WOOL GREASE: MARKETING A BY-PRODUCT

DISSERTATION

Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of The Ohio State University

By

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Approved by:

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Adviser
PREFACE

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Robert S. Raymond

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September, 1953
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CHAPTER I

INTRODUCTION

A comprehensive survey of the economic aspects of the production, distribution, and consumption of wool grease has never before been made in the United States. The recurring shortage 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.

Statement of Purpose

This study was designed to collect data on the cost of scouring wool and producing grease as a by-product, 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 which produce, distribute, and consume it. It is expected that this analysis will also yield an estimate of the prices which can be obtained throughout the wool grease industry at a given level of production.

Inevitably, this study, like every other one, is part of several larger pertinent problems and touches many other areas of industrial activity. Among these larger problems are stream pollution and national defense. 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.

Scope and Method of Study

This study involved all of the wool grease refiners, nearly all
of the grease wool scourers in the United States, and a cross section
of the industrial users. Preliminary information to set up the study
was obtained by personal interviews with leaders in the textile indus-
try. Lists of names in the above groups were compiled from many
different sources, such as Davison's Textile Blue Book, Thomas' Regis-
ter of Manufacturers, trade associations, equipment manufacturers, and
chambers of commerce. 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 (See Appendix A). A follow-
up letter was mailed to non-respondents; where practicable, a personal
interview was obtained to explain the project in greater detail.¹

¹ Lowell Textile Institute, where this study was made, is located
in the center of the apparel wool scouring area. Most of the carpet
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 questionnaires, telephone, letter, and where practicable, by means of a personal interview. Since 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.

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<td>Lanolin</td>
<td>The material refined from wool grease known as technical lanolin, U.S.P. lanolin, or cosmetic lanolin.</td>
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<td>Wool grease</td>
<td>The greasy material in wool secreted by the sebaceous glands of the sheep.</td>
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<td>Apparel wool</td>
<td>Wool finer than grade 40's.</td>
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<tr>
<td>Carpet wool</td>
<td>Wool coarser than grade 40's, which if imported into the United States would enter duty free.</td>
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<td>Scourer</td>
<td>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.</td>
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<td>Refiner</td>
<td>A lanolin manufacturer who distributes both wool grease and lanolin.</td>
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wool is scoured in or near Philadelphia. (On May 25, 1953, the name of the school was changed to Lowell Technological Institute.)

2 The term lanolin (Latin — lana — wool) originated in a patent specification in 1882 issued to two German inventors, Braun and Liebreich.
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 of higher fatty acids 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 the true oils and fats such as tallow, margarine, and lard, wool grease (also lanolin) does not become oxidized more than enough to form a surface film which 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 spermaceti or paraffin, 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 (thirty to forty percent of the unsaponifiable 3

Chemically it is a compound formed by condensation of an organic acid with an alcohol.

4 At least thirty different acids are present. For a complete list see A. W. Weitkamp, "Acidic Constituents of Degras," Journal of the American Chemical Society, Vol. 67, 1945, pp. 1471-151.
part), and for alcohols and acids not known to occur in 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 five to ten 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. Its reputation as an emollient is based upon its affinity for water and the fact that it approximates the natural secretions of the human skin.

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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 plasticiser are attributed to the alcohol portion.
CHAPTER II

WOOL GREASE SUPPLY IN THE UNITED STATES

Many of the current and potential industrial uses for wool grease are limited by the amount 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 by-product 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 by-product by thirty-eight scourers of apparel wool that recover the wool grease from their scouring liquors. The other and secondary source consists of imports.

Centrifuged grease which is suitable for refining into lanolin is produced by thirty-five domestic scourers. The other three scourers recovered, by the acid cracking method, approximately twenty 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 at a cost of approximately one cent a pound with sodium sulphite and was sold under ceiling prices of the Office of Price Stabilization (hereinafter referred to as O.P.S.) at approximately fifteen cents a pound in contrast to twenty cents a pound for centrifuged grease. Acid-cracked
FIGURE 1
Total Wool Grease Available for Consumption, United States, 1931-1952

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 \( r = 0.749 \), indicating by the square of that number that approximately fifty-six percent of the variations in wool grease production may be accounted for by variations in mill consumption of apparel wool. The other forty-four 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 came in 1934 when only 381.4 million pounds of grease wool were scoured, and the high point, during World War II when 1122.5 million pounds of grease wool were scoured in the United States. 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 two 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 in leather stuffing, fur dressing, belt dressing, and drawing.

Formula is \( r = \frac{\varepsilon(XY)}{\sqrt{\varepsilon(X^2)} \sqrt{\varepsilon(Y^2)}} = \frac{11631275}{\sqrt{1446540} \sqrt{537795827}} = 0.749 \)
FIGURE 2

Amount of Wool Grease Recovered in Relation to the Production and Consumption of Apparel Wool (Scoured Basis), United States, 1931-1952

FIGURE 3
Wool Grease Imports by Grades, United States, 1931-1952

Thousands
of Pounds

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 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 suitable (economically) for refining into lanolin.

Factors Affecting the Supply of Wool Grease

There are many factors which affect the supply of wool grease. The chief one is the amount 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, 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.

The other factors which affect indirectly the potential supply of wool grease through their effect on wool consumption are:

1. Decreased production of domestic wool.
2. Increased imports of woven wool apparel fabrics.
3. Increased imports of scoured wool and wool tops.

Such as the froth flotation process for grease recovery recently developed in Australia by the Commonwealth Scientific and Industrial Research Organization.
4. Increased use of other apparel fibers, particularly synthetic.

The following discussion shows the extent to which these four factors affect the potential volume of grease recovery in the United States.

1. The decreased production of domestic wool reduces an assured potential source of grease because nearly all domestic wool is scoured within the United States.\(^3\) The trend of domestic production is definitely down, as shown in Table 1, but it may stabilize at the present level because of the Department of Agriculture's price support program for wool. The gap between increased wool requirements and reduced domestic supply has been bridged by imports. There has been a trend toward increased imports of wool in the scoured state. To the extent that this trend continues, it will reduce the potential source of grease recovery.

2. Increased importation of woven wool fabrics, as shown in Figure 4, decreases the potential recovery of grease from equivalent consumption of raw wool in United States mills since the wool is scoured abroad. It is estimated that each square yard of cloth represents two pounds of grease wool. The possible loss of wool grease because of this trend has been substantial during the past three years. In 1952, for example, it is estimated at eleven million pounds.

\(^3\) No carpet wool is produced in the United States, 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.
TABLE 1

Apparel Wool Production and Exports,
Actual Weight of Shorn and Pulled Wool, United States
(Millions of pounds)

<table>
<thead>
<tr>
<th>Year</th>
<th>Wool Production</th>
<th>Wool Exports*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1945</td>
<td>378.5</td>
<td>28.8</td>
</tr>
<tr>
<td>1946</td>
<td>342.2</td>
<td>16.0</td>
</tr>
<tr>
<td>1947</td>
<td>308.0</td>
<td>12.7</td>
</tr>
<tr>
<td>1948</td>
<td>278.4</td>
<td>1.1</td>
</tr>
<tr>
<td>1949</td>
<td>248.5</td>
<td>15.7</td>
</tr>
<tr>
<td>1950</td>
<td>247.8</td>
<td>6.8</td>
</tr>
<tr>
<td>1951</td>
<td>251.4</td>
<td>0.2</td>
</tr>
<tr>
<td>1952</td>
<td>266.0</td>
<td>0.03</td>
</tr>
</tbody>
</table>

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


3. Importation of scoured wool and wool top has increased tremendously during recent years, resulting in a further loss of potential domestic grease recovery. The increase in wool top imports is due to the maintenance of differentials in dollar-peso exchange rates in Argentina and Uruguay which favor wool top exports over raw wool exports. Uruguay, for instance, allows an exchange of 2.15 pesos per U.S. dollar to top exporters but maintains a rate of 1.52 pesos to wool exporters. Top makers thus have a price advantage of forty

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4 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
Total Annual Imports of Woven Wool Apparel Fabrics, United States, 1946—1952

Millions of Square Yards

United Kingdom

All Others

percent of all top imported came from Uruguay, the equivalent of approximately thirty-five million pounds of greasy wool. This is shown in Figure 5.

4. The increased use of other apparel fibers, particularly synthetic, is a potential long term factor which may affect the domestic supply of wool grease. Perhaps the outstanding fact about synthetic textile fibers is that they have increased in amount each postwar year except 1949. Rayon and acetate textile capacity is expected to be three and one-quarter times that of the 1939 level by late 1953, but it will be chiefly in high tenacity tire yarns. Other man-made fiber production increased from five million pounds in 1940 (mostly nylon) to 210,000,000 pounds in 1951. Not all of this production competes with wool as the raw material for clothing. A proportion of 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 one hundred percent wool textiles. An authoritative statement on the future uses of man-made fibers as wool substitutes has been made by Mr. Giles Hopkins, Technical Director, The Wool Bureau, Inc., New York, as follows:

Opinions on future uses of artificial fibers vary considerably. Most of the statements are made by protagonists for the new fibers. Eventual use will depend only on the proved performance in actual service over a considerable period of time.

One difficulty of evaluating future use is that at the present time we do not know enough about the relationship between fiber properties and fabric performance to anticipate
FIGURE 5
Imports of Scoured Apparel Wool and Wool Tops, United States
1946 - 1952

Millions of Pounds

Scoured wool
Uruguay wool top
Argentine wool top
Wool top, other countries

Source: Bulletin of National Association of Wool Manufacturers,
all of the possibilities. We have new fibers such as Orlon
and X-51 which give a greater loft than wool and apparently
have the ability to maintain this loft. However, these
fibers absorb practically no moisture, thus causing static
difficulties and certain discomforts with respect to non­
absorption of moisture. In other words, each time that a
new fiber is produced with a quality which rivals wool in
some of its strongest characteristics, new qualities which
are generally considered to be a disadvantage are associated
with them. Some of these advantages will, no doubt, eventually
give way to the extensive application of engineering investi­
gation. Such investigations are now going on in the fields
of dyeing, finishing, and static elimination.

About the only generalization which we can make is that
it is highly probable that the new fibers will find their
use in blends to a greater extent than as pure fiber constructions.

It seems probable that a smaller proportion of the dollar which
the consumer spends for clothing will be used for apparel wool.

Wool Grease Potential for the United States, 1935-1952

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 which make them
unsuited for special effects.

Inasmuch as there is less than five percent grease in carpet wool
(grade 40 and coarser, all of which is imported duty free) it is the
consensus among carpet wool scourers and grease recovery equipment
manufacturers 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. U. S. wool production and U. S. imports of grease wool would not be an accurate base for this estimate since there is often a considerable lag between production or importation and consumption, as shown by Figure 6. The most realistic data on which to base grease production is "U. S. Mill Consumption of Apparel Wool," compiled by the United States Bureau of the Census and published in its Facts for Industry, series M155-01. 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.

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, 1942-1945 inclusive, scoured apparel wool imported into the United States averaged nineteen percent of total wool imports on a
FIGURE 6
Apparel Wool Supply and Mill Consumption, 1935-1952
(Calendar Years, Clean Basis)

clean basis. In 1951 and 1952 scoured wool and wool top amounted to approximately seventeen percent and twenty-two percent, respectively, of total United States apparel wool imports on a clean basis (See Figure 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. This has been done by the Bureau of Agricultural Economics of the United States Department of Agriculture in Wool Statistics, 1949, CS-37, Table 28, page 35.

For the years 1948, 1949, 1950, and 1951, mill consumption data for apparel class wool were not available on a grease basis from the 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. It now remains to apply to each of the grades a factor which most nearly represents the grease content of that grade.\(^5\)

Nearly all of the scientific studies of the grease content of wool have been made abroad,\(^6\) and because of their wide range of grease content they are unsuitable for estimating the grease content of wool.\(^5\)

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\(^5\) The lower grease content of a small proportion of the total, consisting of pulled wool, has been ignored. In 1951 pulled wools constituted sixteen percent of domestic production and less than one percent of imported wools.

### TABLE 2

Approximate Average Clean Yield of Domestic and Imported Apparel Wool, Shorn, by Grades

<table>
<thead>
<tr>
<th>Grade</th>
<th>Domestic (percent)</th>
<th>Foreign (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine (6Us and finer)</td>
<td>40</td>
<td>54</td>
</tr>
<tr>
<td>1/2-blood (60s, 62s)</td>
<td>43</td>
<td>57</td>
</tr>
<tr>
<td>3/8-blood (56s, 58s)</td>
<td>52</td>
<td>64</td>
</tr>
<tr>
<td>1/4-blood (50s, 52s)</td>
<td>55</td>
<td>67</td>
</tr>
<tr>
<td>Low 1/4-blood (46s, 48s)</td>
<td>58</td>
<td>70</td>
</tr>
<tr>
<td>Common (4Us)</td>
<td>61</td>
<td>68</td>
</tr>
<tr>
<td>Braid (40s and coarser)</td>
<td>61</td>
<td>71</td>
</tr>
</tbody>
</table>


consumed in the United States. In addition, there are reports of laboratory trials on wools from one or two countries and from only a few breeds of sheep. It has therefore been necessary to rely upon the knowledge and experience of a few men 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 was as follows:

<table>
<thead>
<tr>
<th>Grade of Grease Wool</th>
<th>Grease Content (as a % of grease weight of wool)</th>
</tr>
</thead>
<tbody>
<tr>
<td>60's and finer</td>
<td>12 - 14%</td>
</tr>
<tr>
<td>50's to 60's</td>
<td>8 - 11%</td>
</tr>
<tr>
<td>48's and coarser</td>
<td>5 - 7%</td>
</tr>
</tbody>
</table>

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7 Dr. Werner von Bergen, Director of Research, Forestmann Woolen Co., Passaic, New Jersey; Mr. Hugh Christison, formerly Chief Chemist, Arlington Mills, Lawrence, Massachusetts; Mr. T. N. Crowley, American Chemical Paint Company, Ambler, Pennsylvania; and Mr. Fritz Kobayashi, Chief Chemist, Ames Worsted Company, Lowell, Massachusetts.
These factors were applied to the three categories of grease wool for the years 1935 to 1951 in estimating the potential supply of wool grease in the United States.

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 in the form of scoured wool and wool top which have been imported and are thus not a source of domestic wool grease. The corrected total potential supply of wool grease is compared to the actual amount in the United States in Table 3.

