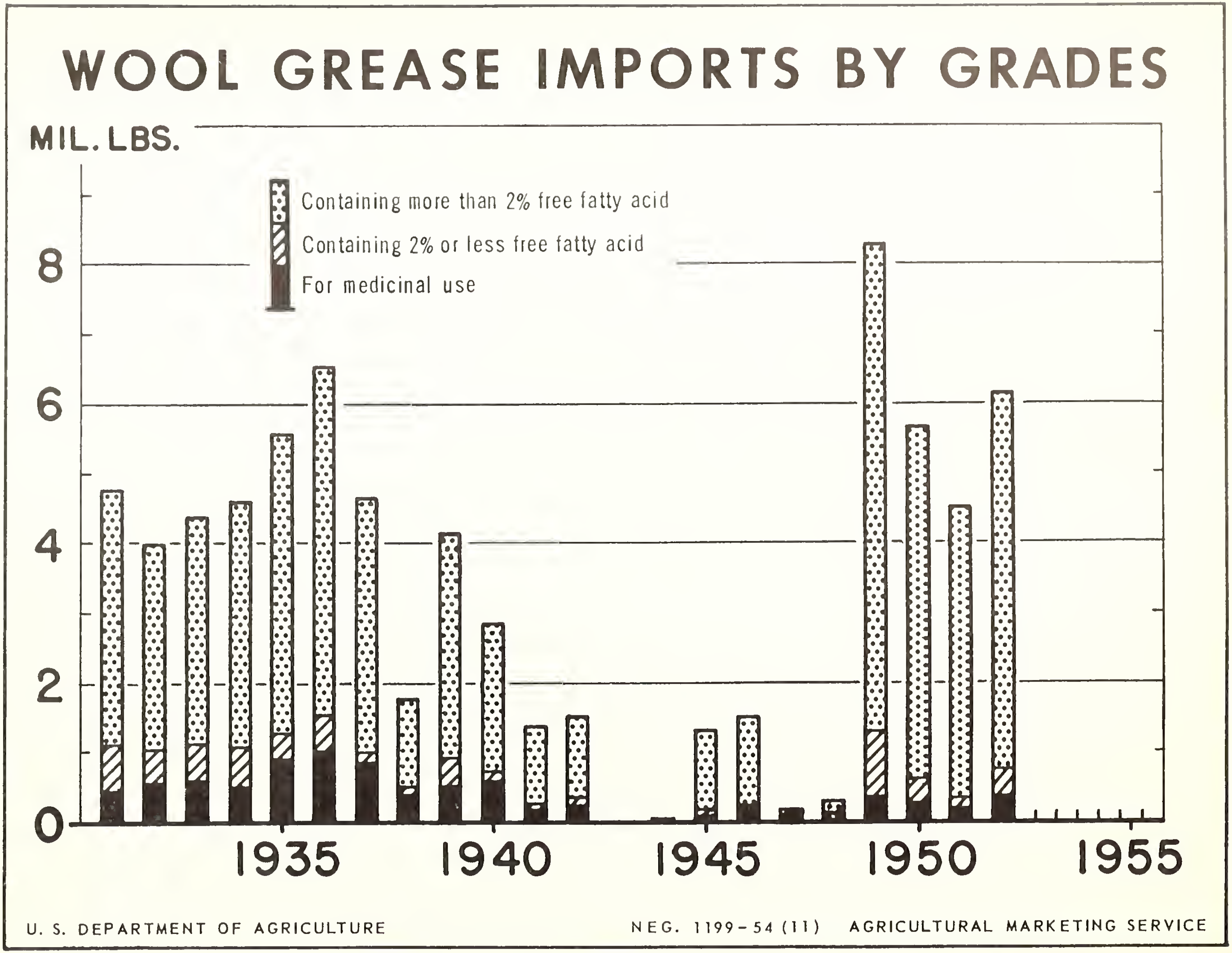

WOOL GREASE IMPORTS BY GRADES
MIL. LBS.
Containing more than 2% free fatty acid
Containing 2% or less free fatty acid
For medicinal use
8
6
4
2
0
1935
1940
1945
1950
1955
U. S. DEPARTMENT OF AGRICULTURE
NEG. 1199-54 (11)
AGRICULTURAL MARKETING SERVICE

Figure 3

There are some other factors that affect indirectly the potential supply of wool grease through their effects on wool consumption. These are the decreased production of domestic wool; the increased imports of scoured wool, wool tops, and other manufactures; and the increased use of other apparel fibers, particularly synthetics.

The decreased production of domestic wool reduces an assured potential source of grease because nearly all domestic wool is scoured within the United States. 10/ The trend of domestic production is definitely down, as shown in table 1, but it may stabilize close to the present levels.

Table 1.- Apparel wool: Production and exports of shorn and pulled wool, United States, 1945-52

Item	1945	1946	1947	1948	1949	1950	1951	1952
	Mil. lbs.	Mil. lbs.	Mil. lbs.	Mil. lbs.	Mil. lbs.	Mil. lbs.	Mil. lbs.	Mil. lbs.
Production	378.5	342.2	308.0	278.4	248.5	247.8	251.4	266.0
Exports 1/	28.8	16.0	12.7	1.1	15.7	6.8	.2	.03

1/ Includes hair of angora goat, alpaca, and other like animals. Exports during 1945, 1946, and 1947 were to western European countries for relief purposes.

United States Department of Agriculture, Bureau of Agricultural Economics, Wool Production and Income 1951-52 (43), and United States Department of Agriculture, Agricultural Statistics, 1952. Pp. 436-37 (50).

Importation of scoured wool, wool top, and woven wool fabrics has increased tremendously during recent years, resulting in a further loss of potential domestic grease recovery (figures 4, 5). 11/

10/ Practically all wool produced in the United States is apparel wool, and exports of domestic wool are small, mostly Ohio Delaines shipped to Western Europe for use in blends for super-warp yarns because of their strength.

11/ Foreign supplies are not appreciably increased because few countries outside of Western Europe have stream pollution laws, and these countries do not recover grease.

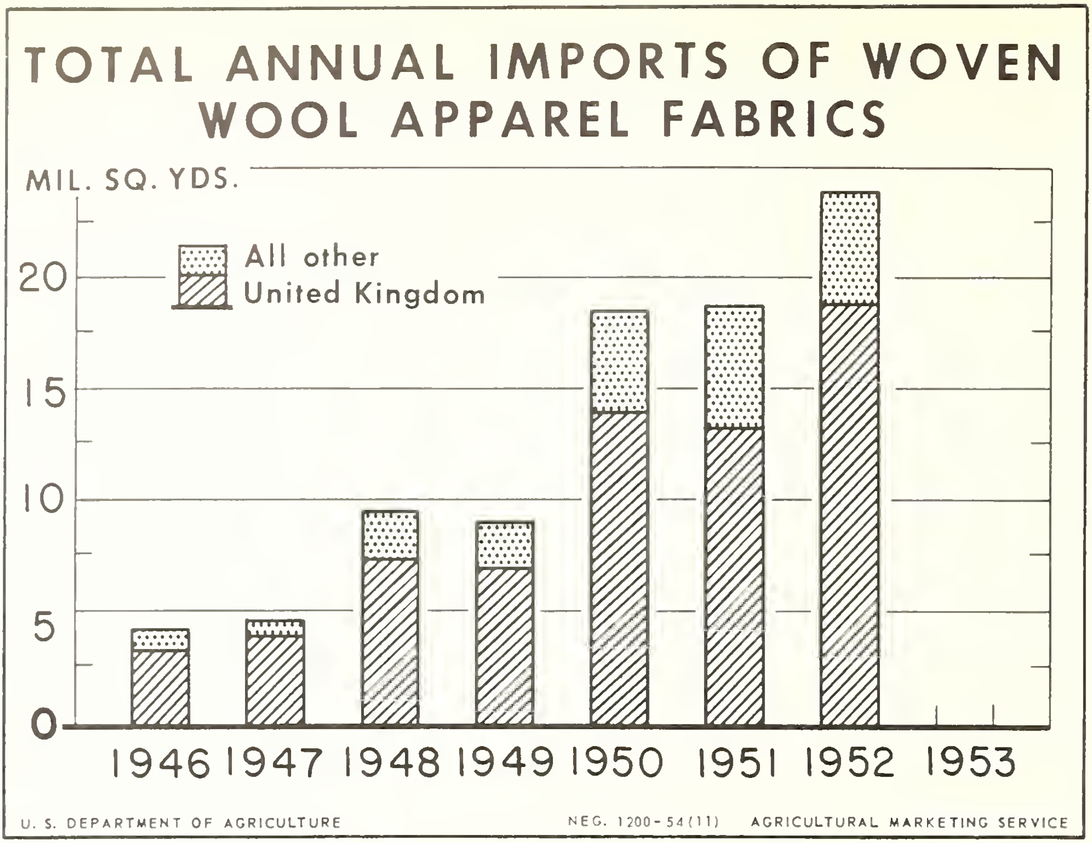


Figure 4

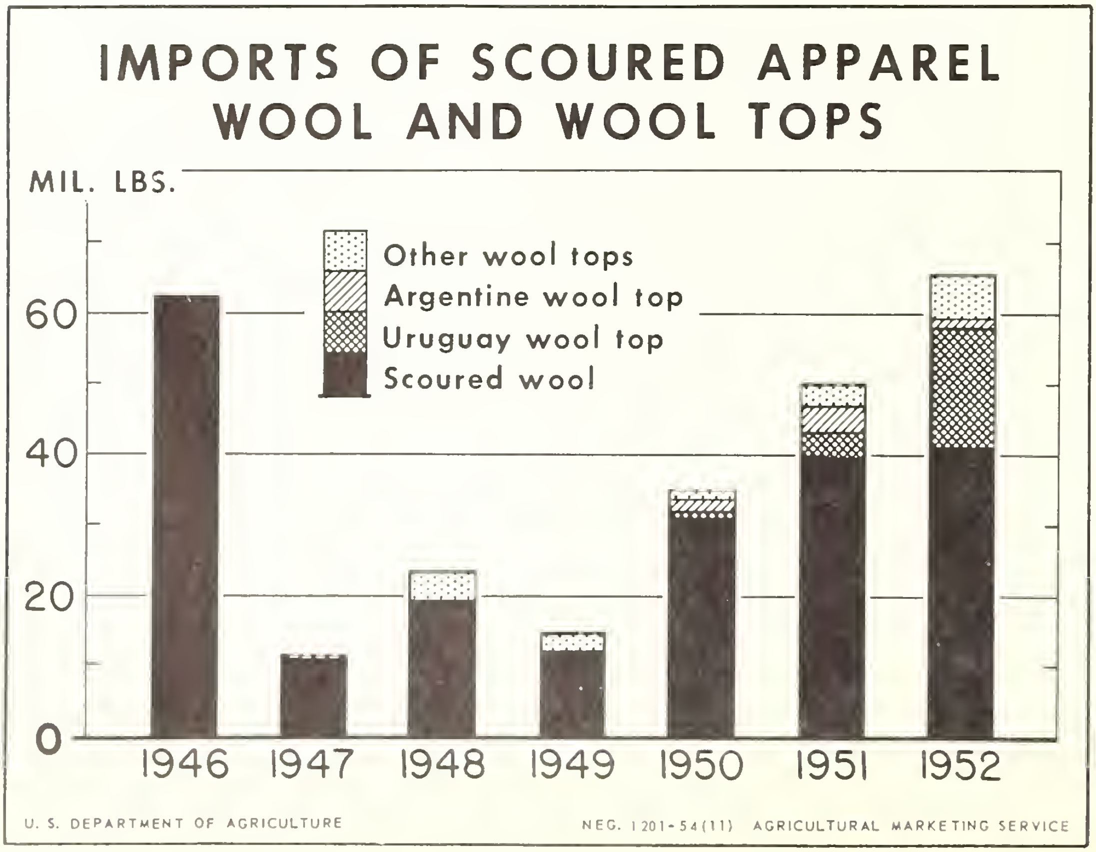


Figure 5

The possible loss of wool grease because of this trend has been substantial during the period 1946-52.

The increased use of other apparel fibers, particularly synthetics, is a potential long-term factor that may affect the domestic supply of wool grease. Perhaps the outstanding fact about synthetic textile fibers is that they have increased in quantity each postwar year except 1949. Rayon and acetate textile capacity by late 1953 was estimated at 3-1/4 times the 1939 level, but it was chiefly in high-tenacity tire yarns. Other man-made fiber production increased from 5 million pounds in 1940 (mostly nylon) to 210 million pounds in 1951. Not all of this production competes with wool as the raw material for clothing. Wool fiber is now used in blends with many of the new fibers, such as Orlon, Dacron, Acrilan, Dynel, and others, in uses formerly filled by 100 percent wool textiles. It seem probable that a smaller proportion of the dollar the consumer spends for clothing will be used for apparel wool.

Wool Grease Potential for the United States, 1935-52

There are two general categories of wool used in the United States, and they take their names from the uses to which the fiber is put. Apparel wool is used principally for clothing but also in the manufacture of blankets, upholstery, drapery fabrics, and industrial felts. Carpet wools are coarser, stronger, harsher in feel, kinky rather than wavy in appearance, and have color defects that make them unsuited for most apparel purposes.

Inasmuch as there is less than 5 percent grease in carpet wool (grade 40 and coarser, all of which is imported duty free if for certain specified uses such as floor coverings, etc.) it is the consensus among carpet wool scourers and manufacturers of grease recovery equipment that grease recovery could be accomplished only at a loss under any system now known. The State of Pennsylvania has been the most zealous in cleaning up its waterways, and it is significant that although nearly all of the carpet wool scourers are located in or near Philadelphia, none of them has installed grease recovery equipment. Carpet wools can therefore be ruled out as an economical source of wool grease in the United States.

The scouring of apparel wool (all grades finer than 40's) by United States wool scourers is the only source of domestic wool grease. An estimate of the potential supply of wool grease must therefore be based on the amount of apparel wool scoured annually in the United States and its grease content. United States wool production and United States imports of grease wool would not be an accurate base for this estimate as there is often a considerable lag between production or importation and consumption, as shown by figure 6 (44, 45). The most realistic data on which to base grease production is "U. S. Mill Consumption of Apparel Wool," compiled by the U. S. Bureau of the Census and published in its Facts for Industry, series M15H-01. Prior to 1942, wool was considered as consumed when carded or otherwise advanced beyond scouring or raw stock dyeing; and beginning in January 1942, wool was considered as consumed (1) on the woolen system when laid in mixes and (2) on the worsted system when entering scouring bowls. Beginning in August 1948, consumption on the worsted system is taken as the sum of top and noil production.

However, United States mill consumption data include scoured wools imported for consumption; assuming that these are consumed in the year in which they are imported, an allowance must be made for them, since they are not a potential source of wool grease. During the war years, 1942-45 inclusive, scoured apparel wools imported into the United States averaged 19 percent of total wool imports on a clean basis. In 1951 and 1952 scoured wool amounted to approximately 15 percent and 17 percent, respectively, of total United States apparel wool imports on a clean basis (fig. 5).

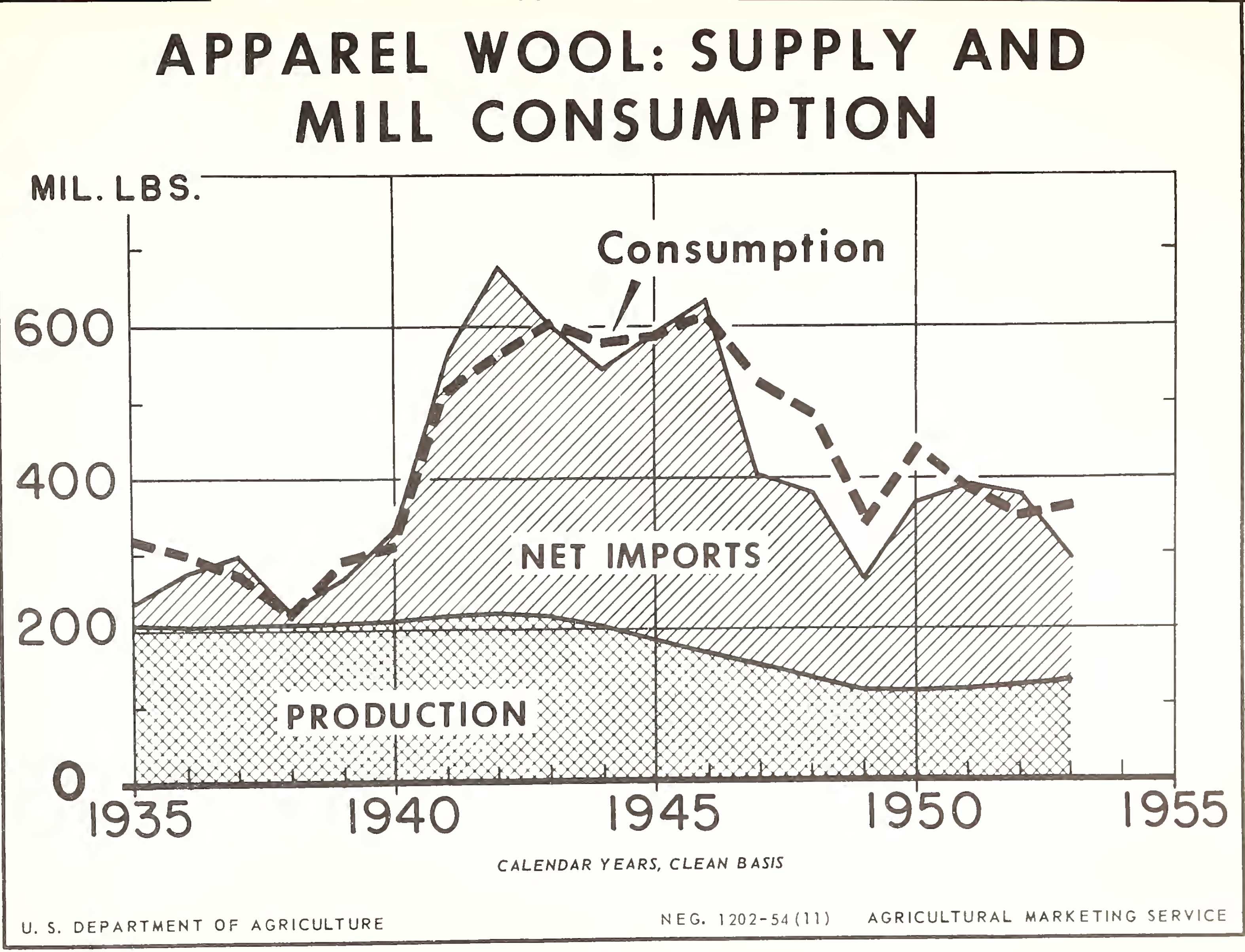
The grease content of wool varies with the fineness of the fiber. In general the finer the wool the greater the grease content, and it is therefore desirable in order to increase the accuracy of the wool grease estimate to separate the total mill consumption of apparel wool for each calendar year into three categories. (46)

For the years 1948-51 data for mill consumption of apparel class wool were not available on a grease basis from Bureau of the Census or Department of Agriculture data. Table 2 has therefore been used to convert the data for those years from a scoured to a grease basis.

Table 2.- Apparel wool: Percentage clean yield of domestic and imported shorn wool, by grades

Grade	Domestic	Imported
	Percent	Percent
Fine (64s and finer)	40	54
1/2-blood (60s, 62s)	43	57
3/8-blood (56s, 58s)	52	64
1/4-blood (50s, 52s)	55	67
Low 1/4-blood (46s, 48s)	58	70
Common (44s)	61	68
Braid (40s and coarser)	61	71

United States Bureau of the Census, Facts for Industry: Wool Manufactures, September 1952, p. 2, (48).



APPAREL WOOL: SUPPLY AND MILL CONSUMPTION
MIL. LBS.
600
400
200
0
Consumption
NET IMPORTS
PRODUCTION
1935
1940
1945
1950
1955
CALENDAR YEARS, CLEAN BASIS
U. S. DEPARTMENT OF AGRICULTURE
NEG. 1202-54 (11)
AGRICULTURAL MARKETING SERVICE

Figure 6

It now remains to apply to each of the grades a factor which most nearly represents the grease content of that grade. 12/ Although much work has been done on the shrinkage rate for every kind of wool consumed in the United States, very little is known about the grease content. Shrinkage includes all of the impurities in the fleece such as suint and vegetable and mineral matter as well as the grease. Growers, traders, manufacturers, and all those who produce, distribute, or process wool are interested in the shrinkage because it constitutes the basis of payment in every transaction until the wool is scoured. For example, it is the dealer's ability to estimate shrinkage that often makes the difference between his profit and loss. Experienced wool dealers can estimate it within 1 percent. They need to be accurate, because underestimating the shrinkage by 2 percent will wipe out their own margin; and overestimating it will cause them to lose out to their competitors. Another reason that shrinkage rates are well known and that little attention is paid to grease content is that customs duties on imported wool are based on the scoured or clean fiber content. In recent years more than two-thirds of the apparel wool consumed in the United States has been imported. Its shrinkage is determined scientifically by coring each bale, scouring the sample thus obtained, and weighing the clean fiber. No distinction is made between the grease and any other impurity.

Nearly all of the scientific studies on the grease content of wool have been made abroad, and in their wide range they exhibit the same defects as a basis for estimating the grease content of wool consumed in the United States as the data in tables 3 and 4. They are reports of laboratory trials on wools from one or two countries and from only a few breeds of sheep and they indicate only a range for the grease content when there is a need for more specific information. It has therefore been necessary to rely upon the knowledge and experience of a few men 13/ who have been closely connected with wool scouring and grease recovery in order to estimate the grease content of wools consumed in the United States. Their estimate is as follows:

12/ The lower grease content of a small proportion of the total, consisting of pulled wool, has been ignored. In 1951 pulled wools constituted 16 percent of domestic production and less than 1 percent of imported wools.

13/ Werner von Bergen, director of research, Forstmann Woolen Company, Passaic, N. J.; Hugh Christison, formerly chief chemist, Arlington Mills, Lawrence, Mass.; T. N. Crowley, American Chemical Paint Company, Ambler, Pa.; and Fritz Kobayashi, chief chemist, Ames Worsted Company, Lowell, Mass.

Grade of grease wool	Grease content (percentage of grease weight of wool)
60's and finer	12 to 14 percent
50's to 60's	8 to 11
48's and coarser	5 to 7

Table 3.- Range of percentage of grease content in wool, by type and specified lengths (39)

Type	Good length	Irregular	Short
	Percent	Percent	Percent
Merino			
70's and up	15 - 20	1/13 - 15	14 - 17½
64/70's	16½- 22	13 - 20½	11½- 15
64's	16 - 18	14½- 20½	2/10 - 19
	Super	Good	Average
Crossbred			
58 to 60/64's	9½- 19	11 - 13½	7 - 13
32/36's to 56/58's	5½- 14½	9 - 12½	6 - 7

1/ Wools in this group originated from Queensland.
2/ The high grease content wools are from South Australia.

Table 4.- Range and average percentage of fleece constituents in Australian wool

Item	Merino		Crossbred		Fellmongered	
	Range	Average	Range	Average	Range	Average
	Percent	Percent	Percent	Percent	Percent	Percent
Wool fiber	29.4-66.8	48.9	49.3-72.2	61.0	50.6-70.0	63.0
Grease	10.0-25.4	16.1	5.3-19.3	10.6	9.9-20.0	15.8
Suint	2.0-12.0	6.1	4.4-13.4	8.2	0.1- 1.4	0.6
Dirt	6.3-43.8	19.6	4.3-23.7	8.4	6.4-21.5	11.2
Moisture	8.1-12.6	9.6	9.5-14.2	12.0	7.2- 9.6	8.8

Wool Science Review, No. 6, September 1950, p. 44 (20).

These factors were applied to the three categories of grease wool for the years 1935 to 1952 in estimating the potential supply of wool grease in the United States, with the results shown in table 5.

Thus far it has been assumed that United States mill consumption data contained only grease wool. This is not so, however, because a portion of the apparel wool consumed by United States mills each year is imported scoured wool and is thus not a source of domestic wool grease. This error is corrected in table 6. The corrected total potential supply of wool grease is compared to the actual amount in the United States in table 7.

There are several reasons why United States production of wool grease averages a little less than 14 percent of the potential supply. The chief one is the relative inefficiency of the methods of recovering wool grease. From a technical standpoint, the centrifuge used by most domestic scourers to separate the miscible liquids of the scouring effluent is an engineering achievement of a high order, but only a small proportion of the grease in the fleece is recovered. The second reason is that although wool scouring is largely done in the New England area, a number of the individual establishments are small and widely separated. The majority do not scour a sufficient volume of the finer grades of apparel wools to make the recovery of grease an economical operation, and they are unable as yet to pool their effluents for economical treatment. (The quantity and types of wool required for the economic operation of grease recovery equipment are discussed in the section devoted to the cost of recovering grease.)

Demand for Apparel Wool

Because of the close correlation between the quantity of apparel wool scoured in the United States and the amount of wool grease produced, any forecast for wool grease production must be based on the demand for apparel wool. An examination of the factors affecting that demand is therefore pertinent. A brief history of the supply and demand conditions for apparel wool in the United States before, during, and after World War II will be useful in this connection.

The United States imports far more apparel wool than it produces each year. On the assumption that these imports are consumed each year about as imported, table 8 shows that on the average this country produces about a third of the apparel wool that it consumes. The wide fluctuations in consumption of apparel wool are also apparent in this table, ranging from a low of 220 million pounds in 1938 to 610 million pounds in 1946, immediately after the war. During the war years, 1941-45, consumption averaged 569 million pounds per year, about half of which was used to make clothing for the armed forces. (42)

Table 5.- Potential supply of wool grease, United States, 1935-52

Year	60's and finer	50-60	48 and coarser	Total
	Million pounds	Million pounds	Million pounds	Million pounds
1935------	52.0	29.7	3.1	84.8
1936------	44.0	24.9	4.7	73.6
1937------	38.8	20.9	4.3	64.0
1938------	36.6	19.7	2.1	58.4
1939------	48.8	24.5	3.2	76.5
1940------	52.7	22.6	3.1	78.4
1941------	76.8	31.8	6.2	114.8
1942------	75.1	37.9	8.7	121.7
1943------	68.6	48.1	7.5	124.2
1944------	64.0	44.3	7.3	115.6
1945------	65.7	44.4	6.5	116.6
1946------	80.1	35.1	9.3	124.5
1947------	82.6	26.1	7.5	116.2
1948------	81.8	22.9	4.6	109.3
1949------	52.3	20.9	3.1	76.3
1950------	66.8	25.7	3.6	96.1
1951------	59.8	21.8	3.1	84.7
1952------	57.3	19.0	2.9	79.2

Calculated from United States Department of Agriculture, Bureau of Agricultural Economics, Wool Statistics (Washington, D. C.: U. S. Government Printing Office, 1949), p. 35, table 28 (46).

Table 6.- Potential supply of wool grease corrected for imports of scoured wool, 1935-52

Year	Supply of wool grease 1/	Imports for consumption of scoured wool: Duitable clean content 2/	Imports for consumption of scoured wool: Grease content 3/	Supply of wool grease corrected
	1,000 pounds	1,000 pounds	1,000 pounds	1,000 pounds
1935--	84,800	614	123	84,677
1936--	73,600	2,088	418	73,182
1937--	64,000	3,138	628	63,372
1938--	58,400	560	112	58,288
1939--	76,500	1,929	386	76,114
1940--	78,400	5,329	1,066	77,334
1941--	114,800	29,217	5,843	108,957
1942--	121,700	74,288	14,858	106,842
1943--	124,200	90,492	18,098	106,102
1944--	115,600	73,126	14,625	100,975
1945--	116,600	78,084	13,321	103,279
1946--	124,500	62,376	12,475	112,025
1947--	116,200	11,686	2,334	113,866
1948--	109,300	19,868	3,954	105,346
1949--	76,300	12,930	2,586	73,714
1950--	96,100	31,374	6,275	89,825
1951--	84,700	39,541	7,382	77,318
1952--	79,200	41,231	7,760	71,440

1/ From table 5.
2/ Bulletin of the National Association of Wool Manufacturers, pp. 2-245 (31).
3/ Grease content estimated at 10 percent of grease weight.

Table 7.- Estimated potential and actual recovery of wool grease, United States, 1935-52

Year	Wool grease: Potential 1/	Wool grease: Actual 2/	Wool grease: Percentage recovered
	1,000 pounds	1,000 pounds	Percent
1935	84,677	9,654	11.4
1936	73,182	6,922	9.5
1937	63,372	7,511	11.9
1938	58,288	5,324	9.1
1939	76,114	7,192	9.4
1940	77,334	9,918	12.8
1941	108,957	13,344	12.2
1942	106,842	15,431	14.4
1943	106,102	15,148	14.3
1944	100,975	17,031	16.9
1945	103,279	17,522	17.0
1946	112,025	19,959	17.8
1947	113,866	22,190	19.5
1948	105,346	18,874	17.9
1949	73,714	9,023	12.2
1950	89,825	14,548	16.2
1951	77,318	11,491	14.9
1952	71,440	8,461	11.8

1/ From table 9.
2/ Bulletin of the National Association of Wool Manufacturers, pp. 2-172 (31).

Table 8.- Apparel wool: Production, imports, and mill consumption, scoured basis, United States, 1935-53

Year	Production	Imports	Mill consumption	
			Total	Per capita
	Million pounds	Million pounds	Million pounds	Pounds
1935--	208.6	26.9	319.0	2.47
1936--	205.1	69.9	299.8	2.31
1937--	206.3	90.5	274.2	2.10
1938--	206.7	19.6	219.6	1.67
1939--	207.5	58.5	293.1	2.21
1940--	210.2	118.4	310.0	2.31
1941--	219.9	334.7	514.4	3.80
1942--	220.9	457.1	560.5	4.10
1943--	215.6	384.4	603.3	4.35
1944--	204.0	341.9	577.0	4.11
1945--	188.4	404.0	589.2	4.16
1946--	169.6	465.0	609.6	4.25
1947--	153.1	253.3	525.9	3.60
1948--	136.9	245.2	485.2	3.26
1949--	120.4	146.9	339.0	2.24
1950--	119.1	248.1	436.9	2.84
1951--	118.7	272.0	382.1	2.44
1952--	127.4	248.4	346.8	2.18
1953--	132.1	163.7	352.5	

"Achieving a Sound Domestic Wool Industry." A report to the President of the United States from the Secretary of Agriculture. Pp. 72-75, December 1953.

Another view of wool consumption in the United States may be obtained from per capita figures in table 8. During the years 1935 to 1939, mill consumption per capita averaged 2.15 pounds. During the war years, 1941 to 1945, it averaged 4.10 pounds, went up to 4.25 pounds in 1946, and declined to 2.24 pounds in 1949, 2.84 pounds in 1950, 2.44 pounds in 1951, and 2.18 pounds in 1952.

The demand for apparel wool is largely derived from the demand for clothing, as more than 75 percent of apparel wool consumed in the United States normally enters into that use (17). The general pattern of consumers' demand for clothing was observed long ago, in 1857, by Ernst Engel as head of the Statistical Bureau of Saxony. One of his four laws of consumption stated that as a family's income increases in amount, the proportion spent for clothing remains approximately the same. This proportion is not strictly true in the United States, as the proportion of family income spent for clothing increases in the upper income (52) levels.

Beyond logical assumption that the demand for apparel wool is a function of the demand for clothing, there is very little precise information available to correlate one with the other. 14/ In addition, such a correlation is hindered by the following factors: First, only about 75 percent of apparel wool consumed in the United States normally enters into the manufacture of items of wearing apparel (17). Second, a factor of importance is the time lag between the demand for apparel wool by the textile manufacturer and the sale of clothing at retail. Finally, the lack of information on inventory demand as well as consumers' demand makes a precise correlation impossible (58).

The price of wool, like the prices of other commodities that bulk large in world trade, is set on a world market, principally at auctions in London, Australia, New Zealand, South Africa, and other wool-exporting countries, and has little effect upon the demand for clothing. A study made by the Department of Agriculture of data relating to retail values of 20 representative wool products and to the farm value of the wool used in their manufacture shows that during the 25 years from 1926 to 1950, returns to growers for the raw wool averaged about 14 percent of the retail prices to consumers for the finished products, as shown in figure 7.

14/ "Lack of reliable consumer and retail wool clothing inventories has prevented anyone within my experience from calculating a good formula for estimating wool demand." Letter dated January 27, 1953, from Miss Ruth Jackendoff, Director, Department of Economics and Statistics, Wool Bureau, Inc., New York, N. Y.

The proportion of the retail value of the wool used in apparel varied irregularly with the prices of wool, ranging from almost 18 percent in 1928 to about 6 percent in 1932, and averaged 16 percent in 1950 (19). This means that the price of raw wool might fall considerably and not have commensurate effect on the retail price of items made of apparel wool. Wages and other costs of manufacture and distribution tend to be more stable than prices of raw materials.

There seems to be substantial agreement among all competent observers that, in the long run, under given conditions of climate and social habits, the demand for clothing and, consequently, wool consumption in the United States are not governed so much by raw wool prices as by the general level of prosperity in this country. 15/ This is reflected by the national income and the level of employment (fig. 8) (6, 17, 51).

The following conclusions are derived from the preceding discussion:

(1) The production of wool grease in the United States is directly dependent on the amount of apparel wool scoured in the United States.

(2) Mill consumption of apparel wool is a function of the demand for clothing.

(3) No close correlation between year-to-year variations in the demand for clothing and the consumption of apparel wool is possible (statistically) for the reasons discussed above.

(4) In the long run

(a) Consumer expenditure for clothing varies directly with consumer purchasing power.

(b) Consumption of apparel wool tends to be high when disposable personal income is high and vice versa.

15/ "The income elasticity of clothing expenditure is high and this means that during depressed periods the adverse effect of falling incomes on the level of wool consumption is likely to be much stronger than the counteracting effect of lower raw wool prices (5)."