There are several reasons why United States production of wool grease averages a little less than fourteen percent of the potential supply. The chief one is the relative inefficiency of the methods of recovering wool grease in the United States. 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. This will be discussed in greater detail in a later section devoted to a description of the various methods of recovery. The second reason is that although wool scouring is largely done in the New England area, the individual establishments are small and are separated by many miles. 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 to pool their effluents for economical treatment as in the Bradford area in England.
### TABLE 3

**Actual Wool Grease Recovery as a Percent of Estimated Potential Recovery, United States, 1935-1952**

<table>
<thead>
<tr>
<th>Year</th>
<th>Estimated Wool Grease* (000) lbs.</th>
<th>Wool Grease Recovered in the U.S. (000) lbs.</th>
<th>Percent Wool Grease Recovered</th>
</tr>
</thead>
<tbody>
<tr>
<td>1935</td>
<td>81,677</td>
<td>9,654</td>
<td>11.4</td>
</tr>
<tr>
<td>1936</td>
<td>73,132</td>
<td>6,922</td>
<td>9.5</td>
</tr>
<tr>
<td>1937</td>
<td>63,372</td>
<td>7,511</td>
<td>11.9</td>
</tr>
<tr>
<td>1938</td>
<td>58,288</td>
<td>5,324</td>
<td>9.1</td>
</tr>
<tr>
<td>1939</td>
<td>76,114</td>
<td>7,192</td>
<td>9.4</td>
</tr>
<tr>
<td>1940</td>
<td>77,334</td>
<td>9,918</td>
<td>12.8</td>
</tr>
<tr>
<td>1941</td>
<td>108,957</td>
<td>13,314</td>
<td>12.2</td>
</tr>
<tr>
<td>1942</td>
<td>106,842</td>
<td>15,431</td>
<td>14.4</td>
</tr>
<tr>
<td>1943</td>
<td>106,102</td>
<td>15,118</td>
<td>14.3</td>
</tr>
<tr>
<td>1944</td>
<td>100,975</td>
<td>17,031</td>
<td>16.9</td>
</tr>
<tr>
<td>1945</td>
<td>103,279</td>
<td>17,522</td>
<td>17.0</td>
</tr>
<tr>
<td>1946</td>
<td>112,025</td>
<td>19,959</td>
<td>17.8</td>
</tr>
<tr>
<td>1947</td>
<td>113,866</td>
<td>22,190</td>
<td>19.5</td>
</tr>
<tr>
<td>1948</td>
<td>105,346</td>
<td>18,874</td>
<td>17.9</td>
</tr>
<tr>
<td>1949</td>
<td>73,714</td>
<td>9,023</td>
<td>12.2</td>
</tr>
<tr>
<td>1950</td>
<td>89,825</td>
<td>14,548</td>
<td>16.1</td>
</tr>
<tr>
<td>1951</td>
<td>77,318</td>
<td>10,328</td>
<td>13.3</td>
</tr>
<tr>
<td>1952</td>
<td>71,440</td>
<td>8,161</td>
<td>11.9</td>
</tr>
</tbody>
</table>

* Wool grease potential computed from grease content of apparel wool consumed in the United States.
The amount and types of wool required for the economic operation of grease recovery equipment will be discussed in the section devoted to the cost of recovering grease.

**Demand for Apparel Wool.** Because of the close correlation between the amount of apparel wool scoured in the United States and the amount of wool grease produced, any forecast for wool grease must be based on the demand for apparel wool. An examination of the factors affecting that demand is therefore pertinent to this study. 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 to show the pattern of production and consumption.

The United States imports far more apparel wool than it produces each year. On the assumption that these imports were consumed each year about as imported, Table 1 shows that on the average this country produces less than one-third of the apparel wool which it consumes. The wide fluctuations in consumption of apparel wool are also apparent in this table, ranging from a low of 220,000,000 pounds in 1938 to 610,000,000 pounds in 1946, immediately after the war. During the war years, 1941-45, consumption averaged 569,000,000 pounds per year, about half of which was used to make clothing for the armed forces.\(^8\)

Another view of wool consumption in the United States may be obtained from per capita figures in Table 4. During the years 1935-39

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**TABLE 1**

Apparel Wool Production; Imports, and Consumption
(Scoured Basis), United States, 1935-1952

<table>
<thead>
<tr>
<th>Year</th>
<th>Domestic Production (000,000 lbs)</th>
<th>Net Imports** (000,000 lbs)</th>
<th>Mill Consumption (000,000 lbs)</th>
<th>Per Capita, pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>1935</td>
<td>189</td>
<td>27</td>
<td>319.0</td>
<td>2.49</td>
</tr>
<tr>
<td>1936</td>
<td>185</td>
<td>70</td>
<td>299.8</td>
<td>2.33</td>
</tr>
<tr>
<td>1937</td>
<td>187</td>
<td>91</td>
<td>274.2</td>
<td>2.12</td>
</tr>
<tr>
<td>1938</td>
<td>187</td>
<td>19</td>
<td>219.6</td>
<td>1.68</td>
</tr>
<tr>
<td>1939</td>
<td>188</td>
<td>59</td>
<td>293.1</td>
<td>2.22</td>
</tr>
<tr>
<td>1940</td>
<td>190</td>
<td>119</td>
<td>310.0</td>
<td>2.33</td>
</tr>
<tr>
<td>1941</td>
<td>199</td>
<td>335</td>
<td>514.4</td>
<td>3.83</td>
</tr>
<tr>
<td>1942</td>
<td>200</td>
<td>457</td>
<td>560.5</td>
<td>4.13</td>
</tr>
<tr>
<td>1943</td>
<td>195</td>
<td>384</td>
<td>603.3</td>
<td>4.38</td>
</tr>
<tr>
<td>1944</td>
<td>184</td>
<td>342</td>
<td>577.0</td>
<td>4.14</td>
</tr>
<tr>
<td>1945</td>
<td>170</td>
<td>404</td>
<td>589.2</td>
<td>4.18</td>
</tr>
<tr>
<td>1946</td>
<td>153</td>
<td>465</td>
<td>609.6</td>
<td>4.38</td>
</tr>
<tr>
<td>1947</td>
<td>139</td>
<td>253</td>
<td>525.9</td>
<td>3.63</td>
</tr>
<tr>
<td>1948</td>
<td>124</td>
<td>245</td>
<td>485.2</td>
<td>3.29</td>
</tr>
<tr>
<td>1949</td>
<td>109</td>
<td>147</td>
<td>339.0</td>
<td>2.26</td>
</tr>
<tr>
<td>1950</td>
<td>108</td>
<td>247</td>
<td>436.9</td>
<td>2.86</td>
</tr>
<tr>
<td>1951</td>
<td>119</td>
<td>272</td>
<td>382.1</td>
<td>2.43</td>
</tr>
<tr>
<td>1952</td>
<td>127</td>
<td>288</td>
<td>347.0</td>
<td>2.20</td>
</tr>
</tbody>
</table>

Source: Based on data compiled from reports of the U.S. Bureau of the Census.

* Domestic production as reported by the Agricultural Estimating Service, United States Department of Agriculture, converted to a scoured basis, using 40 percent yield for shorn wool and 67 percent yield for pulled wool.

** Imports for consumption less exports of domestic wool. Wool entered free as an act of international courtesy is not included. Data for the years 1935-41 include all foreign wool except Donskoi, Smyrna, East Indian, Chinese, and similar wools particularly suitable for floor coverings. The data for these years include a small quantity of duty-free wool and exclude a small quantity of duty-paid wool. Data for later years include all duty-paid wool and exclude all duty-free wool.
mill consumption per capita averaged 4.13 pounds. During the war years, 1941-45, it averaged two pounds, went up to 4.4 pounds in 1946, and declined to 2.26 pounds in 1949, 2.86 pounds in 1950, and 2.43 pounds in 1951.

The demand for apparel wool is derived from the demand for clothing, since more than seventy-five percent of apparel wool consumed in the United States normally enters into that use. 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, being much higher in the upper levels as shown by the following statement for United States consumers during 1935 and 1936:

Because the average amount spent for clothing increases more rapidly with increasing income than do the amounts spent for food, housing, and household operations, the percent of total expenditures devoted to clothing rises as we move up in the income scale. Absorbing only 7.5% of total expenditure for the income class under $500, it expands to 15% of total consumption expenditures for the income class of $20,000 and over.10

Beyond the well-known fact that the demand for apparel wool is a function of the demand for clothing, there is very little precise informa-


tion available to correlate one with the other. There is, in fact, some evidence to indicate that the correlation would not be a direct or a close one. First, as stated above, only about seventy-five percent of apparel wool consumed in the United States normally enters into the manufacture of items of wearing apparel.

Second, the total demand for apparel wool is composed of consumer demand and inventory demand, as summarized in the following four statements from an article by F. F. Rafael:

1. Total demand for apparel wool - as measured by raw wool consumption - is composed of consumer demand and inventory demand, inasmuch as wool consumption in excess of retail sales increases inventories at some stage of production or distribution, whereas conversely, wool consumption below retail sales reduces inventories.

2. These inventory changes show a rather well-defined cyclical pattern.

3. The inventory cycle is closely and positively related to changes in the price of wool; that is, the accumulative phase of the cycle is accompanied by rising prices and the period of inventory reduction by falling prices.

4. Forecasts of total demand and of wool prices, therefore, should be based on estimates of inventory demand in addition to calculation of consumer demand.

Third, as this article points out, there is some lapse of time between the demand for apparel wool by the textile manufacturer and the sale of clothing at retail. Many processes and stages of distri-

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12 Hermie, op. cit., p. 18.

bution intervene between the purchase of wool and the purchase of clothing at retail. It is this time lag and the lack of information on inventory demand as well as consumers' demand which make a precise correlation impossible.

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 in 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 twenty representative wool products and to the farm value of the wool used in their manufacture shows that during the twenty-five years from 1926 to 1950, returns to growers for the raw wool averaged about fourteen percent of the retail prices to consumers for the finished products as shown in Figure 7.

The proportion of the retail value of the wool used varied irregularly with the prices of wool, ranging from almost eighteen percent in 1928 to about six percent in 1932, and averaged sixteen percent in 1950. This would mean that the price of raw wool might fall considerably and have little or no 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

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FIGURE 7
Marketing and Manufacturing Margins for Wool Products,
United States, 1926-1950

* In combining the retail values for the 20 items, prices were weighted by the number of articles purchased by the average wage earner's family as reported by the Bureau of Labor Statistics.

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.

W. A. Westerman, who has produced one of the most definitive works on the demand for wool in the United States, has found a close correlation between the gross national product and total wool consumption, and between per capita consumption of raw wool and national income. He also states that, "In the past, expenditure on clothing as a whole has shown close correlation with both consumer expenditure and with gross national income."\(^{16}\)

Another author states that, "When employment and national income are at a high level, demand for clothing is great and America needs and consumes more raw wool. As the cycle dips and business conditions stagnate, incomes, then demand for clothing, and finally, consumption of wool fall off."\(^{17}\)

Mr. A. M. Hermie has investigated the relationship between per capita income, clothing consumption, and wool consumption as shown in Figure 8. He states that, "Consumer expenditure for clothing varies directly with consumer purchasing power. Consumption of

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\(^{15}\) "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." Gerda Blau, "Wool in the World Economy," Journal of the Royal Statistical Society, December, 1946, p. 38.


\(^{17}\) Ibid., p. 29.
FIGURE 8
Clothing and Apparel Wool—Clothing Expenditures and Wool Consumption in Relation to Income, Per Person in U.S.

% of 1935-39

apparel wool in the long run tends to be high when disposable income is high and vice versa. However, only a small part of the year-to-year variation in mill consumption was found to be associated with changes in disposable income and prices of apparel wool. A partial explanation lies in the fact that consumption by mills reflects anticipated future rather than current consumer demand for textile products. Fluctuations in inventories may be largely responsible for the extreme and somewhat erratic fluctuations in the mill consumption of the raw fiber.18

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.

---

18 Hermie, op. cit., p. 25.
Wool Grease Recovery Forecast, 1955 and 1960

In view of the importance of the demand for apparel wool in estimating grease recovery and in the absence of a proved technique for estimating that demand in the United States, it is assumed, for purposes of this study, that future per capita demand for apparel wool will fluctuate between the 1935-1939 average and 1949-1952 average. These are 2.17 pounds and 2.14 pounds, respectively, of apparel wool per capita. These are applied to the medium series of estimates of United States population for 1955 and 1960 shown in Table 5. The medium series is used because the Census Bureau announced on April 1, 1953, that the United States population was 159,068,000. This indicates that the medium series most nearly approximates the present actual rate of increase.

TABLE 5

Projection of Total United States Population
(Including Armed Forces overseas)
(In Thousands)

<table>
<thead>
<tr>
<th>Date (July 1)</th>
<th>Low Series</th>
<th>Medium Series</th>
<th>High Series</th>
</tr>
</thead>
<tbody>
<tr>
<td>1955</td>
<td>161,190</td>
<td>163,186</td>
<td>165,758</td>
</tr>
<tr>
<td>1960</td>
<td>165,174</td>
<td>171,176</td>
<td>179,812</td>
</tr>
</tbody>
</table>


The forecast demand for apparel wool in 1955 and 1960 is shown in Table 6.
### TABLE 6

Forecast Demand for Apparel Wool (Scoured Basis), United States

(Thousands of pounds)

<table>
<thead>
<tr>
<th>Date</th>
<th>Based on 1935-1939</th>
<th>Based on 1949-1952</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>per capita consumption</td>
<td>per capita consumption</td>
</tr>
<tr>
<td>1955</td>
<td>354,114</td>
<td>398,171</td>
</tr>
<tr>
<td>1960</td>
<td>371,452</td>
<td>417,669</td>
</tr>
</tbody>
</table>

Based on the recovery rate experienced in recent years the wool grease recovered from the apparel wool consumption forecast as shown in Table 6 would be between ten and a half and eleven and a half million pounds in 1955 and between eleven and twelve million pounds in 1960. This forecast assumes no significant changes in scouring or grease recovery techniques, in the demand for wool grease as reflected in increased prices, or in legal pressures on scourers to abate stream pollution. It is expected, however, that there will be a gradual increase in imports of wool grease from European countries due to the installation of centrifugal grease recovery equipment there.
CHAPTER III

GREASE WOOL SCOURING IN THE UNITED STATES

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

Information on grease wool scouring in the United States has been obtained by means of questionnaires (Appendix A) filled out by eighty-eight of the one hundred five wool scourers in the United States and from interviews with fifty-six of them. Additional information was obtained from the two manufacturers of scouring equipment, C. G. Sargent's Sons, Graniteville, Massachusetts, and Hunter Machinery Company, North Adams, Massachusetts; from soap companies which have made many tests of their detergents to improve scouring efficiency; and from the faculty, graduate students, and staff of the Lowell Textile Institute, who have had long experience with the chemical and engineering aspects of the scouring process and with the equipment and materials used.

Since 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.
and to present the data collected from the sources listed above in ways that will be meaningful to the layman as well as to the scourer.

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. The following list shows the number in each category.

Grease Wool Scouring Establishments in the United States

<table>
<thead>
<tr>
<th>Type of Establishment</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commission scourers</td>
<td>18</td>
</tr>
<tr>
<td>Combing plants</td>
<td>15</td>
</tr>
<tr>
<td>Yarn manufacturers</td>
<td>13</td>
</tr>
<tr>
<td>Fully integrated textile mills</td>
<td>59</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>105</strong></td>
</tr>
</tbody>
</table>

Commission scourers, as their name implies, scour wool for others on commission. Their charges are remarkably uniform, being three cents a grease pound for wool shrinking more than fifty percent and three and a quarter cents for wool shrinking less than fifty percent. Heavy bleaching and carbonizing are one half cent a pound extra. Their method of operation is different from that of the other three types of

\[1\] Selling and some administrative costs would be less for those under common ownership.
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; and hence, their costs of operation are higher. Some of the extra services which 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 four 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 scour, 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 dryer to storage bins or is fed directly to the cards.

4. **Hand picking at the dryer.** 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.

5. **Bleaching wool.** Commission scourers bleach lightly with hydrogen peroxide nearly all the wool which they scour to make it whiter in color. Commission scourers usually have five or six bowl trains, and use the last bowl for bleaching, instead of the four bowl trains used by most woolen and worsted mills.
6. Better control. Commission scourers are called upon to scour to more critical limits (i.e., customer's demand). They will consistently leave .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 which they take out, which costs the most to remove.

Offsetting their higher costs, due to the extra services which they perform and to their flexibility in operation, are two minor sources of income. One is due to their scale of operation. A commission scourer must normally handle eight to ten 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 which is recovered in and around the duster or opener, the bowls, sumps, and dryer 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 amounts to 1 to 5 percent depending on whether it is a long staple Australian or Cape wool, which hangs together well, or a short Texas shearing, which scatters more in handling. Customers are unable to distinguish between shrinkage and waste.

Combing plants usually do not own the wool which 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; and hence 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 for 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 dryer 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, e.g., scouring one or two 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 which make it convenient to buy through the wool dealers on Summer Street.

The first question which 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. 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 on grease wool from one point in the far west to Boston is $3.18; whereas the carload rate from the same point to Boston on scoured wool is $5.96.

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2 The two scouring equipment manufacturers report that they receive similar inquiries at the rate of one or two a month.
FIGURE 9
Geographical Distribution of Scourers, United States, 1953

Source: Wool scouring questionnaires, Appendix A.
2. Few mills use only one type of wool. They use blends. These blends are easier to make at places where other wools are available and in sorting the grease wool and/or in scouring.

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

4. Suitable supplies of water of the required softness (hardness not over twenty 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 them are located on the Merrimack and Connecticut river systems. This concentration has made the enforcement of water pollution control laws in these and similar areas a potent factor in grease recovery. This factor and the possibility of cooperative action are discussed in Chapters VII and VIII.

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Exceptions are small, fully integrated woolen mills in the middle and far western states which use wool produced locally. They are usually highly specialized, manufacturing blankets and light weight woolen goods which are sold in nearby markets.
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 a waterproof overcoat but also prevents the fibers from felting. The amount of grease not only increases with the fineness of the wool, ranging from five to twenty percent of its grease weight, but there is variation in the amount found on the wool of sheep of different ages (see Appendix B, Table 26). There is even a substantial difference in the amount of impurities found in wool on different parts of the body (see Appendix B, Table 27). A recent study in the United States found that ram wool had a shrinkage of six percent more than ewe wool because of its higher grease content.¹

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


² 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, lanopalamic, and capric acids. Suint
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 two to twenty 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 five to forty 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 the following table.

**TABLE 7**

<table>
<thead>
<tr>
<th>Type</th>
<th>Grease %</th>
<th>Suint %</th>
<th>Dirt %</th>
<th>Vegetable Matter %</th>
<th>Shrinkage %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine</td>
<td>10-40</td>
<td>2-20</td>
<td>5-40</td>
<td>0.5-2.0</td>
<td>30-70</td>
</tr>
<tr>
<td>Medium</td>
<td>5-20</td>
<td>2-20</td>
<td>5-20</td>
<td>1.0-5.0</td>
<td>20-50</td>
</tr>
<tr>
<td>Long</td>
<td>5-10</td>
<td>2-20</td>
<td>5-10</td>
<td>0.1-2.0</td>
<td>10-30</td>
</tr>
<tr>
<td>Carpet Wool</td>
<td>5-10</td>
<td>2-20</td>
<td>5-20</td>
<td>0.5-2.0</td>
<td>20-40</td>
</tr>
<tr>
<td>Hairs</td>
<td>2-8</td>
<td>1-3</td>
<td>5-20</td>
<td>0.1-1.0</td>
<td>15-30</td>
</tr>
</tbody>
</table>


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 is determined by the breed and the climate and to a lesser extent by the age and sex of the sheep.

2. The amount of suint in the wool. This is determined mainly by 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, loose sandy soil in a dry, windy climate will produce a wool with a large shrinkage.

4. The amount of moisture present. This is largely determined by climate.

More than twice as much wool is imported into the United States as is produced domestically. In 1951 these imports were from forty-seven different foreign countries where they were produced from about thirty different breeds of sheep which 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, determines each year the variety, composition, and amount of the impurities which must be removed from their wool when it is scoured in the United States. Moreover, 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, e.g., a combing, yarn or textile mill.

From the relatively few establishments in the United States that 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 whose impurities vary widely in kind and amount from week to week and even from day to day. Moreover, he must operate on a continuous, mass production basis using cheap chemicals, soap and soda ash, which 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, is unlikely to develop into an exact science.

Another important reason is to be found in the personnel and operating policies which are common in the industry. Although the chemistry of the emulsion-type scouring process is well known, 6 and accurate physical and chemical tests have been devised for scouring

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efficiency, the actual operation of the scouring train is usually in the hands of an experienced and trusted employee, not technically trained, who adds more soap and soda ash to one of the scouring bowls according to the appearance and feel of the clean wool going into the dryer?

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 one which is considered to be economic.

Emulsion Scouring

The washing of wool is a skill which has been practiced since ancient times. In spite of the best efforts of many competent chemists and engineers and the expenditure of millions of dollars on research, pilot plants, and full scale trials, 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.

In one interview on September 3, 1952 that was typical of the attitude of most superintendents and mill operators, Mr. James Kershaw of Amoskeag—Lawrence Mills, Manchester, New Hampshire, said, "We do not attempt to be scientific in scouring our wool. Our man looks at it and feels it and uses his own judgment about dumping in more soap or soda."

Mr. Bryan Leonard, East Weymouth Wool Scouring Company, East Weymouth, Massachusetts, in an interview on February 12, 1953, said, "Scouring is done mostly by rule of thumb, and in commission scouring one must have a flexible thumb."
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 at the present time. 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 0.5 percent grease and 12 percent moisture, at the minimum cost and with minimum damage to the fiber.

The phrase minimum cost is applicable 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 is dependent, 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 minimum costs are
forestalled by the nature of the raw material and the requirements of the subsequent manufacturing processes.

The nature and amount of the impurities in grease wool as described in the preceding section determine the equipment, materials, and the methods used in scouring.

**Equipment, Materials, and Methods.** Scouring equipment is designed to remove all of the impurities with the least amount of agitation which causes felting and losses in subsequent operations. The equipment, called a scouring train, consists of three parts: a duster; a number of vats called bowls, about three feet deep, holding from 1500 to 2000 gallons of water; and a dryer. See Figures 10, 11, and 12 (C. G. Sargent's Sons Corporation). In the duster or opener, into which the wool is fed by hand as it comes from the sorters or from storage, the wool 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 dryer where a continuous stream of hot air reduces the moisture content to the amount
FIGURE 10

Wool Scouring Equipment: Opener and Duster

Courtesy of C. C. Sargent's Sons Corporation
FIGURE 11

Wool Scouring Equipment: Scouring Bowls

Courtesy of C. G. Sargent's Sons Corporation
Figure 12

Wool Scouring Equipment: Dryer

Courtesy of C. G. Sargent's Sons Corporation
desired in succeeding operations.

Scouring trains in commercial use in the United States usually have four, five, or six bowls and vary in width from four to six 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 six feet in width. There are three two-bowl and one seven-bowl trains in operation, as shown by the following table:

**TABLE 8**

Distribution of Scouring Trains by Number of Bowls

<table>
<thead>
<tr>
<th>Number of Trains</th>
<th>Number of Bowls</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>16</td>
<td>3</td>
</tr>
<tr>
<td>68</td>
<td>4</td>
</tr>
<tr>
<td>78</td>
<td>5</td>
</tr>
<tr>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>1</td>
<td>7</td>
</tr>
</tbody>
</table>

Source: Information obtained from eighty-eight respondents to questionnaire survey (See Appendix A). No distinction is made as to width.

The bowls beyond the fourth one are used for bleaching and/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; and 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.8

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.

Synthetic detergents are most likely to be adopted among 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 contains only clear warm water (or water

and alkali with a minimum pH\(^9\) 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, being composed of the potassium salts of long chain fatty acids, is therefore itself a soap and acts as a detergent. 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.

\(^9\) The pH system is a convenient scale ranging from 0 to 14, the lower end being strongly acidic and the upper end being strongly alkaline. A pH of 7 is neutral.
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.

**Scouring Costs.** The data presented in this section are based on information collected from twenty-three 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. Since 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 determine what the total costs are and to allocate a portion of them 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 a particularly difficult problem in this industry because the commission scourer, who is the only one whose costs can be directly and easily allocated to a point of grease wool or clean fiber, is not typical of all U. S. 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 simple 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 size older equipment?
4. What is the scale of operation? Is the equipment operated continuously throughout the year on one, two, or three shifts?
5. Is the scouring operation located in or near the center of a town with all facilities, such as a railroad siding and a steam supply, 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 by-products recovered that can decrease scouring costs?

These questions indicate some of the conditions which determine scouring costs. Early in this investigation it was observed that each mill was almost unique in many respects which affected its costs. The two illustrations which follow are typical of those 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, for purposes of
comparison 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. Ordinarily carpet wool scourers
are not required to treat their waste waters because coarse wool con-
tains a small proportion of impurities, but Mill A is located on a
stream whose volume of water is small compared to the waste water dis-
charged 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 one man approximately four hours per day to operate,
since it is largely automatic. However, in order to keep waste treat-
ment costs low, a nonionic synthetic detergent is used, and the wool is
scoured in a neutral solution. This increases chemical costs to about
two-tenths of a 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 to 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 3 uses these virgin wools and about twice as much by weight of noils 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 which 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 which is stained or clotted with paint or vegetable matter is picked out by hand. Granted that 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.

The possible combinations of land, labor, capital equipment, and entrepreneurial ability are infinite in the wool scouring industry. There is no one best way which results in the lowest scouring cost per pound. There are an infinite number of ways, each of 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.

Following is a list of those differences in operation which account for differences in cost.

1. Equipment  
2. Materials  
3. Method of Operation  
4. Location  
5. Integration  
6. Size

A description of the ways in which they affect scouring costs together with the specific costs incurred in scouring grease wool is given in Appendix C.

The data above have been applied 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. Over 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 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,

This information was collected by the author by personal observation and interviews at fifty-six scouring establishments during 1952.
interpolations from the cost data will be necessary.

Costs for a Commission Scourer: The following costs are submitted as being representative of those of a commission scourer processing approximately ten million pounds of grease wool annually. This is a normal size for a commission scouring operation in the United States during the post-World War II period. Costs are based on the assumptions set forth in Appendix C. If chiefly apparel wool were 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 factors of location, size, or method of operation would raise the total cost to between $2.45 and $3.00 per 100 pounds of grease wool scoured in a normal year which is the range for commission scourers in the United States.

Costs for Scouring Departments of Integrated Mills. Since this is a decreasing cost industry, there are significant differences in cost due to the size of the operation. The following data 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
TABLE 9
Average Costs for a Commission Scourer

| Cost per 100 lbs. of grease wool | £1.211 |

Direct Labor

Based on the following schedule.

<table>
<thead>
<tr>
<th>For each shift</th>
<th>No. Men</th>
<th>Wage Rate</th>
<th>Cost per hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>From storage to machine</td>
<td>2</td>
<td>1.51</td>
<td>3.02</td>
</tr>
<tr>
<td>Feeder of Machine</td>
<td>2</td>
<td>1.47</td>
<td>2.94</td>
</tr>
<tr>
<td>Train Operator</td>
<td>2</td>
<td>1.53</td>
<td>3.06</td>
</tr>
<tr>
<td>Dryer Operator</td>
<td>2</td>
<td>1.47</td>
<td>2.94</td>
</tr>
<tr>
<td>Handyman</td>
<td>1</td>
<td>1.47</td>
<td>2.94</td>
</tr>
<tr>
<td>Warehouse wool handlers</td>
<td>6</td>
<td>1.45</td>
<td>8.70</td>
</tr>
<tr>
<td>Balers or Bagger</td>
<td>2</td>
<td>1.45</td>
<td>2.90</td>
</tr>
<tr>
<td>Mechanic</td>
<td>1</td>
<td>1.75</td>
<td>1.75</td>
</tr>
<tr>
<td>Supervisor</td>
<td>1</td>
<td>2.50</td>
<td>2.50</td>
</tr>
<tr>
<td><strong>Total direct labor cost per hr.</strong></td>
<td></td>
<td><strong>$29.26</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Annual direct labor cost</strong></td>
<td></td>
<td><strong>$121,194.00</strong></td>
<td></td>
</tr>
</tbody>
</table>

Materials

| Rent | Based on a space 100 x 125 feet for two trains and adjacent storage space 100 x 200 feet. Suitable buildings 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. | .167 |
| Steam | Based on dumping the scouring bowls twice each week | .34 |
| Electricity | Based on an average consumption of 980 kwh. per shift | .109 |
| Repairs and Supplies | | .045 |
| Depreciation on Equipment | | .082 |
| Indirect Labor | Includes clerical help, taxes, and fringe benefits. | .32 |

Total cost per 100 pounds of grease wool scoured

| Total cost per 100 pounds of grease wool scoured | $2,389 |
buyer may also be in charge of the scouring department. The smallest mill whose costs are given here would scour the one million pounds of grease wool which it uses annually by operating its scouring train one week out of the month on a two shift basis and dumping the bowls daily. The mill scouring five million pounds annually would use one four bowl train two shifts daily, dumping the bowls not more than twice a week, and scouring an average of 100,000 pounds a week. The mill scouring ten million pounds annually would operate in the same manner with two trains. The largest mill would need three trains to scour twenty million pounds of wool annually. Two of these trains would be operated continuously for three shifts and the other for two shifts daily for fifty weeks a year.

### TABLE 10

Scouring Costs for Integrated Mills per 100 pounds of Grease Wool

<table>
<thead>
<tr>
<th>Cost Item</th>
<th>1,000,000</th>
<th>5,000,000</th>
<th>10,000,000</th>
<th>20,000,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Labor</td>
<td>$0.543</td>
<td>$0.470</td>
<td>$0.486</td>
<td>$0.459</td>
</tr>
<tr>
<td>Indirect Labor</td>
<td>0.807</td>
<td>0.268</td>
<td>0.169</td>
<td>0.111</td>
</tr>
<tr>
<td>Materials</td>
<td>0.134</td>
<td>0.134</td>
<td>0.134</td>
<td>0.134</td>
</tr>
<tr>
<td>Supplies</td>
<td>0.150</td>
<td>0.030</td>
<td>0.030</td>
<td>0.023</td>
</tr>
<tr>
<td>Depreciation—1 bowl train</td>
<td>0.343</td>
<td>0.069</td>
<td>0.069</td>
<td>0.051</td>
</tr>
<tr>
<td>Rent—Lowell, Mass. area</td>
<td>0.237</td>
<td>0.047</td>
<td>0.047</td>
<td>0.035</td>
</tr>
<tr>
<td>Steam—Lowell rate</td>
<td>0.208a</td>
<td>0.425</td>
<td>0.420</td>
<td>0.418</td>
</tr>
<tr>
<td>Electricity—Lowell rate</td>
<td>0.142</td>
<td>0.098</td>
<td>0.086</td>
<td>0.078</td>
</tr>
<tr>
<td><strong>Total cost per 100 lbs. of grease wool</strong></td>
<td>$2.564</td>
<td>$1.541</td>
<td>$1.441</td>
<td>$1.309</td>
</tr>
</tbody>
</table>

a 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. Since more than half the impurities, by weight, in grease wool are water soluble and since 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, i.e., a solvent to remove the grease and a mild soap and alkali bath to remove the remaining impurities.