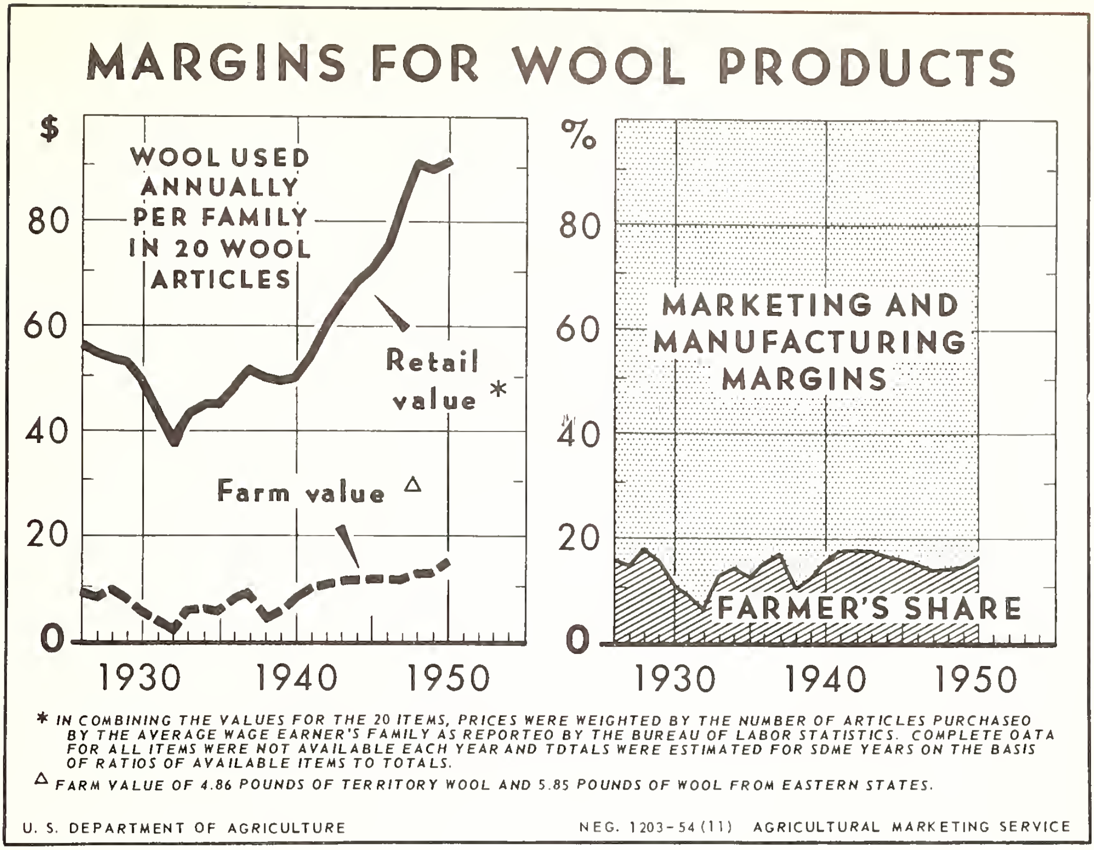


Figure 7

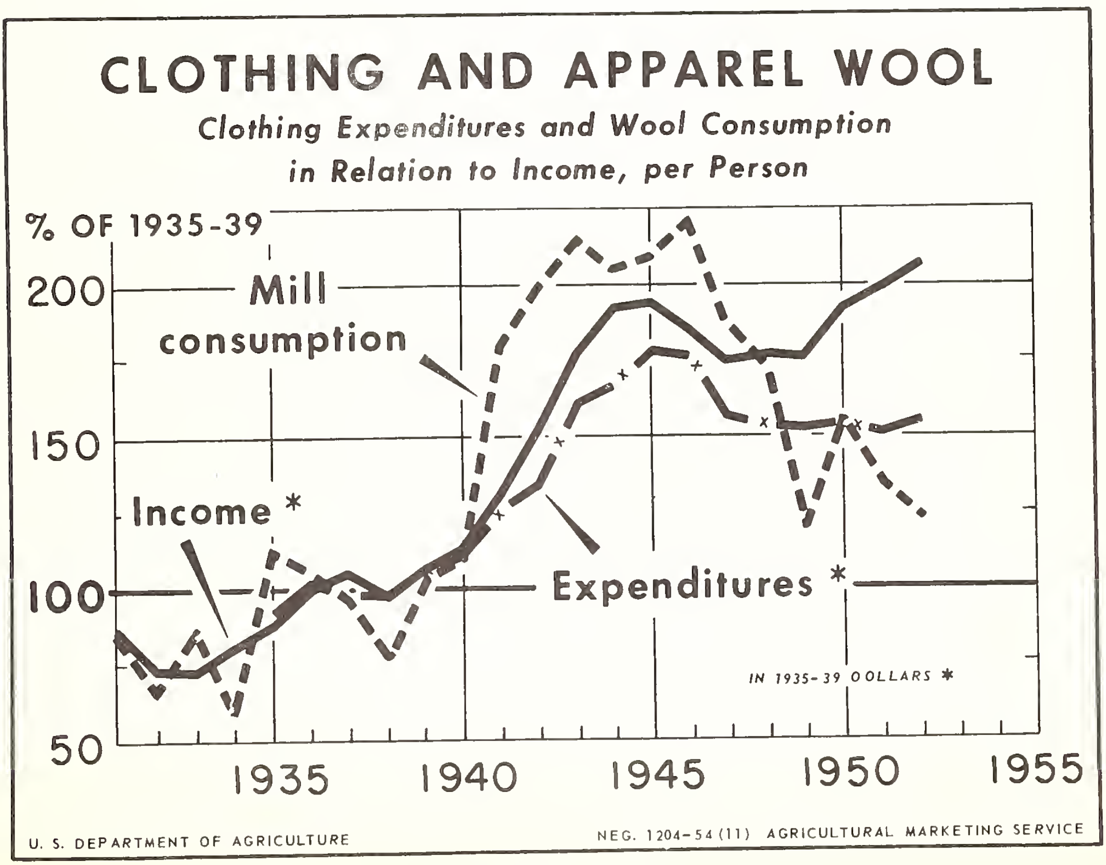


Figure 8

GREASE WOOL SCOURING IN THE UNITED STATES

The quantity, quality, and cost of wool grease are affected by the wool scouring operation itself, as well as by the recovery process. Therefore, a description of scouring techniques, costs, and other factors that affect wool grease production is essential to an understanding of the problems of wool grease recovery and marketing.

As this is an economic study, no effort has been made to evaluate wool scouring techniques, to determine detergent efficiency, or to investigate optimum scouring conditions for wool, such as alkalinity and temperature. The purpose is rather to describe the equipment, materials, and methods currently used in the United States.

Description of the Industry: Its Functions and Geographical Distribution

Grease wool is scoured by four kinds of establishments in the United States. They are commission scourers, combing plants, yarn manufacturers, and fully integrated textile mills. Each represents one or more stages in the manufacture of wool cloth or knitted fabrics. Some of them are under common ownership as subsidiaries or as branch plants, or their stock is owned wholly or in part by the mill companies who further process their output. However, since each of them is an independent unit in its administration, cost, sales and tax accounting, and physical plant, each is treated as a separate establishment in this survey. 16/ The following list shows the number in each category.

Grease wool scouring establishments in the United States

Commission scourers	18
Combing plants	15
Yarn manufacturers	13
Fully integrated textile mills	59
Total	105

16/ Selling and some administrative costs would be less for those under common ownership.

Commission scourers, as their name implies, scour wool for others on commission. Their charges are remarkably uniform, being 3 cents a grease pound for wool shrinking more than 50 percent and 3.25 cents for wool shrinking less than 50 percent. Heavy bleaching and carbonizing are 0.5 cent a pound extra. Their method of operation is different from that of the other three types of scourers. They must be more flexible and be able to handle peak loads. They scour many more kinds of wool and perform more services than do the other scourers; hence their costs of operation are higher. Some of the extra services they perform for their customers without charge are as follows:

(1) Storage. Free storage is provided for a reasonable length of time before scouring and for 4 weeks after scouring. A commission scourer may have a million pounds of wool on hand at a time, owned by his customers.

(2) Weighing and handling. The bales or bags may be weighed both before and after scouring; and if the commission scourer's warehouse is not nearby, the wool may have to be trucked to his storage area.

(3) Baling or rebagging. Since a commission scourer does not own the wool he scours, it must be shipped to his customers, which involves putting it back into the bags or baling it. In combing, yarn, or integrated mills the clean wool is blown from the drier to storage bins or is fed directly to the cards.

(4) Hand picking at the drier. This is done by some, but not all, of the other types of scourers. It consists of picking out the larger pieces of vegetable matter still embedded in the clean wool as well as stained pieces, black wool, and cotts (small knots of matted wool).

(5) Bleaching wool. Commission scourers bleach lightly with hydrogen peroxide nearly all the wool they scour to make it whiter. Instead of the four-bowl trains used by most woolen and worsted mills, commission scourers usually have five- or six-bowl trains, and use the last bowl for bleaching.

(6) Better control. Commission scourers are called upon to scour to more critical limits (that is, customer's demand). They will consistently leave 0.5 percent of residual grease in the wool, which assists in subsequent processing, and dry the wool to the required 12 percent moisture content. It is the last 5 to 8 percent of moisture, of the 88 percent they take out, that costs the most to remove.

Offsetting their higher costs, due to the extra services they perform and to their flexibility in operation, are two minor sources of income. One results from their scale of operation. A commission scourer must normally handle 8 to 10 million pounds of grease wool annually to cover all costs, and this enables him to recover the grease from his scouring effluent. (This is not true for commission scourers of carpet wool.) A recovery rate of 1 percent of the grease weight of the wool would net him about $10,000 annually at present grease prices. The other source of income is a controversial one. It is from the waste recovered in and around the duster or opener, the bowls, sumps, and drier when the equipment is cleaned up after the wool has been scoured, dried, and rebagged, and includes stained, cotted, and other inferior parts. This waste ranges from 1 to 5 percent of the grease wool, depending on whether it is a long staple Australian or Cape wool, which hangs together well, or a short Texas shearling, which scatters more in handling. Customers are unable to distinguish between shrinkage and waste.

Combing plants usually do not own the wool they process, but in their scouring operation they resemble yarn manufacturers and integrated mills more than they do commission scourers. They will usually undertake commission scouring during any slack business period, but they are generally called upon only when the commission scourers are too busy or when a rush job occurs; hence they do not provide storage and bleaching nor are they as expert in the uniform control of residual grease and moisture content on all types of wool. With their four-bowl trains they scour wool on commission as they would their own.

Combing plants, yarn manufacturers, and integrated mills operate their scouring trains more economically, apart from the extra services, because they can operate continuously on one or a few grades of wool which they have learned to scour with the minimum amount of labor and materials. Extra labor is not needed by them for peak loads as it is by commission scourers. If necessary they can operate their scouring trains continuously for three shifts on three consecutive days each week to reduce costs. Their main function is to keep ahead of the carding machines.

Nearly all worsted mills do their own scouring because they use a blend--that is, a mixture of wools of different grades and origin--which is made in sorting. Scouring is a continuation of this process so that when the wool comes from the drier it is thoroughly blended. Woolen mills may have their wool scoured on commission because their blends are made after scouring with a mixing picker just prior to carding and because the blends can be made more accurately after scouring than before, owing to differences in shrinkage. The exception to this practice is found in the many small fully integrated woolen mills located in the middle and far western States which use wool produced in the surrounding area. Their costs may be higher than the price charged by a commission scourer, but freight rates make it impractical to ship the wool elsewhere to be scoured. Labor in such small mills is not highly specialized and may be fully employed in a variety of ways, for example, scouring 1 or 2 days a week and on other processes the rest of the time.

The geographical distribution of scouring establishments by States is shown in figure 9. The concentration of scourers around Boston and Philadelphia is no accident but is due to the fact that most of the apparel wool and all of the carpet wool consumed in the United States enters these ports. Boston had an early lead in importing wool for the first New England mills and has developed the highly specialized sales, financial, and storage facilities that make it convenient to buy through the wool dealers on Summer Street.

The first question that occurs to those who look at the broad pattern of production, distribution, and consumption of wool in the United States is why wool is not scoured near the place where it is produced. 17/ Why should freight be paid on all of the impurities in grease wool (domestic wool, for example, shrinks 50 percent or more) instead of just the clean fiber? The answer can be given in four parts:

(1) The difference in freight rates between grease and scoured wool amounts to almost as much as the shrinkage. For example, the carload rate per hundredweight on grease wool from one point in the Far West to Boston is $3.18; the carload rate from the same point to Boston on scoured wool is $5.96.

(2) Few mills use only one type of wool. 18/ They use blends. These blends are easier to make where other wools are available and where the grease wool is sorted or scoured.

(3) The grease in raw wool protects the fiber during long periods of shipment and storage.

17/ The two scouring equipment manufacturers report that they receive similar inquiries at the rate of 1 or 2 a month.

18/ Exceptions are small, fully integrated woolen mills in the middle and far western States that use wool produced locally. They are usually highly specialized, manufacturing blankets and lightweight woolen goods that are sold in nearby markets.

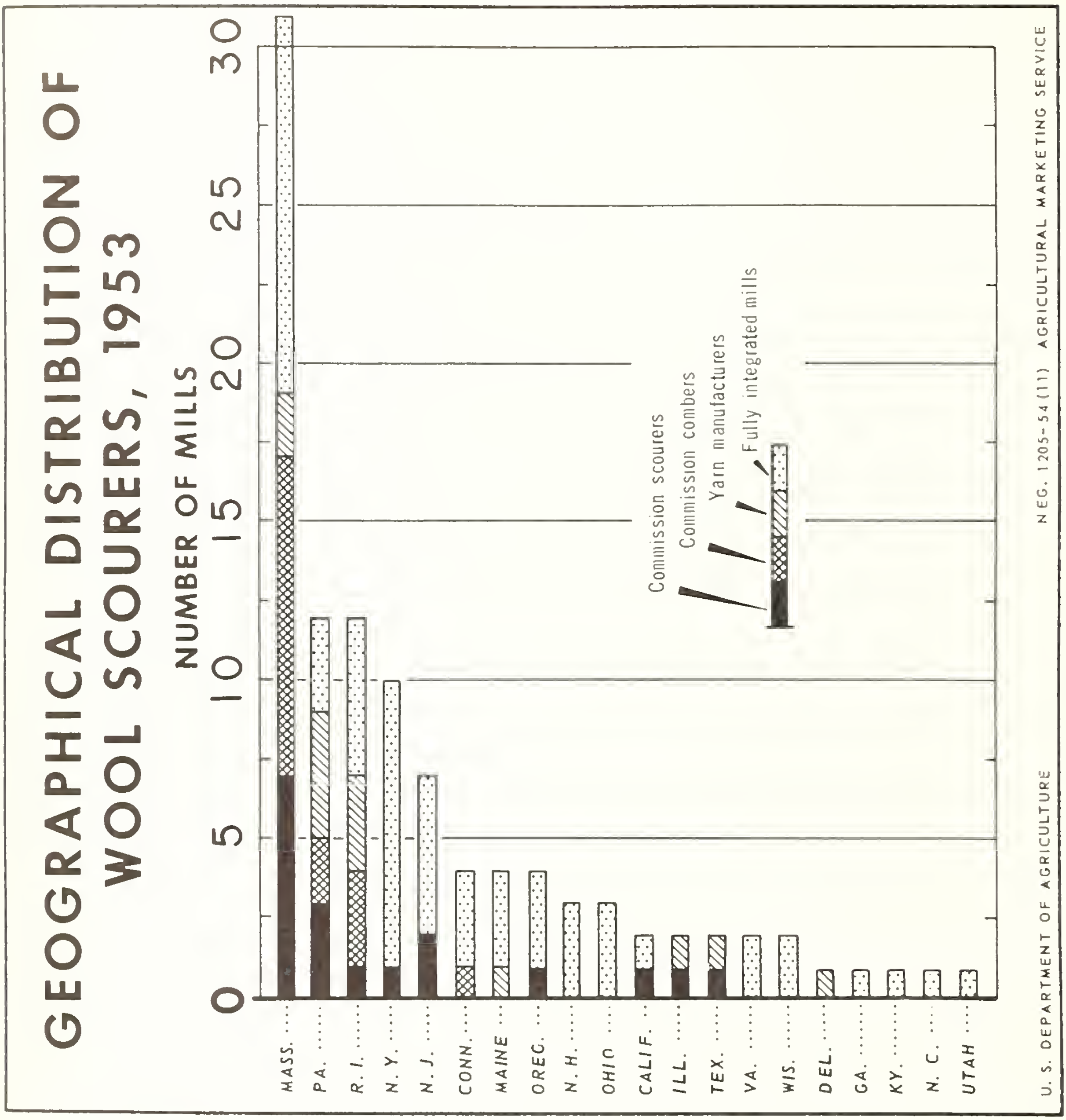

GEOGRAPHICAL DISTRIBUTION OF WOOL SCOURERS, 1953
NUMBER OF MILLS
0
5
10
15
20
25
30
MASS.
PA.
R. I.
N. Y.
N. J.
CONN.
MAINE
OREG.
N. H.
OHIO
CALIF.
ILL.
TEX.
VA.
WIS.
DEL.
GA.
KY.
N. C.
UTAH
Commission scourers
Commission combers
Yarn manufacturers
Fully integrated mills
U. S. DEPARTMENT OF AGRICULTURE
NEG. 1205-54 (11) AGRICULTURAL MARKETING SERVICE

Figure 9

(4) Suitable supplies of water of the required softness (hardness not over 20 parts per million) must be available for scouring, dyeing, and other processes.

The geographic concentration of the scouring industry in the highly populous southern New England and Philadelphia areas has placed a heavy pollutional load on the streams in those regions. In the areas where scourers are concentrated, as shown in figure 9, the mills are usually located on waterways which can provide the necessary volume for their needs. In the New England area, for example, many of the mills are located on the Merrimack and Connecticut river systems. This concentration has made the enforcement of laws for the control of water pollution in these and similar areas a potent factor in grease recovery.

Grease Wool Impurities and Their Effect on the Scouring Operation

The nature and characteristics of grease wool as a raw material in scouring will be described in this section to show the problems faced by the wool scourer and the ways in which they affect his operation.

Wool as it is sheared from living sheep or pulled from the pelts of slaughtered animals contains three groups of impurities:

(1) Wool Grease. This is the secretion of the sebaceous glands of the sheep and is essential to its well-being. It not only provides waterproof overcoat but also prevents the fibers from felting. The quantity of grease not only increases with the fineness of the wool, ranging from 5 to 20 percent of its grease weight, but varies in the wool of sheep of different ages (table 9). There is even a substantial difference in the amount of grease found in wool on different parts of the body (table 10). A recent study in the United States found that ram wool had a shrinkage of 6 percent more than ewe wool because of its higher grease content (59).

(2) Suint. This water-soluble substance is the dried perspiration of the sheep and is composed largely of soluble potassium soaps. 19/

19/ A more specific chemical analysis shows that suint is composed of inorganic salts, such as potassium carbonate, potassium sulphate, potassium chloride, sodium carbonate, and the salts of fatty acids such as potassium salts of oleic, lanopalmic, and capric acids. Suint also contains small amounts of urea, protein, and some carbohydrate. H. H. Webber, "Public Health Progress Report," (Unpublished manuscript, Lowell Technological Institute, 1951.) P. 3. Also see Freney, M. R., Council Sci. Ind. Research (Australia) Bul. No. 130 (1940).

Table 9.- Average weight of fleece and grease content of wool, by age of ewe

Age of ewe	Average weight		Percentage of grease in fleece
	Greasy fleece	Grease	
Years	Pounds	Pounds	Percent
1	9.12	1.18	12.9
2	10.43	1.40	13.5
3	11.59	1.73	14.9
4	11.14	1.60	14.4
5	11.20	1.71	15.3
6	11.12	1.75	15.7
7	10.22	1.50	14.7

Spencer, D. A., Hardy, J. J., and Brandon, M. J., Factors that Influence Wool Production with Range Rambouillet Sheep (38).

Table 10.- Percentage distribution of grease in the fleece of Wurtemburg sheep

Region	Percentage grease content	Region	Percentage grease content
	Percent		Percent
Shoulder	8.24	Sides	10.52
Neck	8.83	Belly	12.42
Legs	10.20	Back	15.41

Barker, S. G., Wool Quality, p. 20 (4).

It is an impurity of shorn wool only, since it drops out with much of the dirt in the slaughterhouse or pullery. It usually comprises 2 to 20 percent of the grease weight of the wool, depending on the breed of the sheep and on the environment.

(3) Dirt, Sand, and Vegetable Matter. These impurities in grease wool show the widest variation in character and amount. They comprise from 5 to 40 percent of the grease weight of the wool, depending principally on the environment and care given the sheep.

The percentage of the weight of grease wool lost when the impurities listed above are removed in scouring is called shrinkage. The percentage of clean fiber weight left after scouring is called the yield. In general, the finer the wool the greater the weight of impurities in it and therefore the greater the shrinkage. This is illustrated in table 11.

In general, shrinkage, being determined by the amount of impurities in the fleece, is influenced by the following:

(1) The amount of grease in the wool. This depends on the breed and the climate and to a lesser extent on the age and sex of the sheep.

(2) The amount of suint in the wool. This depends mainly on the breed and the climate.

(3) The amount of dirt and vegetable matter in the wool. This is mainly a function of the type of soil, climate, and pasture or range on which the sheep feed; for example, sheep raised on loose, sandy soil in a dry, windy climate will produce a wool with a large shrinkage.

(4) The amount of moisture present. This largely depends on the climate.

The United States imports more than twice as much wool as it produces domestically. In 1951 these imports were from 47 foreign countries where they were produced from about 30 breeds of sheep that varied considerably in appearance and in amount and character of their wool. Sheep are raised in every country in the world under various conditions from sea level to mountain heights, from Iceland to South Africa, and from Peru to Afghanistan. The environment of these sheep, including the climate, the pasture or rangeland, and the type of soil, influence each year the variety, composition, and quantity of the impurities that must be removed from their wool when it is scoured in the United States. Moreover,

Table 11.- Range in percentage composition of grease wool, by types

Type	Grease	Suint	Dirt	Vegetable matter	Shrinkage
	Percent	Percent	Percent	Percent	Percent
Fine	10-40	2-20	5-40	0.5-2.0	30-70
Medium	5-20	2-20	5-20	1.0-5.0	20-50
Long	5-10	2-20	5-10	.1-2.0	10-30
Carpet wool	5-10	2-20	5-20	.5-2.0	20-40
Hairs	2- 8	1- 3	5-20	.1-1.0	15-30

Von Bergen, W., and Mauersberger, American Wool Handbook, p. 397 (55).

wool is grown by many small primary producers and is sold and marketed in relatively small lots at different times throughout the year, depending upon the country of origin. The identity of the individual grower's clip is preserved through several stages of distribution until it is acquired by a manufacturer, for example, a combing, yarn, or textile mill.

As relatively few establishments in the United States scour grease wool, it is evident that the capacity of any one of them is sufficient to handle even the largest individual clip in a few days or in a few weeks. The wool scourer in the United States must therefore produce a uniformly clean product from a raw material having impurities that vary widely in kind and quantity from week to week and even from day to day. Moreover, he must operate on a continuous, mass-production basis using soap and soda ash that can damage the fiber unless closely watched and controlled by experienced personnel. These are the principal reasons why wool scouring, although it may be closely controlled by automatic temperature, alkalinity, and other controls, has not developed into an exact science.

Another important reason is to be found in the personnel and operating policies common in the industry. Although the chemistry of the emulsion-type scouring process is well known (21), and accurate physical and chemical tests have been devised for scouring efficiency, the actual operation of the scouring train is usually in the hands of an experienced and trusted employee, not technically trained, who applies soap and soda ash to the scouring bowls according to the appearance and feel of the clean wool going into the drier.

Scouring Methods

Technically, the impurities in grease wool can be removed efficiently and with minimum fiber damage by the use of solvents, sound waves, freezing, and several other methods; but in the United States, emulsion scouring is now the only way considered economical.

Emulsion Scouring

The washing of wool is a skill that has been practiced since ancient times. In spite of the research efforts of many competent chemists and engineers, the scouring of grease wool in the United States has not advanced much beyond the method used by pastoral people in ancient times who washed their wool in the streams beside which their sheep were pastured.

General Description.- Wool washing, or wool scouring, as it is known commercially, is accomplished by agitating the wool mechanically in one or more vats of soapy water, rinsing it in clean water, and drying it. This emulsion scouring is the only method used to clean grease wool on a commercial scale in the United States. It is a wholly mechanized continuous operation designed to produce a uniformly clean product suitable to the needs of those manufacturers who further process it into top, yarn, and cloth. Emulsion scouring is designed to remove the maximum amount of impurities from the raw wool, except anywhere from 0.5 to 2 percent grease and 12 percent moisture, at the minimum cost with minimum damage to the fiber.

The phrase minimum cost applies not only to the scouring process but also to all subsequent operations. Noilage, for example, is an important element of cost in the next stage of manufacture, the production of tops. Noils are the short fibers separated from the longer fibers in the combing process when wool is made into tops. Noilage represents a loss to the top maker and depends, apart from the normal complement of shorter fibers present in every blend of sorted wool, upon the felting of the wool in scouring and the breakage of the fibers in carding. Increased mechanical agitation of the wool in the scouring bath would increase scouring efficiency, but minimum cost in scouring is limited by the need to decrease the mechanical agitation of the wool to prevent felting. Felting leads to breaking of the fibers in separating them in the carding machines and to increased noilage in combing. There are many other examples where achievement of minimum cost in one process is forestalled by the nature of the raw material and the requirements of the subsequent manufacturing processes.

The nature and quantity of the impurities in grease wool as described in the preceding section determine the equipment, materials, and the methods used in scouring. (See Appendix B for a discussion of technical methods and equipment used in scouring.)

Scouring Costs.- The data presented in this section are based on information collected from 23 mills that scoured a total of 202.2 million pounds of grease wool in 1951. All four types of scourers are represented among these in about the same ratio as in the industry as a whole. As scouring in most mills in the United States is only one of many processes in the production of tops, yarn, or cloth, it is difficult to allocate a portion of total costs to the scouring operation on an equitable basis. Mills do not keep identical financial records, so that accounts of the same name may refer to different kinds of expenditures. Fiscal years do not coincide with calendar years, and in accounting there are as many difficult-to-decide borderline cases as in any other area of business administration. The allocation of costs is particularly difficult in this industry because the commission scourer, who is the only one whose costs can be directly and easily allocated to a pound of grease wool or clean fiber, is not typical of all United States scourers as to size and method of operation. All other scouring establishments allocate their costs on the basis of the number of balls of top, pounds of yarn, or yards of cloth.

The question to be answered in this section is, "What does it cost to scour a pound of wool?" The answer is clear if the answers to additional questions are forthcoming.

(1) How dirty is the wool?

(2) How clean will it be when scoured?

(3) Is it scoured with large-scale modern equipment or small older equipment?

(4) What is the scale of operation? Is the equipment operated continuously throughout the year on 1, 2, or 3 shifts?

(5) Is the scouring operation located in or near the center of a town where all facilities, such as a railroad siding and a steam supply, are available, or in a rural area with few facilities?

(6) Is wool scoured on commission or as a department of a vertically integrated mill?

(7) Does the scouring effluent require treatment before discharge into a sewer or public waterway?

(8) Are any byproducts recovered that can decrease scouring costs?

These questions indicate some of the conditions that determine scouring costs. Early in this investigation it was observed that each mill was almost unique in many respects that affected its costs. The two illustrations that follow are typical variations rather than extreme cases.

In some locations, depending not only on the State but also on the size of the stream and the class of wool scoured, mills are required to treat their effluent before discharging it into a public waterway. Waste treatment is properly a part of the cost of scouring wool in that location. Moreover, it would not be possible to separate the few direct and indirect costs of scouring only, to compare with other mills, because the waste treatment affects the method of operation, as shown in the following example. Mill A scours carpet wool and treats its effluent.[3] Ordinarily, carpet wool scourers are not required to treat their waste waters because coarse wool contains a small proportion of impurities, but Mill A is located on a stream whose volume of water is small compared to the waste water discharged by the mill. The waste treatment plant consists of several large tanks in which the emulsion is cracked and a filter press in which the sludge is dewatered under heat and pressure. It requires the services of 1 man approximately 4 hours a day to operate, as it is largely automatic. In order to keep waste treatment costs low, however, a nonionic synthetic detergent is used, and the wool is scoured in a neutral solution. This increases chemical costs to about 0.2 cent per pound of grease wool, which is high for carpet wool. The management of Mill A has tried using a regular soap solution with an alkali builder at pH 10 for scouring, but the extra cost of cracking this emulsion in the waste treatment plant more than offsets the reduction in scouring cost. Hence total cost of scouring is less with the high-cost detergent material.

A second example shows that each mill has an individual problem in its scouring operation and that even when costs in an integrated mill are allocated on an equitable basis, the results may not be comparable with the costs of any other mill. A considerable quantity of apparel wool such as Texas, Cape, and Australian merino is used in the production of felt for paper making and hat bodies. Mill B uses these virgin wools and about twice as much noils by weight in its felt. These are blended in scouring and carbonized to eliminate every piece of vegetable matter. The latter is a serious defect in felt for hats and is not eliminated sufficiently by Peralta rolls or in carding as in fabric production. In addition every lot that needs it is depainted with pine oil and scoured again lightly to remove the pine oil. At the end of these processes the wool is carefully inspected, and every piece stained or clotted with paint or vegetable matter is picked out by hand. Even if it were possible to allocate costs to this one department in the mill, its costs would certainly differ from those of the scouring department of another mill that produced felt for other uses. In addition, the other mills may or may not recover grease or treat their waste water.

Many combinations of land, labor, capital equipment, and entrepreneurial ability are possible in the wool scouring industry. There is no one best way that results in the lowest scouring cost per pound. An almost infinite number of combinations exist which may result in the lowest cost for the particular set of conditions under which the wool is scoured. It is also a fact that, although scouring costs in an integrated mill might be higher than the price charged by a commission scourer, the mill would continue to scour its own wool. The necessity for worsted mills to make their own blends in scouring and the convenience of having the wool delivered to the cards at a steady rate without being dependent on a commission scourer would overbalance any difference in costs. Moreover, a commission scourer in baling or rebagging the wool compresses it so that it loses some of its loftiness and elasticity.

Factors Affecting Scouring Costs.- Following is a list of those elements of operation that account for differences in cost. 20/

(1) Equipment. Scouring trains have from 2 to 7 bowls (see Appendix B, table 27) and vary in age from 1 to 30 years. These differences cause variation in depreciation and maintenance. Depreciation among scourers ranges from zero to more than $4,000 on a new 6-foot-wide train. Labor costs vary widely depending on the type of equipment. Labor costs are less for one 6-foot-wide train than for two 4-foot-wide trains scouring the same amount of wool. Labor costs can be cut still further if the single train is installed in a U-shape instead of in a straight line.

(2) Materials. There are about 6,000 different wools and almost as many different ways to scour them. Combinations of materials used in scouring range from synthetic detergents only, through various proportions of synthetic detergents, soap, and soda ash, to soap and soda ash only. For example, the latter combination is found in various proportions from 1:1.33 to 1:13.5 among the 23 mills examined in this study. The former figure of 1 pound of soap to 1.33 pounds of soda ash is not a true indication of technical or economic inefficiency but rather

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20/ This information was collected by personal observation and interviews at 56 scouring establishments during 1952.

of the type of wool scoured. The ratio of 1 pound of soap to 13.5 pounds of soda ash is used on a three-shift operation with recirculation of the degreased liquor. However, it is apparent that materials used in scouring in one mill could double in cost in another mill using the same grade of wool if, for example, a particular run is extremely dirty and requires much larger amounts of soap and soda ash.

(3) Method of Operation. The method of operation is principally a function of size and varies from a steady 3 shifts a day for 5 days a week, through 2 shifts for 3 days a week, to 1 shift a day seasonal operation. Continuous operation means substantial savings in costs of water, steam, and soap and soda. Those scourers who recover grease realize substantial savings in soap and soda costs up to 25 percent by recirculating the degreased liquors and using them continuously for as long as a week at a time, but these savings depend on size as well as method of operation. For example, the amounts of wool scoured per pound of soap and soda ash ranged from a combination of

275.8 pounds of wool to 1 pound of soap
23.6 pounds of wool to 1 pound of soda ash

to

51.3 pounds of wool to 1 pound of soap
26 pounds of wool to 1 pound of soda ash.

The former was an economical, continuous, three-shift operation using a centrifuge for degreasing, and dumping once a week. The latter was a one-shift operation that dumped the bowls daily after each shift. Desuinting is more economical in the consumption of chemicals but there is little appreciable difference in overall costs between the desuinting and counterflow methods. Type of wool scoured and recovery of grease determine the method used.

(4) Location. Some scouring establishments are located in or near cities in a substantial brick, multistory, multitenant building with access to water, steam, electricity, railroad siding, trucking facilities, and a municipal sewage system into which the scouring waste can be discharged without cost. However, there is more than 50 percent difference in rental rates (in favor of the Lowell-Lawrence area) between comparable facilities in the Philadelphia and Lowell-Lawrence, Mass., areas. Other scourers of various sizes are housed in wooden and cinderblock buildings in rural areas on streams so small that they must treat all of their waste waters and hold them in lagoons until high water periods. One scourer is unable to get sufficient water to scour during

August if the summer has been a dry one. Some scourers pay to discharge their wastes into municipal sewers. The cost of waste disposal is properly chargeable to a scouring operation and accounts for wide variation in scouring costs due to location. Some scourers manufacture their own electricity and steam. Some have no access to a railroad siding but depend wholly on truck transportation.

(5) Integration. The extent of vertical integration influences costs. Steam costs for scouring are much less for a yarn-manufacturing plant or a fully integrated mill than for a commission scourer or commission comber because the former use feed-back water in a heat exchanger. The cost of electricity is also less because of lower rates on increased amounts.[a] Only the commission scourer has the extra costs of bleaching, controlled drying, rebagging, and storing clean wool. The others produce clean fiber that is fed directly to the cards or is blown into bin storage. Indirect labor costs tend to decrease as the degree of integration increases, but these vary more directly with the size of the operation.

(6) Size. There are economies in scouring due to the scale of operation. As it is a continuous process, more productive time can be realized on a 2- or 3-shift operation. On a 1-shift operation an extra hour of unproductive labor is needed at the beginning to make ready and at the end to clean up.

Direct labor costs for the 23 mills in this study vary from 0.9 cent per grease pound for a 1-shift operation scouring approximately 2 million pounds of wool annually to 0.1 cent for a 2-shift operation with 3 trains scouring 20 million pounds of wool annually. Large mills in urban areas are more likely to be unionized than small mills. The rates paid to scouring-department personnel vary not only between union and nonunion mills, but also between New England and other areas. The ability of small mills to use labor employed partially or part time on scouring and at other jobs as well is a big factor in their labor costs.

The steam needed to heat the bowls initially is enough to maintain them at the desired temperature for 2 hours during the shift. Steam costs per pound of wool are thus decreased if the bowls are used continuously and dumped only once or twice a week. Not only are there savings in amounts used per pound of wool scoured, but the rates, if steam is purchased (or the additional cost if it is produced in the mill's own plant), are lower on the additional amounts. The amount of electricity used per pound of wool scoured is constant, but the lower rates on the additional amount of electricity used effect savings for the larger mill. Size, being an important factor in grease recovery as mentioned above, makes possible economies in scouring due to recirculation of the degreased scouring liquor.

In general, the variable costs such as labor, materials, steam, and electricity, which are by far the larger part of scouring costs, do not increase proportionately with each increase in the number of pounds of wool scoured. It is, or course, the relatively fixed costs, such as indirect labor, taxes or rent, depreciation, maintenance, and supplies, which remain almost constant in amount and which can be spread over increased amounts of wool scoured to give lower costs per pound.

The wide variation among scourers as to equipment, materials, methods of operation, location, degree of integration, and size makes meaningless the presentation of any average, median, or mode as representative of costs in the industry. A practical alternative has therefore been followed. The sample of firms in the industry who contributed data on their costs to this study have been used as benchmarks in determining costs for several kinds of scourers. Certain assumptions have been made in setting up these benchmarks and are fully stated. These assumptions closely approximate the conditions under which wool is scoured in the United States.

Following is a general description of the specific costs incurred in scouring grease wool.

Rental Rates: Rent in all cases is based on space in a multistory, multitenant building with access to a railroad siding, truck loading dock, warehouse, steam, and electricity. The area allowed for each train is 50 x 125 feet with an increase of 50 feet in width for each additional train. The annual rental rate used is 38 cents per square foot. Warehouse storage space is figured at 34 cents per square foot. This rate is for Lowell, Mass. 21/ Rates for similar facilities in Lawrence, Mass., are slightly lower. The annual rentals for scouring per square foot for other areas are as follows:

Boston, Mass.	$0.50
Paterson - Passaic, N. J.	.34
Providence, R. I.	.30
Philadelphia, Pa.	.65 - .75

Direct Labor: Costs are based on the personnel and base rates shown in table 12. These are union rates for the southern New England area and include a cost-of-living bonus of 6 cents per hour. The rates for the northern New Jersey and Philadelphia areas are approximately the same.

21/ Obtained from Lowell Development Company, 95 Bridge Street, Lowell, Mass.

Table 12.- Direct cost of labor for scouring wool, southern New England, 1951

Item	Hourly rate	Personnel per shift		
		1 train	2 trains	3 trains
	Dollars	Number	Number	Number
From storage to machine	1.51	1	2	3
Feeder of machine	1.47	1	2	3
Train operator	1.53	1	2	3
General handyman	1.45	-	1	1
Supervisor	2.50	1/2	1/2	1/2
		Dollars	Dollars	Dollars
Cost per hour		5.76	11.72	16.23

Production costs are based on 1,200 pounds of grease wool per hour averaged out to include allowances for starting up, running out, cleaning, and repairs. This nonproductive time is estimated to be about eight hours per week. The production while running is 1,500 pounds per hour. The difference between fine, medium, and coarse wool is not considered because the variations within the grades themselves make it impossible to determine costs by grade; therefore all grades are lumped together and averages are used.

Depreciation: This current expense is based on 1952 replacement cost for a scouring train 4 feet wide consisting of a wool opener and automatic feed, two 24-foot bowls and two 16-foot rinse bowls equipped with squeeze rolls, and a 7-section drier 30 feet long. The total cost of this equipment installed is $68,537. Another bowl could be added for $13,652. At a rate of 5 percent the annual depreciation for a 4-bowl train is $3,426 and for a 5-bowl train, $4,108.

Repairs and Supplies: Repairs to equipment have been estimated at $1,000 and supplies other than equipment at $500 for a total of $1,500 annually.

Indirect Labor: This cost includes management and clerical costs, maintenance, payroll taxes, and fringe benefits. Payroll taxes, and fringe benefits are included for all labor, both direct and indirect (table 13). Costs for a commission scourer would be higher.

Table 13.- Indirect cost of labor per year for scouring wool, by specified quantities scoured

Item	Cost of labor for scouring			
	1,000,000 pounds	5,000,000 pounds	10,000,000 pounds	20,000,000 pounds
	Dollars	Dollars	Dollars	Dollars
Management, clerical and maintenance costs	6,750.00	9,750.00	11,000.00	12,500.00
Taxes and fringe benefits, 11 percent of total labor-------	1,320.00	3,669.00	5,874.00	9,779.00
Total ----------	8,070.00	13,419.00	16,874.00	22,279.00
Cost per 100 pounds of grease wool-------	.807	.268	.169	.111

Materials: Cost of materials (soap and soda ash, and synthetic detergents) in common use in the industry was examined and reduced to a common denominator; that is, the cost per 100 pounds of grease wool scoured. The average cost for the 9 different detergents and methods is $0.134 per 100 pounds of grease wool. This is based on soap that is at least 90 percent pure and synthetic detergents that contain at least 50 percent active ingredients by weight.

Electricity: Electric power costs shown in table 14 are based on the schedule of rates in Lowell, Mass. Rates for the Philadelphia area are approximately equal to those in Lowell, Mass.

Table 14.- Cost of electricity for scouring specified quantities of wool, Lowell, Mass.

Wool scoured annually	Trains	Shifts	Weeks	Cost per month	Schedule
Million pounds	Number	Number	Number	Dollars	
1	1	2	12	118.92	Based on Rate C, 2,500 kw.-hr. of use per month.
5	1	2	50	408.20	Based on Rate G, 60 kw of demand and 22,000 kw.-hr. of use per month.
10	2	2	50	722.56	Based on Rate G, 120 kw of demand and 44,000 kw.-hr. of use per month.
20	2 1	3 2	50	1,314.48	Based on Rate G, 180 kw of demand and 88,000 kw.-hr. of use per month.

Steam: Cost of steam is based on the following schedule: 22/

$1.687	per	1,000 lbs.	for	first		50,000	lbs.	per	month
1.587	"	"	"	the next		50,000	"	"	"
1.487	"	"	"	"	"	100,000	"	"	"
1.387	"	"	"	"	"	300,000	"	"	"
1.387	"	"	"	all over		500,000	"	"	"

The above costs for steam have been applies in the following examples to the most typical size of commission scourers in the United States and to the scouring departments of four different sizes of integrated mills. More than 90 percent of the mills that scour grease wool in the United States lie within this range. The information presented is of the nature of optimum costs. Deviations from the method of operation detailed above or variations from the scale of operation assumed in the illustrations will

22/ Lowell, Mass., rate.

result in a different schedule of costs. If they are higher it is not implied that the establishment is operating at a loss. Since no mill in the United States is of the exact size or operates in all respects according to the assumptions made above, interpolations from the cost data will be necessary.

Costs for a Commission Scourer: The costs shown in table 15 are submitted as being representative of those of a commission scourer processing approximately 10 million pounds of grease wool annually. This is a normal size for a commission scouring operation in the United States at the present time. Costs are based on the assumptions set forth earlier in this chapter. If chiefly apparel wool is being scoured, it would pay to install centrifugal grease recovery equipment.

Other items of expense such as water, owner's salary, interest, waste treatment, additional storage space, and other costs due to location, size, or method of operation would raise the total cost in a normal year to between $2.45 and $3.00 per 100 pounds of grease wool scoured, which is the range for commission scourers in the United States.

Costs for Scouring Departments of Integrated Mills: As this is a decreasing cost industry, there are significant differences in cost due to the size of the operation. The data in table 16 are representative of actual costs incurred by the scouring departments of integrated mills of various sizes in the United States. Their costs in general are lower than those incurred by commission scourers because they render fewer services, have lower rates for steam and electric power, and have lower administrative and overhead costs. As an example of lower administrative costs, in many mills one man will supervise both the card room and the scouring department; or the wool buyer may also be in charge of the scouring department.

The smallest mill for which costs are given here would scour the million pounds of grease wool it uses annually by operating its scouring train 1 week out of the month on a 2-shift basis and dumping the bowls daily. The mill scouring 5 million pounds annually would use one 4-bowl train 2 shifts daily, dump the bowls not more than twice a week, and scour an average of 100,000 pounds a week. The mill scouring 10 million pounds annually would operate in the same way with 2 trains. The largest mill would need 3 trains to scour 20 million pounds of wool annually. Two of these trains would be operated continuously for 3 shifts and the other for 2 shifts daily for 50 weeks a year.

Table 15.- Average cost per 100 pounds of grease wool for a commission scourer to process 10,000,000 pounds of grease wool annually, by items

Item	Cost	Item	Cost
	Dollars		Dollars
Direct labor 1/	1.211	Repairs and supplies	0.045
Material	.167	Depreciation on equipment	.082
Rent 2/	.155	Indirect labor 4/	.32
Steam 3/	.34	Total	2.389
Electricity 5/	.109	Annual direct labor cost	121,194.00

1/ Based on the following schedule:

Item	Each shift		
	Men	Wage rate	Cost per hour
	Number	Dollars	Dollars
From storage to machine	2	1.51	3.02
Feeder of machine	2	1.47	2.94
Train operator	2	1.53	3.06
Drier operator	2	1.47	2.94
Handyman	1	1.47	1.47
Warehouse wool handlers	6	1.45	8.70
Balers or baggers	2	1.45	2.90
Mechanic	1	1.75	1.75
Supervisor	1	2.50	2.50
Total			29.28

2/ Based on a space 100 x 125 feet for two trains and adjacent storage space 100 x 200 feet. Suitable building equal in area in a suburban location in the New England area with concrete floors, cinder block walls and wooden roofs and equipped with heating, lighting, plumbing, and sprinkler systems with boiler house and equipment would cost approximately $235,000

3/ Based on dumping the scouring bowls twice each week.

4/ Includes clerical help, taxes, and fringe benefits.

5/ Based on an average consumption of 980 kw.-hr. per shift.

Table 16.- Cost of scouring 100 pounds of grease wool for integrated mills

Item	Cost per 100 pounds for mills scouring -			
	1,000,000 pounds	5,000,000 pounds	10,000,000 pounds	20,000,000 pounds
	Dollars	Dollars	Dollars	Dollars
Direct labor	0.543	0.470	0.486	0.459
Indirect labor	.807	.268	.169	.111
Materials	.134	.134	.134	.134
Supplies	.150	.030	.030	.023
Depreciation - 4-bowl train	.343	.069	.069	.051
Rent - Lowell, Mass. area	.237	.047	.047	.035
Steam - Lowell rate	1/ .208	.425	.420	.418
Electricity - Lowell rate	.142	.098	.086	.078
Total	2.564	1.541	1.441	1.309

1/ Scouring bowls are dumped after each shift.

Other Methods of Scouring

A practical alternative to emulsion scouring has long been sought, and many have been developed both in the United States and abroad. As more than half the impurities, by weight, in grease wool are water soluble and as the grease on the fiber is completely soluble in many volatile organic solvents such as naphtha and trichlorethylene, most of the new developments have included a combination of the two processes; that is, a solvent to remove the grease and a mild soap and alkali bath to remove the remaining impurities. Experiments at Lowell Technological Institute involving batch scouring, where the wool is placed in metal kiers or drums, have explored the possibility of using liquid paraffins at 60° C., and hot and cold methyl, ethyl, and isopropyl alcohols. 23/ Ethyl chloride, methylcyclohexanone, carbon tetrachloride, carbon disulphide, dichlorethane, and many other petroleum naphthas and chlorinated hydrocarbons have also been used.

23/ Weber, H. H., "Public Health Progress Report," (Unpublished manuscript, Lowell Technological Institute, 1951) p. 3.

Notwithstanding the record of success and failure of several methods of solvent scouring as recounted in the following pages, many leaders in the industry think that a more efficient method of removing impurities from grease wool at lower cost will eventually be developed from a solvent process. Some of the requirements for such a solvent and for a process for using it can be simply stated. They are, however, extremely difficult to combine in a practical, economical full-scale operation. The solvent should be cheap and readily available in large quantities. It should be nontoxic, noninflammable, and easily cleaned, by centrifuge or settling, or volatile so that it could be distilled at low temperatures and recovered for reuse. The process should preferably be wholly mechanized, capable of continuous operation on a large scale, and applicable to all types of wool used in the United States. It should preferably use existing equipment or existing equipment with slight modifications and should be able to operate under neutral conditions at room temperature and pressure.

The most successful solvent scouring operation in the United States was carried out on a large scale (over 1 million pounds a week) for about 50 years at a mill in Lawrence, Mass. The wool, in batches of 2,500 pounds, was packed by hand into large kiers from which the air was evacuated. The grease was dissolved from the fiber by flooding the kiers three times with naphtha of three different degrees of purity. After the naphtha was drained off, hot air was introduced to dry the wool so that no fumes were released when the kiers were opened. The wool was taken out by hand and washed in clear water in a regular scouring bowl, the water-soluble suint acting as a detergent. The grease naphtha solution was passed through a charcoal filter, which removed the dirt, slime, and odor, and through a calcium chloride filter to remove water. The naphtha was distilled for reuse, leaving a brown grease of low acidity that was used in an emulsion for rope making, in stuffing leather, and in lubricants. This grease had the following characteristics.

Melting point	97 to 108° F.
Moisture	2 to 2-1/2%
Ash	.1 to .8 of 1%
Free fatty acid (figured as oleic acid)	About 7 to 8%
Saponifiable matter	About 60%
Specific gravity at 60° F.	967
Saponification No.	113 to 123
Acid value	Not over 20.9
Viscosity at 210° (Tagliabue)	284 to 292
Flash point	372 to 390° F.
Fire test	527 to 536° F.
Cold test	94° F.
Iodine value, about	27

The solvent method of scouring has the advantage over the emulsion method of minimizing breaking and felting of the fibers and thus decreasing losses in the subsequent processes of carding and combing. It can also be closely controlled to leave the required amount of grease on the wool fiber, and, being a closed system, is economical in operation except for the hand labor in packing and unpacking the kiers. More grease can be recoverd by solvent scouring, at lower cost, than by any other known method. Production of grease at this mill was approximately 30,000 pounds each 24 hours - about 12 percent of grease wool weight.

An attempt was made by a Philadelphia firm to introduce an improved method of solvent scouring by using a noninflammable solvent, trichlorethylene, in a continuous wool-degreasing unit. A pilot plant was operated for several years by this company, and two of the machines were built and sold. One of these was recently operated for about a year by a carpet manufacturer near Philadelphia, but it is not now in operation. It was a closed system, the solvent being distilled for reuse, and it produced a dry cake from the sludge and brown grease that needed to be washed and centrifuged before it was salable. The wool emerging in mat form from the drier section of the degreasing unit gave off a considerable amount of dust before it dropped into a desuinting bowl of clear water. Workers objected to the dust, and the difficulties involved in solving this problem persuaded the management to abandon the experiment.

The floor space occupied by the unit was about three times as large as for a regular scouring train and centrifuge of equal capacities. Experience gained with the machine indicated that it would be economical only for continuous operation or solvent losses would be prohibitive, and for the finer grades of apparel wool which have a high grease content. Labor and material costs with this unit were about equal to those in emulsion scouring if operated continuously, but the original investment and maintenance costs were much higher. The appearance of the wool was not as light-colored and bright as wool scoured with soap and soda.

Another possibility in solvent scouring is the use of nitrated kerosene (16 cents per gallon in 1952) in the second bowl of a regular scouring train, the first bowl being used for desuinting, the third for a light soap-and-soda scour, and the fourth for rinsing. This method has most of the advantages of any solvent system as far as quality and cost are concerned, but many of the details of this process have not been worked out on a commercial scale.

The frosted wool process was introduced in 1935, but the two mills that installed the equipment discontinued using it just before World War II. The wool was carried into a freezing chamber and cooled to -30° to -50° F. for about six minutes. At this temperature the grease congealed to a brittle solid and could be shaken out with the other solid impurities by opening and dusting machines. The wool was then put through a light scouring solution and dried. The method was especially good with pulled wools.

The use of ultrasonic energy (high frequency sound waves) has been suggested by several persons in this country as a possibility for emulsifying grease and dirt in raw wool. The advantage of this method would be the decrease in felting of the fibers due to the decrease in mechanical agitation. The application of ultrasonic energy to wool scouring was reported as follows: "Laboratory experiments show that the scouring of wool in the presence of ultrasonic waves is very effective. Neutral or only weakly alkaline solutions may be used and the product is whiter, softer, and freer from fiber damage than is wool scoured in the usual way in an alkaline solution. Ultrasonic waves are particularly effective for the disinfection of wool; they render both the wool and the effluent completely sterile, while having no deleterious effect on the fiber." (23, 24)

A laboratory-scale scouring and grease recovery process using water and n-butyl alcohol was developed in 1950 at the Western Regional Research Laboratory of the Department of Agriculture at Albany, Calif.(13). It has not been tried on a commercial scale. Some of the advantages listed for this process are as follows:

(1) Scouring is effected under neutral conditions insuring minimum physical and/or chemical damage to the fiber.

(2) Effluent clarification and grease recovery are a part of the process.

(3) The alcohol is relatively nontoxic, relatively noninflammable, readily available, and easily recoverable by distillation.

(4) The suint can be recycled as fresh scouring solution in a continuous operation.

(5) The presence of the alcohol inhibits putrefaction of the scouring solution making it possible to reuse the scouring solution over an extended period.

(6) The process can be adapted to existing scouring equipment.

(7) The process operates within a relatively narrow concentration range and is therefore potentially more economical than conventional solvent methods, which require complete distillation in each cycle.

Its disadvantages are:

(1) Less than half of the available grease can be recovered.

(2) Pulled wools cannot be scoured without a suitable sequestering agent because of the presence of calcium from the depilatory operation.

Advantages of the Solvent Method of Scouring

(1) Fiber breakage and felting are decreased in the solvent process.

(2) Scouring is done under neutral conditions, decreasing structural damage to the fiber.

(3) More grease can be recovered at lower cost in processes where the solvent is distilled for reuse.

(4) The amount of residual grease on the fiber can be more closely controlled within a narrow range than in emulsion scouring.

(5) The presence of the solvent inhibits putrefaction of the scouring solution thus making it possible to use the scouring solution economically in intermittent operation or for an extended period.

(6) Scouring is not tied to waterways. It can be located anywhere.

Disadvantages of the Solvent Method of Scouring

(1) The process usually cannot be adapted to existing equipment.

(2) When the solvent used must be recovered by distillation as is true in most methods, the necessary equipment requires a substantial investment and is costly to operate and maintain.

(3) The color of the clean wool is not always as light as that of wool scoured with soap and soda.

(4) The grease recovered from the solvent process by distillation is not as good quality as that recovered by centrifuge from an emulsion effluent.

Effects of Scouring Methods on Grease Recovery

The maximum amount of wool grease can be recovered from the solvent method of scouring. However, depending on the price of the solvent, the price of wool grease, and the cost of recovering the grease, it might be more economical to dispose of the solvent by burning or as a waste product than to recover it for reuse. With trichlorothylene at about $1.44 a gallon it would have to be recovered for reuse by distillation in order to make the scouring of grease wool by this method economical. A solvent loss to 2 to 3 percent and the cost of recovering the grease from the sludge after evaporating the solvent would be more than recouped by the sale of grease at present prices. However, the cost of installing and operating solvent scouring equipment makes it uneconomical compared to emulsion scouring methods now in use.

The other possibility in solvent scouring, a cheap solvent such as nitrated kerosene at 16 cents a gallon, which can be used as a fuel after it is fully saturated with grease and dirt from the scouring, is economically feasible but not technically satisfactory. Its reuse would depend on (1) the cost of recovery by distillation, settling, chilling, or centrifuging, (2) the cost of recovering the grease from the resulting sludge, and (3) income from the grease. The price of wool grease in the United States during the last decade and the cost of recovering it after the scouring operation have made its production wholly secondary to the production of clean fiber.

At present, grease wool can be scoured most efficiently and economically in the United States with the conventional scouring train and soap, soda ash, and water. The maximum amount of grease can be recovered from this emulsion effluent by the acid cracking method. So far, this method has been used chiefly to abate stream pollution. On a large scale it is profitable if operated continuously. There are, however, more economical ways for scourers processing an average of 100,000 pounds of grease wool or less each week to abate stream pollution; e.g., simply by cracking the emulsion, settling it, and filtering the sludge. This decreases the solid material and biological oxygen demand to acceptable limits for disposal in streams, without producing any salable byproduct, such as grease.

The alternative method of recovering grease from an emulsion effluent is the centrifuge. It produces the highest quality grease, is economical to operate, and is adapted to intermittent operation; but it produces less than half the quantity of grease recovered by the acid cracking method and has little effect on the pollutional load of the effluent.

WOOL GREASE RECOVERY IN THE UNITED STATES

Wool grease is the only byproduct currently recovered from the scouring effluent. The recovery of others, such as the potassium carbonate and potassium sulphate in the suint salts, is not economically feasible because of natural deposits of potash throughout the world from which these chemicals can be produced at much lower cost.

Out of the 105 wool scourers in the United States, 38 operate grease recovery equipment. Of these, 3 use the acid cracking method, and 35 have installed centrifuges. The others do not recover grease for one or more reasons, as indicated in table 17.

Table 17.- Scourers giving reasons for not recovering grease, by specified amounts scoured annually

Reason	Scourers processing annually - million pounds					
	Less than 1	1-2	3-4	5-9	10-19	20 and over
	Number	Number	Number	Number	Number	Number
A. Majority of wool scoured of low grease content	8	6	4	2	4	2
B. Recovery systems too costly to employ	7	9	2	2	3	2
C. Amount of wool scoured too small to warrant investment	10	7	0	0	0	1
D. No problem of stream pollution-consequently no necessity for effluent treatment	9	2	4	2	1	1
E. Market for wool grease too unstable	2	3	2	0	2	2

Data compiled from 50 respondents in questionnaire survey. Some indicated more than one reason for not recovering grease.

An analysis of the answers by respondent companies to the question concerning reasons offered for nonrecovery of grease, showed the following characteristics:

(1) Carpet wool scourers who work with wools of low grease content, do not have to recover grease out of necessity (to clean their effluent), or out of economic desire (low content makes grease recovery uneconomical).

(2) Nearly all small scourers indicated that recovery systems were too costly to employ or that the amount of wool scoured was not large enough to warrant the investment.

(3) Those scourers located at or near tidewater, or in the Midwest or Far West, or where they could dump their wastes in municipal sewerage systems, were not interested in grease recovery because they felt that they had no stream pollution problem.

(4) There were no significant differences by States in the answers from plants of the same size scouring the same class of wool.

Economic Basis for Wool Grease Recovery

In all cases the primary motive for recovering grease from the scouring effluent has been the possibility of a net profit on the operation. A secondary consideration, given more weight in some locations than in others, has been stream pollution abatement. Technically, there are more efficient and economical ways to produce an acceptable effluent than by recovering the grease (27). These would vary, of course, depending on costs of labor, material, and equipment used in the recovery process and on the market price of the grease.

An example is Mill D located in the New England area. It scours an average of 100,000 pounds of fine Australian and Texas wool per week, using approximately 100,000 gallons of water. The cost of treating the effluent is as follows:

Investment in Waste Treatment Plant

4 - 11,000 gal. tanks) 1 - reaction tank) 1 - 3,000 gal. tank) 1 - compressor)	$23,000
1 - acid tank	1,500
1 - acid feed	1,000
Pumps, collection sump, and lagoons	10,000
Total	$35,500

Treatment cost for 100,000 gallons of effluent per week

Alum consumption 3,000 lbs. @ $1.65 per 100 lbs.	$49.50
Acid consumption 4,000 lbs. @ $1.00 per 100 lbs.	40.00
Labor @ $1.50 per hour, 48-hour week	72.00
Depreciation	34.00
Total cost	$195.50

To recover grease as a part of the waste treatment would require an additional investment of $15,000 to $30,000 and the services of two additional employees at $1.50 per hour. The management of this mill has chosen to recover grease with a centrifuge at a rate of 3 percent of the grease wool processed and to produce an acceptable effluent by treating the waste as cheaply as possible rather than risk the additional investment, the extra cost of operation, and the uncertainty of a larger net return. The sale, at 18 cents per pound, of 3,000 pounds of centrifuged grease pays for the entire cost of the waste treatment and contributes substantially to the payment of the cost of scouring the wool.

In many of the States where scourers are located it has been the policy of public health enforcement agencies not to enforce existing statues on stream pollution until compliance has become economically feasible, that is, until waste treatment methods have become cheap enough for the individual mill to install. If the mill is large enough, the economic feasibility of the waste treatment is usually connected with grease recovery, but only where the amount of the scouring waste is very large in proportion to the volume of water in the stream has it been necessary to install the more expensive acid-cracking plant. Additional information on this aspect of grease recovery is presented in the section on the acid-cracking method of recovering grease.

Although wool grease is usually referred to as a byproduct of the wool scouring or the wool textile industry, strictly speaking, wool grease may or may not be produced as a byproduct. Where the scouring process necessarily produces clean fiber and wool grease simultaneously, the latter is produced under conditions of joint supply or joint cost. These conditions do not exist in the United States, where all scouring is done by the emulsion method and where the resulting effluent can be retained for use or treated in some other way. The scouring liquor is the raw material, so to speak, for the production of wool grease, and the latter is therefore a true byproduct and not a joint product.

An example of the production of grease as a joint product with clean fiber was shown in the solvent scouring system of the mill in Lawrence, Mass., described in more detail on page 43 in which the process, in order to be economical and continuous, required the recovery of the solvent by distillation for reuse. The grease, being completely dissolved in the solvent, was simultaneously recovered as the wool was processed and clean fiber was produced. Another example of wool grease produced as a joint product would be those mills required to recover the grease from their scouring effluent to abate stream pollution. This has not materialized in the United States because there are other and cheaper means of producing an acceptable effluent in those States which enforce stream pollution laws, 24/ for example, a calcium chloride process (27) and biological filters which would reduce the biological oxygen demand (B.O.D.) of the water to acceptable limits. In all plants in the United States, therefore, wool grease is a true byproduct of the wool scouring process.

This distinction is highly significant in the allocation of costs. When two goods are necessarily produced at the same time by one process (joint supply) the cost of producing one is so inextricably interwoven with the cost of producing the other that the allocation of costs is impossible. We cannot say what it took to produce either one, as we could in the solvent scouring process. In practice one is designated the main product and one the byproduct, and they are priced so that the total return is equal to their cost of production. Theoretically in the long run their normal price would tend to equal their cost of production. The price of either one would be affected by the demand for the other; for example, an increased demand for wool would result over a long period not only in an increase in the production of clean fiber but also an increase in the quantity of grease produced. Without an increase in the demand for grease comparable to the increased demand for wool, the price of grease would fall. Hence the rule is that the prices of joint products tend to diverge. This has not been a factor in wool grease prices in the United States.

Even though wool grease is produced as a true byproduct in the United States, there may be several instances in which it is produced under conditions where the costs of scouring and the costs of recovery overlap. These occur when municipal authorities charge a fee for receiving the scouring effluent in the local

24/ This is done by several mills, one near Millbury, Mass., the other located in Little Falls, N. J.

sewage system, or when grease recovery is undertaken by a subsidiary or separate company to whom payment is made by the scourer. These two areas of joint cost with wool are relatively insignificant, but the third one is more substantial. Most of the centrifugal grease recovery equipment in the United States is operated in a closed system in which the scouring liquor is taken from the sumps under the squeeze rolls of the second or third bowls and, after being degreased in the centrifuge, is returned to one of the bowls for reuse, as the liquor still has much of its detergent power. This not only reduces the quantity of soap and soda needed (estimated savings amount to 20 to 25 percent) but also decreases the volume of water used and the steam necessary to heat it. Thus, grease recovery has an area of joint costs with scouring, and it is as difficult to allocate the savings in this method as it was the costs in the others.

For this study, the significant difference between the recovery of wool grease as a true byproduct and as a joint-cost product is that the latter would continue to be produced as long as wool was scoured. The recovery of grease as a byproduct would be discontinued whenever the market price fell below the cost of producing it. For both centrifuged and acid-cracked grease the price would have to be lower than it has been during the last decade for this to happen.

However, if there were any change in the quantity of wool scoured or in its grease content, the cost per pound of grease recovered would be affected more in the acid-cracking system because of larger fixed overhead expense. But as all of the acid-cracking plants are now concerned by stream pollution, it is doubtful whether recovery would be discontinued for any short period even if such changes should occur.

Recovery of Wool Grease by Centrifuge

Wool grease is recovered by two methods in the United States, one a mechanical process using a centrifuge, and the other a chemical process in which the scouring emulsion is cracked or broken by adding sulphuric acid and the grease and sludge settled out and separated by filtering under heat and pressure.

Information about the centrifugal method of recovering wool grease was obtained from questionnaires completed by 24 of the 35 scourers in the United States who use centrifugal equipment and from interviews with 23 of them. Four of the nonrespondents had only recently installed centrifuges and had been operating for less than a year. Their costs were therefore not included in the survey. The 24 respondents scoured a total of 262,523,794 pounds of grease wool and produced 5,695,876 pounds of dry wool grease during 1951. 25/ This was a recovery rate of 2.2 percent of the grease weight of the wool. Supplementing the information supplied by respondents, technical data were furnished by the equipment manufacturers and five of the grease refiners.

Costs for this section were compiled from data collected from 11 grease producers who were chosen as representative of the whole group in size and kind of operation. Costs were found to vary mainly with the amount of grease produced, which depended on the quantity of wool scoured and its origin and fineness and, to a lesser degree, on the kind of scouring establishment--commission scourer, comber, yarn manufacturer, or fully integrated mill.

The centrifuge works on the same principle as a cream separator. In addition to separating the grease and water, it also removes the suspended solids as a sludge. Only about 30 to 40 percent of the grease content of the wool is recovered by this method when the equipment is operating most efficiently, but it does produce a high quality grease that is low in free fatty acid and has little odor and a good light tan color. All of the grease recovered by this method is suitable for refining into lanolin. However, there is very little improvement in the pollutional characteristics of the scouring liquor as it is discharged into the stream. Further chemical or biological treatment of this waste would be necessary to abate stream pollution, or to make it the same as the waste discharged from the acid cracking process.

The centrifuge is nearly always located close to the scouring train and is employed in two ways: (1) In a batch system in which the scouring liquor is used for a time, then pumped to a storage tank, and run through the centrifuge before being discharged; (2) in a closed system in which the scouring liquor is taken from the second bowl where the grease concentration is highest, usually from the sump under the squeeze roll, and then circulated through the centrifuge, where it is degreased and returned to the third bowl. It is returned to the second bowl in a counterflow system. In this way the scouring liquor may be used for as long as a week at a time. The only loss occurs when the sumps in the hopper type settling tank are opened several times each hour to dump the heavier

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25/ The amount of wet grease recovered by one type centrifuge was reduced by 25 percent to put it on the same basis as grease produced by another type centrifuge. The wet grease recovered by the former type centrifuge contains 25 to 30 percent excess water compared to the grease recovered by the latter type centrifuge.

dirt particles and when the sludge is discharged from the centrifuge. The closed system is used by most of the scourers with centrifugal equipment. The scouring liquor can be retained for longer periods with a consequent saving of 20 to 25 percent in scouring costs because of less soap, less water, less steam, and the productive time that the train is in operation is increased.

The following information is preliminary to a discussion of costs. The minimum installation of centrifugal grease recovery equipment consists of a heating unit, a cooler, a settling tank, a reserve tank, and a centrifuge. The scouring liquor is heated to 190° F. and passes to a large settling tank with 60° hopper-type sumps and thence to the centrifuge unit. In a closed system the degreased liquor is cooled to 120° F. in a heat exchanger before being returned to the scouring bowl. In a batch system the liquor does not need to be cooled.

Grease recovery would hardly be profitable at present market prices unless the operation was large enough to handle 3 to 4 million pounds of medium grade wool or 2.5 to 3.5 million pounds of fine wool annually. 26/ In terms of scouring equipment this would mean a two-shift operation on a single train. At an average of 1,000 pounds per hour, with an 8-hour shift and a 5-day week, 4 million pounds could be scoured annually. However, a single grease recovery unit is capable of handling 1,500 to 2,000 gallons of liquor per hour and would be adequate to recycle the liquors from 3 scouring trains if they were compatible and could be mixed in the reserve and settling tanks. For example, a large worsted mill could use 1 centrifuge unit for 3 trains because all of them would be scouring the same kind of wool. But it is unlikely that a commission scourer could use 1 centrifuge for 3 trains because he handles wools with a wide variety of impurities, each needing a scouring solution of different strength. The liquors from each train would be mixed in recycling, the solutions in all trains would soon be equalized, and the scouring of the different types of wool in each train would soon be adversely affected. The alternatives would be to waste the liquor from the least greasy wool or to use a batch process and hold the liquor in a reserve tank until it could be centrifuged on the third shift when the other trains were not in use. A grease recovery unit for each train would give the greatest flexibility in the use of scouring equipment, but offsetting this is the cost of centrifugal equipment, as shown below.

Two companies in the United States supply all of the centrifugal grease recovery equipment to wool scourers at present. The

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26/ One mill in the United States recovers grease profitably from scouring two million pounds of fine wool annually.

minimum grease recovery unit sold by one of these companies cost $24,720 f.o.b. Philadelphia in 1953. Installation cost including necessary tanks, heater, cooler, foundation, wiring, and piping is $15,000 to $20,000. The primary centrifuge unit in this assembly handles 1,500 to 2,000 gallons per hour. The wool grease discharged in wet form from the primary unit is immediately reemulsified with large volumes of hot water at 190° F. and dried in a second centrifuge which has a capacity of 50 pounds of neutral, dry grease per hour. The OPS ceiling price for this grease from June 1952 to March 1953 was 20 cents per pound. This installation would be sufficient to handle the output of a single train scouring 1,000 pounds of fine wool an hour with a recovery rate of 5 percent. Another secondary unit (called a rerun super centrifuge) could be added for $3,300 to take care of another train scouring fine wool or 3 trains scouring medium wool so that an investment of approximately $45,000 is needed to produce 100 pounds of wool grease an hour. This is the normal output from 2 trains scouring fine wool or 3 trains scouring medium wool. A vacuum drier could be added for $5,000 to reduce the moisture content so that the grease could be sold for 30 cents a pound under OPS Ceiling Price Regulation 146, issued June 3, 1952.

The other company's installation uses a centrifuge which differs from the first-mentioned company's equipment in several ways. First, it produces a wet grease, which may have up to 30 percent moisture content and which sold for an OPS Ceiling price of 18 cents a pound on a 5 percent maximum moisture basis. Second, the centrifuge unit is not sold outright but is leased for a 10 percent royalty. The royalty may be collected in grease or its market price equivalent in money at the option of the company supplying the equipment. This company has adequate refining facilities to handle its own royalty grease and that of all of its customers. It also furnishes without charge the services of two sales representatives, who are engineers, to service its grease recovery equipment, as well as its scouring and waste treatment processes. The initial cost of the minimum grease recovery unit that can recycle the effluent from 3 scouring trains is $18,000. This represents the cost of the tanks, heater, and cooler and their installation. By recovering wet grease this type centrifuge recovers for sale a larger percentage of the grease in the scouring effluent. All of the centrifuges in a mill are usually operated by one man (union rate is $1.50 per hour) unless they are located so far apart that this is impractical.

It is apparent from the preceding discussion that wool grease is produced under conditions of decreasing cost. The initial investment is large and operating costs are small, so that increasing amounts of grease can be produced with little additional expense. Similarly, a decline in the quantity of wool scoured would result in a more than proportional increase in the cost per pound of grease recovered. This is shown in figure 10 and is based on 1951 data collected from eleven mills, each scouring from 2 to 32 million pounds of wool annually, that recovered a total of 4,948,602 pounds of grease. The cost of recovery in cents per pound is shown for mills scouring from 2.5 to 30 million pounds annually. As the cost is a function not only of the amount of wool scoured but also of the percentage (based on the grease weight of the wool) of grease recovered, the lines on the chart represent different recovery rates as indicated. Costs include labor maintenance, cost of containers and their return, and depreciation. 27/ For the smaller mills, a 2-shift operation is assumed. For larger mills and commission scourers it was assumed that a second centrifuge would be added for flexibility in scouring after 3 trains were fully utilized on 2 shifts. This would be needed for 10 to 15 million pounds of grease wool and would raise the average cost per pound of grease by an increase in depreciation and maintenance. The same mechanic could service both installations. The average cost per pound using only 1 centrifuge and going to a 3-shift operation would be lower, as shown by the dotted lines.