Notwithstanding the record of success and failure of several methods of solvent scouring as recounted in the following pages, it is the opinion of many leaders in the industry that a more efficient method of removing impurities from grease wool at lower cost will eventually develop 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.
Arlington Mills. The most successful solvent scouring operation in the United States was carried out on a large scale (over one million pounds a week) for about fifty years at the Arlington Mills in Lawrence, Massachusetts. The wool, in batches of 2500 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, and a brown grease of low acidity remained which was used in an emulsion for rope making, in stuffing leather, and in lubricants.

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 recovered by solvent scouring, at lower cost, than by any other method. Production of grease at Arlington Mills was approximately 30,000 lbs. each 24 hours — about 12 percent of grease wool weight.
Smith Drum and Company. An attempt to introduce an improved method of solvent scouring, by using a non-inflammable solvent, trichlorethylene, in a continuous wool degreasing unit, was made by Smith, Drum and Company of Philadelphia, Pennsylvania. 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. It is not now in operation. It was a closed system with the solvent being distilled for reuse, producing a dry cake from the sludge and a brown grease which needed to be washed and centrifuged before it was saleable. The wool emerging in mat form from the dryer section of the degreasing unit gave off a considerable amount of dust before it dropped into a desuinting bowl of clear water. This created a personnel problem, and it was the difficulties involved in solving this problem which persuaded the management to abandon the experiment.

The floor space occupied by the unit was about three times as great 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 having 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

U. S. Patents 2,368,916, 2,593,422, 2,621,506.
as light colored and bright as wool scoured with soap and soda. 12

**Fiala Process.** Another possibility in solvent scouring is the use of nitrated kerosene (sixteen cents per gallon) 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 so far as quality and cost are concerned, but many of the details of this process have not been worked out on a commercial scale. 13

**American Chemical Research Corporation.** A recent development in solvent scouring is a process 14 using a mixture of sulphuric acid, ketone, (methyl - ethyl), and water developed by Mr. M. Levin of Lowell, Massachusetts, who has formed the American Chemical Research Corporation to promote its use. The solvent is partially soluble in water so that it forms an azeotropic mixture which can be distilled off for reuse at 60°F. The solvent costs less than one dollar per gallon, but it is inflammable and toxic, and equipment must be devised so that it can be used in a closed system.

In connection with all solvent scouring, it should be pointed out that continuous operation is necessary to minimize solvent losses and that unless the solvent is cheap enough to be disposed of by burning or can be cleaned by centrifuging, settling, chilling, etc., the distillation apparatus necessary to recover it for reuse is expensive to set up, control, operate, and maintain. Moreover, solvent scouring

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13 Interview with Mr. Fred Fiala, Cleveland, Ohio, December 31, 1952.

14 U. S. Patents, 2,508,406 and 2,508,407.
does not eliminate stream pollution because the suint content is putrescible as well as the grease, as shown by the following table.

**TABLE II**

Comparison of Scour Wastes from Mills Using Soap With One Mill Scouring with Naphtha
(Data given in lbs. per 100 lbs. wool)

<table>
<thead>
<tr>
<th>Dissolved Solids</th>
<th>Suspended Solids</th>
<th>Oxygen Alkalinity (5 min.)</th>
<th>B.O.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Volatile</td>
<td>Total Volatile</td>
<td>Fats</td>
<td></td>
</tr>
<tr>
<td>Average of four mills using soap</td>
<td>26.3</td>
<td>17.1</td>
<td>7.2</td>
</tr>
<tr>
<td>Solvent Scour</td>
<td>15.7</td>
<td>7.0</td>
<td>5.5</td>
</tr>
</tbody>
</table>


**Frosted Wool Process.** The frosted wool process was introduced in 1935, but the two mills which installed the equipment discontinued using it just prior to 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 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.

**Scouring by Sound Waves.** 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 has been reported in a Russian magazine, Tekstilnaya Promyshlennost, April, 1952, 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." 15

During the early part of 1953 the development of a household machine using ultrasonic energy for washing clothes was announced by Fairbanks Ward Industries, Inc., Chicago, Illinois.

**Butyl Alcohol Method.** 16 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, California. 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 damage to the fiber.


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

3. The alcohol is relatively nontoxic, relatively nonflammable, 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 as follows:

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 effected 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 scoured with soap and soda.

4. The quality of the grease recovered from the solvent process by distillation is not as good as that recovered by centrifuge from an emulsion effluent.
Effect 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 latter, it might be more economical to dispose of the solvent by burning or as a waste product than to recover it for reuse. With trichlorethylene at about $1.44 per 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 of 2–3 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 sixteen 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 the cost of recovery by distillation, settling, chilling, or centrifuging; the cost of recovering the grease from the resulting sludge; and the income from the grease. The price of wool grease in the United States during the last decade and the cost of recovering it in connection with the scouring operation have made its production wholly secondary to the production of clean fiber.

At the present time grease wool can be scoured most efficiently and economically in the United States with the conventional scouring
train and the cheap materials, soap, soda ash, and water. The maximum amount of grease can be recovered from this emulsion effluent by the acid cracking method. This method has been used thus far 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; i.e., simply by cracking the emulsion, settling, and filtering the sludge. This decreases the solid material and the biological oxygen demand to acceptable limits without producing any saleable by-product, 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 by-product currently recovered from the scouring effluent. The recovery of others, such as the suint salts, potassium carbonate and potassium sulphate, is not economically feasible because of natural deposits of potash throughout the world from which this material can be produced at much lower cost. One commission scourer reported in the questionnaire survey the production of 10,000 pounds of fertilizer annually from his scouring operation without grease recovery. It was concluded that he collected and sold the material left under the opener which contained some short wool fibers and would be a source of nitrogen.

Out of the one hundred five wool scourers in the United States, thirty-eight operate grease recovery equipment. Three of these use the acid cracking method, and thirty-five have installed centrifuges. The others do not recover grease for one or more reasons, as indicated in Table 12.

A study of the completed questionnaires from which the table was compiled (Appendix A) showed the following characteristics.

1. Carpet wool scourers did not have sufficient grease in their effluent to make it necessary to treat it in any way, for grease recovery or to abate stream pollution, as shown by their answer to Question 8-A.

2. Nearly all small scourers indicated Question 8-B and 8-C together.
<table>
<thead>
<tr>
<th>Reason</th>
<th>Amount of Grease Wool Scoured Annually (millions of pounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Less than 1 1-3 3-5 5-10 10-20 More than 20 \n</td>
</tr>
<tr>
<td>B. Recovery systems too costly to employ</td>
<td>7 9 2 2 3 2</td>
</tr>
<tr>
<td>C. Amount of wool scoured too small to warrant investment</td>
<td>10 7 0 0 0 1</td>
</tr>
<tr>
<td>D. No problem of stream pollution - consequently no necessity for effluent treatment</td>
<td>9 2 4 2 1 1</td>
</tr>
<tr>
<td>E. Market for wool grease too unstable</td>
<td>2 3 2 0 2 2</td>
</tr>
</tbody>
</table>

Comments: Not interested in recovering grease

Source: Data compiled from fifty respondents in questionnaire survey (Appendix A). Some indicated more than one reason for not recovering grease.
3. Question 8-D was indicated most often by those scourers located at or near tidewater or in the Mid- or Far West and by those who were able to dump their waste into a municipal sewage system.

4. There were no significant differences in the answers from plants of the same size scouring the same class of wool due to their location in different states, showing little difference in the enforcement of stream pollution laws among the states.

**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. This is so because, technically, there are more efficient and economical ways to produce an acceptable effluent than by recovering the grease.¹ These would vary, of course, depending on labor and material or equipment costs in the recovery process and 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

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treating the effluent is as follows.

**Investment in Waste Treatment Plant**

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 - 11,000 gal. tanks</td>
<td>$23,000</td>
</tr>
<tr>
<td>1 - reaction tank</td>
<td></td>
</tr>
<tr>
<td>1 - 3,000 gal. tank</td>
<td></td>
</tr>
<tr>
<td>1 - compressor</td>
<td></td>
</tr>
<tr>
<td>1 - acid tank</td>
<td>1,500</td>
</tr>
<tr>
<td>1 - acid feed</td>
<td>1,000</td>
</tr>
<tr>
<td>Pumps, collection sump and lagoons</td>
<td>10,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>535,500</strong></td>
</tr>
</tbody>
</table>

**Treatment cost for 100,000 gallons of effluent per week.**

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alum consumption 3,000 lbs. @ $1.65 per 100 lbs.</td>
<td>$48.50</td>
</tr>
<tr>
<td>Acid consumption 1,000 lbs. @ $1.00 per 100 lbs.</td>
<td>$10.00</td>
</tr>
<tr>
<td>Labor @ $1.50 per hour, 48 hour week</td>
<td>72.00</td>
</tr>
<tr>
<td>Depreciation</td>
<td>34.00</td>
</tr>
<tr>
<td><strong>Total cost</strong></td>
<td><strong>194.50</strong></td>
</tr>
</tbody>
</table>

To recover grease as a part of the waste treatment would require an additional investment of fifteen to thirty thousand dollars and the services of two additional employees at $1.50 per hour. The management of this mill has chosen to recover grease at a rate of three percent of the grease wool processed with a centrifuge and 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 greater net return. The sale, eighteen cents per pound, of the 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 as well as the intent.
of the legislatures not to enforce existing statutes on stream pollution until compliance has become economically feasible; i.e., 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 chapter on the acid cracking method of recovering grease.

Although wool grease is usually referred to as a by-product of the wool scouring or the wool textile industry, an economist, strictly speaking, would say that wool grease may or may not be produced as a by-product. Where the scouring process necessarily produces clean fiber and wool grease simultaneously, the latter is said to be 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 by-product and not a joint product.

An example of the production of grease as a joint product with clean fiber was in the solvent scouring system of the Arlington Mill, described in more detail on page 65, in which the process to be economical and continuous required the recovery of the solvent by distillation for reuse. The grease being completely dissolved in the solvent was
inevitably and simultaneously recovered as the wool was processed and clean fiber was produced. Another example in which wool grease would be produced as a joint product would be those mills required to recover the grease from their scouring effluent to abate stream pollution. This is not so in the United States because there are other and cheaper means of producing an acceptable effluent in those states which enforce stream pollution laws; e.g., a calcium chloride process developed by J. A. McCarthy at the Lawrence Experiment Station of the Massachusetts Department of Public Health and biological filters which would reduce the B.O.D. ¹ to acceptable limits. In all cases in the United States therefore wool grease is a true by-product 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 (i.e., 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 in the solvent scouring process. In practice one is designated the main product and one the by-product, 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

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² This is done by several mills, e.g., Ramsbarn Mills which is on a very small stream near Millbury, Massachusetts, and Beattie Manufacturing Company, Little Falls, New Jersey.

³ McCarthy, op. cit., pp. 75-83.

¹ It is commonly written B.O.D. and means the amount of oxygen required to stabilize, biologically, the organic matter contained in a waste. Its measurement together with the measurement of the amount of the dissolved oxygen carried by the stream, forms the principal basis for prediction of the undesirable effects which a waste will have on the stream.
their cost of production. The price of either one would be affected by the demand for the other; e.g., an increased demand for wool would result over a long period not only in an increase in the amount of clean fiber but also an increase in the amount 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 by-product 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 are first, when municipal authorities charge a fee for receiving the scouring effluent in the local sewage system, and second, when grease recovery is undertaken by a subsidiary or separate company to whom payment is made by the scourer. These 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 and/or third bowls and after being degreased in the centrifuge is returned to one of the bowls for reuse since it still has much of its detergent power. This not only reduces the amount of soap and soda needed (estimated savings amount to 20–25 percent) but also decreases the amount 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 case as it was the costs in the others.
The significant difference between the recovery of wool grease as a true by-product and as a joint cost product for this study is that the latter would continue to be produced so long as wool was scoured. The recovery of grease as a by-product 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 past decade for this to happen.

However, if there were any change in the amount 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 greater fixed overhead expense. But since 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, the grease and sludge settling out and being separated by filtering under heat and pressure.

Information about the centrifugal method of recovering wool grease was obtained from questionnaires completed by twenty-four of the thirty-five scourers in the United States who use centrifugal equipment and from interviews with twenty-three of them. Four of the non-respondents had only recently installed centrifuges and had been operating for less than a year. Their costs were therefore not included in the
survey. The twenty-four respondents scoured a total of 262,523.794 pounds of grease wool and produced 5,695,876 pounds of dry wool grease during 1951. 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 eleven 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 amount of wool scoured and its origin and fineness and, to a lesser degree, on the kind of scouring establishments; i.e., commission scourer, comber, yarn manufacturer, or fully integrated mill. Detailed cost data were collected on the Wool Grease Recovery Cost Form shown in Appendix A.

The centrifuge works on the principle of a cream separator; but in addition to separating the two immiscible liquids, 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 which 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

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5 The amount of wet grease recovered by DeLaval centrifuges was reduced by 25 percent to put it on the same basis as grease produced by Sharples centrifuges.
the scouring liquor as it is discharged into the stream. Further chemical and/or biological treatment of this waste would be necessary to abate stream pollution, or to make it equal to the waste discharged from the acid cracking process.

The centrifuge is nearly always located to close proximity to the scouring train and is employed in two ways: First, it is employed 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. Second, it is used 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 dirt particles and when the sludge is discharged from the centrifuge.

The second method is used by most of the scourers with centrifugal equipment. It enables the scouring liquor to 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 an increase in the productive time that the train is in operation.

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 degree 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. In terms of scouring equipment this would mean a two shift operation on a single train. At an average of 1000 pounds per hour, with an eight hour shift and a five day week, four million pounds could be scoured annually. However, a single grease recovery unit is capable of handling 1500-2000 gallons of liquor per hour and would be adequate to recycle the liquors from three scouring trains if they were compatible and could be mixed in the reserve and settling tanks. For example, a large worsted mill could use one centrifuge unit for three trains because all of them would be scouring the same kind of wool. But it is unlikely that a commission scourer could use one centrifuge for three 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 alternative would be to waste the liquor from the least greasy wool or by using a batch

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6 One mill in the United States recovers grease profitably from scouring two million pounds of fine wool annually.
process to hold it 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 minimum grease recovery unit sold by The Sharples Company now costs $24,720 f.o.b. Philadelphia. 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 1500 to 2000 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 fifty pounds of neutral, cry grease per hour. The O P S ceiling price for this grease from June 1952 to March 1953 was twenty cents per pound. This installation would be sufficient to handle the output of a single train scouring 1000 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 $3300 to take care of another train scouring fine wool or three 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 two trains scouring fine wool.