It should be pointed out that there is not the same linear correlation between the amount of wool scoured and the amount of grease produced for a commission scourer that there is for a comber, a yarn manufacturer, or a fully integrated textile mill. A commission scourer may have scheduled a 3-day run of fine South African Cape wool on all his trains and in the middle of it receive a call from a customer asking if he can scour 100,000 pounds of Texas lambs wool immediately. Unless he can pump the effluent to a reserve tank and has an open shift to run it through the centrifuge, the commission scourer will have to dump it and lose the entire grease content of 4,000 to 5,000 gallons of scouring liquor. The commission scourer's cost per pound of grease is also higher, as mentioned above, because he scours wools of all kinds in scouring solutions that are not compatible and hence is forced to waste the solution from the least greasy wool. The conditions under which grease is recovered in each mill are unique, and there is a considerable variation in costs depending on the skill of the operators in the adjustment of the machine and in its upkeep to get the maximum recovery rate and to decrease maintenance costs.

In addition to the direct costs given in this illustration a portion of the total overhead costs of the mill should be allocated to the grease recovery operation so that it will bear a part of the supervisory, accounting, utilities, and other expenses. This may be done on the basis of the number of square feet of floor space occupied, the amount of the investment, the man-days of labor, or on some other equitable basis.

27/ Any royalty payments would also increase the cost per pound.

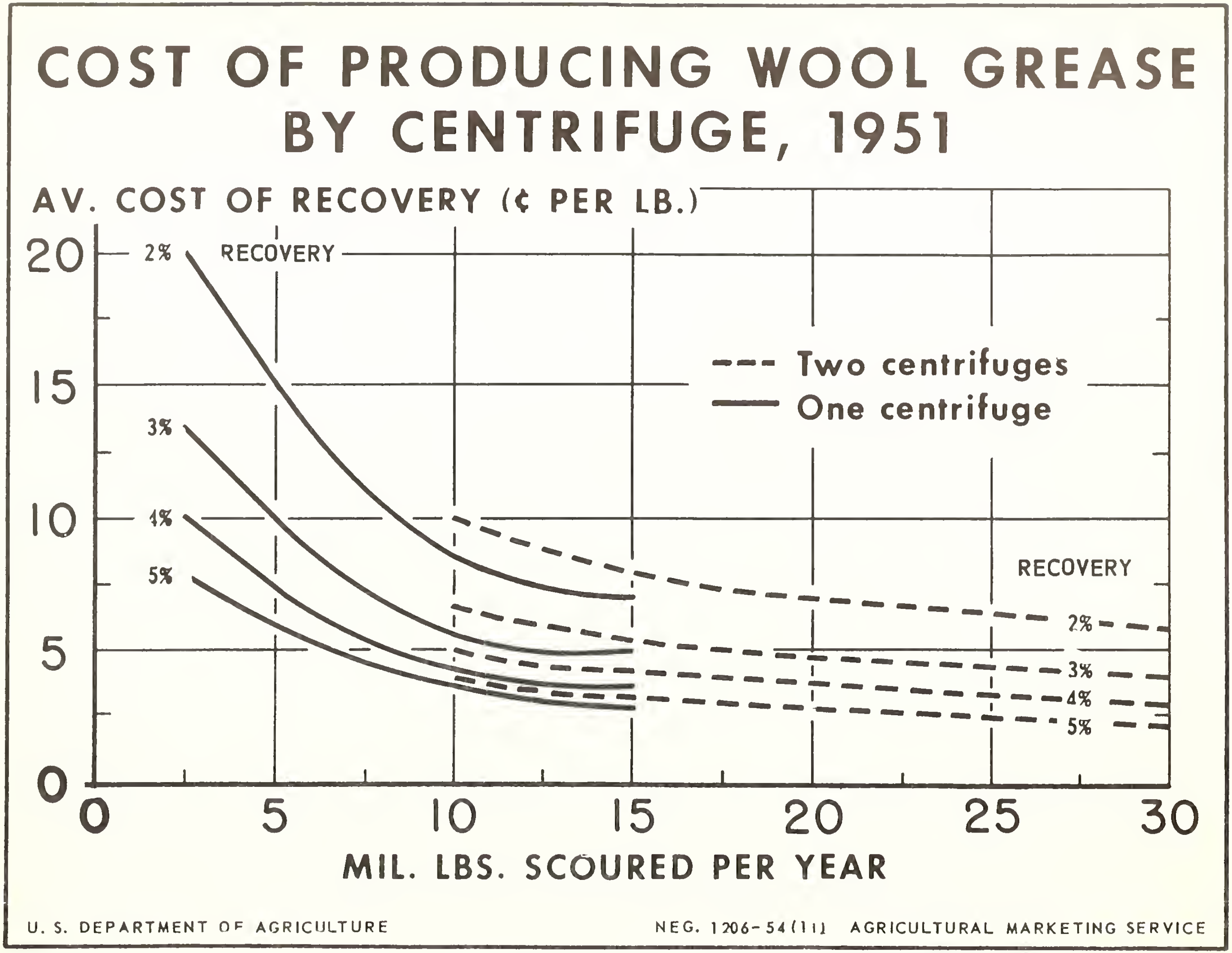
COST OF PRODUCING WOOL GREASE
BY CENTRIFUGE, 1951
AV. COST OF RECOVERY (¢ PER LB.)
20
15
10
5
0
2%
RECOVERY
3%
4%
5%
Two centrifuges
One centrifuge
RECOVERY
2%
3%
4%
5%
0
5
10
15
20
25
30
MIL. LBS. SCOURED PER YEAR
U. S. DEPARTMENT OF AGRICULTURE
NEG. 1206-54(11)
AGRICULTURAL MARKETING SERVICE

Figure 10

A minimum amount of wool scoured annually with a sufficient grease content and efficient and continuous operation of the centrifuge equipment is only half the battle for profits from wool grease. Prices received for the grease are the other half. Prices paid to wool grease producers in normal times are based on the quality of grease and on the general supply and demand situation for that type of grease at the time it is put on the market. Since World War II, one refiner has paid a producer from 8-1/2 to 26 cents per pound for the same quality of neutral wool grease within a period of 3 years. In New York, as shown in figure 11 (34, 35), the prices for several grades of wool grease have not fluctuated so violently. Both the quality of the grease and the market price are almost wholly beyond the control of the scourer. Clean fiber at minimum cost is the desired end result, and the quantity and quality of grease are secondary. A good job of scouring will net the scourer more money, and he therefore subordinates all other acitivities to that end. The quality of the grease may vary with the strength and age of the scouring solution, with the origin and grade of wool scoured, and with many other factors. Pulled wools yield grease that is dark in color and somewhat inferior to grease from shorn wool as a raw material for lanolin. For some undetermined reason grease wool held for a long period in storage yields very little grease.

The Acid-Cracking Method of Grease Recovery

The acid-cracking process of recovering grease is currently employed by only three scouring establishments in the United States. They are large integrated mills, each scouring more than 10 million pounds of grease wool annually. Each establishment is located on a stream that has a volume of water small in proportion to the waste emptied into it. Continuous discharge of the scouring waste from a centrifugal process would be possible only at periods of flood water and therefore cannot be used. The choice of the acid-cracking method of recovering grease was therefore an acceptable solution not only for stream pollution abatement but also for economic reasons.

The acid-cracking process removes approximately 85 to 95 percent of the grease and suspended solids, but the effluent is always acid and contains in solution much organic matter, which becomes putrescible on neutralization. It is, however, a far more acceptable effluent than that from the centrifugal process. See table 18 for a comparison. Sixty to seventy percent of the grease can be recovered, about twice that by the centrifugal process; but offsetting this recovery rate are the lower quality of the grease produced and the high initial installation and

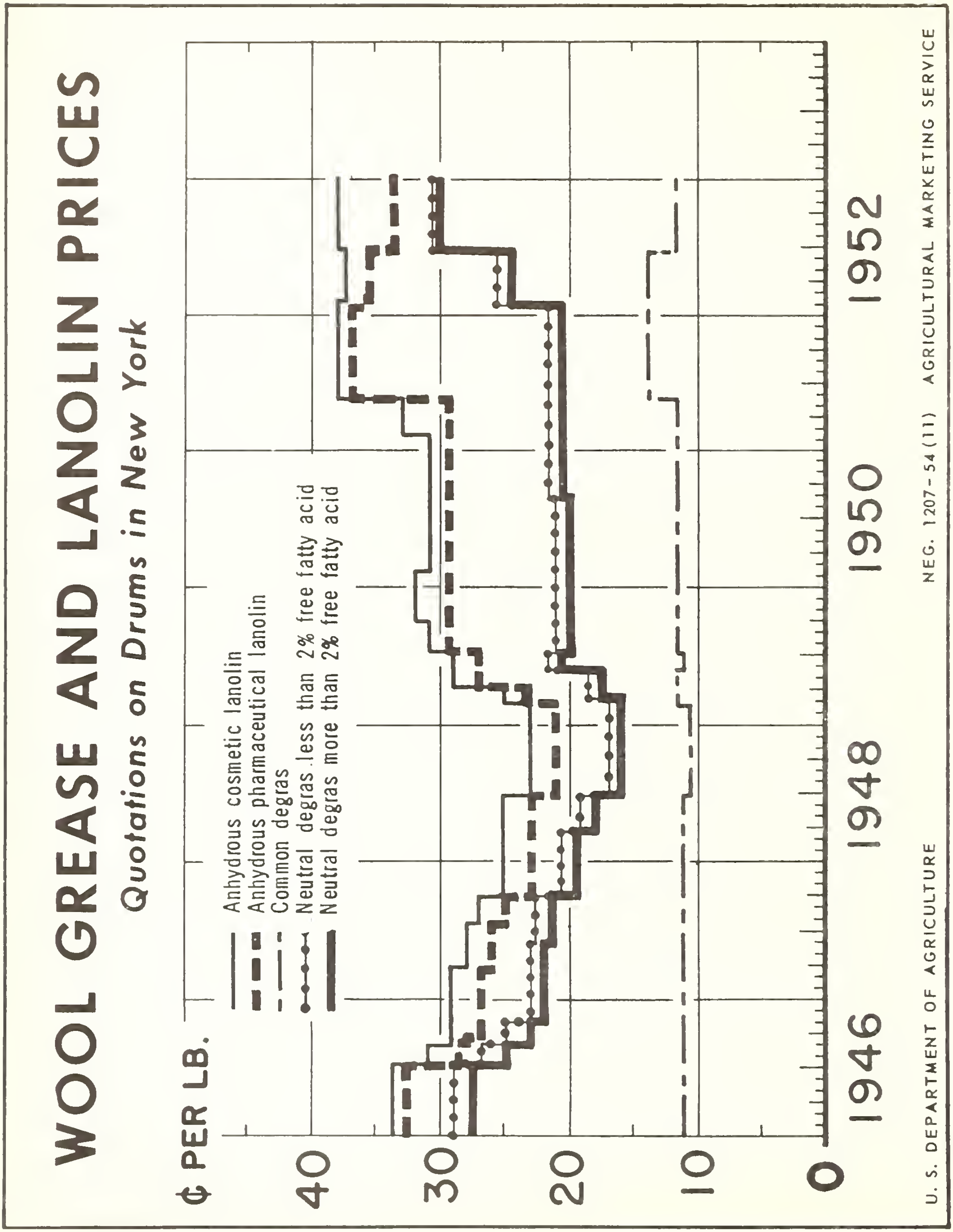
WOOL GREASE AND LANOLIN PRICES
Quotations on Drums in New York
¢ PER LB.
40
30
20
10
0
Anhydrous cosmetic lanolin
Anhydrous pharmaceutical lanolin
Common degras
Neutral degras less than 2% free fatty acid
Neutral degras more than 2% free fatty acid
1946
1948
1950
1952
U. S. DEPARTMENT OF AGRICULTURE
NEG. 1207-54(11) AGRICULTURAL MARKETING SERVICE

Figure 11

Table 18.- Impurities in wool scouring wastes
by method of grease recovery

Item	pH	Alka-linity	Suspended solids	Volatile suspended solids	Fats	B.O.D.	Oxygen absorbed (4 hrs.)
		p.p.m.	p.p.m.	p.p.m.	p.p.m.	p.p.m.	p.p.m.
Acid-cracking: 1/							
Domestic sewage wool scour mixture----------	7.6	686	1,200		640		228
Effluent from Acid cracking----	5.8	39	112		56	284	117
Effluent from final trickling filters----------	6.4	24	32			22	26
Hypochlorite method 2/---------							
Wool scour waste		6,700	12,000		8,500	5,500	
After treatment--					200	600	
Centrifugal method 3/							
Wool scour waste-	10.1	9,100	25,000	22,000	22,500	3,600	
Final centrifuge effluent---------	10.0	150	340	334	1,050	195	

1/ Hiller, W. H., "The Recovery, Processing and Marketing of By-Products at the Esholt Works of the Bradford Corporation," p. 2. Bradford, England: reprinted September 1952 (18).
2/ Faber, H. A., and Howard, P. F., "Wool Scouring Wastes Treated by New Chemical Process," Water and Sewage Works. Vol. 93 (1946), pp. 467-73 (12).
3/ New England Interstate Water Pollution Control Commission, Textile Wastes. A Review, 1936-50, p. 28, table VIII (32). Boston: New England Water Pollution Control Commission, 1950.

operating costs. Acid-cracked grease usually contains 8 to 18 percent free fatty acid; it is darker in color than centrifuged grease, has a stronger odor, and sold for only three-fourths as much under OPS ceiling prices.

In a typical acid-cracking system of grease recovery, the hot wool suds from the second and third bowls and the steeping water from the first bowl of the scouring train are screened and conveyed to a series of settling tanks outside the mill building. The fourth bowl of rinse water is usually discharged directly into the stream unless a counterflow system is used. Water from the first (desuinting) bowl may be pumped to lagoons to await high water periods before being discharged into the stream. The heaviest solids are screened and settled out in concrete settling tanks. The cold effluent is then pumped up into large, wooden, silo-type tanks and mixed with a stream of dilute sulphuric acid by agitation with compressed air. This reduces the pH from 10 - 11 to 3 - 4. The effluent flows by gravity to thickening and settling tanks where after 5 hours, the emulsion having cracked, a clear acidic liquid is decanted from between an upper layer of scum and the sludge on the botton. This acid liquor is held in lagoons apart from the desuinting liquor until high water. The sludge and top scum are pumped to another storage tank, agitated with steam to decrease the viscosity of the grease, and gradually drawn off to plate and frame filter presses where by means of heat (200°F.) and pressure (50 pounds per square inch) the grease and water are squeezed out through filter cloths, collected in troughs, and separated by flotation as the mixture is cooled. The water is pumped to the lagoons. The grease may be further dried by heating or centrifuging to less than 1 percent moisture content and then desulphurized. Sulphur is found in crude wool grease as a residual impurity because it is a constituent of some pesticides used on sheep in some countries. Free sulphur may also result from the biological degradation of the scouring liquor. Sodium sulphite is added to the grease and combines with the free sulphur to form sodium thiosulphate, which is water soluble and can be washed out of the grease. A higher price can be obtained for desulphurized grease. The dry cake resulting from the filter press contains about 15 to 20 percent grease. It is hauled to farms in the vicinity and after weathering a few months can be spread as fertilizer.

The acid-cracked grease is not suitable for refining into lanolin but is used for lubricants, cutting oils, leather stuffing, and cordage emulsions.

An inconvenience of the method is the odor from the lagoons and the expense of removing the settled solids. This is usually done during the winter when the material is frozen. A special installation designed primarily to abate stream pollution is in operation at a mill located in Massachusetts. The scouring effluent is first mixed with calcium hypochlorite, 6 to 7 percent by volume, approximately equal to the alkali in the solution, in order to oxidize organic matter and permit separation of the sludge containing calcium carbonate and insoluble soaps. The clear liquor is discharged directly into the stream. The sludge and scum are acidified with sulphuric acid to a pH 4 to 5, heated, and filter-pressed. This yields a cake that dries readily and a grease-water mixture, which is separated in a gravity separator. The grease is concentrated, steamed, desulphurized, and run into drums. The B.O.D. of the scouring effluent before treatment is 5,000 to 6,000 parts per million and after treatment is 600 to 700 parts per million. A description of the result of this installation is as follows: "The effect of such treatment has been immediately apparent in the improved appearance of the stream into which the treated effluent is discharged. The present effluent no longer contributes sludge deposits, decomposing solids, grease, or excessive oxygen demand. Fish and other aquatic life have returned to the stream not far below the point at which the effluent enters"(12).

Costs for the acid-cracking process are difficult to assess. In each plant the economic success depends not on the technical efficiency of the process but on the quantity and fineness of the wool scoured and the market price of the grease. The fixed charges of interest, depreciation, power, steam, and labor costs are almost independent of the quantity and type of wool scoured. The chemical costs per pound of grease are directly variable but will be proportionately higher for wastes low in grease than for those high in grease, and the percentage recovery of grease will be lower from wastes low in grease. It follows, therefore, that additional amounts of grease could be recovered for little more than the cost of the chemicals, filter cloths, and other directly variable costs.

Offsetting the very low cost of recovery for increasing amounts of wool scoured, it should be pointed out that a decline in the volume of wool scoured below the break-even point, a change to coarser wools, or a decline in the market price of grease would make this system of recovery a very heavy burden of expense. As stated before, it is efficient for large-scale continuous operation. Present plants require 4 to 6 men per shift to operate.

Under the OPS price schedule in force in 1952 there was a larger gross return from the acid-cracking method of grease recovery than from the centrifugal method when both kinds of establishments were scouring the same amount and types of wool. This is true because the proportion of grease recovered by acid-cracking is approximately double that recovered by centrifuging, whereas the price of acid-cracked grease is 15.5 cents per pound compared with 20 cents per pound for centrifuged grease. There is a substantial net return, chiefly because of depreciated equipment, to those plants now using the acid-cracking method on a large scale.

Several large engineering firms in Boston familiar with the treatment of wool-scouring wastes estimate that an acid-cracking plant for grease recovery capable of treating at least 100,000 gallons of effluent daily and designed not only to recover the grease but also to produce an acceptable effluent would now cost $250,000 to $300,000. This includes suitable tanks, sumps, lagoons, and a building 30 by 40 feet to house the presses and other equipment. This process would require 4 to 5 men per shift, 2 shifts per day to operate,and would entail an annual expense for chemicals of approximately $15,000. This is considered the answer to the stream pollution problem for a large mill. It may not be an economical answer, as pointed out above, and it is entirely beyond the financial resources of most of the scourers in the United States.

It may be helpful for the purpose of allocating costs to look at the component parts of the problem above. It is true that grease recovery and waste treatment are handled together as an inseparable problem, but actually waste treatment may be a cost of scouring in that location, as pointed out elsewhere in this report, and should therefore be allocated as a cost to the scouring operation rather than to grease recovery.

The following discussion is centered upon the economic possibilities of the acid-cracking method of grease recovery for medium-sized mills scouring approximately 100,000 pounds of apparel wool per week or 5 million pounds annually. These are the mills that have installed centrifugal grease recovery equipment and so far have found it not only a profitable but also an adequate answer to the abatement of stream pollution as far as public health authorities are concerned. A change in the policy under which State public health laws are administered may change the picture in the future.

The next step for such mills is to treat the centrifuged effluent as cheaply as possible before discharging it to the stream. This may be done by simply pumping it to lagoons, allowing it to settle, and discharging the liquor during periods of high water. A further step is to add acid and crack the scouring emulsion, which will cause more of the suspended and dissolved solids to settle out in the lagoons so that a relatively clear liquor can be discharged to the stream during periods of high water.

A further step in cleaning up the centrifuged effluent has been taken by several mills in the United States and is considered by them as part of their operating costs in their present location. For a capital expenditure of $30,000 to $35,000 each, several mills during 1952 installed waste-treatment plants which handled 100,000 to 150,000 gallons of effluent per week and produced an acceptable effluent to discharge into the stream. In addition to the acid-cracking process mentioned above, which is carried out in large tanks, the resulting sludge is heated and filter pressed. The equipment can be operated by one man on each shift.

Thus far only processes for waste treatment of the centrifuged liquors have been considered. The next step is the recovery of grease in connection with these waste treatment plants. This would involve an additional expenditure of $25,000 to $30,000 for tanks, filter presses,and grease separating equipment. All the effluent from the scouring train would be acid cracked, but only the centrifuged liquor from bowls No. 2 and No. 3 where the grease is concentrated would be heated and filter pressed. At least one mill is contemplating this change at present. This is substantially the same process now used by the three large mills described above, but it is here considered on a much smaller scale as an additional treatment for the centrifuged effluent. It is estimated that for every pound of grease recovered by the centrifuge another 1-1/2 pounds can be recovered by acid-cracking the centrifuged effluent. With a recovery rate of 2 percent for a mill scouring 100,000 pounds of fine to medium apparel wool per week, the 2,000 pounds of centrifuged grease at 20 cents per pound would yield $400 per week. The approximate cost of obtaining the additional 3,500 pounds of grease by acid cracking would be as follows:

Income per week from acid-cracked grease 3,500 lbs. @ 12¢ $420

Expenditures per week:

Depreciation Based on straight line depreciation at the rate of $2,000 per year for a capital expenditure of $30,000. This is the additional investment necessary to add grease recovery equipment to waste treatment plant.	$40

Operating costs:

Chemicals	$ 90	
Labor	125	
Maintenance and supplies	20	$275
Net income per week		$145

It should be emphasized that these are approximate optimum costs for the grease recovery operation only. It will produce a better effluent for discharge into the stream than a waste treatment process alone and might prove a more economic solution to the problem of waste treatment (for apparel wool scourers) when a centrifuged effluent is no longer acceptable, in specific locations, to State public health authorities.

Following is a summary of the advantages and disadvantages of the acid-cracking process.

Advantages

(1) It produces a much better effluent and about twice as much grease as any mechanical process.

(2) It uses a cheap, readily available chemical, sulphuric acid.

(3) It can be operated by unskilled labor.

(4) It makes use of conventional , nonspecialized chemical processing equipment.

Disadvantages

(1) The equipment is costly to install, operate, and maintain.

(2) Two to four men per shift are required compared to one man per shift for centrifuge recovery.

(3) A poorer quality of grease is recovered.

(4) Scouring liquor cannot be recirculated after being degreased.

(5) It is economical only for relatively large-scale, continuous operation.

(6) A much larger area is required for processing equipment, sumps, and lagoons, and the effluent is sometimes malodorous.

Aeration Method of Recovering Wool Grease

Although only two methods of recovering wool grease are used in the United States, there are others which have been used on a commercial scale in other countries (14). They are variations of an aeration process in which the scouring emulsion after being cooled is mechanically agitated as air is blown in or compressed air is bubbled up through it. The grease is concentrated on the surface and forms a froth. The grease can be separated from the froth by skimming and heating.

An improvement in this process was recently developed in Australia by the Commonwealth Scientific and Industrial Research Organization and is in operation on a commercial scale. 28/ The scouring effluent is mechanically agitated with an impeller and compressed air in a series of tanks. The froth containing the grease is washed by a counterflow of water and further agitated until it contains the maximum amount of grease, about 20 percent by weight, and is relatively dry and stable. Grease containing 3 to 20 percent free fatty acid can be obtained from the froth by acid cracking and hot-filter pressing, or a grease containing less than 0.5 percent free fatty acid can be recovered by dispersing the froth in an alkaline solution, heating to the boiling point, and settling or centrifuging.

THE REFINING AND MARKETING OF WOOL GREASE

The wool grease refiners in the United States distribute most of the imported grease and nearly all (estimated at 90 percent) of the grease recovered by United States wool scourers. Total sales of 2 million dollars indicate that it is a small industry, but the special qualities of wool grease have made it important in a variety of industrial uses.

The Wool Grease Refiners

There are nine companies in the United States that refine wool grease into lanolin. A list of the refiners and their products is

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28/ Evans, L. F., and Ewers, W. E., "An Aeration Process for the Recovery of Wool Wax from Scour Liquor - Revised Statement." Australian Journal of Applied Science, Vol. 4 (1953), pages 552-78, Appendix I. Edwards, G. R., Mansfield, W. W., and Pagels, A. G., ibid, pages 579-80.

given in table 19. All but two are located in the New York area. They refine most of the domestic centrifuged wool grease and some of the imported centrifuged grease.

The nine refiners may be divided into three categories according to their method of operation, as follows:

(1) Refiners primarily engaged in refining and distributing wool grease.

(2) Refiners primarily engaged in manufacturing and distributing other materials, such as chemicals, with wool grease refining representing a small part of their total business.

(3) One fully integrated wool scourer who refines wool grease and distributes lanolin in consumer product.

All of the refiners in the first two categories produce Technical, U. S. P., and Cosmetic grades of lanolin. They also sell Common Degras, Crude, and Neutral wool grease, both desulphurized 29/ and untreated. The three grades of wool grease differ in moisture, free fatty acid, and ash content and decrease in darkness of color and strength of odor in the order named. They come from imported wool grease, which is usually high in free fatty acid and is rarely used as material for lanolin, and from domestic wool grease from centrifugal or acid-cracking plants. "Crack back," a residue from the refining process that has a high free fatty acid content, is also a source of Crude and Common Degras. Additional products made by some of the refiners include absorption bases, and other lanolin derivatives for specialized uses in cosmetics and pharmaceuticals.

In the first category the two largest firms process about 80 percent of the domestic production and handle about 60 percent of the imports. The two companies in the second category refine and distribute wool grease, but it constitutes only a small part of a full line of industrial and agricultural chemicals they sell.

In the third category is the fully integrated wool scouring company, which refines not only the grease from its own wool scouring operation but also additional supplies purchased from other scourers, and markets some of the lanolin it produces in a line of cosmetics under its brand name through department stores in the larger eastern cities of the United States.

29/ Desulphurized wool grease is required for use on bright metal surfaces.

Table 19.- Wool grease refiners and their products, United States

Refiner	Wool grease		Lanolin			Derivatives		Other products
	Common degras	Other grades	Cos-metic	U.S.P.	Tech-nical	Absorp-tion bases	Wool grease alcohols and fatty acids	
American Chemical Paint Company	X	X	X	X	X			
American Lanolin Company	X	X	X	X	X			Toilet Lanolin, Paralan Oil-(rust preventive)
Bopf Whittam Corporation	X	X	X	X	X			
Croda, Inc. 1/	X	X	X	X	X	X	X	
Fanning Chemical Company	X	X	X	X	X			
Hummel Chemical Company	X	X	X	X	X			
Lanatex Products, Inc.	X	X	X	X	X	X		
N. I. Malmstrom & Company	X	X	X	X	X	X	X	Lubricating Oil Additives, Lanolin soaps, various lanolates
Robinson-Wagner Company	X	X	X	X	X	X	X	Liquid esters and alcohols, amines and amides, water and oil soluble forms of lanolin and lanolin derivatives
Botany Mills	Lanolin lotion, lanolin formula 70 cream, lanolin triple action cream, superfatted lanolin soap, lanolin hair cream, pure lanolin							

1/ Croda, Inc., has its wool grease refined on commission.

There is one other firm that should be mentioned with the refiners. It is the American subsidiary of a well known English firm located in Yorkshire, England. The subsidiary offers domestically produced wool grease and lanolin, several grades of imported wool grease, and several lanolin alcohols and fatty acids that are imported from the parent company in England.

The Refining Process

The refining of wool grease consists essentially of purification, that is, removing impurities such as sulphur and free fatty acids, decreasing the moisture and ash content, deodorizing, and bleaching. One method of refining a crude wool grease consists of emulsifying it in a hot water solution containing soap, and adding alkaline chemicals, such as alkali silicate, to remove the free fatty acids and to dissolve protein impurities. If a light-colored product is desired the emulsion is treated with a bleaching agent such as hydrogen peroxide, sodium perborate, or sodium percarbonate. Next, the addition of a small amount of water-soluble sulfonated oil (castor, neats-foot, rapeseed, corn, or soya bean) causes the clear grease to rise to the top while the water solution carrying the soap, dirt, and water-soluble sulfonated oil settles rapidly to the bottom. The top grease layer when separated from the water layer and washed in hot water to remove all of the water-soluble impurities is of United States Pharmacopeia grade. It can be centrifuged to reduce the moisture content if an anhydrous grease is desired.

Specifications for U.S.P. grades of lanolin are shown in Appendix A. Light color and absence of odor are desirable for cosmetic grades, and the lanolin may be further bleached by first mixing the grease in aqueous solution with sodium hypochlorite and then adding an aqueous mixture of sodium chlorite to a pH of 9 or 10. Since the U. S. Pharmacopeia does not specify color exactly, several refiners have set up their own color standards. One is based on A.S.T.M. standards and is used when customers request color information; cosmetic grade is indicated on a scale from 1.75 to 2.50, while pharmaceutical grade extends from 2.50 to 3.25.

Only 80 to 85 percent of the crude raw material recovered by centrifuges is refined into lanolin. About 5 percent, by weight, is lost in the refining process. An additional 10 percent is recovered as "crack back," which is high in acid content and is sold for fur dressing, lubricants, and similar uses. Wool grease from the first-run centrifugal machines yields approximately 65 pounds of lanolin per 100 pounds of wet grease (25 to 30 percent is water).

The refiners use only centrifuged wool grease as a raw material for lanolin because it can be more economically refined than acid-cracked grease. The value added in manufacture is shown in the tabulation below. The grease was purchased from the producers at 18 to 20 cents per pound and refined into the higher grades in the schedule. This price differential existed only during the 1951-52 period when crudes were very scarce; usually the spread is less.

O P S ceiling price per pound for lanolin and wool grease, June 1952-March 1953

	Dollars
Lanolin	
USP special anhydrous cosmetic grade	0.405
USP anhydrous cosmetic grade	.355
USP anhydrous pharmaceutical type	.355
USP hydrous pharmaceutical type	.320
Technical, ash maximum 1/10 or 1 percent, moisture maximum 1/10 or 1 percent, acid maximum 3/4 of 1 percent	.310
Wool grease	
Neutral, fully refined	
Acid maximum 2 percent, ash maximum 1/10 of 1 percent, moisture maximum 1/10 of 1 percent	.305
Over 2 percent acid, ash maximum 1/10 of 1 percent, moisture maximum 1/10 of 1 percent	.300
Crude centrifugal, not refined	
Dry, moisture maximum 2-1/2 percent, ash maximum 3/4 of 1 percent, maximum 1-1/2 percent F.F.A.	.200
Wet, over 5 percent moisture, maximum 2-1/2 percent F.F.A., anhydrous basis	.180
Common degras, moisture maximum 2-1/2 percent, 1/4 to 1 percent ash	
Maximum 11 percent F.F.A.	.120
Over 11 percent F.F.A.	.110

	Dollars
Desulfurized	
Neutral	
Acid maximum 3 percent	.205
Acid maximum 6 percent	.180
Degras	
Acid 6 to 10 percent	.155
Acid 10 percent and above	.145

United States Office of Price Stabilization (53).

Much of the material is produced to customer specification, particularly as to color, viscosity, and odor, and for this an additional charge may be made. Special trade names are employed for the top cosmetic grades in order to obtain product differentiation. Uses for the grades shown in the above tabulation are given in the section on Wool Grease and Lanolin in Industrial Uses.

Competition in the Industry

Although wool grease refining is a relatively small industry, and two firms process and distribute the greater part of the total sales, it might well serve as an example of a truly competitive industry. The competition stems from five main causes:

(1) General shortage of material. This is due not only to the decrease in apparel wool scoured in the United States but also to the increased uses found for wool grease and lanolin.

(2) Excess capacity. Reference to figure 1 will show the peak production of wool grease during the war years and the variation in the amounts produced during the postwar period. The industry has an excess refining capacity at present as evidenced by the fact that each refiner during each of the last 2 years has found it necessary to shut down his plant part of the time.

(3) Decreasing cost industry. Once the capital investment is made and the plant is operating, additional quanitities of grease can be refined for little more than variable or out-of-pocket costs. This fact, coupled with the excess capacity of each refiner and the limited supply of raw material, creates competitive pressure among the refiners.

(4) Comparable products. Each of the refiners can produce a product comparable in nearly every respect to anything any other

refiner can produce, and as refiners buy and sell by specification they compete on both the demand side and on the supply side in a market that approximates nearly perfect competition.

(5) Business rivalries. Production secrets are closely guarded in this industry. All of the present firms were set up by former employees of the older firms and personal competition intensifies the business rivalries.

The Marketing of Wool Grease and Lanolin

Wool grease and lanolin are semimanufactured industrial goods; that is, they are purchased for industrial or business use, and the purchaser intends to resell them in some other form. Except for certain wholesalers who regularly handle small quantities of the product and serve as merchant middlement in the channel of distribution, both the refiners and industrial users process the material in some way to make it suitable for a particular use. In general, the refiners remove some of the impurities, and the industrial consumers use it as a constituent of the final product they manufacture and sell.

It is estimated that least 90 percent of the wool grease and all of the lanolin, both imported and domestic, is marketed through the refiners (fig. 12). Their technical functions and their relationship with the producers were discussed in the preceding section. The marketing functions the refiners and other middlemen perform and the buying habits and motives of industrial users will be discussed in the following pages.

Marketing Functions

A clearer understanding of the marketing of wool grease and lanolin may be gained from a description of the marketing functions performed by those who handle this material from producers to industrial users. A description of the functions performed by each producer, middleman, and industrial user is essential to an analysis of the efficiency of the marketing system. The absence, duplication, or inefficient performance of the marketing functions as well as their cost can be noted and evaluated.

The marketing of wool grease in the United States begins with the 38 wool scourers who recover grease. Their principal marketing function is selling. During 1951 and 1952 they were in the fortunate position of having a commodity in great demand. Very little effort and no expense were necessary in selling. One producer who installed grease recovery equipment in 1952 had more

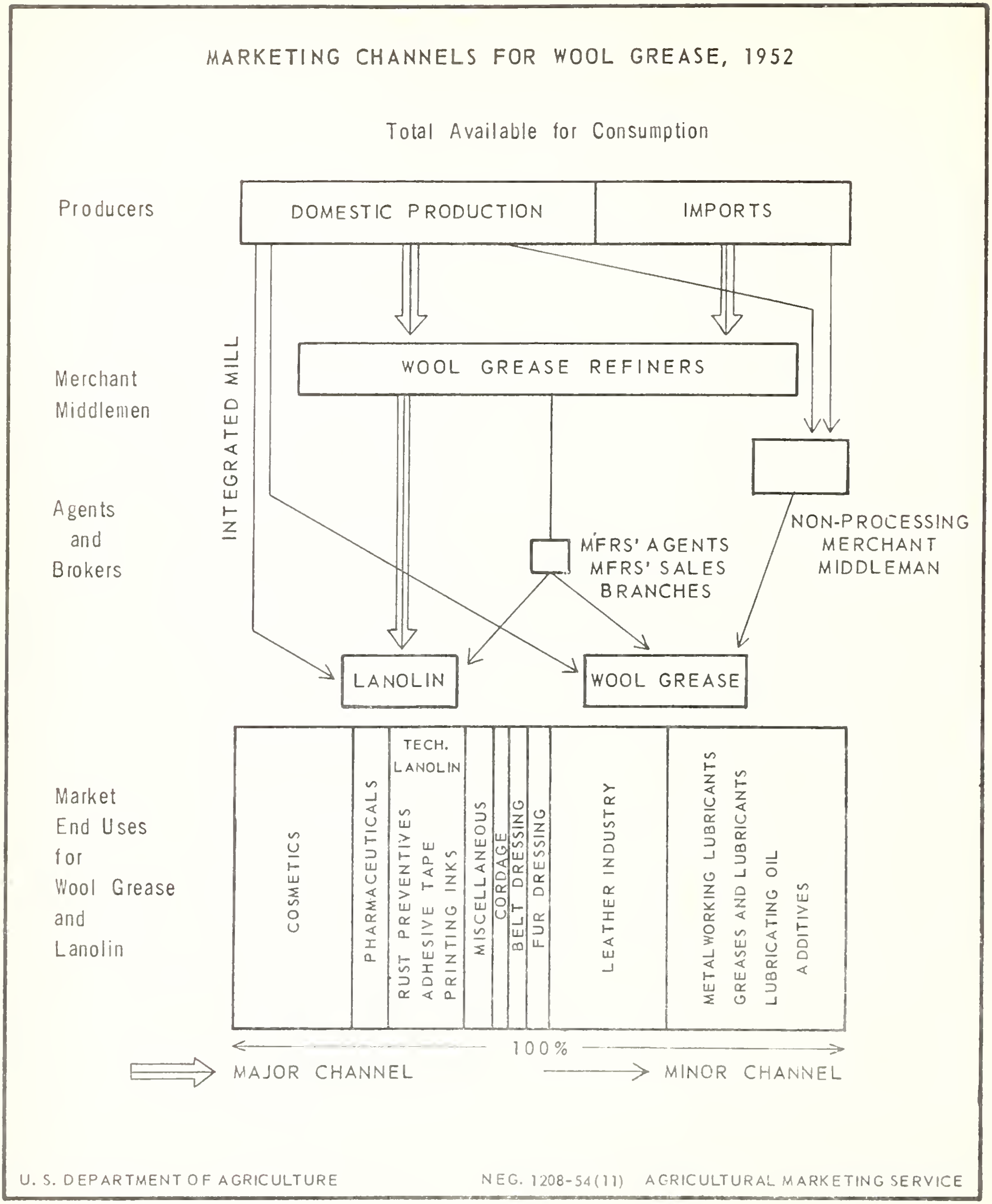
MARKETING CHANNELS FOR WOOL GREASE, 1952
Total Available for Consumption
Producers
DOMESTIC PRODUCTION
IMPORTS
Merchant Middlemen
WOOL GREASE REFINERS
INTEGRATED MILL
Agents and Brokers
MFRS' AGENTS MFRS' SALES BRANCHES
NON-PROCESSING MERCHANT MIDDLEMAN
LANOLIN
WOOL GREASE
Market End Uses for Wool Grease and Lanolin
COSMETICS
PHARMACEUTICALS
TECH. LANOLIN
RUST PREVENTIVES
ADHESIVE TAPE
PRINTING INKS
MISCELLANEOUS
CORDAGE
BELT DRESSING
FUR DRESSING
LEATHER INDUSTRY
METALWORKING LUBRICANTS
GREASES AND LUBRICANTS
LUBRICATING OIL
ADDITIVES
100%
MAJOR CHANNEL
MINOR CHANNEL
U. S. DEPARTMENT OF AGRICULTURE
NEG. 1208-54(11)
AGRICULTURAL MARKETING SERVICE

Figure 12

than 50 inquiries within 2 months after he began operating asking for his output of wool grease. Selling was far more difficult during the early 1930's when mill yards and warehouses were stacked for months at a time with rusting drums full of grease. As this grease was a byproduct and could be held without additional cost, no financing was necessary, and little storage expense incurred.

The other marketing functions performed by the producing mills consist of: (1) Testing the grease for free fatty acid, moisture, and sulphur content; and (2) providing storage, although they did not need to do much of the latter during 1951 and 1952 because eager buyers took their output almost as soon as it was produced. Producers sell f.o.b. mill, allowing a 1 percent cash discount for payment in 10 days or the net amount after 30 days. Their small inventories eliminate much of the risk of price changes and require little financing. Most of their market information comes from the refiners. Their customers, whether refiners or industrial users, are better equipped and more competent to undertake a larger share of the marketing.

The refiners in the United States provide all of the marketing functions for lanolin and the grease they sell without refining, as follows:

Buying: The refiners are active in searching out sources of supply both in the United States and abroad, some even offering to finance the installation of grease recovery equipment. They stand ready at any time to buy any quantity of grease of any quality at the market price within the limits of their capacity to finance it. They regularly visit the mills in person to discuss the market situation and prices. They submit bids by mail for any lot offered by domestic or foreign producers. The prices they are willing to pay reflect the demand for their products. As importers they often buy the entire output of large mills in England, Germany, France, Italy, Japan, and other wool-consuming countries, dealing with them directly or through their agents abroad or in the United States.

Selling: The refiners are active in creating a demand for their products. They advertise in the trade journals of the several industries using their products and engage in personal selling. In expanding the market for his product the refiner usually approaches companies in the same field as others that are already using it and calls attention to the physical and chemical properties of his material that make it appropriate for a particular product or process. If the quantity available and the price are satisfactory to the purchasing agent, the refiner will furnish a few pounds of the grade required, with specification sheets and any other data that might help the customer's technical staff to evaluate its use. The refiners will rarely recommend a specific use or a formula unless the customer has adequate facilities and personnel trained to test the resulting product. They do not care to incur responsibility for a customer's process or the product's use.

The two largest refiners have sales representatives in Chicago to handle sales in that area. The same function is performed for other refiners by small chemical supply houses who, acting as drop shippers on a margin of 5 percent, have the material shipped directly to their customers. Some sales are also made through manufacturers' representatives. It is estimated that the volume of sales through these middlemen represents less than 10 percent of the total marketed through the refiners to industrial users.

One of the primary obstacles in selling has always been the fluctuation of the supply. It is an unfortunate paradox that this instability has sometimes made it difficult to sell even the amount of wool grease available. Industrial users require a steady and assured supply because they in turn must make commitments to their customers and are anxious to keep their share of the market. Some of the largest potential users of wool grease and lanolin have, therefore, refused to start using it at all and have accepted substitutes. The difficulty in changing product formulas is the most common reason for this type of sales resistance encountered by the refiners. To offset it they offer a supply contract to their customers, guaranteeing a minimum quantity to be delivered during the next 6 months or year. This simply means that they must be cautious in their selling and carry larger inventories. One of the sales arguments of the larger refiners is that they are able to advise customers well in advance of any material shortage or price increase. However, as in every other industry, there are a few "price buyers" to whom a uniform and assured supply means little. For a half cent per pound or less they will change suppliers.

As a byproduct,wool grease is not sufficiently important for any increased demand to affect the amount produced. Moreover, the long term supply prospect for wool grease is not reassuring as explained in the section on Wool Grease Supply in the United States. Domestic production of wool and consumption per capita have declined sharply since the war.

Transportation and Storage: Refiners usually buy and sell wool grease and lanolin f.o.b. shipping point in 55-gallon steel drums (with removable heads) weighing 400 to 450 pounds each, when filled. Shipments from the producing mills vary in size from less than a truckload to a full carload (95 drums), depending on the storage space available at the mill and the needs of the refiner. The drums are furnished by the seller and are returned at his expense (freight collect). A deposit of $5 may be required to insure the return of the drums. Shipments to industrial users are generally made in drums but occasionally in tank cars (165 drums) to large consumers, particularly oil companies.

The refiners find it necessary to maintain large inventories to assure a steady supply to their customers. Shipments of domestic grease are in transit less than a week. Imported wool grease takes from 15 to 45 days to arrive after date of shipment. Fortunately it is a stable product that does not turn rancid, discolor, or deteriorate like other greases while in storage. It can be, and often is, stored in the open in the steel drums in which it is transported. A steam coil or some similar method of heating is necessary to empty the drums.

Financing and Risk Taking: Compared to other industries, very little financing is necessary because only the refiners carry large inventories and they buy from, and usually sell to, companies that are much larger and financially stronger than they are.

This is not a seasonal business on the supply side or the demand side, as wool is scoured throughout the year and the industrial requirements for wool grease and lanolin, such as those for leather, lubricants, rust preventives, cosmetics, and pharmaceuticals, are also very steady. Hence there are no seasonal inventories to be financed except when price increases are expected and when wool grease is imported from overseas in increased amounts.

The principal risk assumed by the refiners is due to the fluctuations in the market price of wool grease. Large industrial consumers often require not only a 6-month or 1-year contract guaranteeing delivery of a minimum quantity, but also a firm price for that time. The refiner, therefore, must often assume for his customers the risk of price increases and has the expense of maintaining large inventories for their protection. It is not unusual for a refiner to have an inventory of more than 1 million pounds. However, such a contract is desirable because it enables the refiner to produce a certain grade of his product for an assured outlet. Price fluctuations have not been violent during the last decade, as shown by figure 11, and the prices of all grades move together. When the refiner pays more for crude centrifugal wool grease, he is able eventually to charge more for it. His margin does not vary widely.

Market Information: The refiner, moreover, is in the best position of anyone who produces, distributes, or uses wool grease to minimize the risks incurred not only by his suppliers both here and overseas but also by his customers. He watches new technical developments, notes the supply and price of other oils and greases that are good or close substitutes for his products, and keeps a vigilant eye on his competitors' activities. With this knowledge he tries to anticipate and prepare for the changes in market conditions that will affect his business.

The suspension of OPS price ceilings was foreseen in the early part of 1953. The refiners accumulated as much extra material as they could and then let their inventories decline when the producers refused to ship for several months in anticipation of price increases when Regulation 146 was lifted.

Standardization: Like most other industrial goods, wool grease is bought and sold from the producer to the industrial user on the basis of specifications. The refiner, for example, buys from the producer on the basis of moisture, free fatty acid, sulphur, and ash content. The industrial user buys from the refiner or importer on the basis of all of the specifications above plus additional ones for viscosity, color, and odor, and sometimes for special requirements as shown by the following example.

WOOL GREASE, REFINED

Specifications

Product shall be free of dirt and other foreign material.

TESTS

1.	Color	Medium to dark brown
2.	Dropping point, °F.	95-120
3.	Free fatty acid (as Oleic), percentage	10.0 max.
4.	Saponification number	100-140
5.	Iodine number	20-60
6.	Water, percentage	3.0 max.
7.	Ash, percentage	0.15 max.
8.	Mineral acidity	None
9.	Insoluble impurities (F.A.C. Method)	0.2 max.

The refiners have been directly responsible for the establishment of standards for their products, and this is one of their important marketing functions. It is not surprising to find the standards for all grades so well developed in this industry because:

(1) The refining process can be, and is, carefully controlled to produce a uniform product.

(2) Most of the lanolin produced from the refining of wool grease in the United States is used in cosmetics and pharmaceuticals. All of the lanolin in these uses must be of U.S.P. grade or better. U.S.P. specifications are comprehensive. See Appendix A for U.S.P. tests for identity, quality, and purity of Wool Fat and Hydrous Wool Fat.

(3) The various industries in which wool grease and lanolin are used are accustomed to buying all of their materials on the basis of chemical analysis and U.S.P. standards. Moreover, they employ trained personnel, usually industrial chemists, competent to set up and maintain standards for their products.

The marketing functions of industrial users of wool grease and lanolin are usually limited to buying and transportation. The purchasing agents of these companies usually buy on the basis of specifications furnished by their own professionally trained staff, a chemist, or a technical or research laboratory group in the company. The purchasing agent of a large company will usually buy from only one refiner and, on the basis of the size of the order and the need for the material, will obtain the best price that he can. There is no evidence of reciprocity practices in buying policies in this industry.

There is an exception in the drug industy to the general conditions stated above. Several large pharmaceutical supply houses buy large quantities(one of them buys nearly half a million pounds) of U.S.P. lanolin annually in bulk and sell it in 1-, 5-, 25-, 100-, and 400-pound units to manufacturers of proprietary products and to retail druggists. These wholesale drug companies, selling a full line of drugs, medicinal ingredients, some proprietary medicines, and sick room supplies, perform all of the marketing functions and are able to distribute lanolin on a nationwide scale at a much lower cost than the refiner or any other middleman. The limited amount of lanolin that small manufacturers and retail druggists can buy at one time makes the cost of selling this one item by the refiner prohibitive, but the wholesale drug salesman with a full line of drugs and sick room supplies is likely to get a profitable order each time he calls on a customer.

Circumventing the Refiner in the Channel of Distribution

The marketing structure of this industry has been remarkably stable. The reasons for the evolution and persistence of this marketing structure in its present form are both technical and historical. On the technical side it is apparent that lanolin can be obtained only as the result of a refining process. In the United States very few scourers produce enough wool grease and no industrial consumers use enough lanolin to make it economically worth while to operate their own refining plants even if they could develop a technically successful process. Industrial users would be extremely reluctant to depend upon overseas sources. Apart from all the other services he performs, the refiner's technical competence assures his place in the channel of distribution for lanolin (fig. 12).

There is another technical reason for the handling by refiners of nearly all the distribution to industrial users. A large proportion of the wool grease consumed in the United States is used in mixtures with other fats and oils and in formulas for various purposes. The physical and chemical properties of these mixtures are carefully determined by analysis and experiments to ensure their suitability. For example, wool grease of a certain grade is especially suited for use in inks that contain a large proportion of pigments of low oil absorption or high specific gravity as the grease improves their lifting and working qualities. It may constitute only 5 percent by weight of the total product, but for the industrial user it is extremely important that the wool grease he buys adds these qualities to his product. He therefore carefully specifies what these physical and chemical characteristics shall be.

Only the refiner can meet these specifications consistently with a uniform product; hence the industrial user prefers this source of supply. Even in those uses requiring only the lower grades of crude wool grease, such as fur dressing, where the specifications are not critical, the industrial users prefer a uniform product. Wool scourers have little control over the quality of the crude grease they produce because it depends on the origin and grade of wool they scour, the strength and age of their scouring liquors, and other factors, all of which may vary daily. In short, a producer cannot in most cases guarantee to deliver two drums of grease which are alike, and there is thus little chance for the industrial user to circumvent the refiner except in a few industries where specifications for wool grease are not critical and where there is price inelasticity of demand.

The use of wool grease in industrial lubricants is an example of the fact that the refiner can occasionally be eliminated from the channel of distribution. When metals are bent, drawn, bored, cut, extruded, shaped, or altered in form, a lubricant is needed. A variety of oils and greases, including wool grease, are used for this purpose. The demand for wool grease in this use is relatively stable and as wool grease is usually a small proportion of the lubricant and the latter in turn represents only a small part of the cost of the finished metal product, any fluctuation in the cost of wool grease will not alter the demand for it. A relatively low free fatty acid content and a low sulphur content are about the only specifications for wool grease in this use, and both of these can be met consistently by many producers.

The other reason that this marketing structure endures is a historical one. Nearly all of the producers and industrial users have been in their particular industries for many years and are aware of the extent of price fluctuations and shortages in the past. These shortages and price fluctuations have made industrial users wary of becoming dependent on one primary source of supply. Producers, on the other hand, are unwilling to depend on one industrial user or one use to dispose of their whole output. The refiners have in the past always been willing to buy a producer's whole output at the market price besides performing the functions of physical supply. Thus a ready market for the producer and uniform quality for the industrial user are the two principal reasons why the refiners are not easily circumvented in their marketing function, even when the product can be sold to consumers in its original form. Other less important reasons are that management in scouring establishments is production-minded and essentially conservative. Sales contacts for this byproduct lie outside the field where the other products of the scourers are sold. Usually the management prefers not to disturb existing relationships with refiners and undertake the trouble and expense of finding industrial users whose needs coincide with the quality and quantity of grease produced by the scouring mill.

The experince of Mill D, located in Massachusetts, is typical of those few that sell directly to industrial users and illustrates their motives for doing so. Mill D produces 10 to 12 drums of centrifuged grease per week. Approximately the same amount of grease is produced each week because the scouring department operates at an almost constant rate throughout the year. Like many other mills in New England, it buys wool top from combing plants to fill its need for wool beyond the capacity of its scouring department. Mill D sells around half of its grease output in small lots, 10 to 15 drums at a time, to a half dozen customers who use 50 to 60 drums per year. Their specifications are not critical except with respect to the sulphur content. Most of them make industrial lubricants, producing such specialities as steam cylinder oils, drawing compounds, and cutting oils, which are sold to a large number of metalworking firms. When the ceiling price on wool grease was lifted in March 1953, Mill D raised its price to its customers from 20 cents to 26 cents per pound and encountered little sales resistance. It sells the other half of its annual production to one of the refiners.

The reasons for selling directly to industrial users, as stated by the person in charge of wool grease sales, are familiar to all who have studied marketing. First, a higher price could be obtained for the grease sold directly to industrial users. The latter, on the other hand, pay less for the grease than if they bought from the refiners because they share the refiner's margin with the mill. Second, Mill D uses its direct sales as insurance against the fluctuating prices offered by the refiners. In the past the mill has been dissatisfied with its dependence upon the refiners as its sole outlet. Interviews with the industrial users established a third reason for direct sales. The purchasing agents of these companies preferred to buy directly from mills not only because of the lower price but also because the refiners gave less consideration to their small orders during the periods of shortage. However, none of the companies had purchased their entire needs from one mill or one refiner since the only solvent-grease producing mill closed down. They bought from several mills directly or from a mill and a refiner.

Wool Grease Exports

Sales of wool grease to foreign buyers fluctuate widely from year to year and offer only an uncertain outlet for domestic production. Tables 20 and 21 show the quantity and value of United States exports of domestic and foreign wool grease, by country of destination, for the years 1949-51. Prior to 1949 and after 1951, exports of wool grease (and lanolin) were not reported separately by the U. S. Department of Commerce but were included under Classification Schedule B with other greases. Prior to 1949 wool grease was included with hog grease exports (commodity number 085805), and after 1951 it was included in inedible greases and fats, not elsewhere classified (commodity number 085898).

Nearly all of the foreign grease exported from the United States has been refined into lanolin here. A large part of the domestic grease exports has also been refined and is widely distributed among countries in Western Europe and the Western Hemisphere. Canada and Mexico have been steady purchasers of substantial quantities of crude and neutral wool grease. Exports to Italy in 1951 were in large part due to the development of a fur-dressing industry there.

Table 20.- Exports of domestic wool grease, by country of destination, United States, 1949-51 (49)

Country of destination	1949		1950		1951	
	Quantity	Value	Quantity	Value	Quantity	Value
	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars
Canada	214,897	32,449	98,119	16,052	310,721	46,361
Mexico	36,946	8,277	118,072	17,603	434,384	77,685
Salvador	800	240				
Honduras	799	250				
Costa Rica	600	198	4,900	1,336		
Cuba	6,912	1,392	51,803	7,632	23,207	4,936
New Antilles	8,800	1,100	17,083	2,284	34,580	4,774
Guatemala			818	277		
Nicaragua			500	165		
Colombia	15,546	4,746	29,825	10,429	31,395	9,652
Paraguay	830	170				
Venezuela	10,547	2,774	36,555	7,916	15,410	5,559
Surinam			1,480	488		
Ecuador	800	214	1,200	357		
Peru	2,723	769	905	280	18,286	6,803
Bolivia			2,376	772	2,567	1,062
Chile	12,300	3,367	4,774	1,507	13,723	5,169
Uruguay			20,199	5,906	23,991	8,058
Argentina	11,024	1,700	27,812	6,665	423,520	162,167
Brazil	15,511	3,293			37,126	14,743
United Kingdom	11,856	2,371				
Belgium	3,497	706	130,595	20,567	657,622	90,287
France	4,622	1,743	9,220	2,952	9,573	3,634
Austria			109,200	20,966		
Switzerland	27,092	4,935	82,375	20,434	73,637	22,984
Italy	21,879	3,918	20,705	4,453	948,810	97,493
Denmark					15,466	5,256
Greece	4,354	1,491	7,913	2,595	14,590	5,901
Iran			4,888	800		
Israel P. A.	1,440	490				
Afghanistan			2,500	812		
Philippine Republic	1,150	390	931	305		
China			8,837	2,510		
Japan					50,136	16,721
Belgian Congo			1,760	466		
Union of South Africa	5,200	1,022	1,650	512	8,667	2,872
Countries under $1,000					14,594	5,652
Total	420,125	78,005	796,995	157,041	3,162,005	597,769

Table 21.- Exports of domestic wool grease, by country of destination, United States, 1949-51 (49)

Country of destination	1949		1950		1951	
	Quantity	Value	Quantity	Value	Quantity	Value
	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars
Canada			500	136		
Mexico	17,730	6,157	22,557	9,306	48,567	5,325
Cuba	1,895	225				
Colombia			800	248		
Paraguay			800	264		
Ecuador			397	130		
United Kingdom			9,052	7,082		
Germany			7,054	1,320		
Netherlands					11,023	1,020
Japan					24,408	7,476
Countries under $1,000					4,774	896
Total	19,625	6,382	41,160	18,486	88,772	14,717

Wool Grease Price Structure Analysis

The demand for wool grease is relatively steady during any given year because of the large amounts used with other materials in formulating industrial products and because these formulas are not readily changed. The steady demand is also due to the fact that it is used in processes where it is a very small part of the total cost. About 20 percent of the domestic output would be produced regardless of cost even in the long run because its recovery is necessary for stream pollution abatement. The other 80 percent of domestic centrifuged grease would continue to be recovered until its price fell below the variable costs of production, the greatest part of which is labor. It is therefore apparent that factors other than changes in demand and cost of production are important in the determination of wool grease prices.

Price-Making Factors and Their Relative Importance 30/

The most important long-term factor in the price of wool grease is the general level of industrial activity. The use of oils and fats in nonfood products (other than soap and drying-oil products) is closely associated with the trend of industrial production (2). Wool grease consumption also varies closely with the defense component of industrial production.

The total amount of fats and oils used in industrial products and processes has increased slightly, but the per capita rate in recent years has declined, owing largely to the displacement of soap by detergents, as shown by figure 13. A breakdown by major uses of the total volume consumed shows that the decline in use for soap was primarily responsible for the decreased per capita consumption. This was due to the advent of synthetic detergents after World War II. 31/ A rise in "other" industrial uses did not entirely offset the decline in soap use. Other industrial uses include various types of processes, chemicals, pharmaceuticals, toilet articles, rubber, textiles, synthetic organic detergents, tin and terne plate, metalworking, and many others. The increased per capita consumption of fats and oils in the other industrial uses named above has been due principally to the high level of industrial acitivity in the United States since World War II (41).

To the extent that its properties are unique and irreplaceable, wool grease shared in the increased demand for fats and oils in industrial uses. This increased demand in the long run has stimulated imports and has increased the price of wool grease. The price increases have weakened the competitive position of wool grease because nearly all of the fats and oils that are good or close substitutes for it have declined in price during the postwar years (41). These substitutes have in the long run partially or wholly replaced wool grease (and lanolin) in marginal uses.

The principal short-term factor that affects the market price of wool grease is supply. Except for several years during

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30/ A correlation analysis was made of the factors affecting wool grease prices. This analysis yielded unsatisfactory results. the details are reported in Appendix C, pages 151 and 152.

31/ Some synthetic detergents use a fat base, but most of them are made from petroleum derivatives or coal tar products. When fat is used, it has about 3-1/2 times as much detergent power as the same fat would have if it were converted to soap.

World War II and the period from June 1952 to March 1953, the prices of wool grease and lanolin have always reflected the relationship between the amount available for consumption and the demand by industrial users. This demand in turn is derived from the demand for their products by consumers. Because this demand, over short periods, is relatively constant, fluctuations in supply are more closely associated with short-term price fluctuations than with demand.

There has been a steady demand for wool grease and lanolin during the postwar period when the general level of industrial activity has been maintained at a high level. During these years the effect of a steady demand and a fluctuating supply on the price is shown for all grades in figure 11. A more clear-cut supply-price relationship for U.S.P. lanolin can be seen in figure 14 (11). There is a few months' lag between changes in price and changes in supply because it takes time for the refiners to process the material and to change price quotations in contracts with customers.

A secondary short-term factor (it is also a long-term factor as explained above) affecting the price of wool grease is the price of other (nonfood) fats and oils used in industrial products and processes. Wool grease and lanolin compete with many other animal and vegetable fats and oils; and, depending on what physical or chemical properties of wool grease and lanolin are being utilized (such as lubricating or emulsifying ability, cholesterol content, or melting point), these other materials are, in specific uses, good or close substitutes. Tallow, for example, is a close substitute for wool grease in leather stuffing and fatliquoring and in some industrial lubricants. It is available intremendous quantities as a byproduct of the meat-packing industry During the postwar period its decline in price from 18 to 4 cents a pound caused it to be substituted for wool grease in marginal uses. This is typical of the interdependence of supply, demand, and price among fats and oils in industrial uses.

Price Elasticity of Demand

In nearly all industrial uses the cost of fats and oils is only a small part of the final product, and hence a large percentage change in their prices would have little effect on the amounts consumed. This is true for inedible fats and oils in general and is essentially true for wool grease; however, it does not preclude the replacement of one fat or oil by another whose supply is more plentiful or whose price is lower, as in the example of tallow cited above.

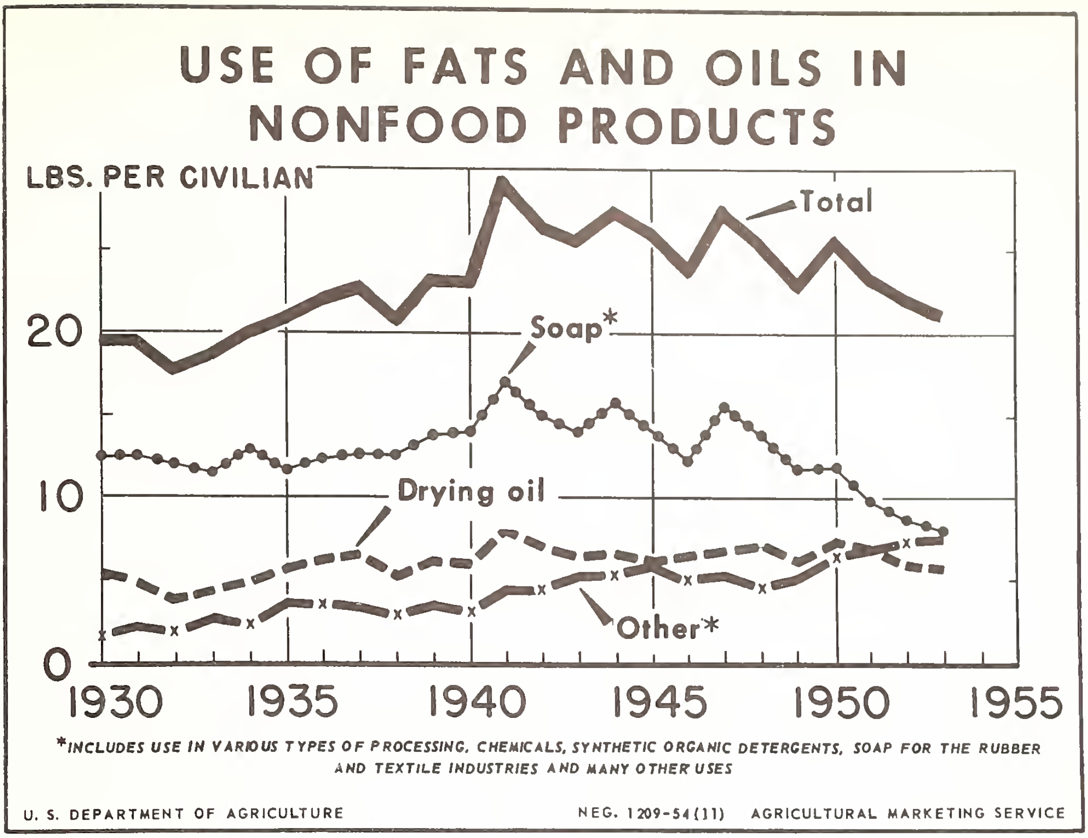

Figure 13

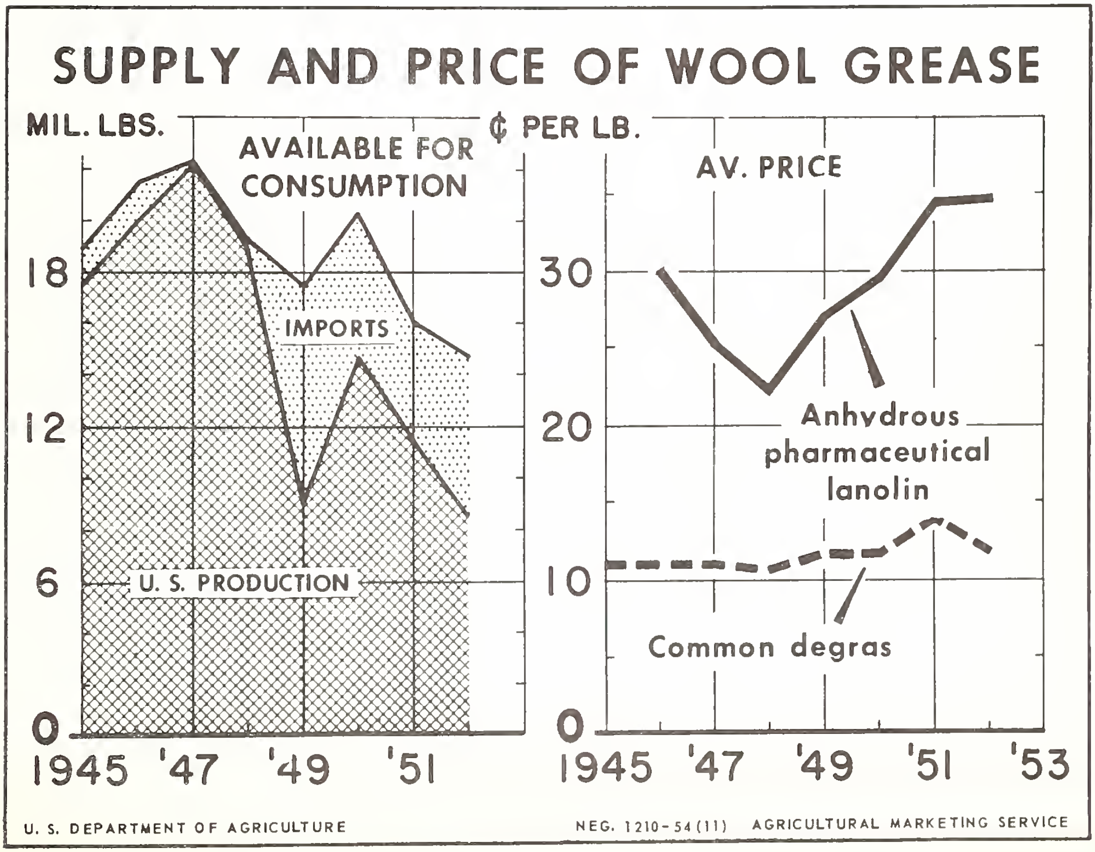

Figure 14

In certain uses where lanolin touches the human skin, as in cosmetics and pharmaceuticals, the demand for lanolin (from which the demand for wool grease is derived directly) is almost perfectly inelastic. This is due partly to its superior physical characteristics, such as its emolliency, its ability to form water-in-oil emulsions, its stability during long periods of storage, and also to the appeal which advertising has built for it among ultimate consumers. A glance along the shelves of any drugstore will persuade anyone interested in marketing that manufacturers and advertisers believe that, to sell any product these days, it is helpful to have lanolin in it. Nearly all of these products are formulated and are proprietary compounds that have wide profit margins and use a small proportion of lanolin. Limited price increases for lanolin can be absorbed, or, if necessary, smaller amounts of lanolin can be used. However, even in these uses there are substitutes,such as liquid and hydrogenated vegetables oils in cosmetics and benzolated lard and petrolatum in pharmaceutical salves and ointments. In these uses an increase in price within the normal price ranges has little effect on the amount consumed. However, the amount of wool grease (lanolin equivalent) demanded under these conditions is limited, probably not exceeding 2 to 3 million pounds annually; if the price of wool grease were to reach 40 cents per pound, the consumption of lanolin manufactured from it would fall off sharply.

In other uses, such as leather, cordage, rust preventives, and industrial lubricants, wool grease competes on a price and supply basis (that is, whether they are produced independently or are byproducts of a stable industry) with many other animal, vegetable, and marine oils, waxes, fats, and greases. Many of these materials possess physical characteristics in specific uses comparable to those exhibited by wool grease, such as being soft, unctuous, odorless, and colorless, or having plasticizing and lubricating properties or the ability to form a thin air-tight film on metals and to blend with other fatty materials. Outside of cosmetic and pharmaceutical uses there are few in which wool grease is indispensable. Moreover, even its unique or superior physical qualities are often outweighed in industrial applications by the more stable price pattern and supply characteristics of other materials. In the lower price ranges, therefore, in which it competes with petrolatum, tallow, cod and sperm oils, the demand for wool grease is relatively elastic, and it is estimated by the trade that amounts up to 30 million pounds could be sold.

During any year, if the supply of wool grease decreases, it will be marketed at higher prices to those users whose demand is relatively inelastic. During periods of increased supply, it will be distributed to users whose demand is progressively more elastic.

Effect of Price Fluctuations on Industrial Users

It has long been the accepted practice among the producers of wool grease to get the highest price possible for all of their production and to carry no inventories except in anticipation of higher prices. Contrary to the beliefs of most wool scourers, it is doubtful that the current practice of maximizing income in the short run benefits them in the long run. There are relatively few industrial uses in which wool grease is indispensable, as shown in the following section. The other oils and greases with which it competes can be used to obtain almost the same end result in an industrial process or in a product which meets the needs of an ultimate consumer almost equally well. In nearly all cases the industrial products in which wool grease is used are proprietary compounds that are sold on a performance basis and not for the specified amounts of certain materials they contain. Under these conditions the amounts of wool grease they contain vary widely.

Wool grease and lanolin are usually bought by the purchasing agents of large companies, who are well aware of the possibility of using other materials and are equally aware of the price and supply situation for these substitutes. When the price of wool grease and lanolin increases or they become difficult to buy in quantities needed, the technical staffs of the various companies are alerted to the situation. In many companies that formulate their products, the formulas are reexamined and the advisability of using less wool grease and more of another material that is more stable in price and supply is considered. Every year new compounds are developed that have specialized uses in the industries using wool grease and lanolin. This has been particularly true of petro-chemicals since 1949. During any extended period of high prices for wool grease, the refiners note that a few of the customers who are forced to substitute other materials are irretrievably lost. As a result, the refiners foresee a decline in the demand for wool grease as presently used and they are therefore developing new products from lanolin in an attempt to maintain their business on a sound basis.