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FIGURE 13

Grease recovery Equipment

Courtesy of The Sharples Corporation
wool or three trains scouring medium wool. A vacuum dryer could be added for $5,000 to reduce the moisture content so that the grease could be sold for thirty cents a pound under O P S Ceiling Price Regulation 146.8

The American Chemical Paint Company installation using a DeLaval centrifuge differs from the Sharples Company equipment in several ways. First, it produces a wet grease which may have up to 30 percent moisture content and which sold for an O P S ceiling price of eighteen cents a pound on a 5 percent maximum moisture basis. Second, the DeLaval 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 American Chemical Paint Company. 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 which can recycle the effluent from three scouring trains is $18,000. This represents the cost of the tanks, heater, and cooler and their installation. By recovering wet grease the DeLaval 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

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8 Issued June 3, 1952.
FIGURE 14
Grease Recovery Equipment

Courtesy of De Laval Separator Company
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 amount of wool scoured would result in a more than proportional increase in the cost per pound of grease recovered. This is shown in Figure 15 and is based on 1951 data collected from eleven mills scouring from two to thirty-two million pounds annually who 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. Since 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 and, for the smaller mills, assume a two shift operation. For larger mills and commission scourers it was assumed that a second centrifuge would be added for flexibility in scouring after three trains were fully utilized on two shifts. This would be needed for ten to fifteen 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 one centrifuge and going to a three shift operation would be

9 Any royalty payments would also increase the cost per pound.
FIGURE 15
Average Cost per Pound of Producing Wool Grease by Centrifuge, 1951

Grease Wool Scoured Annually in Million Pounds

Source: Computed from data from a representative sample of mills.
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 three 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 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 4000 to 5000 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 whose scouring solutions 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 by the number of square feet of floor space occupied, the amount of the investment, the man-days of labor in this department compared to the
man-days of labor in the whole establishment or on some other equitable basis.

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 producers in normal times are based on the quality of grease produced and, second, on the general supply and demand situation prevailing for that type of grease at the time when it is put on the market. Since World War II, one refiner has paid a producer prices ranging from 8 and one-half cents to 26 cents per pound for the same quality of neutral wool grease within a period of three years. In the larger market, as shown in Figure 16, 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 amount and quality of grease are secondary. A good job of scouring will net the scourer more money, and he therefore subordinates all other activities 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.
FIGURE 16
Wool Grease and Lanolin Prices, Quotations on Drums in New York, 1946 - 1952

45
40
35
30
25
20
15
10


Source: Oil, Paint and Drug Reporter, 1946-1952
The Acid Cracking Method of Grease Recovery

The acid cracking process is currently employed by only three scouring establishments in the United States. They are large integrated mills, each scouring more than ten million pounds of grease wool annually. Each establishment is located on a stream whose volume of water is small in proportion to the waste emptied into it. Continuous discharge of the scouring waste with 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 98 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 13 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 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 CPS 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
### TABLE 13

Comparison of Impurities in Wool Scouring Wastes

<table>
<thead>
<tr>
<th></th>
<th>pH</th>
<th>Suspended Solids</th>
<th>Volatile Suspended Solids</th>
<th>Fats</th>
<th>B.O.D.</th>
<th>Oxygen Absorbed (l Hrs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Acid-Cracking:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Domestic Sewage-Wool Scour Mixture</td>
<td>7.6</td>
<td>686</td>
<td>1200</td>
<td>640</td>
<td>117</td>
<td>228</td>
</tr>
<tr>
<td>Effluent from Acid cracking</td>
<td>5.8</td>
<td>39</td>
<td>112</td>
<td>56</td>
<td>24</td>
<td>117</td>
</tr>
<tr>
<td>Effluent from final trickling filters</td>
<td>6.4</td>
<td>24</td>
<td>32</td>
<td>22</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td><strong>Hypochlorite Method:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wool scour waste</td>
<td></td>
<td>3700</td>
<td>12000</td>
<td>8500</td>
<td>5500</td>
<td></td>
</tr>
<tr>
<td>After treatment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>200</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>600</td>
</tr>
<tr>
<td><strong>Centrifugal Method:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wool scour waste</td>
<td>10.1</td>
<td>9100</td>
<td>25000</td>
<td>22500</td>
<td>3600</td>
<td></td>
</tr>
<tr>
<td>Final centrifuge effluent</td>
<td>10.0</td>
<td>150</td>
<td>310</td>
<td>334</td>
<td>195</td>
<td></td>
</tr>
</tbody>
</table>


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 five hours, the emulsion having cracked, a clear acidic liquid is decanted from between an upper layer of scum and the sludge on the bottom. 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 increase 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, and the grease may be further dried by heating or centrifuging to less than one 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 from desulphurized grease. The dry cake resulting from the filter press contains about fifteen to twenty percent grease. It is hauled to farms in the vicinity and after weathering a few months can be spread as fertilizer.  

An additional inconvenience is the odor from the lagoons and the expense of removing the settled solids. This is usually done during the winter months when the material is frozen. The acid cracked grease is not suitable for refining into lanolin but is used for lubricants, cutting oils, leather stuffing, and cordage emulsions.

Costs for the acid cracking process are difficult to assess. In each case the economic success is dependent not on the technical efficiency of the process but on the amount 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 amount 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

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10 Based on interviews and inspection tours by the author, November, 1952.
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 four to six men per shift to operate.

Under the recent O P S price schedule there was a larger gross return from the acid cracking method of grease recovery than from the centrifugal method when both establishments were scouring the same amount and types of wool. This is true because the amount of grease recovered by acid cracking is approximately double that recovered by centrifuging, while the price of acid cracked grease is 15.5 cents per pound compared to 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 one hundred thousand 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 thirty by forty feet to house the presses and other equipment. This process would require four to five men per shift, two 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 one hundred thousand pounds of apparel wool per week or five million pounds annually. These are the mills which have installed centrifugal grease recovery equipment and which thus far have found it not only a profitable but also an adequate answer to the abatement of stream pollution so 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, waste treatment plants have been installed in several mills during the past year which can handle 100,000 to 150,000 gallons of effluent per week and produce 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 the present time. 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 one and one half pounds can be recovered by acid cracking the centrifuged effluent. With a recovery rate of two percent for a mill scouring one hundred thousand pounds of fine to medium apparel
wool per week, the two thousand pounds of centrifuged grease at twenty cents per pound would yield four hundred dollars per week. The approximate cost of obtaining the additional thirty five hundred pounds of grease by acid cracking would be as follows:

Income per week from acid cracked grease 3500 lbs. @ 12¢ $420.00

Expenditures per week

Depreciation $40.00

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.

Operating Costs

Chemicals 90.00
Labor 125.00
Maintenance and Supplies 20.00 275.00

Net Income per week $115.00

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. They are variations of an aeration process in which the scouring emulsion after cooling 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. 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 3–20 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 and/or centrifuging.

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CHAPTER V

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 ninety percent) of the grease recovered by United States wool scourers. Total sales of two million dollars indicate that it is a small industry; however, 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 given in Table 11. All but two are located in the New York area. They refine most of the domestic centrifuged wool grease recovered in the United States and some of the imported centrifuged grease.

History

Wool grease and lanolin were being imported to the United States in limited quantities up to World War I. Mr. N. I. Malmstrom, owner of one of the oldest firms, believes the lanolin volume imported during those years to have been less than one million pounds per year.1

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1 Information on the wool grease refiners was obtained chiefly by means of interviews with each of them between November, 1952, and June, 1953.

2 Extract from letter from Mr. E. Henry Holm, N.I. Malmstrom and Company, dated April 29, 1953.
<table>
<thead>
<tr>
<th>Company</th>
<th>Wool Grease</th>
<th>Lanolin</th>
<th>Derivatives</th>
<th>Other Products</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Common</td>
<td>Other</td>
<td>Cosmetic</td>
<td>Absorption &amp; Other Products</td>
</tr>
<tr>
<td></td>
<td>Legras</td>
<td>Grades</td>
<td>U.S.P.</td>
<td>Wool Grease</td>
</tr>
<tr>
<td>American Chemical Paint Company</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>American Lanolin Company</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Bopf Whittam Corporation</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Croda, Inc.*</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Fanning Chemical Company</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Hummel Chemical Company</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Lanasetex Products, Inc.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>N.I. Malmstrom &amp; Company</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Robinson-Wagner Company</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Botany Mills</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**United States Wool Grease Refiners and Their Products**

- **Wool Grease**: X
- **Lanolin**: X
- **Derivatives**: X
- **Other Products**: X

**Absorption & Other Products**

- **Wool Grease**: X
- **Alcohols & Fatty Acids**: X

**Other Products**

- **Toilet lanolin, paralan oil- (rust preventive)**
- **Lubricating oil additives, lanolin soaps, various lanolates**
- **Liquid esters and alcohols, amines and amides, water and oil soluble forms of lanolin and lanolin derivatives**

* Croda, Inc., has its wool grease refined on commission.
At that time, there was no domestic production of wool grease. The first American refining of wool grease to lanolin was done by Horace Taylor of Swift and Company in 1906.

In 1909 the DeLaval Separator Company initiated a program aiming at the wider use of centrifugal force in industrial applications, and one of the men to head this experimental work was Mr. N. I. Malmstrom. In 1914 tests were undertaken at DeLaval in Chicago, in cooperation with the North Star Woolen Company in Minneapolis, to explore the use of centrifuges on wool scouring liquors. In 1915 Mr. Malmstrom sold the first complete installation of such equipment in the United States to the North Star Woolen Mill Company.

In the following years up to 1917, Mr. Malmstrom sold many complete installations of which he recalls the following:

Eavenson & Leavering, Camden, N. J.
Boynton Wool Scouring, Chicago, Ill.
Clyborn Wool Scouring, Chicago, Ill.
Barre Wool Combing, South Barre, Mass.
Wanskuck Mills, Providence, R. I.

He believes that the original Hudson and Atlantic Mill installations were also handled by him.

In 1915, James Baillie, a chemist in Minneapolis, started to study the refining of wool grease and produced lanolin from the material recovered by the North Star Woolen Mill. In 1917 the newly formed North Star Chemical Works, Inc., a joint venture by North Star Woolen Mill and Messrs. Baillie and Malmstrom, moved into the grease producing
area in Lawrence, Mass. The most important job for the young organization was to satisfy the demand by the United States Army, Gas Defense Division, for hydrous lanolin used to protect the skin of the soldiers against mustard gas. The output was sent, in accordance with shipping order from the Army, to the Colgate, Mennen, Larkin, and Williams Companies, who in turn made the so-called "Sag-paste" known to front line soldiers in World War I. The name of the company in Lawrence was later changed to American Lanolin Company.

In 1919, N. I. Malmstrom sold his interest in North Star Chemical Works and agreed for a time to develop the production, refining, and marketing of wool grease in Botany Mills, Inc. N. I. Malmstrom & Company was founded in 1920 and built its first refining facilities at its present location in 1921. Mr. Frank Fanning, owner of Fanning Chemical Company, was sales manager of the Malmstrom firm prior to starting his own business in 1951.

Bopf-Whittam Corporation, the oldest wool grease refiner now operating in the United States, was established in 1914 under the impetus of World War I, which cut off foreign sources of lanolin. Mr. Arthur P. Bopf, a competent chemist who had been associated with Mr. Whittam in the Alden S. Swan Company of New York, organized the first successful lanolin manufacturing company in this country. A former employee of this company, Mr. M. P. Gutowski, established Lanaetex, Inc. in 1936. It is now operated by his three sons.

Hummel-Robinson Company began producing lanolin commercially in 1917 and became the forerunner of two firms as the result of its failure. Mr. August Hummel formed the Hummel Chemical Company; and
Mr. A. Wagner, an officer and stockholder, resigned from the original firm in December, 1931, to form his own company. Several months later Mr. John C. Robinson also joined the new firm, and the name was changed to Robinson-Wagner Company, Inc.

The American Chemical Paint Company entered the field in 1938 when they began to install centrifugal grease recovery equipment on a royalty basis. After selling the royalty grease which they collected to another refiner for several years, they acquired refining facilities and began to produce lanolin.

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 are:

M. I. Malmstrom & Company
Robinson-Wagner Co., Inc.
Lanaetax, Inc.
Bopf-Whittam Corporation
American Lanolin Company
Fanning Chemical Company

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 are Hummel Chemical Company and American Chemical Paint Company.

3. The one fully integrated wool scourer who refines wool grease and distributes lanolin in consumer products is Botany Mills, Inc.

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\(^3\) and untreated. The three grades of wool grease differ in moisture, free fatty acid, and ash content and have a darker color and a stronger odor in the order named. They come from imported wool grease, which is usually high in free fatty acid and rarely used as material for lanolin, and domestic wool grease from centrifugal or acid cracking plants. "Crack back," a residue from the refining process which has a high free fatty acid content, is also a source of Crude and Common Degras. The products sold by the refiners are listed in Table II.

In the first category the two largest firms, N. I. Malmstrom and Company and Robinson-Wagner Company, Inc., process about eighty percent of the domestic production and handle about sixty percent of the imports. In addition to the regular grades of wool grease and lanolin mentioned above, they produce absorption bases, and the latter company makes other lanolin derivatives for specialized uses in cosmetics and pharmaceuticals. The four other firms in this category are small, sole proprietorships or partnerships, with six to eight employees, and do not employ a full-time chemist.

In the second category, the Hummel Chemical Company and the American Chemical Paint Company refine and distribute wool grease, but it constitutes only a small part of a full line of industrial and agricultural chemicals which they sell. Several years ago American Chemical Paint Company undertook the production of cholesterol from lanolin, but partly because of a decline in the price of this alcohol

\(^3\) Desulphurized wool grease is required for use on bright metal surfaces.
through competition from another source, the project was not technically or economically successful.

In the third category is Botany Mills, Inc., 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 which it produces in a line of cosmetics under the brand name BOTANY through department stores in the larger eastern cities of the United States. It is the only fully integrated producer.

There is one other firm which should be mentioned with the refiners. Croda, Inc. is the American subsidiary of a well known English firm of that name at Snaith, Yorkshire; the American subsidiary is controlled by Nichols and Company, a United States firm which controls several commission combing mills from which Croda, Inc. buys wool grease. It is refined on a commission by one of the smaller United States refiners. Croda, Inc. offers this domestically produced wool grease and lanolin, several grades of imported wool grease, and a number of lanolin alcohols and fatty acids which 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.

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The process was designed to produce cholesterol at $8.00 per pound which would sell at about $12.00 per pound. Meanwhile a Netherlands manufacturer, Von Schuppen en Zoon, developed a better process, and cholesterol was imported into the United States at $4.25 per pound C.I.F. New York, plus duty of 12½ ad valorem.
decreasing the moisture and ash content, deodorizing, and bleaching. One method of refining a crude wool grease (U.S. Patent 2,417,329) 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 and hydrogen peroxide, or a per salt yielding hydrogen peroxide in solution, to bleach the grease to a light color. Next, the addition of a small amount of water soluble sulfonated oil (castor, neats-foot, rapeseed, corn or soya bean) causes a rapid separation of clear grease on 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 D. Light color and absence of odor are desirable for cosmetic grades, and the lanolin may be further bleached (U.S. Patent 2,481,463) 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 of the refiners have set up their own color standards. One of them reports as follows:

We have set up a color standard of our own based on A.S.T.M. American Society for Testing Materials [standards] and we report the color values obtained by this standard to...
our customers when they request this information. Arbitrarily, we classify material of color 1.75 to 2.50 as U.S.P. cosmetic grade, 2.50 to 3.25 as pharmaceutical grade.5

Only eighty to eighty-five percent of the crude raw material recovered by centrifuges is refined into lanolin. About five percent, by weight, is lost in the refining process. An additional ten 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 sixty-five pounds of lanolin per hundred pounds of wet grease; (twenty-five to thirty 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 Table 15. The grease was purchased from the producers at eighteen to twenty cents per pound and refined into the higher grades in the schedule. This price differential existed only during the 1951-1952 period when crudes were very scarce; usually the spread is less.