WOOL GREASE AND LANOLIN IN INDUSTRIAL USES

Wool grease and lanolin are used in many products and processes in a variety of industries in the United States. All of those in which its use is of economic significance have been considered in this study. In order to analyze the relative importance of each use and its effect on the total demand it was necessary to seek answers to the following questions about wool grease (lanolin) in each industry.

(1) How is it used?

(2) What are the physical or chemical properties that make it desirable in this use in terms of an ideal product?

(3) How much was used in 1952 or in recent years?

(4) What are the available susbtitutes and to what extent can they be substituted?

(5) How critical is the price of wool grease (or lanolin) in each use?

(6) How was it marketed?

(7) What is the outlook in present industrial uses? Potential uses?

From interviews with industry people who use wool grease or lanolin in their manufacturing operations, it became apparent that any projection on a poundage basis as to the future industrial utilization pattern of wool grease was extremely hazardous. The large number of variables involved in such a projection makes it necessary to categorize the best estimate of future demand as an "educated" guess. Such variables as the volume of grease available, the consumption of apparel wool, the amounts of imported grease, the availability of cheaper substitutes, and other considerations indicate the difficulties of even an informed estimate of the future trend for wool grease.

Quantities of wool grease and lanolin used in 1952 by various industries are summarized in table 22. The petroleum industry was by far the largest user of wool grease--about 6 million pounds in 1952. The next largest user of wool grease was the cosmetics industry which consumed about 2 million pounds of lanolin. None of the other industrial users of wool grease consumed more than a million pounds each in 1952. In these industries, the magnitude of use ranged from less than 10,000 pounds to about three-fourths of a million pounds in 1952. Future estimates of the trend and outlook for wool grease in each present use also can be found in table 22.

In the following sections of this chapter the discussion of wool grease and lanolin in industrial uses parallels the refining process. Starting with the leather industry's needs for the least refined type of wool grease, the discussion follows the industrial uses as the wool grease is refined and its quality improved to the most refined lanolin to fill the cosmetic industry's demand.

Table 22.- Estimates of present markets for wool grease and lanolin by use, 1952, with estimates for potential markets 1/

Item	Wool grease	Lanolin	Total in 1952	Future trends and outlook
	Million pounds	Million pounds	Million pounds	
Major uses:				
Leather industry	0.75		0.75	Steady 2/
Fur dressing	.6		.6	Steady to expanded
Belt dressing	.4		.4	Very slow decline
Cordage	.35		.35	Steady; strong increase if price declines
Printing inks		0.1	.1	Steady, fair increase if price declines
Petroleum industry:			6.0	Excellent, use could easily double with steady supply at low price
Rust preventives		1.5		
Greases and lubricants	2.0			
Metalworking lubricants	1.5			
Oil additives	1.0			
Adhesive tapes		.4	.4	Steady, directly related to production of tape
Pharmaceuticals		.7	.7	Poor 3/
Cosmetics		2.0	2.0	Strong 4/
Minor uses:				
Agriculture			5/	No estimate
Paint	.03		.03	Steady
Tape, other than adhesive	.1		.1	Steady
Automobile polish	5/		5/	Steady
Sheep branding fluid	5/		5/	Steady
Veterinary salves and ointments	5/		5/	Steady; stronger if price declines
Rubber	5/		5/	Steady
Soap	5/	.25	.25	Steady, could improve with popularity of "lanolin"
Industrial hand cleaners and protectants		5/	5/	Steady to good

1/ Assuming a fairly constant supply with steady price conditions. The estimates are made on the basis of information gathered from industrial leaders during the course of the survey. 2/ Shoe orders by Defense Department can cause much greater demand. Consumption in war year 1951 totaled 1,750,000 pounds. 3/ Reinclusion of lanolin in U. S. Pharmacopeia could cause great recovery of demand in this use. 4/ At the present time there is a strong sales appeal when "lanolin" is included in cosmetic products. A decline in this appeal could seriously affect the use. 5/ Insignificant amount--10,000 pounds or less.

As the wool grease is refined and its price consequently raised the buyers of the product are able to be less price-conscious as their higher-markup end product allows for a greater spread available for price fluctuation.

Wool Grease in the Leather Industry

The principal use of wool grease in the leather industry is in stuffing or currying 32/ the upper leather known as Army Retan, used for Army shoes and combat boots and the best quality of heavy civilian work shoes such as those worn by miners. This leather is ordinarily 5-1/2 ounces in the bend area, and only 65 to 70 packer hides out of 100 are suitable for this use. Wool grease is also used in stuffing mixtures for heavy leathers, such as rigging and linesmen's belts, where pliability and high tensile strength are required. Some is used for sheepskins, goatskins, and the hides of other domestic animals tanned with the hair on. Small quantities are also used by curriers of transmission belting, textile machinery leathers, and harness.

In the primary process of tanning Army Retan leather all natural oils, fats, and greases are removed from the raw skins to accelerate penetration of the tanning chemicals. Stuffing is the operation in which the wet leather after tanning is impregnated with a large amount of oils and greases. 33/ It is done after the hide has been dehaired, split, chrome tanned, and rolled to remove the excess moisture. 34/ The stuffing operation consists of tumbling a pack of wet leather in a wooden drum at 200° F. while adding a mixture of oils and greases heated to 180° F. This mixture is absorbed in about half an hour and makes the leather soft, pliable, and water repellent. It also increases its tensile strength and resistance to tearing. In addition to its physical characteristics, which help to impart the desirable qualities listed above, wool grease acts as a plasticizer for the harder waxes used in the stuffing compound.

32/ These terms are used interchangeably because both refer to the application of oils and greases to wet leather (28, p. 745).

33/ When only a small amount of oil is to be added, it is applied in the form of an emulsion and is known as fatliquoring.

34/ Chrome tanned leather has a much greater resistance to heat and abrasion than vegetable tanned leather.

Federal Specification KK-L-311, General Specification for Leather and Leather Products, does not state that wool grease must be used in a stuffing mixture for Army Retan, but information received from several leather trade associations and from a representative sample of tanners and suppliers by means of interviews and questionnaires indicates that at present in the United States all tanners use from 12 to 15 percent of wool grease in their stuffing compound for Army Retan leather. This common degras varies from 10 to 15 percent free fatty acid and sold for 11 to 15 cents per pound during 1951 and 1952. Its price was 3 to 4 cents higher in June 1953. Tanners use it for the following reasons:

(1) It comes within the melting point range, 105° F. to 120° F. specified.

(2) It prevents the crystallization of other oils and greases used in the stuffing mixture.

(3) It is contained in the stuffing mixtures made up and sold to the trade suppliers.

(4) The research laboratory of the Tanner's Council of America, Inc., has prepared a helpful outline covering the technical aspects of manufactuing Army Retan leather for those tanners with little previous experience with it and recommends the following stuffing compound which contains wool grease. 35/

	Percent
Currier Vac Grease	25
Currier Hard Wax	25
Wool Grease	15
Moellon Degras	15
Tallow	20

The grease content (chloroform extractable) of Army Retan is 22 to 28 percent of the leather's dry weight; 15 percent of the grease content is wool grease.

The above information on present practice in leather tanning has been confirmed by information received by interviews and questionnaires from 18 of the largest tanneries in the United States, which produce more than 90 percent of Army Retan leather, and from suppliers of tanners' oils who sell ready-mixed stuffing compounds to the smaller tanners.

35/ O'Flaherty, Fred, "Military Chrome - Retan Upper Leather," (Unpublished study made by Tanner's Council Laboratory, University of Cincinnati, Cincinnati, Ohio, n.d.), p. 4.

For example, a typical stuffing mixture used by one of the largest tanneries in New England is as follows:

Army Retan Stuffing Mixture
(For 700 pounds of wet leather, pressed weight)

	Pounds	
Vatgrease W.	28	Soc. Vac.
Hardgrease No. 13.	42	Soc. Vac.
Vatgrease A.	3	Soc. Vac.
Wool Grease	12	
Waterless Moellon	15	
Total	100	

Another stuffing mixture 36/ is as follows:

Army Retan Stuffing Mixture
(For each 500 pounds of leather, pressed weight)

	Pounds
Waterless Moellon	15
Oleo-stearine	15
Vaseline	15
Wool Grease	30
Tallow	10
Cod Oil	8
Total	93

At present, consumption of wool grease in the leather industry varies principally with the output of Army Retan as its use in other types of leather is relatively steady. This will probably continue to be true in the future. In 1951, which was a peak year for military requirement, approximately 1-3/4 million pounds went into this use in the leather industry, apart from its use in other types of leather and fatliquors. In that year the output of Army Retan leather was approximately 80 million square feet. In 1952, preliminary estimates indicate that not more than 25 million square feet of Army Retan were produced so that consumption of wool grease in that use was probably not more than 3/4 million pounds.

In earlier years, when wool grease suitable for use in the leather industry was available in large quantities at low cost from a mill using the solvent scouring process, more than 3 million pounds of wool grease were used annually. "According to a survey made of 1950 operations, 3,725,981 pounds of wool grease were used by tanners."37/

36/ Modern Practice in Leather Manufacture by J. A. Wilson, p. 482. New York: Reinhold Publishing Company. 1941.

37/ Extract from letter from J. G. Schnitzer, Director, Leather Division, Technical Equipment and Consumer Goods Bureau, National Production Authority, Department of Commerce, dated March 17, 1953.

Wool grease is preferred for stuffing mixtures. However, substitutes are available on a price basis. These are: Moellon degras, sperm oil, cod oil, paraffin wax, petrolatum and other petroleum-based products, and tallow. The best substitutes are the oleo stearines, which are available in large quantities and are generally much lower in price than wool grease.

Although most of the tanners interviewed said they actually prefer wool grease in their tanning processes, many of them have cut down their use of wool grease for the following reasons:

(1) Many reasonably good substitutes are available from oil suppliers.

(2) Wool grease has priced itself out of the market.

(3) Uneven production of grease complicates their supply problem.

Nearly all the tanners indicated that they had used the grease formerly produced by a mill in Massachusetts that is now closed down, and many of them are currently using foreign grease only or as a supplement to fill out limited United States production.

Wool grease used by the larger tanneries and the larger suppliers of tanner's oils is always purchased in drums, not in tank cars, and usually in less-than-carload lots. Most of the wool grease is bought from refiners rather than directly from wool scourers. Because of the shortage of wool grease during 1952, the refiners, who buy most of the imported wool grease, allocated the domestic grease among their customers, because it was subject to low OPS ceiling prices, and made up the rest of their customers' needs from higher priced foreign supplies. The larger tanneries make up their own stuffing mixtures and fatliquors.

The smaller tanneries buy stuffing mixtures and fatliquors, in which wool grease is incorporated, as proprietary compounds from suppliers who also sell them many other oils, greases, fats, primary chemicals, finishes, and pigments used in other processes. They have few specifications for the materials they buy and depend on the suppliers to furnish them proper materials and to help them with their technical problems. A few of the suppliers stated that they considered wool grease indispensable in stuffing mixtures and that their consumption did not vary appreciably from one year to the next. It must be remembered, however, that the ingredients and the proportion of each in the stuffing mixture are not divulged by the supplier of tanner's oils to his customers. He sells a mixture that will produce a satisfactory end result, and as it is well known in the industry that heavy upper leather can be stuffed with a variety of oils and greases, it is therefore possible to vary the amount of wool grease in the mixture, substituting a cheaper material. In general the amount used varies inversely with the price.

For the usual buyers of wool grease in the leather industry there are two factors which make it economical and technically feasible to buy directly from the producers instead of through the refiners. First, the specifications are not critical; the free fatty acid content can vary between 10 and 25 percent, the wool grease does not need to be desulphurized, and color and odor are acceptable over a wide range. Second, the usual size of an order is less than a carload. This is convenient for the wool scourer to handle, and with several small customers he does not need to use valuable warehouse space. Both tanners and suppliers stated in interviews that they would rather buy from the wool scouring mills than from the refiners. They expected to pay lower prices to the mills and they counted on more consideration for their small needs when suppliers were short.

Wool Grease in Fur Dressing

Wool grease (common degras) is considered an indispensable ingredient in fur-dressing oils, and no completely satisfactory substitute has yet been developed. Its use in this industry is ordinarily limited to fancy furs (from wild animals). It is not used on rabbit, lamb, and sheep skins.

The conversion of raw furs into a condition suitable for garment use is actually a special case of leather tanning. The dried pelt received by the fur dresser is softened by soaking, is fleshed, and is tanned in a solution of salt and alum called the bite or pickle. After the skins are dried to a moisture content of 30 percent, kicking oil or grease 38/ is applied by swabbing directly on the flesh side of the pelt. The pelts then go to the kicker where the oil is kneaded or tramped into the skin, displacing the water present on the fibril surfaces. Following this the skins are drummed in sawdust to remove the excess oil and subjected to a number of finishing processes.

38/ This is a trade term for the mixture of wool grease and other materials applied to fancy furs to render them soft and pliable. The name is derived from the machine called a kicker which kneads the oil into the pelt.

The kicking process in fur dressing is analogous to the currying and stuffing processes of the leather tanner. A typical kicking oil contains 40 percent wool grease, and the other 60 percent is made up of fats, fatty oils, and mineral oil. The amount of wool grease used may vary from 30 percent to 50 percent of the mixture. Less is used as wool grease becomes higher in price.

Wool grease is useful in fur dressing, and in other industries, principally because it is a surface active agent. Wool grease when added to mineral oil causes the mixture to preferentially wet and spread on the damp surface of the leather. It wets not only the exterior surface but also the tiny leather fibrils which make up the structure of the leather. The water content of the skin is therefore especially important when the oil is applied. If too much water is present it will form a continuous liquid surface instead of penetrating into the skin structure. If too little water is present the fibrils will adhere to each other in an impervious mass. Because of its ability to pick up and suspend water in the form of a water-in-oil emulsion, wool grease will tolerate an excess of water content in the skin and still accomplish its purpose. The coating of wool grease and oil on the skin fibrils protects and waterproofs the skin to some extent. This is necessary if the pelt is to be subjected to subsequent wet operations such as dyeing. The softness, drape, stretch, and to some extent the durability of the finished pelt depends upon the degree to which each individual skin fibril has been coated with oil. This coating serves as a moisture barrier and a mechanical lubricant, allowing the skin fibrils to slide freely over each other and retarding the tendency to gelatinize and cohere when exposed to moisture after oiling.

Other properties of wool grease that make it useful to the fur dresser are its tackiness and plasticity range. Many furs are drummed from 5 to 10 hours with sawdust during the finishing processes. Other fats tend to drum out and are absorbed in the sawdust, leaving the skin dry and hard. Wool grease remains in the pelt.

The chemical stability of wool grease is useful in the leather and fur industries. It remains unchanged in the leather indefinitely. Less stable animal and vegetable fats and oils tend to break down into fatty acids and other decomposition products. In some cases the degradation process or its products are destructive to the leather, and undesirable colors and odors develop. Wool grease does not have these disadvantages.

Tallow can be substituted for wool grease in the kicking oil to some extent, but it is not as surface active nor as chemically stable as wool grease. Possible replacements for wool grease in whole or in part are sorbitol and mannitol esters and their derivatives, polyoxyalkylene amides and amines, polyoxalkylene and glycol esters, blown rapeseed oil, oxygenated hydrocarbons, and segregated and blown fish oils. The last two compete with wool grease in price but are not as effective in use.

Although many of these products are superior to wool grease when considered solely as oil-soluble surfactants (surface acting agent), most of them lack secondary properties such as color, odor, tackiness, and plasticity range. In addition they may have detrimental characteristics of their own. These deficiencies must be made up either in the formulation of the fur dressing oil or in adjustments in the fur dressing method. Consequently they cannot be considered as serious competitors with wool grease except during periods of scarcity or high price. The same situation holds true in varying degree wherever wool grease is used. The principal danger is that substitute products will be allowed to occupy the market long enough to become entrenched through adjustment of methods and materials.

Several reasons militate against the use of wool grease substitutes in this industry. The fur dresser does not own the skins he processes; consequently he has little to gain and much to lose by experimenting with other materials. Any change, however small, in color, texture, odor, or other characteristics of the finished pelt is usually interpreted as deleterious by the owner of the skins or the manufacturer of fur garments. The pelts are then less readily salable. Even an improvement may become a liability to the fur dresser who is held responsible for anything that happens to the skins. The perishable nature of furs and their value make it hazardous to tamper with established practice. Changes would require research facilities the industry does not possess. Finally, wool grease is normally the cheapest and best material available.

At prices prevailing at the time this study was written (1953) of 13 to 15 cents per pound, wool grease was still from 2 to 3 cents cheaper than the nearest single competitive product and 5 to 8 cents per pound cheaper than any effective mixture that might replace it in the fur industry. However, an assured supply is considered even more important than price.

Fur dressers are not direct purchasers of wool grease as are some tanners. The wool grease they use is supplied to them in fur dressing oils compounded principally by four manufacturers. The largest of these firms used approximately 1 million pounds of common degras annually in 1947, 1948, and 1949, which was about two-thirds of the total consumed in this industry during those years. The sale of furs has declined steadily since 1950 and was probably at a record low in 1952. During this year only about 600,000 pounds of wool grease were used, owing not only to declining fur sales but also to a critical shortage of wool grease. 39/ Based on discussions with industry leaders, it is estimated that if the supply of wool grease were stable, the industry could use from 750,000 to 1,000,000 pounds at prices prevailing in 1952, even in poor business years, and in peak years these figures would be doubled. The fur dressing industry is particularly subject to fluctuations due to taxes, fashion, and the level of consumer incomes.

The whole fur dressing industry, including the suppliers of fur dressing oils, is concentrated in the New York area. The size of the latter firms and their location make it economically feasible for them to buy directly from wool scourers abroad. Most of the wool grease available for import has a high free fatty acid content and is suitable for this use without further processing. Nearly all of the wool grease used in fur dressing in 1952 was imported directly by the suppliers of fur dressing oils rather than through the refiners, import brokers, or merchant middlemen. The suppliers would prefer to buy directly from domestic producers but they find the supply of common degras usually scarce and its price generally higher. 40/

Wool Grease in Belt Dressing

Almost all commercial belt dressing contains wool grease and most manufacturers consider it an indispensable ingredient. However, due to the increased use of composition V-belts and direct drives in place of leather belts and overhead shafting, the demand for belt dressing is declining.

The longer a belt is at work the more its original dressing disappears. To replace the oils that have volatilized in the belt's operation, to lubricate the leather fibers, and to preserve its natural elasticity the belt should be redressed. Belt dressing acts as a cleanser for the belt surface and restores

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39/ One bright spot in this industry is that the fur dressing oil manufacturers have been supplying increasing amounts of fur dressing oils to the Italian fur industry during the past 2 years.

40/ It is produced by only three mills in the United States.

the natural pulley gripping qualities of the leather. Belts may accumulate mineral oil and grease from the drive motor or nearby machinery that will cause them to slip. This should be cleaned off before the dressing is applied. Neatsfoot and castor oils and wool grease can be used to lubricate and preserve the leather and increase its tackiness. Most commercial belt dressings contain about 50 percent wool grease.

Another form of belt dressing is made in sticks, and contains about 50 percent wool grease. It is a temporary expedient used simply to increase the coefficient of friction between the belt surface and the pulley. Rosin and small amounts of beeswax, neatsfoot oil or castor oil are the other ingredients. Some fish or animal glues may also be used in place of the rosin. The wool grease acts as a stable plasticizer and vehicle for the other ingredients and lubricates the leather surface fibers to keep them pliable and prevent cracking. Although the application of belt dressing containing rosin prevents the belt from slipping by increasing the surface friction between the belt and drive pulley the crystalline structure of this ingredient causes it to cut into the leather fibers on the belt's surface and leads to increased wear and deterioration. Most of those who manufacture belt dressing deplore the use of rosin but feel that they will lose a part of their market if their product does not contain it.

The manufacturer's specifications for wool grease are not critical. They can use a dark-colored grease with a free fatty acid content of 15 to 20 percent and odor is not important. With these specifications it would be possible for belt-dressing manufacturers to buy directly from scourers either in the United States or abroad. Most of the larger manufacturers have used imported grease for the last 2 years due to the scarcity of domestic supplies of this quality but have bought it through Unites States refiners or importers acting as brokers or merchant middlemen. It is estimated by informed industrial representatives that approximately 400,000 pounds of crude wool grease are used annually in belt dressing.

Some of the manufacturers of leather belting either make their own belt dressing and recommend it for use on their belts or they buy it in bulk from a belt-dressing manufacturer and package it under their own brand name. Nearly all of it is sold to industrial users at about 75 cents per pound through mill supply houses and jobbers.

Wool Grease in Cordage

Cordage oil is used in the manufacture of all Manila rope as a fiber-surface lubricant and for protection from moisture while the rope is in use. Cordage oil is necessary in all rope making to lubricate the fibers in the combine and drafting operation. Cordage oil enables the rope to stretch and bend easily without internal friction or fiber breakage. Cordage oil constitutes 14 to 15 percent of the total finished weight of the rope, and wool grease may constitute up to 15 percent of the weight of the cordage oil.

The major part of all cordage oils consists of mineral oil equal in viscosity to S.A.E. 10. As rope is sold by the pound, it is advantageous to use an oil as heavy in weight (not viscosity) as possible and in amounts up to 15 percent maximum. Beyond that point the lubricant can be substituted for fiber only at a sacrifice of breaking strength in the product. Most of the large oil-refining companies sell three grades of mineral oils for cordage lubricant: Coastal at 13 cents a gallon, paraffin at 14 cents a gallon, and solvent process at 19 to 20 cents a gallon. Other oils or greases such as high grade tallow and other stearines may be added, but wool grease is preferred because it is physically stable in use; that is, it does not turn rancid or darken in color. Experience has shown that a mixture of wool grease and mineral oil spreads more evenly and that a greater amount of lubricant sticks on the fiber than when mineral oil is used alone.

About 20 establishments produce nearly all of the rope manufactured in the United States. Two of these firms produce about half of the total amount. Nearly all of those who responded to a questionnaire survey of this industry mentioned that they had formerly used wool grease from a mill in Massachusetts that is now closed. Apparently a substantial portion of the mill's grease was used in cordage. It averaged 8 to 10 percent free fatty acid and at 12 cents a pound was very satisfactory. It was the loss of this relatively cheap source of supply when the mill closed in 1950 that led to the use of refined tallow and other greases and waxes with the basic mineral oil.

The United States Navy is a large user of wool grease in cordage at the present time. The Navy became interested in mildew-resistant treatment of all cordage as a result of World War II experiences in the South Pacific. The Boston Navy Yard produces about 5 million pounds of rope and uses approximately 100,000 pounds of wool grease annually. This wool grease is purchased on bids submitted by the refiners under Navy Department Specification 14G7a, February 15, 1946.

Although no actual data exist as to the number of pounds of Manila rope manufactured annually in the United States, the Cordage Institute estimates that average annual sales are about 75 million pounds excluding sales to the Federal Government. Annual sales to the United States Government are about 15 million pounds. This would mean a potential market for about 2 million pounds of wool grease annually in cordage. However, it is doubtful whether more than 350,000 pounds was consumed in this use in 1952. It is apparent that its use in cordage is dependent upon defense procurement. During World War II the output was approximately three times that of a normal peacetime year. However, it is not hard to start or stop the use of wool grease in this industry as there are no formulation problems.

Cordage manufacturers have no specifications for wool grease except a maximum of 15 percent free fatty acid and not too dark a color. The sulphur content is not considered too important in this use by the trade. 41/ These requirements make it technically possible and economically feasible for the cordage manufacturers to buy domestic grease directly from the wool scourers and imported grease through brokers. The cordage manufacturers do not use large quantities of wool grease; their production is steady throughout the year; they usually have warehouse space and the financial ability to carry an inventory sufficient to meet their needs for a few months if their supply is cut off until they can find another source. As it is not indispensable they can discontinue its use altogether. The principal deterrent to the use of wool grease in cordage is its price. A lower price and a steady supply would cause most of the purchasing agents for cordage manufacturing establishments to reconsider its use.

Wool Grease and Lanolin in Printing Inks

Wool grease is used in printing inks as a lubricant to improve their working and setting qualities, as a plasticizer or extender, and as an agent to retard the penetration of the ink, thus reducing strike-through in printing. Wool grease has more length or string than most other waxes and greases, which makes it useful in printing inks. It also has the ability to hold small amounts of paraffin or beeswax in suspension, thus preventing

41/ From a technical point of view, it seems that the sulphur content of wool grease for cordage lubrication would be an important consideration. On exposure to air (and in this application conditions would be ideal for maximum exposure) sulphur is oxidized to acid products that would cause deterioration of cordage fibers.

them from crystallizing out of the inks and causing graininess after the ink has set. Lanolin can be used in overprint varnishes to reduce picking or lifting and to permit smooth and uniform printing.

Ordinary inks are mixtures of pigments, oils, varnishes, and driers and vary widely in their composition, depending on the kind of printing press and the type and grade of paper on which they are to be used. When special qualities are desired or when it is necessary to eliminate offsetting, sticking, or picking, various combinations of waxy or greasy compounds are added to the basic mixtures. Wool grease, tallow, beeswax, and vegetable and mineral waxes are suitable for this purpose. They act as emulsifying and dispersing agents preventing flocculation or agglomeration of the pigment particles. They also tend to break up the gel formations of the varnishes by reducing their cohesion and adhesion.

Soap was used for this purpose in earlier years but suffered from the disadvantage that it had to be cooked into the ink mixture. Wool grease, amber petrolatum, or the calcium or sodium soap greases, which are of varying viscosity, can be used more economically. One author states, "Wool grease is especially suited for use in inks that contain considerable proportions of pigments of low oil absorption or high specific gravity, as it tends to improve their lifting and working qualities. Its principal use, however, is in combination with either paraffin or beeswax as a noncrystallizing compound for use in first color, opaque, process yellows." (57)

Inks of various kinds are manufactured by nearly a hundred establishments in the United States. Not all of them use wool grease and lanolin. Their use depends on the kind of ink produced and on the price of wool grease. Wool grease and lanolin are always a small proportion of the total weight of the finished product. In answers submitted to an industry questionnaire it appears as though most ink manufacturers would use from 3 to 10 percent of wool grease in their lithographic inks and specialty products. However, price is an important consideration. An increase in price causes them to lessen the amounts of wool grease used or eventually to eliminate its use entirely.

Although most authorities believe that there are adequate substitutes for wool grease and lanolin in the formulation of printing inks as mentioned above, a few of the companies surveyed consider this material unique in the qualities it adds to their product and feel that it is indispensable in this use.

The United States Government Printing Office in Washington, D. C., uses approximately 4,000 pounds of anhydrous neutral wool grease annually in the manufacture of mimeograph inks. The formula contains 80 percent wool grease by weight. 42/

Since wool grease and lanolin are used in only a few types of printing inks in small proportions, the total use in this industry is not large. The largest single user in this survey consumed a total of 30,000 to 40,000 pounds of wool grease and lanolin annually. The usual amounts reported were between 1,000 and 2,000 pounds. "Sixty of the largest ink makers reported a total of 150,000 pounds of all animal base fats and soaps for the year 1951." 43/

From the data collected in this survey, a conservative estimate is that 90,000 to 100,000 pounds of wool grease and lanolin are used annually in printing inks in the United States. The demand for them is quite steady by some companies who believe that they are indispensable in their product. Other companies use them strictly on a price basis, using a substitute, such as tallow, when it is lower in price, or eliminating wool grease altogether from their formulas. There is no significant potential market here that is not supplied. Maximum use in this industry would probably be about 130,000 pounds annually.

Wool grease and lanolin are purchased by specification from the refiners in less-than-carload lots as needed. The products in which they are incorporated are sold under various trade names as being suitable for a particular use. They are not sold as containing specific amounts of certain ingredients, and hence the amounts of wool grease and lanolin may vary each year.

Wool Grease and Lanolin in the Petroleum Industry

The petroleum industry uses more wool grease than any other and offers the greatest potential market for any additional amounts that might be recovered in the United States or imported from abroad. Quantities of wool grease used in lubricants and greases in 1944-48 are shown in table 23. Census data are not available

42/ Extract from letter from Mr. M. S. Kantrowitz, Technical Director, United States Government Printing Office, Washington, D. C., dated December 23, 1952.

43/ Extract from a letter from the National Association of Printing Ink Makers, dated March 19, 1953.

Table 23.- Wool grease available for consumption and used in lubricants and greases, 1944-48

Year	Available for consumption	Used in lubricants and greases (47)	
		Total	Percentage
	1,000 pounds	1,000 pounds	Percent
1944	17,077	5,200	17
1945	18,812	4,387	23
1946	19,959	3,457	19
1947	22,329	5,983	27
1948	19,164	5,583	29

for more recent years, but based on discussions with industry leaders it is estimated that approximately 6 million pounds of wool grease were used by the petroleum industry in 1952 out of a total available supply of 14 million pounds. Considering the increase in price that took place between those years, the use of wool grease in the petroleum industry is very steady. The industry uses wool grease in four classes of products as shown by the following estimates:

	Million pounds
Rust preventives	1.5
Greases and lubricants	2.0
Metalworking lubricants	1.5
Lubricating oil additives	1.0

Rust Preventives

Technical lanolin is used as a temporary rust preventive on metal parts. It has a free fatty acid content of 0.5 percent to 1 percent and a very low ash and moisture content. From the refiner's viewpoint, this is the material which has been refined but often does not quite meet the U.S.P. tests.

Temporary rust preventives, also known as slushing compounds, are intended to protect metal against oxidation and corrosion during the intervals between manufacture, assembly, shipment, and use. This usually represents a period not exceeding six months.

Straight petroleum oils are not satisfactory rust preventives since their efficiency is simply dependent upon the waterproof layer which keeps moisture from the metal. They can be easily displaced from the metal surface by water. The protection petroleum oils afford can, however, be increased by the addition of lanolin and petroleum sulfonates.

In tests carried out at 90 percent relative humidity and 35° C., lanolin or lanolin added to petrolatum was found to be effective, although some staining was noted, probably due to the presence of acidic constituents or sulphur compounds (40).

Commercial temporary oil rust preventives are a mixture of a light petroleum distillate, such as kerosene, and 10 to 25 percent of technical lanolin. Petroleum sulfonates may also be added. The metal parts are usually dipped into the mixture and allowed to drain, but they may also be sprayed, brushed, or swabbed. The light petroleum base evaporates leaving a thin, plastic film which adheres tenaciously to the metal and effectively inhibits corrosion and oxidation. Whole engines can be dipped before shipment, and no further treatment is necessary to prepare them for use. The coating on internal parts serves as a lubricant when the engine is started. The protective coating can be wiped off the external parts if desired. Compounds containing lanolin used by the Armed Forces include AN-C-124a Soft-Film Corrosion Preventive and MIL-C-6708 Compound Exterior Surface, Hard Film Corrosion Preventive.

The effectiveness of lanolin as a temporary rust preventive is due not only to its chemical and physical stability, (that is, it does not turn rancid when exposed to air and can form a thin, tenacious film) but also to its properties as a surface active agent. It absorbs more tenaciously to the metal surface than does water and builds up a film of emulsion which is not easily displaced and which offers high resistance to the diffusion of water and oxygen.

Substitutes for lanolin in this use are numerous, depending on the interpretation of "temporary." Oxidized petrolatum is used extensively. It is sold to steel mills as a suitable replacement for wool grease. It is both cheaper and more plentiful than lanolin. No qualitative data are available as to its effectiveness.

Petrolatum can also be used with rosin oil and a corrosion inhibitor, such as sodium or potassium bichromate. Other substitutes for lanolin are micro-crystalline waxes from crude petroleum fractions, and spermaceti wax, which has some merit in this use. Sperm oil has been used but is not as effective a barrier against moisture.

The use of lanolin as a rust preventive fluctuates widely. It was large during World War II, when 4 to 5 million pounds went into this use annually. It decreased to not more than 1-1/2 million pounds in 1952.

A substantial part of the rust preventives containing lanolin is supplied to other industrial users by a major petroleum refiner and a manufacturer of oil compounds for naval and marine uses.

Greases and Lubricants

Lubricating greases are mixtures of mineral oils and a soap in a semisolid, stiff paste form. The conditions of use determine the relative proportion of oil and soap, the fatty materials used in making the soap, the metal base used in forming the soap, the degree to which the soap is hydrated, and the method of solidifying the grease after the soap and oil have been heated to a high temperature to obtain a homogeneous solution. The principal fatty materials used in making the soaps are inedible tallow and greases such as those shown on the following pages. The metallic components are usually sodium, lithium, calcium, potassium, aluminum, or barium. Lubricating greases may also contain graphite, rosin, petrolatum, and asphalt, depending upon the intended use.

Wool grease, rapeseed oil, sperm oil, and others of the higher fatty acid type can be added to greases in small quantities to increase oiliness by improving the load-carrying ability of the film. The action of these oils is similar to that which they perform in liquid lubricants.

Neutral, desulphurized wool grease is used in steam cylinder oils whose basic ingredient is a still residue known in the trade as 600 W stock with a viscosity of 210 to 250. Typical concentration for a good lubricant for a steam cylinder with low pressure wet steam is 3 to 6 percent. Wool grease may also be used for lubricating metal surfaces under superheated steam pressure, 700 to 800 pounds per square inch, in which it acts as an emulsifying agent.

Metalworking Lubricants

When metals are worked in such processes as machining, grinding, stamping, spinning, drawing, blanking, molding, rolling, forging, and extrusion, lubricants are necessary between the forming tool and the work metal to cool, lubricate, and cushion both the tool and the work. These lubricants must be provided in areas of high unit pressure (boundary lubrication). They may also be needed to minimize surface friction, thus precluding temperature rise, and to dissipate the heat (physical cooling) generated by the deformation of the metal. They also act as an antiweld agent, prevent adhesion and pickup, prevent wear on tools and dies, and flush away ordinary contaminants, such as dirt and scale, from the working surfaces.

Because of the different physical properties of the work metals and tools, the number of processes used, and the great variety of conditions, such as speed and temperature, under which the operations are carried on, it is apparent that metalworking lubricants must be highly specialized to meet specific needs. Because no one lubricating material has all of the necessary physical and chemical qualities, many different kinds of mineral oils, fatty oils and fatty acids, waxes, soaps, minerals, synthetic chemical compounds, and water are used in blends or compounds that can meet the necessary mechanical, metallurgical, and chemical conditions. Most metalworking lubricants have a mineral oil base, not only because this material is plentiful and cheap, but also because with the addition of sulphur, phosphorus, and chlorine compounds it can form, under conditions of extreme pressure, a smooth, microscopically thin film in place of the normal oil film.

The addition of a fatty oil to mineral oil increases lubricity or "oiliness" and adds to the load-carrying ability of the oil film. The addition of fatty oils is also advantageous under high heat conditions. The fatty oil will move toward the hot spot and provide lubrication whereas the mineral oil will fry up into little spheres and leave the surface dry. This spreading quality of a fatty oil, due to its more rapid lowering of surface tension, accounts for the higher load-carrying ability of the compounded oil. There are many applications where it would be difficult to provide oil films without fatty oil additives. Fatty oils are not often used alone because they become rancid when exposed to air. This is a field where the physical and chemical properties of wool grease make it valuable, and its potential application is many times its present use. However, it must compete with the fatty oils (tallow, lard oil, sperm oil, castor oil, rapeseed oil) which have similar properties. In some cases the supply of these oils is almost unlimited, and some of them are cheaper than wool grease.

Following is a description of the different metalworking processes and the lubricants in which wool grease is used or is potentially useful, depending upon its price and supply.

Drawing Compounds: Drawing compounds in paste or fluid form are used to minimize friction and wear on the die used in metal-forming processes known as drawing. Minimizing friction decreases the hot spots and gives a better-looking surface on the finished product by eliminating metal tears and scratches. These compounds are used for tubing, bars, rods, and wire, all of which are pulled through dies, and in press drawing, stretch forming, and metal spinning. Their function is to cool, to lubricate under extreme pressure, and to cushion the contact of the metal surfaces. Steel tubes and bars are covered with a baked lime coating before drawing, and a mineral oil or mineral plus fatty oil is allowed to flow onto the stock just as it enters the die. Only mineral oils or mineral and fatty oils are used for lubricating nonferrous metals.

Ferrous and nonferrous rod and wire drawing processes are sometimes lubricated by dry sodium soap compounds but more often by emulsions of fats, fatty oils and acids, soaps (sodium, potassium, and aluminum), and sulfonated oils in water. The fatty oils most commonly used are tallow, lard, palm, and rapeseed oils, and wool grease. The fatty oil emulsion is circulated on the die and on the metal for its cooling as well as its lubricating effect. The fatty acid maximum for nonferrous metal is held to less than 1 percent but may range up to 3 percent in ferrous metals.

In press drawing, stretch forming, and metal spinning a great variety of soaps, fats, emulsions, oils, and grease compounds are used as lubricants to preserve the die, to produce a good finished surface, and to prevent seams, wrinkling, and fracture of the work metal. They are applied by spray or hand swab. For copper and brass the lubricant usually contains from 5 to 15 percent fatty oils. For aluminum, magnesium, and zinc, mineral oil with a high free fatty acid content, 10 to 20 percent, is used. The viscosity of the lubricant depends in all cases upon the thickness of the work metal and the depth of the drawing or cupping.

Metal Cutting Oils: Metal cutting with pointed tools, which also includes grinding, honing, and lapping, uses approximately half of all the fluid lubricants consumed in metalworking. Wool grease has a high potential market in this field because of its emulsifying properties, and because it does not become rancid as does lard, which is widely used. However, it is used very little at present because of its fluctuating price and supply.

Cutting oils should not turn rancid or develop offensive odors. When used as an emulsion, they should not gum or rust the machines or the work. The lubricants used in metal cutting are inactive mineral oils to which 10 to 25 percent of fatty oils, such as tallow, lard, rapeseed, and sperm oils are added, and activated mineral oils containing sulphur, chlorine, and phosphorus. The latter are more commonly used in industry at present because they are high-pressure lubricants.

Emulsions of mineral oil and an emulsifier base, or of soap plus fatty oils with water are also used where the cooling effect of the lubricant is desirable. However, tool edges do not last as long with emulsified lubricants as with the straight mineral oil type. Light mineral oils having a Saybolt viscosity of 100 to 150 seconds at 100° F. are used in cutting oil emulsions. An example of an emulsified cutting oil is as follows:

	Percent
Mineral oil	80
Rosin oil	5
Potash	2
Wool grease	5
Blown rapeseed oil	8

Other fatty oils are substituted for wool grease when they become cheaper.

Another typical formula with a sulphur chlorinated mineral oil base is as follows:

	Percent
Mineral oil	80
Sulphur	1
Chlorine	1
Fatty oil	18

An important requisite of all formulas for industrial lubricants in the petroleum industry is that the ingredients must be available in large quantity and at reasonable cost.

Mold Coatings: Mold coatings include a wide range of materials used to protect the die or mold surface and to prevent adhesion of the cast material to the mold. Coatings used in casting steel ingots are aluminum powder suspensions, pitch, and tar. For molding copper and brass the following mold coatings are typical:

(1) Fatty oils and mineral oils.

(2) Pigments such as mica or graphite suspended in mineral and fatty oil mixtures.

(3) Fatty oils such as lard, tallow, wool grease, rapeseed, and hydrogenated fish oils.

All of these are volatilized and flashed off when the molten metal is poured into the mold. They compete in this use on the basis of price and supply, and the use of wool grease has gradually declined.

Extrusion Lubricants: Ferrous and nonferrous metals can be forced through a die while hot or cold to give them the desired cross sectional shape. Lubricants for hot extrusions usually contain graphite suspended in an oil-soluble soap. Tallow, rapeseed oil, and wool grease have been used as cold extrusion lubricants for steel as a final coating, but present industrial practice is to dip the metal pieces covered with the phosphate solution into dilute sodium stearate solutions containing small amounts of free fatty acids, chlorinated waxes, lard, or sulfonated tallow. Cold-extrusion lubricants for nonferrous metals are applied by dipping and air drying. They usually consist of some combination of lard, beef or mutton tallow, wool grease, soap, and beeswax. Aluminum extrusions are lubricated with a compound of two-thirds medium-hard waxes (melting point about 100° F.) and one-third lanolin, fatty acids, or similar materials.

Lubricant Additives

The use of wool grease in mineral oils for lubrication has long been known, but only in recent years has it been used to improve lubrication in internal combustion engines under high temperatures. Typical concentration of additives in crank-case oils is 1 to 10 percent. These additives serve to improve the oxidation stability and the anticorrosive characteristics of lubricating oils.

One group of these additives is prepared by reacting an oxygenated organic compound (which may be an ester wax, such as wool grease and lanolin, sperm oil, butyl stearate, ethyl lactate, methyl oleate, cocoanut oil, or babassu oil) with an unsaturated hydrocarbon and a phosphorus sulphide. An example of this involves the mixing of 23 parts of phosphorus pentasulphide, by weight, with 30 parts of a diluent neutral oil and 100 parts of wool grease.

The mixture is agitated for an hour at 300° F. and filtered. Another lubricant additive, which promotes combustion of deposits in the combustion zone of internal combustion engines and produces high stability in crankcase oils, is made of a mineral oil such as S.A.E. 20, 5 percent of chromium naphthenate, and 1.5 percent of the reaction product of phosphorus pentasulphide on wool grease.

When lubricating oils contain such additives, their ordinary tendency to break down is inhibited, and the lubricant preserves clean metal surfaces. For ordinary engine use, from 0.5 percent to 3 percent is sufficient; more may be added to prevent ring sticking. Diesel engine oils may contain up to 10 percent of such additives. From 5 to 25 percent of the material can also be used in extreme pressure oils for lubricating hypoid gears, and from 5 to 100 percent may be used in greases, depending on the purpose for which they are intended.

Wool grease competes with other waxes and oils in this use, as stated above, but seems to be preferred when it is available in sufficient quantities at 8 to 10 cents per pound.

Lubricant additives are almost wholly in the hands of a few of the major oil companies who buy their supply of wool grease in tank-car lots (165 drums per car). The great potential market offered by this use can only be realized by a steady and assured supply from domestic or foreign sources. It is estimated that 5 to 6 million pounds of wool grease could be marketed at prices up to 10 cents per pound for lubricant additives. Present consumption in this use approaches 2 million pounds annually.

In addition to being used in petroleum products in which they compete with other fats and oils, wool grease and lanolin have certain uses in which their unique qualities are indispensable.

Lanolin is used in the packing and bearings of pumps, compressors, and valves operating on mixtures of light petroleum hydrocarbons and halogen acids. An example occurs in catalytic isomerization plants where it is necessary to pump a mixture of butane and hydrogen chloride. Straight petroleum oils are unsuitable because they are soluble in the hydrocarbon. The usual greases containing soap are also unsuitable because of their reactivity with hydrogen chloride. Other oils and greases are also unsuitable for either or both of these reasons. Lanolin may be used as the lubricating base plus 10 percent flake or powdered graphite, which serves as a carrier, or in accordance with the following formula:

	Percent
Anhydrous lanolin	99-65
Graphite	1-20
Beeswax	0-15

Lanolin is nonreactive with hydrogen halides at normal temperatures and at all pressures up to 350 pounds per square inch.

Two distinct sizes of firms manufacture and distribute the rust preventives, greases, lubricants, and metal-drawing compounds in which wool grease and lanolin are used in the petroleum industry. Large or small, their greatest assets are their experience and the technical service they can render to their customers. It is not surprising, therefore, to find the small companies competing easily in a local market with the major oil refining and distributing companies whose distribution and technical services are nationwide. Although the general principles of industrial lubricants are well known, their specifications are tailored to the conditions (including personnel) existing in each plant. The service a small manufacturer can offer a nearby customer often will offset any small savings the latter can effect by buying from a large supplier.

The large size of some firms in the petroleum industry would seem to indicate that they could buy crude and neutral wool grease more economically from the wool scourers who produce it than from the refiners. This was true several years ago when a large Massachusetts mill was operating and a large supply was available. However, the scale of their requirements now keeps them as customers of the wool grease refiners; and conversely, it is the smaller firms selling industrial lubricants who can buy directly from the producers. For the large firms, the certainty of supply and the uniformity of the product, which only the refiners can furnish, override the savings that might accrue if they were to take over the marketing functions of exchange and physical supply from the refiners. Moreover, wool grease represents a very small proportion of their total purchases, and the small savings that might accrue are not particularly important.

The materials used in these specialized petroleum products are available to all the manufacturers in fairly well organized markets. Prices may differ by the amount of the actual savings in carload lots compared to less-than-carload shipments and may differ between places by the cost of transportation; otherwise they are uniform to all sizes of firms throughout the country. Similarly, on the demand side the customers for these products are cost conscious in their large-scale manufacturing operations; and competition is keen among the manufacturers of industrial lubricants to produce and distribute their products economically.

Small establishments are located in or near areas where there are a number of metalworking firms. Usually they are highly specialized; that is, one may manufacture and distribute only drawing compounds and cutting oils to the aluminum fabricating industry and compete only in a local market. The larger companies have trained technical staffs at centrally located manufacturing plants such as Chicago, Cleveland, or Philadelphia, and distribute over a wider area by means of branch offices staffed with 1 or 2 technically trained salesmen and a secretary.

Lanolin in Adhesive Tape

Lanolin is used in surgical and pressure-sensitive adhesive tapes as a plasticizer of the "mass," that is, the fabric adhesive. U.S.P. lanolin is commonly used, but if necessary the lanolin can be slightly darker than the U.S.P. grade. It is sterlized before being packaged. Lanolin constitutes 5 to 10 percent of the total weight of the finished product and is used in nearly all of the surgical adhesive tape manufactured in the United States. Less than a half dozen companies manufacture nearly all of it. Interviews with the two largest concerns indicate that approximately 400,000 pounds of lanolin (or about 500,000 pounds of centrifuged wool grease) are consumed in this use annually.

The demand for lanolin in this use is quite steady (almost perfectly inelastic). Other plasticizers which are adequate substitutes for lanolin are available but are not used for the following reasons:

(1) Manufacturers of sick room supplies must prepare their products for a shelf life of 2 to 3 years, and so the materials used in them must be stable for that length of time. Lanolin meets this requirement. It does not darken in color, dry out and crack, or turn rancid.

(2) All of the formulas for the plastic masses containing lanolin now used by manufacturers have been tried and proved by long experience. Costly experiments over long periods are necessary to change them. As a result, the manufacturers continue to use lanolin.

(3) Since lanolin represents such a small proportion of the cost of the finished product, price increases can be absorbed, and the amount used remains unchanged.

Since all manufacturers in this industry are large enough to use substantial amounts of lanolin, they purchase it directly from the refiners on the basis of specifications. This is one of the most stable markets for lanolin. The refiners can sell in carload lots, and contracts are usually renewed annually.

Lanolin in Pharmaceuticals

Lanolin that meets the tests for identity and purity given in the United States Pharmacopeia (see Appendix A) is designated as U.S.P. lanolin, Wool Fat, or Adeps Lanae. Hydrous Wool Fat, or Adeps Lanae Hydrosus, contains not less than 25 percent and not more than 30 percent of water. Of the total amount of U.S.P. and cosmetic grades of lanolin produced annually in the United States, approximately one-fourth goes into pharmaceuticals.

The use of lanolin in pharmaceutical products is based principally on its emollient and emulsifying properties. The water-in-oil emulsions it produces possess good stability toward mild acids and alkalies, which enables them to carry medicaments regardless of pH value. Its stickiness enables it to adhere to the skin, and it does not become rancid. Lanolin is used in concentrations of 5 to 10 percent, principally as a vehicle in ointments, especially when a liquid is to be incorporated. It has the ability to absorb large quantities of water. It gives a distinctive quality to the ointment, increasing its absorption on topical application, and assists in maintaining a uniform consistence for the ointment under most climatic conditions.

Before 1940, when it was believed that greasiness was a prerequisite to the penetration of medicinal substances, the principal ingredients of ointments were lard, lanolin, and petrolatum. More recently, pharmaceutical research has demonstrated that emulsions, either water-in-oil or oil-in-water, could serve as well. The present trend is away from grease and toward hydrophilic ointments because they are more acceptable aesthetically and because their antiseptic power is more readily available; that is, it can be absorbed more readily from a hydrophilic ointment than from one with a higher grease content. The latest developments in this field are the polyethylene glycols which have proved practical in many respects as ointment bases. They are soluble in or miscible with water and other glycols. They are surface active agents, chemically unreactive, nontoxic, nonirritating, and they do not support bacterial or mold growth (16).

The use of lanolin in the preparation of ointments by pharmacists has declined drastically since 1950. In that year it was eliminated as a constituent of all ointments in the fourteenth edition of the United States Pharmacopeia. 44/ The following statement is the official explanation for the omission (60).

44/ The Revision Committee of the United States Pharmaceutical Convention consists of 20 dermatologists and 40 physicians.

> During the past few years the Subcommittee on Dermatologic Products of the U.S.P. has had the pleasure and opportunity of counseling with experts in the field of dermatologic therapy. The result of a series of round table conferences and a still better opportunity to meet with these men at their academy meetings has prompted the deletion of lanolin from the ointments of the U.S.P. Lanolin, you will recall, a product with a sixty year tenure in the U.S.P. now suddenly finds itself an unwelcome guest. It is true that even the determatologists are not in complete agreement on the frequency of sensitization caused by this agent but, since they are the experts to whom such cases are referred, it is their recommendations which should be respected. The 5 percent of lanolin present in Simple Ointment U.S.P. XIII was termed a hidden ingredient. The general practitioner frequently was unaware of its presence and though he might eliminate all other sources of contact with lanolin, he overlooked that which was present in the official vehicle (10).

Eighteen ointments containing lanolin were listed in the United States Pharmacopeia, XIII Edition. In the fourteenth edition, which became official on November 1, 1950, Wool Fat was named only as a U.S.P. substance and was not listed as an ingredient in any pharmaceutical preparation. This meant that pharmacists could not use it for any U.S.P. ointment, but they could and did use it in compounding according to the doctor's prescription.

The lanolin refiners took no notice of this action at the time because the supply of lanolin was scarce and they were enjoying a sellers' market. They have since come to regard it as a hasty and unwarranted action taken on the basis of insufficient evidence. The following statement indicates a refiner's opinion on the subject. 45/

> Lanolin is a natural product that has been in use for about seventy-five years. It is impossible to accurately estimate the number of people who have used the material during that period, but it is safe to say "millions." These users resided in almost all sections of the world and included all types, classes and conditions of humanity. Yet no substantial evidence has appeared anywhere detrimental to the use of lanolin by the average, normal person.

45/ Mr. A. Wagner of Robinson-Wagner Company, New York, N. Y.

In practically all instances, the work and findings of the dermatologists, were based on tests with hypersensitive subjects. The lanolin employed in the tests came from only one or two sources. The incidence of sensitization proved surprisingly small. If due allowance is made for experimental error, the results are almost insignificant and out of all proportion to the "bally-hoo" engendered by them.

Dermatologists know more about the skin and its treatment than any other group. But they are human and make mistakes just like the rest of us, and sometimes unintentionally put the wrong emphasis on the wrong angle. I believe that this has been done with respect to lanolin. Lanolin is a basic natural raw material used largely in cosmetic and toilet preparations. It is used in these products because it possesses certain desirable and necessary properties. It is an efficient emulsifier and effective emmolient. It stabilizes emulsions and develops textural smoothness, etc. In the normal person it does relieve irritation due to dryness of the skin. These, essentially are its functions and are the main reasons for its use.

No one, to my knowledge, of importance in the lanolin industry, recommends the use of lanolin for the treatment of hypersensitive skin conditions. Why judge the product solely from that standpoint, particularly when the incidence of positive skin reactions even under such circumstances is so small? Opinions and conclusions on any product, including lanolin, to be valid, must necessarily be based on a much broader and more substantial basis.

The official ointments now contain, in place of wool fat, two or more of the following ingredients: petrolatum, liquid petrolatum, white wax, cetyl alcohol, glyceryl monostearate, stearic acid, triethanolamine, sodium lauryl sulfate, or some other surface-active agent which serves as a booster for the emulsification process.

The decreased use of U.S.P. lanolin in official prescriptions has been partially offset by its increased use as an ingredient in proprietary salves and ointments. In this use lanolin has benefited from advertising in the cosmetic field, but its physical properties as an emollient and a water-in-oil emulsifier and its stability to a wide range of chemicals, alkalies, and mild acid make it almost indispensable. 46/ One proprietary

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46/ The United States Army Medical Corps used 10,560 pounds of U.S.P. lanolin in 1952.

ointment vehicle is said to consist of 3 percent of the free alcohols from lanolin, incorporated with petrolatum. A similar product is also used, and it is claimed that this vehicle will not reduce metallic oxides but is capable of suspending large proportions of water (7).

The use of lanolin in proprietary pharmaceuticals varies little because of the practical difficulty of reformulation, which often involves market testing as well as laboratory testing. Moreover, the physical properties of lanolin cannot be exactly duplicated in another material.

Table 24 shows that U.S.P. lanolin varied in price only 12 cents over the decade 1941 to 1950. The small proportion of lanolin used in each product and the relatively wide profit margin common in this field decrease the significance of price changes on the manufacturer's demand for lanolin. Price increases of lanolin up to 40 cents per pound can be absorbed by manufacturers without increasing the established selling price or changing to a cheaper material. Between 40 and 50 cents there would not be a marked tendency to replace lanolin unless there was a prospect of a steady price increase relative to other close or adequate substitutes, or if a physical shortage developed. Above 50 cents per pound, at the present price level, there would be a marked tendency first to raise the established selling price and then to move to lanolin replacements.

The distinction between cosmetics and pharmaceuticals is sometimes difficult to make. Toilet lanolin, which is U.S.P. lanolin with perfume added, is an example. When applied to soften the skin it is a cosmetic. When used to promote the healing of chapped skin it is a pharmaceutical.

U.S.P. lanolin used in proprietary products is marketed in drums directly from the refiner to the industrial user in carload and less-than-carload lots. As there is very little difference in the material produced by the different refiners and prices are competitive, manufacturers of pharmaceutical products tend to make contracts with one refiner which are renewed annually with prices adjusted to delivery dates. Sometimes the size of the firm is a consideration. The largest users tend to buy from the largest refiners because the latter have the capacity to supply sufficient material of uniform quality. Table 24 shows the prices received by refiners since 1941.

Table 24.- High and low price per pound of USP lanolin, 1941-53 (9)

Year	High	Low
	Cents	Cents
1941	29	29
1942	30	29
1943	30	30
1944	30	30
1945	32	30
1946	32	27
1947	27	21.5
1948	21.5	21.5
1949	28	20
1950	30	28
1951	34	34
1952	33.5	33.5
1953	1/42	1/33.5

1/ Up to June 1953.

U.S.P. lanolin sold to drugstores to be used in presciptions or sold in bulk over the counter is bought from the refiners in drums by 3 companies, who package and sell it to druggists in containers holding 1, 5, 10, 25, and 100 pounds, along with a full line of drugs, proprietary products, and sick room supplies. It is estimated by the trade that 700,000 pounds of lanolin were consumed in this use during 1952. This is about one-fourth of the amount used 4 years earlier. Lanolin is distributed more efficiently and economically through a wholsealer than from the refiner directly to the retailer. The largest drugstores seldom carry an inventory of more than 25 pounds of U.S.P. lanolin,and small ones do not carry more than 5 pounds. Replacement orders on this one item would not cover the cost of the salesman's call if the refiner were to undertake sales directly to the retailer.

Since the retail drugstore is the only channel by which lanolin unmixed with other materials reaches the ultimate consumer, it is interesting to look at the margins of those who process and distribute it. Each of them except the producers performs all of the marketing functions. (See table 25.)

Table 25.- Price and distributor's margin per pound of anhydrous, USP lanolin, June 1953

Producer and distributor	Price	Margin
	Dollars	Dollars
Producers	0.22	
Refiners	.42	1/0.20
Wholesalers	.81	.39
Retailers	1.21	.40

1/ Refiners' margin includes lanolin manufacturing costs of 7 to 8 cents per pound.

Lanolin in Cosmetics

The new Federal Food,Drug and Cosmetic Act 47/ defines cosmetics as "(1) articles intended to be rubbed, poured, sprinkled or sprayed on, introduced into or otherwise applied to the human body or any part thereof, for cleansing, beautifying, promoting attractiveness, or altering the appearance; and (2) articles intended for use as a component of any such articles, except that such term shall not include soap." For practical purposes, a cosmetic is anything used externally to cleanse, to alter the appearance, or to promote the attractiveness of the person.

Thus, the broad concept of cosmetic includes all preparations, substances, treatments, devices, and operations used in the preventive and corrective care of skin, hair, and nails. Many products formerly classed as cosmetics are now considered borderline products or drugs, because, according to the claims made for them, they are intended to affect some structure or function of the body. This has caused no difficulty in the industry, except that all drug products must list the active ingredients on the label, whereas the contents of products used for embellishment do not have to conform to this requirement.

All lanolin used in cosmetics is of U.S.P. quality or better. The refiners produce two grades usually used in cosmetics that are superior in color and odor to the U.S.P. grade. These two grades are available in hydrous and anhydrous form.

47/ Act approved June 25, 1938, 75th Congress, 3rd Session, 52 Stat., 1040, 21 U.S.C. sec. 301 et seq.; amended June 23, 1939, 76th Congress, 1st Session, 53 Stat. 853.

The Toilet Goods Association has published specifications for many of the substances used in cosmetics. The latest for lanolin is their No. 29, published in May 1948. 48/

Definition:	Anhydrous lanolin is a purified, unctuous, fat-like substance obtained from the wool of sheep.
Color:	Must meet buyer's specification when tested by the prescribed method (color by Lovibond Tintometer).
Odor:	Practically odorless; satisfactory to buyer.
Solubility:	In ethyl ether and chloroform, less soluble in hot alcohol, sparingly soluble in cold alcohol; insoluble in water; mixes without separation with about twice its weight of water.
Melting Point:	36-42 degrees C.

All other specifications and tests--for loss on drying, residue on ignition, free alkali, chloride, water-soluble acids or alkalies, ammonia, glycerine, water-soluble oxidizable substances, acid value, and saponification value--all these conform to the requirements of the U.S.P. (XIII) in values and methods of testing each.

One more test, for adsorption on aluminum oxide (to determine petrolatum-mineral oil) is a special one, devised by the Toilet Goods Association. The maximum of 1.25 percent unadsorbed is allowed.

The Federal Food and Drug Administration is more concerned with the adulteration and misbranding of cosmetic products alleged to be based on or to depend for their efficacy on lanolin, than on the quality of the lanolin per se.

Conforming with their standards for minimum effective amounts of substances on which a declaration on a label may be justified, the Food and Drug Administration requires that 1 percent of lanolin must be present to warrant any claim for effectiveness. In all requirements for quality and properties of lanolin, the Food and Drug Administration follows the specifications of the U. S. Pharmacopeia and the Toilet Goods Association.

48/ Specification No. 29, Anhydrous Lanolin, May 1948, Toilet Goods Association, Inc., 9 Rockefeller Plaza, New York 20, N. Y.

Considerable study has been devoted to ascertaining the actual properties of lanolin which make it useful in medicaments and cosmetics, and the relative merits of lanolin as compared with lard, goose grease, mineral oil, and other fats and waxes used in various combinations. Lanolin is used as an emulsifier in water-in-oil combinations commonly used in emollient creams, hand creams, baby oils, lipsticks, and other preparations intended to impart or maintain softness of the skin, hair, and nails. An extremely valuable property is its capacity to absorb water and watery solutions of many useful compounds, such as astringents, stimulants, and bleaching agents. The amount of water that can be absorbed has been reported within wide limits by various researchers, from a quantity equal to its own weight, to several hundred percent; 300 percent may be accepted as a fair average.

The acknowledged disadvantage of lanolin is its extreme stickiness; but this can be overcome by admixtures of vegetable oils and fats of appropriate properties, or petrolatum or mineral oil. All of these cut the tenacious adherence of lanolin alone, and permit freer lubrication of the surface.

Lanolin has been found to be an emollient of the first order. It is not only innocuous of itself, but it is also helpful as an addition to preparations intended to correct dryness of the skin. Allergenic properties, if any, are very slight; considering the quantities of lanolin used, they are negligible. It is a rare substance that never causes an unfavorable reaction in some individual under some circumstances. A few studies have shown evidence of sensitivity to hydrous lanolin, but these reactions are rare. For all practical purposes, lanolin may be considered harmless under customary conditions of use in cosmetics.

The water-absorbing property of lanolin, which makes it valuable as a protective ointment for the skin and as a vehicle for useful medicaments, is due to its content of cholesterol.

Lanolin is an ingredient in many kinds of cosmetic products used on the skin, in creams, in lotions, in powders, and in colorings such as rouge, lipstick, and eye shadow. Here, as in other uses, lanolin is a valuable ingredient because of its emollient and emulsifying properties. In all <u>facial creams</u> a small proportion of it has a notable softening effect. In <u>cleansing creams</u> it removes watery dirt while other greasy ingredients remove greasy dirt. In <u>emollient creams</u> (formerly called "skin foods," "nourishing creams," "rejuvenating creams," and other optimistic names now ruled objectionable by the Federal Food, Drug and Cosmetic Act) its absorptiveness permits it to carry various specific solutions into the skin for corrective purposes, and it is used then in higher concentrations. Typical formulas for these creams are as follows:

Cleansing Cream

	Parts
Liquid petrolatum	40
Ceresin	16
Lanolin	4
White petrolatum	30
Water, to make	100

Emollient Cream

	Parts
Lanolin anh.	20
White petrolatum	40
Water, to make	100

Some newer types of emollient creams incorporate so-called absorption bases, cholesterol, lecithin, and other fats and waxes, as will be noted in the discussion of lanolin derivatives.

While cleansing and emollient creams are water-in-oil emulsions, finishing or "vanishing" creams are usually of the oil-in-water type. These were once made from stearic acid and water, bound by a little soap, and it was to counteract the drying effects of these that lanolin was introduced. Published formulas show 0.5 to 4 percent.

Lotions that contain lanolin are more exactly liquid creams, with compositions similar to those of solid or semi-solid creams of oil-in-water and water-in-oil emulsions. They have a large water content. Lanolin is included in amounts of from 2 to 10 percent.

Face powders that contain lanolin are usually special ones, supposed to adhere better than those having only the usual dry ingredients, and the lanolin is also alleged to counteract drying effects of the other contents. In these products, including powder-creams, lanolin may be present up to 5 percent.

Among cosmetics sold for coloring purposes, cream and paste rouges are usually emulsions of composition much like that of creams, with lanolin included. Lipsticks are mixtures of fats and waxes, especially the latter because firmness is required. Lanolin is frequently present because of its emollient effect. It has also been used in some eye shadows, up to 10 percent, but under the present cosmetic law it serves only as an emollient, not as a coloring vehicle.

Products designed as preventive screens against sunburn are made up with from 5 to 35 percent lanolin because its ready penetration of the skin and adherence to it help the screening elements to take effect and remain in spite of water. In sunburn remedies, lanolin is a softening agent.

Creams used in manicuring, especially those used to keep cuticle soft between treatments, consist largely of lanolin with a small amount of stiffening waxes.

Because of its origin, wool fat (lanolin) has long been used in medicinal and cosmetic products for both preventive and corrective care of the hair and scalp. These include shampoos, pomades, lotions, oil treatments, hair dressings, and solutions for permanent waving.

Shampoos: Lanolin is used in shampoos, approximately 1 percent by weight, to counteract the rough, drying elements in hard water. Higher concentrations have an adverse effect on the lathering properties. If any of it remains on the scalp and hair it should be beneficial. As far as can be ascertained, no scientific study of this kind has been attempted; most of the information available is merely empirical. The so-called soapless shampoos, based on synthetic detergents and other surface-active agents, are being used increasingly. If a small amount of lanolin is left on the hair after the usually thorough cleansing by such products, it offers a great advantage. Where the lanolin can be added without spoiling the appearance of the product, it should always be considered within the limits of compatibility with other ingredients.

Pomades: The relatively heavy, usually greasy ointments sold as "scalp pomades" are to be considered as borderline products or medicinals, because they are intended for therapeutic effect. They are usually recommended for dry scalp, and the beneficial effect is due both to the ingredients of the ointment and to the massage with which it is applied to the scalp. A rather good preparation of this kind can be made from:

	Parts
Lanolin anhydrous	25
Benzoin Tincture	5
Petrolatum	70

Lanolin can also be used with cocoa butter, castor or olive oil, and several other appropriate fats and waxes. A well-compounded ointment of this kind can be used as a carrier for special medicaments.

Lotions: The products formerly called "hair tonics" may also contain lanolin, either as clear oily fluid or in emulsions. The purpose of such a preparation is to stimulate the scalp just short of irritation, and the lanolin serves to soothe the skin after the stimulating effects abate.

Oil treatments: The oil treatments, so popular both in beauty shops and for treatments at home, are always a step in the correction of hair and scalp conditions--either dry or oily. Three types of oily substances are used--animal, vegetable, and mineral. The mixtures are applied both to the scalp and to the lengths of hair, for local improvement. Lanolin is commonly the animal fat used, incorporated into mixtures of olive and castor oils. As the animal fats are considered to be best absorbed by the hair, but are admitted to leave it dull, any mixture should also contain mineral oil.

Hair dressings: The oily or waxy preparations used to impart brilliance to the hair and hold it in place are called hair dressings. Lanolin has been used little for this purpose, but recent studies of water-in-oil hair dressings showed that it combines well with mineral oil products and some of the new synthetic waxes.

Permanent waving solutions: Because of the resistant character of hair, the solutions used for permanent waving are essentially alkalies, which were admittedly harsh on the hair in the earlier days. Lanolin has been incorporated in several of these preparations, to produce an emulsion for milder action, and it has possibilities also in cold waving.

The Society of Cosmetic Chemists gives the typical range of concentration for lanolin in cosmetic products as follows:

	Percent
Toilet soaps	0 to 2
Shaving creams	0 to 1
Baby oils	0 to 5
Zinc creams	0 to 3
Face creams	0 to 15
Lipsticks	0 to 15
Shampoos	0 to 2

Substitutes for Lanolin in Cosmetics

In efforts to get away from the disadvantages of lanolin--the stickiness and the characteristic odor--derivatives of lanolin containing a part of the cholesterol-rich fraction have been used increasingly in recent years. Unsaturated sterols, of which cholesterol is an example, seem to possess better emulsifying properties than saturated ones, and they also emulsify better with other high molecular weight alcohols, fats, and waxes, which are usually found in most cosmetics. Cholesterol has been identified as the water-absorbing ingredient of lanolin; so it has been used in all types of cosmetic products in place of lanolin itself. It has also been used to make the so-called absorption bases--mixtures with petrolatum or other fats and waxes. Manufacturers or distributors of these products offer suggestions for their use in various cosmetics.

The use of various synthetic waxes as substitutes for lanolin seems to result, not from a shortage of lanolin, but from enterprise on the part of the manufacturers of chemicals to find outlets for the many new synthetic organic compounds, which are being produced in increasing numbers and amounts annually. These substitutes do not present a serious threat to the market for lanolin as shown by their comparative prices in table 26. They are offered as supplying "the same feeling and body as mineral oil or lanolin," thus indicating that bulk or consistency in the finished product is being considered rather than the properties and effects that make lanolin a desirable ingredient in cosmetic formulas.

Table 26.- Wholesale price per pound of lanolin and lanolin substitutes in cosmetics, 1953

Item	Price per pound	
	In drums	10 pounds or less
	Dollars	Dollars
Lanolin, cosmetic quality	0.38	0.48
Ceramol Lanette Waxes	.78	1.50
Atlas Powder Co. Modified lanolins	.59	.69
Carbowaxes:		
400 (liquid)	.29	.49
1,500 (liquid)	.32	.52
4,000 (solid)	.34	.54
Modulan	1.25	
Amerchol L-101	1.20	

Among the most successful (commercially) of the synthetic waxes substituted wholly or partially for lanolin in cosmetic preparations are:

Lanette Waxes: These are various mixtures of the higher normal primary fatty alcohols, mainly C-16 and C-18 alcohols. Lanette Wax SX is a mixture of higher fatty alcohols and an emulsifying agent.

Carbowaxes: These trade-named products are polyethylene glycols. Those of lower molecular weight are liquids; the higher weight compounds are transucent waxy solids. They offer the great advantage of being soluble in water and in many organic solvents.

The polyethylene glycols of 400 and 4,000 molecular weights are recognized by the U. S. Pharmacopeia. The corresponding Carbowaxes are claimed to meet higher standards than the U.S.P. requirements.

These products are featured in compositions for "washable creams"; they have been incorporated in many recipes, causing a modification of the amounts of lanolin or mineral oil usually used. Many recipes, however, list various of these synthetic waxes in combination, and omit lanolin. They are recommended for shaving creams, hair dressings and pomades, for nail polish removers, and pancake make-up.

Lanolin Derivatives. A series of hydrophilic lanolin derivatives made by reacting lanolin and polyoxyethylene sorbitol is offered by one company. They are called modified lanolins and are suggested as substitutes for natural lanolin in many compositions. These products are useful as oil-in-water emulsions and as assistant emulsifiers in water-in-oil emulsions. They may also be used as low efficiency solubilizers for essential oils. They are said to be similar to lanolin, with the advantage of being less sticky and readily soluble in water. They are recommended for hairdressings and for creams of various types, as shown in the following formulas (15).