A trade name such as "Cardinal" (Fanning Chemical Company) or "Prime" (Lanaetex Products, Inc.) may be given to the top cosmetic grade. 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. Uses for the grades shown in Table 15 are given in Chapter VI.

5 Extract from letter from Mr. E. A. Snyder, American Chemical Paint Co., dated April 2, 1953.
TABLE 15
O.P.S. Ceiling Prices for Wool Grease and Lanolin
June, 1952 to March, 1953

<table>
<thead>
<tr>
<th>Description</th>
<th>Ceiling Price per pound f.o.b. processing plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) U.S.P. lanolin, special anhydrous cosmetic grade</td>
<td>$0.405</td>
</tr>
<tr>
<td>(2) U.S.P. lanolin, anhydrous cosmetic grade</td>
<td>.355</td>
</tr>
<tr>
<td>(3) U.S.P. lanolin, anhydrous pharmaceutical type</td>
<td>.335</td>
</tr>
<tr>
<td>(4) U.S.P. lanolin, hydrous pharmaceutical type</td>
<td>.320</td>
</tr>
<tr>
<td>(5) Technical lanolin, ash maximum 1/10 of 1 percent, moisture maximum 1/10 of 1 percent, acid maximum 3/4 of 1 percent</td>
<td>.310</td>
</tr>
<tr>
<td>(6) Neutral wool grease, fully refined, acid maximum 2 percent, ash maximum 1/10 of 1 percent, moisture maximum 1/10 of 1 percent</td>
<td>.305</td>
</tr>
<tr>
<td>(7) Neutral wool grease, fully refined, over 2 percent acid, ash maximum 1/10 of 1 percent, moisture maximum 1/10 of 1 percent</td>
<td>.300</td>
</tr>
<tr>
<td>(8) Crude centrifugal wool grease known as dry, moisture maximum 2 1/2 percent, ash maximum 3/4 of 1 percent, maximum 1 1/2 percent F.F.A., not refined</td>
<td>.200</td>
</tr>
<tr>
<td>(9) Crude centrifugal wool grease known as wet, over 5 percent moisture, maximum 2 1/2 percent F.F.A., not refined, anhydrous basis</td>
<td>.180</td>
</tr>
<tr>
<td>(10) Common Degras, moisture maximum 2 1/2 percent, 1/4 to 1 percent ash, maximum 11 percent F.F.A.</td>
<td>.120</td>
</tr>
<tr>
<td>(11) Common Degras, moisture maximum 2 1/2 percent, 1/4 to 1 percent ash, over 11 percent F.F.A.</td>
<td>.110</td>
</tr>
<tr>
<td>(12) Desulfurized wool grease:</td>
<td></td>
</tr>
<tr>
<td>(a) Neutral wool grease, acid maximum 3 percent</td>
<td>.205</td>
</tr>
<tr>
<td>(b) Neutral wool grease, acid maximum 6 percent</td>
<td>.180</td>
</tr>
<tr>
<td>(c) Degras, acid 6-10 percent</td>
<td>.155</td>
</tr>
<tr>
<td>(d) Degras, acid 10 percent and above</td>
<td>.145</td>
</tr>
</tbody>
</table>

Effect of Shortages and O.P.S.

Due to the increased uses which have been developed for wool grease and lanolin and to the decreased amount of apparel wool scoured in the United States, a sellers' market has existed for several years. Under these conditions the refiners' ability to get enough material to supply their customers' needs has depended upon their personal cordial relations with the producers. This was especially true during the period from June, 1952, to March, 1953, when price ceilings were imposed on all grades. The reasons for the failure of the producers and industrial consumers of wool grease to exploit this shortage and to circumvent the refiner in the channel of distribution will be discussed later.

Because of the shortage of wool grease, several refiners have undertaken to finance the installation of grease recovery equipment in mills which scour a sufficient amount of apparel wool to make it profitable. This is done either directly or through a separate corporation set up for that purpose. The offer is generally made along the following lines: The refiner pays for the type of equipment desired by the scourer in return for the latter's promise to sell him all of the grease at the market price. The grease is credited to the scourer's account until the equipment is paid for. The scourer then owns the equipment outright but is obliged to sell at least half of his grease to the refiner, for a price equal to what he can obtain for the other half, for a year or two. Shortages of this material during recent years have made refiners anxious to tie up sources of supply, but only one or two installations have been financed in this way. The above
arrangement differs from the plan offered by one of the equipment manufacturers, American Chemical Paint Company, in that the scourer does not have to put up any funds and eventually owns all of the equipment.

Another result of the recent shortage was an offer by at least one refiner to a number of the producers to refine their wool grease on a commission basis. The producers could then legally receive the higher ceiling prices for Technical, U.S.P., or Cosmetic grades of lanolin. So far as can be determined this offer was not accepted by any of the producers because it was accompanied by a stipulation that a part of the grease output be sold to the refiner instead of directly to industrial users.

The general shortage of material and the imposition of ceiling prices brought about a new technical development which may eventually affect the refiners. One equipment manufacturer (The Sharples Corporation) has developed a rerun super centrifuge and vacuum dryer and a simple process with which a scourer producing dry centrifuged grease can further reduce its ash and moisture content so that it fulfills the requirements for neutral wool grease (see Table 15), which the producer could sell for thirty-one cents under the recent O.P.S. price schedule. It would be manifestly impossible for the refiner profitably to produce any but the highest grades using neutral wool grease as a raw material at present prices. The super centrifuge costs about five thousand dollars but was purchased by only one or two producers because of the uncertainty as to how long the difference of ten cents a pound would prevail between the ordinary dry centrifuged grease and neutral wool.
grease. The ten cents a pound difference was due wholly to the O.P.S. price schedule, Table 15, and did not reflect market conditions. If the price difference had persisted, owing to the general shortage, the refiners would undoubtedly have raised their prices for Technical and U.S.P. as well as the Cosmetic grades.

**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 which have been 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 post war period. There is an excess refining capacity in the industry at the present time as evidenced by the fact that each refiner during each of the past two 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 amounts 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 the competitive pressure among the refiners.
4. **Comparable products.** Each of the refiners can produce a product which is comparable in nearly every respect to anything which any other refiner can produce; and since refiners buy and sell by specification, they compete on both the demand side and on the supply side in a market which 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 semi-manufactured industrial goods; that is, they are purchased for industrial or business use, and the purchaser intends to resell them in some form. Except for four wholesalers, who regularly handle small quantities of the product and serve as merchant middlemen 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 which they manufacture and sell.

It is estimated that at least ninety percent of the wool grease and all of the lanolin, both imported and domestic, is marketed through

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6 Faesy and Besthoff, Inc., New York, handle a full line of industrial chemicals, the output of one United States wool grease producer, and occasionally, import wool grease. The following handle imported wool grease only along with a line of industrial chemicals: Gallard Schlesinger Chemical Co., New York, and Arthur C. Trask Co., Chicago, Illinois.
the refiners. (See Figure 17). Their technical functions and their relationship with the producers were discussed in the preceding section. The marketing functions which the refiners and middlemen perform and the buying habits and motives of industrial users will be discussed here.

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. The eight marketing functions usually noted by most authorities are buying, selling, transportation, storage, market finance, market risk, market information, and standardization and grading. An understanding 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 thirty-eight wool scourers who recover grease. Their principal marketing function is selling. During 1951-1952 period they have been in the fortunate position of having a commodity in great demand. Very little effort and no expense has been necessary in selling. One

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Total available for consumption

Marketing channels for wool grease, 1952

Figure 17
producer who installed grease recovery equipment in 1952 had more than fifty inquiries within two 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 with no buyers. Since this grease was a by-product and could be held without additional cost, no financing was necessary, and no storage expense was incurred.

The other marketing functions performed by the producing mills are (1) testing the grease for free fatty acid, moisture and sulphur content, and (2) providing storage, although they have not needed to do much of the latter during the years 1951-1952 because eager buyers have taken their output almost as soon as it was produced. Producers sell F.O.B. mill, and are paid within a few days or weeks after shipment. The usual terms are 1/10 net 30. Their small inventories eliminate much of the risk due to 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 which 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 as explained in a preceding section. 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 the domestic or foreign producers. The prices which 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 and paying by means of a letter of credit.

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/or chemical properties of his material which 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 which 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. A statement similar to the following one is usually found at the bottom of all specification sheets:
The data presented herein are based on experiments and information believed reliable. However, we can make no guarantee of performance of, or results obtained, through the use of the products herein described owing to varying conditions in laboratories and plants over which we have no control. Neither can any guarantee be given that the products described or uses outlined, will not infringe any existing patent.

The two largest refiners, N. I. Malmstrom and Company and Robinson-Wagner, Inc., have sales representatives in Chicago to handle sales in that area. The same function is performed for other refiners, such as American Lanolin Company, by small chemical supply houses in Chicago, such as Delamar and Hendrey Chemical Company, 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, such as Palmer Supply Company, Cleveland, Ohio, who sell material only from Lanaetex Products, Inc. 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 which are not by-products. The difficulty in changing product formulae 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 six months or a 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. Through the alternate periods of shortage and oversupply most of the "price buyers" are fairly well known in the industry.

As a by-product, wool grease is not sufficiently important for any increased demand to affect the amount produced. The long term supply prospect for wool grease is not reassuring either, as explained in Chapter II. Domestic production of wool and consumption per capita have declined sharply since the war. Domestic wool production would decline still further except for the wool price support program of the Department of Agriculture.

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 500 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 $5.00 may be required to insure the return of the drums. Shipments to industrial users are generally made in drums but occasionally in tank cars (105 drums) to large consumers, particularly oil companies.

The refiners find it necessary to maintain large inventories to insure a steady supply to their customers. Shipments of domestic grease are less than a week in transit. Imported wool grease takes from 15 to 45 days to arrive after date of shipment. Fortunately it is a stable product which 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. Very little financing is necessary compared to that in other industries because only the refiners carry large inventories and because the refiners buy from, and usually sell to, companies which are much larger and financially stronger than they are. Terms of sale are usually 1/10 net 30.

This is not a seasonal business on the supply side nor on the demand side, since wool is scoured throughout the year and since the industrial uses for wool grease and lanolin, such as leather, lubricants, rust preventives, cosmetics, and pharmaceuticals, are also quite 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 six-month or one-year contract guaranteeing
delivery of a minimum quantity, but also a firm price for that period of time. The refiner must, therefore, often assume the risk or price increases for his customers 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 a 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 past decade as shown by Figure 16, and the prices of all grades move together. When the refiner pays more for the 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 which 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 which will affect his business.

The suspension of O.P.S. 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 116 would be 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. A complete list of the specifications for each grade in common use in the industry is given in Table 15. 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 may have special requirements as shown by the Texas Company's Specification No. 4.

The Texas Company Spec. No. 4
Issued: 4-1-30
Revised: 6-2-52

Wool Grease, Refined - Spec. No. 4
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), %
   10.0 max.
4. Saponification Number
   100-114.0
5. Iodine Number
   20-60
6. Water, %
   3.0 max.
7. Ash, %
   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 D 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. Sales are made f.o.b. refiner's plant, and terms are usually 1/10 net 30 with the empty drums returnable, freight collect. There is no evidence of reciprocity practices
in buying policies in this industry.

There is an exception in the drug industry 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 one, five, twenty-five, one hundred, and four hundred 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 nation-wide scale at a much lower cost than is the refiner or any other middleman. The limited amount of lanolin which 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 that he calls on a customer.

Summary. Wool grease and lanolin, being industrial goods, are usually marketed through the refiners, who can perform all of the marketing functions more efficiently than the producers or the industrial users.

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 only be obtained as the result of a refining process. Very few scourers and no industrial consumers in the United States produce enough wool grease or consume enough lanolin to make it economically worthwhile to operate their own refining plant 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 which he performs, the refiner's technical competence assures his place in the channel of distribution for lanolin. See Figure 17.

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 formulae 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 five 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 which they produce because it depends on the origin and grade of wool which they scour, the strength and age of their scouring liquors, and other factors, all of which may vary daily. In short, a producer cannot guarantee to deliver two drums of grease which are alike, and there is thus little chance of the industrial user's circumventing 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 since 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 an 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 by-product 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 experience 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 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 are in the field of industrial lubricants producing such specialties 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 25 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 purchasing agent, who is 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 pay less for the grease than if it is 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 these same 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 which they received but also because the refiners gave less consideration to their small orders during the periods of shortage. However, none of the

8 Interview by the author, April 24, 1953.
companies had purchased their entire needs from one mill or one refiner
since Arlington Mills closed down. They bought from several mills
directly or from a mill and a refiner.

Summary. Direct sale of wool grease from producer to industrial
user is possible in a few industries but for technical and historical
reasons is not common enough to be economically significant.

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 16 and 17 show the quantity and value of United States exports
of domestic and foreign wool grease, by country of destination, for
the years 1949-1951. Prior to 1949 and after 1951, exports of wool
grease (and lanolin) were not reported separately by the United States
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 which is 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 amounts 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 16

#### United States Wool Grease Exports,
Domestic Wool Grease, Calendar Years 1949-1951
Commodity Number 085810

<table>
<thead>
<tr>
<th>Country of Destination</th>
<th>1949 Quantity (pounds)</th>
<th>1949 Value ($)</th>
<th>1950 Quantity (pounds)</th>
<th>1950 Value ($)</th>
<th>1951 Quantity (pounds)</th>
<th>1951 Value ($)</th>
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<tbody>
<tr>
<td>Canada</td>
<td>211,897</td>
<td>32,149</td>
<td>98,119</td>
<td>16,052</td>
<td>310,721</td>
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<td>36,946</td>
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<td>118,072</td>
<td>17,603</td>
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<td>Honduras</td>
<td>799</td>
<td>250</td>
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<td></td>
<td></td>
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<tr>
<td>Costa Rica</td>
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<td>198</td>
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<td>7,632</td>
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<td>4,774</td>
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<td>Nicaragua</td>
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<td>2,376</td>
<td>777</td>
<td>2,567</td>
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<td>3,367</td>
<td>4,774</td>
<td>1,507</td>
<td>13,723</td>
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<td>5,906</td>
<td>23,520</td>
<td>162,167</td>
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<tr>
<td>Argentina</td>
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<td>1,700</td>
<td>27,812</td>
<td>6,665</td>
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<tr>
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<td>706</td>
<td>130,595</td>
<td>20,567</td>
<td>657,622</td>
<td>90,287</td>
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<td>9,220</td>
<td>2,952</td>
<td>9,573</td>
<td>3,634</td>
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<td>20,434</td>
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<td>97,493</td>
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<td>Greece</td>
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<td>7,913</td>
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<td>11,590</td>
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<td>Union of South Africa</td>
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<td>1,850</td>
<td>512</td>
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<td>Countries under $1000</td>
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<tr>
<td>Total</td>
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<td>78,005</td>
<td>796,995</td>
<td>157,011</td>
<td>3,162,005</td>
<td>597,769</td>
</tr>
</tbody>
</table>

Source: See Table 17
TABLE 17
United States Wool Grease Exports,
Foreign Wool Grease, Calendar Years 1949-1951
Commodity Number 085810

<table>
<thead>
<tr>
<th>Country of Destination</th>
<th>1949</th>
<th></th>
<th>1950</th>
<th></th>
<th>1951</th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Net Quantity (pounds)</td>
<td>Value ($)</td>
<td>Net Quantity (Pounds)</td>
<td>Value ($)</td>
<td>Net Quantity (pounds)</td>
<td>Value ($)</td>
</tr>
<tr>
<td>Canada</td>
<td>500</td>
<td>136</td>
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<tr>
<td>Mexico</td>
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<td>Paraguay</td>
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<td>Ecuador</td>
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<td>130</td>
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<tr>
<td>United Kingdom</td>
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<tr>
<td>Germany</td>
<td>7,054</td>
<td>1,320</td>
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<td>Netherlands</td>
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<td>1,020</td>
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<td>Japan</td>
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<tr>
<td>Countries under $1000</td>
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<td></td>
<td></td>
<td></td>
<td>4,774</td>
<td>896</td>
</tr>
<tr>
<td>Total</td>
<td>19,625</td>
<td>6,382</td>
<td>41,160</td>
<td>18,486</td>
<td>88,772</td>
<td>11,717</td>
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</table>

Wool Grease Price Structure Analysis

Wool grease is a by-product; therefore, unlike most other commodities, its price is not determined in the short run primarily by demand nor in the long run by its cost of production. The demand for wool grease is relatively steady during a year because of the large amounts used with other materials in formulating industrial products and because these formulae 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 twenty 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 eighty 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 demand and cost of production are important in the determination of wool grease prices.

Price Making Factors and Their Relative Importance

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. 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 has declined, owing largely to the displacement of soap by detergents, as shown by Figure 18. Table 18 shows the per capita consumption of inedible fats and oils in nonfood products from 1931 to 1952. A breakdown by major uses of the total volume consumed shows that the decline in use for soap was entirely responsible for the decreased per capita consumption. This was due to the advent of synthetic detergents after World War II. 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, due principally to the high level of industrial activity in the United States since World War II, is shown in greater detail in Table 19 by the domestic disappearance of nonfood fats and oils from 1946 to 1950.

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

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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 three and one-half times as much detergent power as the same fat would have if it were converted to soap.
FIGURE 18

Use of Fats and Oils in Nonfood Products, 1931-1952

LBS. PER CIVILIAN

1935 1940 1945 1950

TOTAL

SOAP

DRYING OIL

OTHER

*Includes use in various types of processing, chemicals, synthetic organic detergents, soap for the rubber and textile industries and many other uses.

### TABLE 18

Per Capita Use of Fats and Oils in Nonfood Products, 1931–1952
(Pounds per person)

<table>
<thead>
<tr>
<th>Year</th>
<th>Soap</th>
<th>Drying oil Products</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1931-35 (Av.)</td>
<td>11.5</td>
<td>4.7</td>
<td>3.1</td>
<td>19.3</td>
</tr>
<tr>
<td>1936-40 (Av.)</td>
<td>12.5</td>
<td>6.0</td>
<td>3.7</td>
<td>22.2</td>
</tr>
<tr>
<td>1942-45 (Av.)</td>
<td>14.3</td>
<td>6.9</td>
<td>5.8</td>
<td>27.0</td>
</tr>
<tr>
<td>1946</td>
<td>11.2</td>
<td>6.4</td>
<td>6.0</td>
<td>23.7</td>
</tr>
<tr>
<td>1947</td>
<td>14.5</td>
<td>6.7</td>
<td>6.0</td>
<td>27.2</td>
</tr>
<tr>
<td>1948</td>
<td>13.0</td>
<td>7.0</td>
<td>5.5</td>
<td>25.6</td>
</tr>
<tr>
<td>1949</td>
<td>11.0</td>
<td>5.7</td>
<td>6.4</td>
<td>23.0</td>
</tr>
<tr>
<td>1950</td>
<td>10.9</td>
<td>6.8</td>
<td>7.6</td>
<td>25.4</td>
</tr>
<tr>
<td>1951</td>
<td>8.8</td>
<td>6.7</td>
<td>7.5</td>
<td>23.1</td>
</tr>
<tr>
<td>1952^</td>
<td>7.8</td>
<td>5.9</td>
<td>8.1</td>
<td>21.7</td>
</tr>
</tbody>
</table>

^Preliminary

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Tallow, inedible, and</td>
<td>1676.5</td>
<td>1581.6</td>
<td>1781.9</td>
<td>1666.4</td>
<td>1806.7</td>
<td>1658.5</td>
<td>1550a</td>
</tr>
<tr>
<td>grease, excluding wool</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>greasea</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Palm oil</td>
<td>50.9</td>
<td>43.2</td>
<td>51.3</td>
<td>56.5</td>
<td>44.2a</td>
<td>40.3</td>
<td></td>
</tr>
<tr>
<td>Fish oils</td>
<td>131.0</td>
<td>156.7</td>
<td>97.9</td>
<td>122.4</td>
<td>121.1</td>
<td>91.4</td>
<td>106</td>
</tr>
<tr>
<td>Marine mammal oil</td>
<td>16.2</td>
<td>12.5</td>
<td>16.4</td>
<td>19.8</td>
<td>31.9a</td>
<td>31.2</td>
<td>30</td>
</tr>
<tr>
<td>Olive oil, inedible and</td>
<td>0.8</td>
<td>0.1</td>
<td>5.2</td>
<td>4.7</td>
<td>4.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>feets</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Babassu oil</td>
<td>44.2</td>
<td>17.8</td>
<td>39.0</td>
<td>32.8</td>
<td>39.5</td>
<td>40.8</td>
<td>15</td>
</tr>
<tr>
<td>Coconut oil</td>
<td>326.2</td>
<td>784.1a</td>
<td>666.5</td>
<td>527.8a</td>
<td>546.8a</td>
<td>499.1a</td>
<td>504j</td>
</tr>
<tr>
<td>Other lauric-acid oilsb</td>
<td>35.2</td>
<td>9.9</td>
<td>19.9</td>
<td>21.4</td>
<td>26.7</td>
<td>13.6</td>
<td>6</td>
</tr>
<tr>
<td>Castor oil, dehydratedc</td>
<td>32.9</td>
<td>33.1</td>
<td>48.2</td>
<td>37.1</td>
<td>47.5</td>
<td>23.6</td>
<td>16</td>
</tr>
<tr>
<td>Linseed oil</td>
<td>680.9</td>
<td>575.2</td>
<td>600.3</td>
<td>453.4</td>
<td>595.0</td>
<td>699.0</td>
<td>557</td>
</tr>
<tr>
<td>Oiticica oil</td>
<td>25.2</td>
<td>12.7</td>
<td>13.1</td>
<td>11.5</td>
<td>12.0</td>
<td>12.0</td>
<td>11</td>
</tr>
<tr>
<td>Tung oil</td>
<td>35.6</td>
<td>106.1</td>
<td>130.2</td>
<td>103.1</td>
<td>109.4</td>
<td>57.8</td>
<td>51</td>
</tr>
<tr>
<td>Neatsfoot oil</td>
<td>1.8</td>
<td>1.2</td>
<td>2.2</td>
<td>2.4</td>
<td>2.7</td>
<td>3.9</td>
<td></td>
</tr>
<tr>
<td>Wool grease</td>
<td>18.9</td>
<td>21.4</td>
<td>21.6</td>
<td>16.6</td>
<td>18.6</td>
<td>14.0</td>
<td>13</td>
</tr>
<tr>
<td>Castor oil, No. 1 and No. 3d</td>
<td>62.5</td>
<td>82.6</td>
<td>80.2</td>
<td>92.9</td>
<td>115.7a</td>
<td>150.5</td>
<td>160</td>
</tr>
<tr>
<td>Rapeseed oil</td>
<td>15.0</td>
<td>5.7</td>
<td>5.7</td>
<td>5.9</td>
<td>8.2</td>
<td>7.0</td>
<td></td>
</tr>
<tr>
<td>Other vegetable oilsae</td>
<td>13.9</td>
<td>7.5</td>
<td>16.4</td>
<td>4.8</td>
<td>12.0</td>
<td>20.3</td>
<td>7k</td>
</tr>
</tbody>
</table>

See following page for footnotes
Footnotes for Table 19

a Factory Consumption, Bureau of the Census.

b Palm-kernel, murumuru-kernel, tucum-kernel, and ouricury-kernel oils.

c Factory production, adjusted for changes in stocks converted to crude basis by dividing by 0.88. Beginning 1949 no conversion made.

d Total domestic disappearance of castor oil minus disappearance of dehydrated castor oil.

e Computed from data on production, imports, exports and factory and warehouse stocks of cashew-nut kernel oil, cashew-nut shell liquid (oil), hempseed oil, Japan wax (tallow), sesame oil, sunflower oil, teeseed oil, vegetable tallow, and minor domestic vegetable oils. The computation also includes (1) exports of vegetable oils not reported separately and (2) shipments to U.S. Territories of all vegetable oils.

f Excludes the estimated quantity of lard reported as grease used in soap.

g Disappearance data for No. 1 and No. 3 castor and sperm oil derived assuming no change in crude stocks in June-August 1950. Stock figures were withheld by Census in these months to make it impossible to calculate reasonably accurate figures for stockpiles of these strategic oils.

h Dates are from October 1, 1951 to October 1, 1952.

i Stocks were withheld by Census in these months to make it impossible to calculate reasonably accurate figures for stockpiles of these strategic oils.

j Factory consumption plus loss.

k Includes neatsfoot oil, sesame oil, olive oil inedible, olive oil "foots", perilla oil, rapeseed oil, sunflower oil, teeseed oil, cashew nut shell liquid (oil), vegetable tallow, and minor domestic vegetable oils.

have weakened the competitive position of wool grease because nearly all of the fats and oils which are good or close substitutes for it have declined in price during the postwar years, as shown in Table 20. These substitutes have in the long run partially or wholly replaced wool grease (and lanolin) in marginal uses.

The principal short term factor which affects the market price of wool grease is supply. Except for several years during 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 on the price of a steady demand and a fluctuating supply is shown for all grades in Figure 16. A more clear-cut supply price relationship for U.S.P. lanolin can be seen in Figure 19. There is a few months' lag in price changes on supply changes 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
TABLE 20
Wholesale Price of Fats and Oils at Specified Markets, 1946-1952

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Tallow, No. 1, inedible, Chicago</strong></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Palm Oil, Congo, drums</strong></td>
<td>10.9</td>
<td>18.4</td>
<td>14.4</td>
<td>5.5</td>
<td>7.6</td>
<td>10.6</td>
<td>4.4</td>
</tr>
<tr>
<td><strong>F.O.B. New York</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cod Oil, Newfoundland, drums, New York</strong></td>
<td>11.6</td>
<td>21.6</td>
<td>23.9</td>
<td>15.9</td>
<td>9.6</td>
<td>15.4</td>
<td>11.4</td>
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<tr>
<td><strong>Sperm Oil, Natural, winter, 45 degrees, New York</strong></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Olive Oil, &quot;fouls,&quot; prime, drums, New York</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Babassu Oil, Tanks, New York</strong></td>
<td>13.1</td>
<td>26.9</td>
<td>25.4</td>
<td>18.8</td>
<td>15.1</td>
<td>18.1</td>
<td>15.3</td>
</tr>
<tr>
<td><strong>Coconut Oil, Crude, tanks, Atlantic Ports</strong></td>
<td>18.0</td>
<td>18.0</td>
<td>24.0</td>
<td>20.2</td>
<td>14.5</td>
<td>19.0</td>
<td>15.8</td>
</tr>
<tr>
<td><strong>Castor Oil, dehydrated, tanks, New York</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Linseed Oil, raw, drums, carlots, New York</strong></td>
<td>23.3</td>
<td>33.8</td>
<td>25.8</td>
<td>21.6</td>
<td>24.0</td>
<td>38.7</td>
<td>34.0</td>
</tr>
<tr>
<td><strong>Citicia Oil, drums, New York</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Tung Oil, tanks, New York</strong></td>
<td>26.8</td>
<td>28.9</td>
<td>21.5</td>
<td>19.8</td>
<td>21.7</td>
<td>30.7</td>
<td>25.4</td>
</tr>
<tr>
<td><strong>Nest's foot oil, 30°, drums carlots, New York</strong></td>
<td>38.4</td>
<td>39.2</td>
<td>23.2</td>
<td>22.4</td>
<td>25.5</td>
<td>38.4</td>
<td>38.8</td>
</tr>
<tr>
<td><strong>Wool grease (degras)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>common, bbls, New York</strong></td>
<td>21.0</td>
<td>16.0</td>
<td>39.6</td>
<td>26.7</td>
<td>25.8</td>
<td>36.4</td>
<td>30.3</td>
</tr>
<tr>
<td><strong>Castor Oil, No. 3 drums, carlots, New York</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Rapeseed Oil, refined, de-natured, tank cars, N.Y.</strong></td>
<td>11.0</td>
<td>11.0</td>
<td>11.0</td>
<td>11.5</td>
<td>11.4</td>
<td>13.0</td>
<td>12.0</td>
</tr>
<tr>
<td><strong>Lard, refined, 1 lb. cartons, Chicago</strong></td>
<td>17.6</td>
<td>29.3</td>
<td>23.3</td>
<td>18.0</td>
<td>20.4</td>
<td>31.5</td>
<td>29.7</td>
</tr>
</tbody>
</table>

**FIGURE 19**
Effect of Supply of Grease on Price

![Graph showing the effect of supply of grease on price](image)

**Cents per pound**

- Anhydrous Pharmaceutical Lanolin
- Common Degras

**Price — Average for the Year**

10
15
20
25
30
35

**Millions of Pounds**

Wool Grease Available for Consumption

14
17
20
23

1945
1946
1947
1948
1949
1950
1951
1952


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 and/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 in tremendous quantities, see Table 19, as a by-product of the meat packing industry. Its decline in price during the postwar period from eighteen to four 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.

Correlation Analysis of Factors Affecting Wool Grease Prices

Discussions with members of the largest wool grease refining firms and others who had twenty years or more of experience with pricing policies and a knowledge of the factors affecting price in this industry elicited the consensus of opinion that wool grease prices (1) were most affected by the amount of wool grease available for consumption (2), which included the amount recovered in the United States and imports; the general level of industrial activity (3); the prices of fats and oils that are good or close substitutes for wool grease (4). The discussion in the preceding section and reference to the use of wool grease in specific industries in Chapter VI — the
amounts and conditions under which it is used — indicate the logic of selecting the three independent variables stated above.