Cold Cream

	Percent
Beeswax	15
Mineral Oil	50
G1431 (polyoxyalkylene sorbitol-lanolin)	3
Borax	1
Water	31

Cold Cream (Soap Free)

	Percent
Mineral oil 65/75	50.0
Beeswax, white	15.0
Spermaceti	2.0
Lanolin (anhydrous)	0.5
G1441 (polyoxyalkylene-sorbitol lanolin)	4.0

Cold Cream (Soap Free) Cont'd

	Percent
Arlacel 60 (sorbitan monostearate)	4.0
Arlacel 83 (sorbitan sesquioleate)	0.5
Veegum Gel (magnesium aluminum silicate)	0.5
Water	23.5
Preservative	q.s
Perfume	q.s

Oil-in-Water Hair Dressing

Petrolatum	7.5
Mineral Oil 65/75	37.5
Beeswax	2.0
G1425 (polyoxyalkylene sorbitol-lanolin)	4.5
Arlacel 83 (sorbitan sesquioleate)	2.0
Water	46.5
Preservative	q.s
Perfume	q.s

Modulan and Amerchol L 101 are modified lanolin products. Their use is shown in the following formulas:

Vanishing Cream

	Parts
Modulan	2
Amerchol CAD	5
Stearic acid	25
Triethanolamine	1.4
Glycerin	5
Water	70
Perfume and preservative	q.s

Hair Treatment Cream

	Parts
Modulan	3.5
Amerchol L-101	9
Glyceryl Monostearate	13.5
Spermaceti	1.5
Mineral oil (70 vis.)	8.5
Glycerin	4.5
Water	59.5
Perfume and preservative	q.s

Diglycols. Among the earlier compounds offered as substitutes for lanolin and mineral oil in cosmetic creams are higher alkyl combinations of glycols. Two such products are being manufactured by one company.

Most of these synthetic waxes and lanolin derivatives are used in compounding oil-in-water emulsions. To supply the properties that only lanolin can impart, the latter substance must be incorporated with them. For ointment bases and cosmetic creams, which are most effective in water-in-oil emulsions, the synthetic compounds cannot serve so effectively.

The Demand for Lanolin in Cosmetics

Lanolin is one of the most valuable and widely used ingredients of cosmetic preparations. There are about 140 different types of cosmetics and related products on the United States market at any one time. About half of them contain lanolin or are based on it. The largest amount goes into creams of the water-in-oil type. However, even in preparations where it is not the base, it is included for its emollient, soothing, emulsifying, or viscous properties.

Based on discussions with industry representatives, it is estimated that approximately 2 million pounds of lanolin are used in cosmetics annually. Most of this amount, but not all of it, is of cosmetic quality, that is, the two highest grades produced by the refiners. The use of lanolin in the cosmetic industry is steady from year to year because the demand for it is relatively inelastic for three reasons. First, as stated above, its physical and chemical properties cannot be exactly duplicated by other materials. Second, it is used typically in small concentrations so that its price fluctuations have little effect on the price of (and hence the demand for) the finished product. Third, manufacturers are reluctant to change their established and accepted formulas. This industry has not felt the recurring shortages of lanolin experienced by industries using the lower grades. During periods when the raw material has been scarce the refiners have, understandably, been eager to supply this market because the production of cosmetic grade lanolin has provided them the greatest net return from their manufacturing operation. During 1952, when there was a general shortage of wool grease and other industries were forced to curtail their consumption, several of the largest users of lanolin in the cosmetic industry undertook national advertising campaigns, expanded their markets, increased their consumption and were not aware of any shortage.

Minor Uses for Wool Grease and Lanolin

Many industries, such as paint, plastics, textiles, paper, glass, yeast, hard floor covering, and chemicals, were canvassed through trade associations, individual firms, and technical and research personnel to learn of other uses for wool grease, lanolin, and derivatives in the United States at the present time.

Although an extensive search of United States and foreign technical publications and patents (1930 to 1953) and personal correspondence with many organizations and researchers both in this country and abroad revealed many potential uses, it is believed that those described in this section represent the total United States market.

The wool grease and lanolin consumed in the minor uses described in the following pages are purchased on the basis of general specifications directly from the refiners.

Agriculture

There are several uses for lanolin in forestry. It has been found to promote wound healing in trees when used alone or with rosin or with shellac overcoated with plastic asphaltum (29).

It has also been found that dipping pine seedling in lanolin, forty grams per liter of water, at transplanting time greatly increased their survival rate by reducing tranpiration until the root systems became established (1).

Lanolin can be used to reduce scald development on stored fruit and to inhibit the sprouting of stored potatoes. Although there are other similar uses for wool grease and lanolin, their consumption in forestry or agriculture directly is not economically significant.

Paint

In 1948 the Bureau of the Census reported that 35,000 pounds of wool grease were used in paint and varnish products (47). Contacts with paint manufacturers in 1952 indicated that only one company was using wool grease (one drum per month) as a paint vehicle.

Tape

It is estimated, from replies by the industry, that approximately 100,000 pounds of wool grease are used annually as a plasticizer in pressure sensitive tapes, other than surgical tape.

Automobile Polish

Approximately 5,000 pounds of wool grease are used annually by one company as a component of automobile waxes, probably as an emulsifier to distribute the other oils or waxes in the mixture when it is used with water.

Sheep Branding Fluid

Wool scourers have long advocated a scourable branding fluid to eliminate depainting and hand picking. A new product known as Lanolin Base Emulsion Branding Fluid was developed by the

Commonwealth Scientific and Industrial Research Organization of Australia in 1950; it gives satisfactory results in the field and can be removed by ordinary soap and soda scouring. The formula is as follows:

Lanolin	pounds	30
G-gum rosin	do.	10
Stearic acid	do.	6-1/2
Triethanolamine	do.	2
Water	gallons	16
Solvent naphtha	pounds	1
Pigment concentration (per 100 gallons):		
Blue	pounds	25
Red	do.	25
Black	do.	50
Green	do.	25

The consumption of lanolin in this use probably does not exceed 5,000 pounds annually.

Veterinary Salves and Ointments

Medications used by veterinarians are often the identical products used by physicans to treat human ailments. The two fields of medicine have much in common. U.S.P. lanolin is used extensively because it works well with water-soluble ingredients and forms ointments with stable and adherent properties which are decided advantages in veterinary medicine. Petrolatum is the chief substitute material; others are those mentioned in the section on pharmaceuticals. Goose grease and chicken fat are also acceptable. The consumption of U.S.P. lanolin in veterinary salves and ointments by those few firms which specialize in this field is not large, since lanolin is a small proportion of the final product, but the demand for it is steady. Following is a typical veterinary ointment:

Pickrokain Ointment

	Percent		Percent
Benzocaine benzoate	1	Petrolatum	50
Picric acid	1	Alcohol	6
Lanolin anhydrous	42		

It is estimated by those in the veterinary profession that not more than 5,000 pounds are consumed in this use.

Rubber

Several large rubber companies mentioned the use of wool grease and lanolin in specialized products, but the volume of production of these items is insufficient to make its consumption in this industry of economic significance.

Soap

Superfatted soaps are produced in limited quantity for people with sensitive skin who prefer an excess of fat instead of an excess of alkali. About 1 percent of lanolin is usually added to the full boiled soap before milling. Although lanolin is preferred, olive oil, peanut oil, or any similar oil or fat can be used. The Bureau of the Census reported the use of lanolin in soap for the years 1944 to 1948 as follows:

	Pounds
1944	184,000
1945	505,000
1946	598,000
1947	422,000
1948	313,000

It is estimated that not more than 250,000 pounds of lanolin were used in superfatted soaps in the United States during 1952. Nearly all of them are produced by small companies as specialty products and are distributed in local markets.

Industrial Hand Cleaners and Protectants

The consumption of lanolin in the highly specialized field of industrial hand cleaners and protectants is growing. Hand cleaners are made for many industries in which workers have special problems in removing grime and soil from their hands. Although no quantitative data can be learned from firms in the soap industry, since all are proprietary products, many of them, particularly liquid soaps, contain from 5 to 10 percent of lanolin for its emollient quality. Many of the industrial hand cleaning soaps for general use are now made from the following formula: (37)

	Parts
Neutral toilet soap	30
Colloidal clay (bentonite or kieselguhr)	30
Synthetic detergent	10
Lanolin	5
Perfume	1

The Navy specifies that its Type III Hand Detergents, Paste and Powder, for Mechanics' Use P-D-221B (Navy Ships) shall be a uniform, free-flowing, nonstratifying mixture in powder form of clean cornmeal, thoroughly saponified soap, and/or active salt-free synthetic detergent, and lanolin (5 percent by weight).

Lanolin is also used in Federal Specification P-S-628a, Soap-Borax Powder for Dispensers varying from 2.5 percent to 3.5 percent by weight.

Workers whose hands are in contact with petroleum oils and greases and hydrocarbon solvents such as gasoline can offset the degreasing effects by the application of an emollient of equal parts of lanolin and cold cream to prevent the skin from drying.

Industrial workers whose jobs bring them in contact with irritant or staining liquids, metallic powders, or solvents harmful to the skin are often unwilling or unable to wear protective gloves or clothing because they are uncomfortable or cause excessive perspiration. Moreover, certain tasks requiring skill or precision must be done with the bare hands. For these workers there are numerous protective ointments based on the general formula (26).

	Percent
Water	65-70
Wax	16-20
Glycerine	8-14

These protective ointments are of 5 main classes.

(1) Vanishing creams that fill the pores with soap that can be washed off after work.

(2) Inert powders such as talc, calamine, titanium, and zinc oxides.

(3) Film formers.

(4) Fatty mixtures which coat the skin with a harmless material.

(5) Miscellaneous cintments.

Fatty mixtures cover the skin with a harmless material which repels water-soluble irritants and screens out harmful oils, greases, and coal-tar derivatives. The simplest mixture for this purpose has been devised by the Factory Department of the British Ministry of Labor. It consists of 3 parts petrolatum and 1 part of lanolin. A synthetic wetting agent may be added to facilitate removal.

The best protection against industrial organic solvents that act as degreasing agents and dissolve the natural protective oils in the skin can be made with lanolin and castor oil as follows:

	Parts
Lanolin	70
Castor oil	30
Wetting agent	2

Lanolin and castor oil are insoluble in cutting oils and soluble oil emulsions, but lanolin is unsuitable for workers making explosives. TNT, picric acid, and hexamine are highly soluble in it (8).

A protective cream for hands in prolonged contact with soapy water, since it has a pH of 5.4, uses lanolin as follows: (25)

	Percent
White wax	10
Hydrous lanolin	5
Glycerol monostearate	12.5
Stearic acid	2
Petrolatum	75.5

A barrier cream for protection against hydrocarbon solvents or emulsified cutting oils and which can be removed with soap and water is given in the following formula: (3)

	Percent
Polyoxyethylene sorbitan, monostearate	5
Lanolin	25
Castor oil	25
Ceresin Wax (64° C.)	5
White petrolatum to make 100%	

Lanolin is also used in a cream for protection against chlorine bleach (30).

Photosensitizing agents derived from coal tars may be screened out by including chemical or physical light screens in preparations like the following: (36)

	Parts
Lanolin	58
Castor oil	30
Titanium dioxide	5
Menthyl salicylate	5
Synthetic detergent	2

Following are the formulas for several creams that remove ink stains from hands.

Ink Removing Cream

	Parts
Carbowax 4,000	50
Water	50
Propylene glycol	50
Triethanolamine	8
Oleic acid	14
Lanolin	7
Terpineol	.5
Mild abrasive (multicel 1,000)	82
Sodium bisulphite	.5

Carbon Paper and Ink Stain Remover Cream

	Parts
Lanolin	3
Carbowax 4,000	19
Carbowax 1,500	19
Triethanolamine	3
Oleic acid	5
Water	19
Terpineol	.5
Multicel 1,000	31
Sodium bisulphite	.1

Since lanolin is usually a small proportion of industrial hand cleaners and protectants, it is estimated on the basis of an analysis of replies to an industry questionnaire that the present and potential market for lanolin in this use is not over 10,000 to 12,000 pounds annually. Many of these products are distributed by the manufacturers of the equipment or materials against which protection is needed. For example, a manufacturer of office duplicating equipment sells a protective cream that enables the ink to be removed quickly and easily from the operator's hands.

There are many other consumer products, such as shoe polish, in which lanolin is stated by the manufacturer to be an ingredient. So far as this survey has been able to determine, it is present in very small amounts.

FUTURE OF THE WOOL GREASE AND LANOLIN INDUSTRY IN THE UNITED STATES

The small size of the wool grease industry, its dependence upon an uncertain source of supply, and the fact that the demand for its products is constantly affected by technological changes in many industries make it almost certain that the industry will be plagued with severe fluctuations in the future as it has been in the past.

The Effect of Stream Pollution Laws

The enforcement of State stream pollution laws and the general upward trend of wool grease prices are the most important long-term factors influencing domestic wool grease production. Pollution abatement is not ordinarily a short-term factor in wool grease production because there are economical methods of treating the waste effluent without recovering the grease. In the long run, the enforcement of stream pollution laws will probably make inadequate existing methods of treatment that do not include grease recovery. On the other hand, maximum grease recovery methods, such as acid cracking, may not solve stream pollution problems, as illustrated by the difficulties of several firms now using that method.

The amount of wool scouring waste is not large compared to the waste from other industries. However, it is one of the most difficult and expensive wastes to treat because it contains large amounts of highly putrescible organic matter. It has become a problem because of the geographical concentration of wool scouring establishments in the most highly industrialized and densely populated section of the country. Textile plants in the New England Interstate Water Pollution Control Compact Area contribute a greater pollution load than any other single industry within the Compact Area. They account for 46 percent of the pollution load produced by all of the industries combined and discharge 80 percent of it to streams in an untreated condition (63).

The primary responsibility for the control of stream pollution rests with the States and their political subdivisions. In most States there has been recognition that what is needed is research and education, rather than coercion, and legislation has reflected that viewpoint. However, nearly all of the States now have adequate legislation on the statute books that permits the exercise of police power through the courts to abate local nuisances. Industry members believe that vigorous enforcement of these laws would, in eliminating stream pollution, also eliminate a large number of the firms that cause it. Waste disposal plants are expensive, and not all firms can bear this burden. In practice, the administrators of State public health agencies, as enforcement officers, can (1) compel the abatement of a nuisance infringing on the riparian rights of owners downstream, (2) insist upon waste treatment by established firms where it is technically and economically feasible, and (3) require new industries to provide waste treatment before giving them permission to discharge into a public waterway.

Although under existing laws it is easier to enforce a policy that requires uniform waste treatment by all mills on a given waterway, this may be an unreasonable and uneconomic policy. Small mills on large streams do not contribute the same pollutional load as do large mills, and unless there is a policy which permits the selection of wastes for treatment and of wastes which may be discharged untreated, there will be an economic loss. Most of the State enforcement agencies, recognizing this, look upon each mill as a separate and unique problem. Massachusetts, for example, which has the greatest pollution problem from scouring wastes, does not recommend any one system of waste treatment, but, where treatment is necessary, permits the mill to select the one which is most economically feasible and which will reduce the pollutional load to acceptable limits.

As the whole length of a river is seldom confined to one State, effective control of pollution has required the formation of interstate agencies for this purpose. The New England Interstate Water Pollution Control Compact, subscribed to by the States of Massachusetts, Rhode Island, Connecticut, Vermont, and New Hampshire, and the Federal Government, is an example of such an agency. One of its functions is the classification of all streams (or parts thereof) according to use. The individual States then undertake to improve and maintain their waterways according to the standard for that use.

The abatement of stream pollution need not be uniform throughout the length of a waterway since it may not be classified for one use throughout its length. A high degree of treatment may be required at some points of pollution and no treatment at all at other points.

Even more controversial than the degree and method of treatment is the assessment of costs. There is no simple legal or equitable solution. It is inequitable, according to mill owners interviewed for this study, to require one mill whose wastes are selected for treatment to pay the costs thereof while another whose wastes are to be discharged untreated pays nothing. Again, it is the mill owners' opinion that if any mill is to be assessed, all should be assessed in proportion to the amount of pollution each produces, whether their wastes are treated or not. Whether they should pay the full cost of treatment is also a debatable point among the mill owners interviewed. The question arises as to whether the general public should not share in the cost since all who use the waterway share in the benefits resulting from its improvement. However, the consensus of opinion among mill owners is that the mills' share should be sufficient to stimulate them toward reducing the amount of polluting matter produced. Any method of assessment is difficult to set up and administer unless the treatment facilities are owned and operated by a municipality, a sewage district, or possibly the State. There are advantages to public ownership and administration of treatment works to those mills in an area where treatment is mandatory.

The Federal Water Pollution Control Act, Public Law 845, has had thus far little effect on wool grease recovery. The United States Public Health Service can act only upon a complaint from a State public health authority that involves pollution coming from an interstate waterway. Most of the State public health authorities have been reluctant to act and none has filed a complaint since the enactment of the law in 1948. Present administrators feel that progress can best be made by working with the State authorities on long-range programs of technical assistance and education.

The degree of enforcement of stream pollution laws upon the industry was determined by interviewing a representative sample of firms. By this procedure it was learned that legal pressure from State authorities has been sufficient to keep alive the interest of wool scourers in new solvent scouring techniques and the waste treatment of scouring liquors. However, legal pressure to "clean up" their effluent has been thus far a minor factor in grease recovery by established firms. For new firms the enforcement of stream pollution laws has been the major factor in their decision to recover wool grease from their scouring effluent. There seems to be little prospect for any change in the immediate future.

Research Suggestions

The problems mentioned throughout this survey suggest several areas worthy of research. In the matter of wool grease shortages, the solution to the problem appears to involve the development of greater efficiency in current recovery processes,or the introduction of an as yet undiscovered method of scouring or recovery which would provide a higher grease yield. The common rate of recovery on the centrifugal system lies between 30 and 40 percent whereas that of the acid-cracking system is 60 to 70 percent. 49/ Where the centrifuge is skimming only the best of the grease available for recovery, it appears as though there are two possible solutions to be sought. First, obviously there is a need to raise the yield of recovered grease. On existing equipment this may be accomplished through three possible avenues of approach. The first leads to the recognition of the need for a more exact control of operations to ensure that all the available grease is being accounted

49/ See pages 58 and 63.

for as far as possible. A moderate rise in the recovery rate as a result of this effort can be expected; however, this should not be considered as the only effort towards maximum recovery.

The second avenue of approach that can be attempted involves the technique suggested by one wool grease refiner which calls for a continuous acid-cracking process to be operated for the scouring effluent remaining after the centrifuge operation has been accomplished. This effluent still contains between 60 and 70 percent of the available grease and could theoretically recover another 30 to 40 percent of grease in the form of common degras. The important point for consideration in this suggestion is the cost of installation of the necessary additional equipment compared with the return to be made from the sale of the additional wool grease.

The third, and probably the most fruitful, avenue of approach is in the field of emulsion technology. In the conventional processes of scouring, which employ either soap and soda ash or the recently developed synthetic detergents, the grease is removed from the fleece by emulsification and the subsequent problems of grease recovery are a direct function of the stability of the emulsion formed. In order to do a satisfactory job of scouring, the emulsion formed by the detergent must be stable under the conditions maintained in the train so as to avoid redeposition of grease and soil on the fiber. This stability imposes the many problems of grease recovery, for the effort necessary to break the emulsion in order to release the grease is in effect the total effort expended in a recovery system. If an emulsion can be accomplished that will perform the job of scouring, but will be of such a nature as to be readily broken under conditions different from those which obtain during scouring, then centrifugation and the chemical methods of recovery would be greatly simplified and the cost reduced considerably. A one-step chemical treatment before centrifugation theoretically should yield the major portion of the grease. Subsequent refining could complete the fractionation of this product into the several commercial grades of grease and lanolin.

The second possible solution to the problem of low rate of recovery would lie in the engineering of a new centrifuge specifically designed for the recovery of wool grease. Although the centrifuges now in use are highly developed products of engineering skill, they are not the last word in wool grease recovery systems as they were not designed primarily for grease recovery. An engineering change designed to raise the yield by even 20 percent would mean large additional amounts of grease available for consumption because fully 80 percent of the domestic supply is recovered by centrifugation.

The shortage of wool grease appears to be in the cheaper grades, specifically that grade known as common degras. Since the closing of a large Massachusetts mill in 1950, there has been no satisfactory replacement of the large production supplied by that extensive operation, a production estimated variously as between one-third and one-half of the total domestic supply of all wool grease. It seems unlikely that any new producers of common degras will appear unless one of two developments occurs. The first would come about if enforcement of stream pollution laws required the treatment of waste to a higher degree than that accomplished by centrifugal treatment. However, acid-cracking produces an effluent that is compatible with most foreseeable requirements, and stricter enforcement of pollution control laws could require large operators to convert to this more acceptable recovery system.

The second possibility would occur if many small contiguous mills could combine their waste water treatment operations to make it profitable for them to install a single large acid-cracking plant.

One area that has been somewhat neglected by research agencies in this country is that dealing with the other byproducts of the wool scouring operation. 50/ Although it is known that the water-soluble suint removed from wool during the scouring processes contains potassium salts and nitrogenous compounds, the nature of these substances has not been completely determined and consequently their economic importance has not been adequately assessed. Increased experimental efforts should be devoted to evaluating the potential worth of these constituents.

During the last 3 years when wool grease has been in occasional periods of shortage, no real difficulty has been experienced by firms requiring the better grades of lanolin. As mentioned earlier in this section, 80 percent of the wool grease recovered in the United States is obtained by means of centrifugal system and as this type of grease is generally of high quality, it is possible for the refiner to work the material up to any grade of lanolin desired. Obviously the highest paying customers have been the first to be satisfied. Certain of the purchasers of lower grades of lanolin have not been promptly supplied by the refiners; but from all evidence, no real shortage

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50/ Basic research on the components of wool grease is being done on a small scale by the Eastern Utilization Research Branch of the Department.

has existed. Assuming then that an increased supply of wool grease and lanolin will eventually be available, it appears that an area worthy of research is that leading to new uses for the material. Industrial research departments of large corporations should evaluate wool grease and lanolin in their products to determine the usefulness of this material as a possible replacement or substitute for the raw materials that are now being used. Finally, research into expanded utilization of wool grease as a byproduct of the wool industry is needed if this industry is to remain in a healthy state. Such research is presently under way on a small scale at the Eastern Utilization Research Branch of the U. S. Department of Agriculture.

One of the most important areas for consideration is that of chemical derivatives of wool grease and lanolin. Although work has been done in this field for some time and several unsuccessful business ventures were launched, the effort should not be discontinued. Scientists have recognized several valuable derivatives from the fractionization of lanolin, and it is a matter worthy of continued effort involving a reasonable chance that a profitable method of recovery can be found. In the very active field of organic synthesis, there is a high probability that lanolin derivatives and fractions possessing highly desirable properties can be developed that will be worthy of exploitation.

Last, but perhaps the only area that can actually hold out a hope for cheaper recovery costs and higher grease yields, is the solvent method of scouring. Regardless of the fact that there are no solvent scouring operations in existence today it is the opinion of many of the leaders in the industry that a workable system will one day be developed. Much current research is being conducted on solvent scouring, and the solution to the problem may be near. Research on wool scouring has been assigned to the Western Utilization Research Branch of the Department.

APPENDIX A - TECHNICAL DESCRIPTIONS (54)

Wool Fat

Adeps Lanae
Anhydrous Lanolin, Refined Wool Fat

Wool Fat is the purified, anhydrous, fat-like substance from the wool of sheep, Ovis aries Linne (Fam. Bovidae).

Description - Wool Fat is a brownish yellow, tenacious, unctuous mass, having not more than a slight odor.

Solubility - Wool Fat is insoluble in water, but mixes without separation with about twice its weight of water. It is sparingly soluble in cold alcohol, more soluble in hot alcohol, and freely soluble in ether and in chloroform.

Melting Range - Wool Fat melts between 36^{o} and 42^{o}.

Loss on Drying - Dry Wool Fat to constant weight on a water bath with frequent stirring: it loses not more than 0.5 percent of its weight.

Residue on Ignition - Wool Fat yields not more than 0.1 percent of residue on ignition.

Alkalinity - Dissolve 2 grams of Wool Fat in 10 cc. of ether and add 2 drops of phenolphthalein T. S.: the liquid is not colored red.

Chloride - Boil 20 cc. of alcohol with 1 gram of Wool Fat under a reflux condenser, cool, filter, and to the filtrate add 5 drops of an alcohol solution of silver nitrate (1 in 50): the turbidity, if any, is not greater than that produced in the same volumes of the same reagents by 0.5cc. of 0.02 N hydrochloric acid (350 parts per million).

Water-soluble acids or alkalies - Warm 10 grams of Wool Fat with 50 cc. of water on a water bath, constantly stirring the mixture until the Wool Fat is melted: the fat separates completely on cooling, leaving the water layer nearly clear and neutral to litmus paper.

Test Liquid - Use the water layer from the test on Water-soluble acids or alkalies for the tests for Ammonia, Glycerine, and Water-soluble Oxidizable substances.

Ammonia - A 10 cc. portion of the solution emits no ammonia vapor when boiled with 1 cc. of sodium hydroxide T. S.

Glycerin - A 10 cc. portion of the filtered solution leaves no sweet residue on evaporation.

Water-soluble oxidizable substances - A 10 cc. portion of the solution does not completely decolorize 0.05 cc. of 0.1 N potassium permanganate within ten minutes.

Petrolatum - Boil 40 cc. of dehydrated alcohol with 500 mg. of Wool Fat: the solution is clear or not more than opalescent.

Acid Value - The free acids in 10 grams of Wool Fat require for neutralization not more than 2 cc. of 0.1 sodium hydroxide.

Iodine Value - The iodine value of Wool Fat is not less than 18 and not more than 36, using 800 to 850 mg. of the Wool Fat.

Packaging and Storage - Preserve Wool Fat in well-closed containers, preferably at a temperature not above 30°.

Hydrous Wool Fat

Adeps Lanae Hydrosus
Lanolin

Hydrous Wool Fat is wool fat containing not less than 25 percent and not more than 30 percent of water.

Description - Hydrous Wool Fat is a yellowish white, ointment-like mass, having not more than a slight odor. Hydrous Wool Fat, heated on a water bath, separates into an upper oily and a lower water layer. When the heating is continued with frequent stirring until the Hydrous Wool Fat ceases to lose weight, a residue remains, which, when melted, is tranparent and when cold is a yellowish, tenacious, unctuous mass completely soluble in ether or chloroform and only sparingly soluble in alcohol.

Solubility - Hydrous Wool Fat is insoluble in water.

Loss on drying - Dry Hydrous Wool Fat to constant weight on a water bath with frequent stirring: it loses not less than 25 percent and not more than 30 percent of its weight, page 733.

Other requirements - Hydrous Wool Fat complies with the tests for Alkalinity, Chloride, Water-soluble acids of alkalies, Ammonia, Glycerin, and Acid value, under Wool Fat, page 668, allowance being made for the proportion of water present.

Petrolatum - Hydrous Wool Fat, deprived of water by drying on a water bath, meets the requirements of the test for Petrolatum under Wool Fat, page 668.

Iodine value - The iodine value of Hydrous Wool Fat, deprived of water by drying on a water bath, is not less than 18 and not more than 36, using 800 to 850 mg. of dried Hydrous Wool Fat, page 705.

Packaging and storage - Preserve Hydrous Wool Fat in well-closed containers, preferably at a temperature not above 30°.

APPENDIX B - SCOURING: EQUIPMENT, MATERIALS, METHODS

Scouring equipment is designed to remove all of the impurities from wool fibers with the least amount of agitation, which causes felting and losses in subsequent operations. The equipment, called a scouring train, consists of three parts: (1) A duster; (2) a series of vats called bowls, about 3 feet deep, holding from 1,500 to 2,000 gallons of water; and (3) a drier. The wool is fed by hand as it comes from the sorters or from storage into the duster or opener where it is beaten against screens to remove some of the dirt and vegetable matter. By means of an automatic feed, it is then conveyed to the first of the series of bowls through which the wool is propelled by mechanical rakes. As the wool leaves each bowl it passes through squeeze rolls to remove most of the dirty scouring solution before being admitted to the cleaner bath in the next bowl. Each bowl is equipped with a false bottom made of perforated stainless steel plates or copper mesh, set about one foot below the surface of the scouring liquor, to keep the wool from sinking too far and to enable heavy sediment to pass through and settle into hopper-type sumps on the bottom, from which it can be discharged with little loss of scouring liquor. At the end of the last bowl the wool is carried into a drier where a continuous stream of hot air reduces the moisture content to the amount desired in succeeding operations.

Scouring trains in commercial use in the United States usually have 4, 5, or 6 bowls and vary in width from 4 to 6 feet. Since each train is built to order by one of two manufacturers in the United States, it can vary considerably in its dimensions. Newer trains are usually 6 feet wide. There are 3 two-bowl and 1 seven-bowl trains in operation, as shown in table 27.

Table 27.- Distribution of scouring trains by number of bowls

Number of bowls	Trains
	Number
2	3
3	16
4	68
5	78
6	9
7	1

Information obtained from 88 respondents to questionnaire survey. No distinction is made as to width.

The bowls beyond the fourth one are used for bleaching or bluing. Trains with the larger number of bowls are usually found in commission scouring establishments and in various kinds of establishments scouring carpet wools.

The chemicals used in scouring in the United States are soap, an alkali (soda ash), and occasionally a synthetic detergent. Their surface active and suspension properties are designed to emulsify and hold in colloidal suspension all of the impurities removed from the fiber that do not readily drop out from their own weight or are not dissolved in the solution. Increased emulsification occurs above the melting point of the grease; therefore the temperature of the scouring bath is maintained at about 115° to 125° F. Additional amounts of soda ash are added to the scouring bowls at regular intervals to maintain the desired concentration, since the alkalinity of the solution is gradually reduced as additional amounts of wool are scoured. The alkali, sodium carbonate, acts as a "builder," increasing the effectiveness of the soap. It also aids in suppression of soap hydrolysis; it acts as a salt, inducing soap from the solution to enter the interface, producing there a concentration of soap molecules, which would otherwise only arise with a much higher strength of detergent; it reacts with suint; and it is to a slight degree absorbed by the fiber (22).

Synthetic detergents are used to some degree (with soap and alkali) by less than half of the scourers in the United States, and are used alone by only a few because of their higher cost. They are effective in scouring all types of wool and give a good color and feel to the clean fiber, but they have several disadvantages which have limited their use:

(1) They are higher in price than soda soaps and more expensive to use. When they are used alone in neutral scouring with no alkali, little detergence will be provided by the natural suint soaps which means a greater consumption of synthetic detergent and higher scouring costs per pound of wool

(2) Personnel experienced in scouring must be trained to use them. Many of the small signs by which it can be determined whether the bowls are working efficiently, such as surface lather, are not valid with detergents, and personnel must be trained to make other tests.

(3) Some are supplied only in liquid form and are harder to store in iron and steel tanks because of corrosion caused by complete degreasing of the metal surfaces.

(4) Synthetic detergents are believed to form an emulsion that is harder to crack in recovering grease by the acid-cracking method and has some effect on the amount recovered by centrifuge.

Synthetic detergents are most likely to be adopted by vertically integrated scourers where the materials cost in scouring is an insignificant part of the total and where allowance can be made for the physical and chemical effects on subsequent processes.

The methods of scouring most commonly used in the United States are the desuinting and counterflow. In the first method the first bowl of the scouring train usually contains clear warm water and alkali with a minimum pH of 9 in which the water-soluble suint salts and vegetable matter are dissolved, and the heavier dirt particles settle out. The water soluble suint fraction contains potassium soaps which act as detergents. This warm water bath is renewed as often as necessary to maintain its efficiency. The second and third bowls are kept at higher temperatures, 115° to 125° F., slightly above the melting point of the grease, and contain the scouring solution, soap (or synthetic detergent), and soda ash. The remaining bowls in the scouring train are kept at temperatures of 115° to 125° F. and are used for rinsing, bleaching, and bluing.

The counterflow method of emulsion scouring may be employed throughout the train or in any part of it, the liquor flowing back from the last bowl to the one before it, until it reaches an overflow or is dumped from the first bowl, thus Waste ← 1 ← 2 ← 3 ← 4 ← Clean Water. A counterflow system may also be employed between the second and third bowls in the desuinting method. The counterflow method reduces the volume of water needed and simplifies the problem of grease recovery by concentrating the greasiest liquor in one bowl instead of several. However, optimum concentration of the solution in each bowl is harder to maintain because of the difficulty of accurately controlling the flowback, and more soap and less alkali are consumed because of the buffering action of the suint salts in the scouring solution.

Various devices are available to test the soap, sediment, grease concentration, and alkalinity of the scouring bath as well as the residual grease content of the clean wool.

APPENDIX C - CORRELATION ANALYSIS OF FACTORS AFFECTING WOOL GREASE PRICES

Discussion with members of the largest wool grease refining firms and others who had 20 years or more of experience with pricing policies and a knowledge of the factors affecting price in this industry elicited the consensus that wool grease prices (X_1) were most affected by the amount of wool grease available for consumption (X_2) (United States production plus imports); the general level of industrial activity (X_3); and the prices of fats and oils that are good or close substitutes for wool grease (X_4). The discussion in the text (page 89) and reference to the amounts and conditions under which wool grease is used in specific industries (pages 94 to 140) indicate the logic of selecting the three independent variables.

An effort was made to measure statistically the effect of these factors on wool grease prices from 1935 to 1951. The war years 1943-45 were omitted because of price controls. The following data were used to represent the variables:

X_1 Price of wool grease (compiled from The Oil, Paint, and Drug Reporter) deflated by the Bureau of Labor Statistics Index of Wholesale Prices.

X_2 Supply of wool grease, U. S. Bureau of the Census figures on amount recovered in the United States plus imports.

X_3 Federal Reserve Board Index of Industrial Production, monthly data, adjusted for seasonal variation, 1935-39 = 100.

X_4 The Revised Index of Wholesale Prices of 17 Major Fats in Other Industrial Uses (1947-49 = 100) deflated by the Bureau of Labor Statistics Index of Wholesale Prices.

Since X_2 and X_3 are in physical terms, the price data X_1 and X_4 were deflated to give a consistent series so that comparison would be possible.

The results of the multiple correlation analysis with these four variables were consistent but unsatisfactory. The coefficient of determination ($R^2 1.234 = 0.2480$) explains only 25 percent of the deviation from the mean. The relative size of the partial correlation coefficients, $r_{12.34} = 0.4324$, $r_{13.24} = 0.2372$, $r_{14.23} = 0.0272$, indicate that, of the three, supply is the most important variable. The general level of industrial activity had less effect and the prices of substitutes had almost no effect during this period. The signs of all the regression coefficients are in the right direction, and except for the degree of deviation explained by the variables the results are consistent with what might have been expected before the analysis was made. 51/ The size of the partial regression coefficient $r_{12.34}$ indicates that a change of 1 million pounds in the supply tends to cause a change in the price (in the opposite direction) of 0.5 cent. Since 75 percent of the variations from the mean are unexplained, there are evidently many other factors, not included in this analysis, that affect wool grease prices and tend to obscure the effect of the above factors. This might be expected by examining the producer's price policy of maximizing their incomes in the short run. The price structure resulting from this policy is preserved through successive stages of distribution by the addition of the margins of the refiners and other distributors and often outweighs the influence of other factors.

The results of this analysis indicate that a case history investigation and an intimate knowledge of the technology of the industries using wool grease are better means of explaining price behavior than are statistical techniques or conventional price theory.

51/ The regression equation is $X_1 = 17.66 - 0.4776X_2 + 0.0188X_3 + 0.0044X_4$.

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