An effort was made to measure statistically the effect of these factors on wool grease prices from 1935 to 1951. The war years, 1943, 1944, and 1945, 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 Seventeen 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 \( R^2 = 0.2380 \) explains only twenty-five percent of the deviation from the mean. The relative size of the partial correlation coefficients, \( r_{12.34} = -0.4321 \), \( r_{12.34} = 0.2372 \), \( r_{12.34} = 0.0272 \), indicate that, of the three, supply is the most important variable. The general level of industrial activity 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. The size of the partial regression coefficient indicates that a change of one million pounds in the supply tends to cause a change in the price (in the opposite direction) of 0.5 cents. Since seventy-five percent of the variation from the mean is unexplained, there are evidently many other factors, not included in this analysis, which affect wool grease prices and tend to obscure the effect of the above factors. This might be expected from the pricing policy of the producers of charging what the traffic will bear (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 type of 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.

Price Elasticity of Demand

The wholesale prices of these nonfood fats and oils during the postwar years are shown in Table 20. Generally speaking, and other things remaining equal, as the price of a commodity increases, the regression equation is:

\[ X_1 = 17.66 - 0.1776X_2 + 0.0188X_3 + 0.0047X_4. \]
amount consumed tends to decrease. Conversely, as the price decreases, consumption tends to increase. These changes vary widely for different commodities and can be measured by reference to their coefficient of elasticity, which is derived by correlating prices with consumption over a period of years. If the coefficient is equal to 1, it implies that changes in price are associated with the same relative change in consumption (unit elasticity of demand). A coefficient greater than 1 implies that changes in price are associated with relatively greater changes in consumption (elastic demand), and a coefficient of less than 1 implies that changes in price are associated with relatively smaller changes in consumption (inelastic demand). When consumption does not respond to changes in price, it has a coefficient of zero (perfectly inelastic 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 means that their elasticity of demand would be close to zero. 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 and/or whose price is lower, as in the example of tallow cited above.

In certain uses where lanolin touches the human skin, as in

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12 Ibid., p. 5.
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 in the current period, it is necessary to have chlorophyll or lanolin in it, preferably both. Nearly all of these products are formulated and are proprietary compounds which 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 vegetable oils in cosmetics and benzolated lard and petrolatum in pharmaceutical salves and ointments. In these uses an increase in price has little effect on the amount consumed within the normal price ranges. However, the amount of wool grease (lanolin equivalent) demanded under these conditions is limited, probably not exceeding two to three million pounds annually; and when the price of wool grease reached forty 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, (i.e., whether they are produced independently or are by-products
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 tight film on metals and to blend with other fatty materials, so that 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 that amounts up to thirty million pounds could be sold.

Determination of the slope (elasticity) and location of each portion middle section of the curve is difficult and would be possible only with an intimate knowledge of all of the present industrial uses for wool grease and lanolin and of the price and supply characteristics of the substitutes for them in these uses. 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, domestic and imported, 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 to get the highest price possible for all of their wool grease 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 chapter. The other oils and greases with which it competes can be used to obtain the same end result in an industrial process or in a product which meets the needs of an ultimate consumer equally well. In nearly all cases the industrial products in which wool grease is used are proprietary compounds which are sold on a performance basis and not for the specified amounts of certain materials which they contain. Under these conditions the amounts of wool grease which they contain can and do 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 and/or they become difficult to buy in quantities needed, the technical staffs of the various companies are alerted to the situation. In many companies which formulate their products, the formulae are reexamined and the advisability of using less wool grease and more of another material which is more stable in price and supply
is considered. Every year new compounds are developed which 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.

The following excerpt from a letter dated April 21, 1953, from Mr. William A. Caddy, Ensign Products Company, Cleveland, Ohio, is an example of the feeling of many industrial users:

Our consumption in 1952 amounted to — tons including all kinds of Degras. This is about one-third of our annual consumption of five years ago. This drop in consumption is due to the fact that we have been forced to reformulate our products to cope with the market supply of Degras.

It is our opinion that there is no substitute for Wool Grease which will do quite as well as Wool Grease. However, we have reformulated various products and are ready to drop the use of Wool Grease in the event that the market becomes such as it was a year ago. If that situation develops again it is extremely improbable that we will ever return to the use of Wool Grease in any of our products.

In any case, it has been our experience that foreign Degras is a much better product than is produced in this country. At present, we are experimenting with foreign Degras in various products, which if successful and in good supply should increase our consumption of Degras by many tons.

We wish to point out the fact that no new products including Degras in the process of manufacture will be presented to the market unless we have a substitute ready formulated which can be used to displace the Degras in the event that a market shortage again occurred.

Obviously we prefer Degras over any substitute but rather than be continually plagued by market shortages we are convinced that the only course of procedure would be to change over entirely to a substitute material.

The refiners foresee a decline in the demand for wool grease and are developing new products from lanolin and new uses for them.
Price Regulation of the Wool Grease Industry,
June 1952 - March 1953

Authority to regulate prices for the wool grease industry and other industries in the United States is found in the Defense Production Act of 1950 (Public Law 77th, 81st Congress) and Executive Order 10161 (15 F.R. 6105). Prices for wool grease and lanolin were first frozen under the General Ceiling Price Regulation at the level in effect during a base period extending from December 19, 1950, to January 25, 1951. Early in 1952 the Office of Price Stabilization requested wool grease producers and lanolin refiners to form Industry Advisory Committees to consult with the agency before it issued a ceiling price regulation for the industry. The wool grease producers Industry Advisory Committee met with O.P.S. officials in Washington on March 20, 1952; and the lanolin producers Industry Advisory Committee met with O.P.S. officials on March 26, 1952. O.P.S. had collected prices on wool grease and lanolin for the base period July 1, 1949, to June 30, 1950, and had prepared weighted average prices for the different grades based on the amount of each grade that was sold during the period. These prices conformed closely to the wartime levels under O.P.A.'s Maximum Price Regulation 53 of 1942. The committee members asked for higher prices to cover current cost conditions which had risen considerably since 1942 but had no cost data to substantiate their claims. O.P.S. officials told the committee members the various alternatives for obtaining higher prices under O.P.S. standards; and since these did not promise any relief from the General Ceiling Price Regulation under
which prices were then fixed, the industry committees agreed to recommend that the proposed ceiling prices be adopted. Accordingly the Office of Price Stabilization issued Ceiling Price Regulation 146 to cover sales of wool grease and lanolin, which went into effect June 3, 1952.

It was inevitable that a price regulation which conformed so closely to a schedule of prices established in 1942 would contain certain inequities and that those which were unfavorable would be complained about and those that were favorable would be exploited.

One disparity under O.P.S. regulation occurred in the pricing of domestic and imported grease and lanolin of the same quality. Since nearly all United States scourers recover grease with centrifugal equipment, a large part of the acid cracked grease, which has a higher free fatty acid content, is imported from other countries. Ceiling prices for imports are established by O.P.S. Ceiling Price Regulation 31 which became effective September 26, 1951. Under this regulation the refiners are allowed their regular mark-up (as of the base period July 1, 1949, to June 30, 1950) on the landed cost of the commodity. Since some acid cracked grease is produced in the United States, it was inevitable that quantities of the same grade would be selling in the same market in the United States for different prices. This occurred, for example, in the Chicago market in December, 1952, and incidentally was a classic case of discriminatory pricing in a competitive market. Imported grease was quoted at twenty-six cents per pound; and because of the general shortage, one refiner was offering a
combination of imported and domestic grease, in equal parts, for any order. Two pounds of imported grease at twenty-six cents would be fifty-two cents. The combination of imported grease at twenty-six cents and domestic grease at eighteen cents would be forty-four cents for two pounds. The brokers who handled only imported wool grease could be undersold.

Another discrepancy in the O.P.S. price structure was exploited by several producers who installed an additional centrifuge to reduce the moisture content of their crude centrifugal grease from 2½ percent to 0.1 percent and its ash content from 3/4 of 1 percent to 1/10 of 1 percent. This allowed their product to be graded as neutral wool grease and sell for an additional ten cents per pound. The cost of the extra centrifuge, about $5,000, could be recovered with the first 60,000 pounds of grease processed, which would be produced in less than six months for many producers. With the change in the national administration in November, 1952, many producers foresaw the end of price controls and did not attempt to change the quality of their grease, fearing that the premium would not prevail in a free market and that they would not have time to recover the cost of new equipment. Reference to Table 15 shows that the refiner could not pay thirty cents per pound for neutral wool grease and further refine it into lanolin selling for 33.5 cents or 35.5 cents per pound. He would handle it at a loss only to fulfill contracts with his customers. The refiner could handle this grease profitably only if it was light enough in color to be refined into lanolin selling at 40.5 cents per pound. The
producer and/or the industrial user would have had to undertake all of the marketing functions to dispose of the darker grease. This would not have been difficult while the ceiling price structure prevailed, but most producers did not care to assume the additional costs of finding their own customers or the risk that the ten cents per pound premium for neutral wool grease would prevail when ceiling prices were abandoned. Hence the ceiling price structure under O.P.S. Regulation 146 produced no significant production or marketing innovations.
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 survey. 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 and/or chemical properties which 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 substitutes and to what extent can they be substituted?
5. How critical is the price of wool grease (or lanolin) in each use?
6. How is it marketed?

Wool Grease in the Leather Industry

The principal use of wool grease in the leather industry is in stuffing or currying the upper leather used for Army shoes and combat

boots, known as Army Retan, 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 a hundred 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.² It is done after the hide has been dehaired, split, chrome tanned³ and rolled to remove the excess moisture. 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.

² 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.

³ Chrome tanned leather has a much greater resistance to heat and abrasion than vegetable tanned leather.
used in the stuffing compound.

Federal Specification KX-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 is now 3 to 4 cents higher (June 1953). Tanners use it for the following reasons:

1. It comes within the melting point range, 105°F.-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 by suppliers.

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

Fred O'Flaherty, "Military Chrome - Retan Upper Leather," (Unpublished study made at Tanner's Council Laboratory, University of Cincinnati, Cincinnati, Ohio, n.d.), p. 4.
25% Currier Vac Grease
25% Currier Hard Wax
15% Wool Grease
15% Moellon Degras
20% Tallow

Army Retan has a 22 percent to 28 percent grease content (chloroform extractable), of which 15 percent would be wool grease in the leather, based on its dry weight.

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

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 lbs. of wet leather, pressed weight)

<table>
<thead>
<tr>
<th>Component</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vatgrease W</td>
<td>26 lbs.</td>
</tr>
<tr>
<td>Hardgrease No. 13</td>
<td>42 lbs.</td>
</tr>
<tr>
<td>Vatgrease A</td>
<td>3 lbs.</td>
</tr>
<tr>
<td>Wool Grease</td>
<td>12 lbs.</td>
</tr>
<tr>
<td>Waterless Moellon</td>
<td>15 lbs.</td>
</tr>
<tr>
<td></td>
<td>100 lbs.</td>
</tr>
</tbody>
</table>

Another stuffing mixture described in *Modern Practice in Leather Manufacture* by J. A. Wilson, p. 482, a standard textbook, is as follows:

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5 Based on interviews in the New England area by the author March, 1953.
Army Retan Stuffing Mixture
(For each 600 lbs. of leather, pressed weight)

Waterless Moellon ........................................... 15 lbs.
Oleo-stearine ........................................... 15 lbs.
Vaseline ................................................... 15 lbs.
Wool Grease ................................................ 30 lbs.
Tallow ....................................................... 10 lbs.
Cod Oil ....................................................... 8 lbs.

Consumption of wool grease at present in the leather industry varies principally with the output of Army Retan since its use in other types of leather is relatively steady. This will also be true in the future. In 1951, which was a peak year for military requirements, approximately one and three-fourths million pounds went into this use in the leather industry, apart from its use in other types of leather and in fatliquors. In that year the output of Army Retan leather was approximately eighty million square feet. In 1952, preliminary estimates indicate that not more than twenty-five million square feet of Army Retan were produced so that consumption of wool grease in that use was probably not more than three-fourths million pounds.

In earlier years, when wool grease suitable for use in the leather industry was available from Arlington Mills solvent scouring process in large quantities at low cost, over three 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.'6

Wool grease is preferred for use in stuffing mixtures. However substitutes are available; and wool grease competes with Moellon degras, sperm oil, cod oil, paraffin wax, petrolatum and other petroleum base products, and tallow to some extent on the basis of price. The best substitutes are the oleo stearines which are available in large quantities and are generally much lower in price than wool grease, although they have a tendency to spue.

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6 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.
The following extracts from letters are typical of many received from tanners and suppliers.

"At the present time substitutes for wool grease are available from many different oil suppliers."

"We could easily use additional amounts of wool grease providing the price of the material is reasonable."

"As a large producer of retan we might easily use 200,000 pounds or more of good wool grease per year, profitably priced in the range of 10-12¢. I might call your attention to the fact that this price is not unreasonable since this price actually existed in the industry less than two and one-half years ago when wool grease seemed to be in long supply."

"We have not yet found an adequate substitute for this material in our industry. We could use additional amounts providing that it is genuine wool grease. We like to have an f.o.b. content of approximately 18% and as moisture proof as possible."

"We know of no satisfactory substitute, but probably if the entire supply was cut off something would be worked out with the combination of mollon and other greases. We have, however, been forced to import this material when the domestic supply was inadequate."

"With wool grease selling at anywhere from 17¢ to 26¢ a pound plus freight, the price puts this material above the price of hide substances on a pound for pound basis. Many work shoe manufacturers have shifted from stuffed leathers to fatliquored leathers because the material price to produce stuffed often priced these leathers higher than fatliquored leathers, with higher amounts of hide substance."

"We were using Domestic until the plants in this country could not produce enough, forcing us to use English. Price is getting out of line."

Nearly all of the tanners queried in this survey mentioned that they formerly used the grease produced at Arlington Mills and that they were now using some imported wool grease. The following comments are typical.
"During the past year it has been necessary for us to fill out our requirements with Belgian wool grease which ran at a much higher cost figure than the domestic material."

"We used English Desulphurized wool grease during 1952."

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 and not 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 O.P.S. 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 which they buy, depending 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 since it is well known in the industry that heavy upper
leather can be stuffed equally well 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; e.g., 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 supplies were short.

Wool Grease in Fur Dressing

Wool grease (common degreasing) is considered an indispensable ingredient in fur dressing oils, and no completely satisfactory substitute has 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, fleshed, and tanned in a solution of salt and alum called the bite or pickle. After the skins are dried to a moisture content of thirty percent, kicking oil or grease 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.

The kicking process in fur dressing is analogous to the currying and stuffing processes of the leather tanner. A typical kicking oil contains forty percent wool grease, and the other sixty percent is made up of fats, fatty oils, and mineral oil. The amount of wool grease used may vary from thirty percent to fifty percent of the mixture. Less is used as it 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 on top of the skin. The oil will spread upon this surface instead of penetrating

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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.
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 depend upon the extent 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 which make it useful to the fur dresser are its tackiness and plasticity range. Many furs are drummed from five to ten 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 an important factor in its use in the leather and fur industries. It remains in the leather unchanged 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. However 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, polyoxyalkylene 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, 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 can not 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 which he processes; consequently, he has little to gain and much to lose by experimenting with other materials. Any change, however small, 8Much of the information regarding the utilization of wool grease in fur dressing was obtained from Mr. Phillip Dwyer, Chief Chemist, O. L. King & Co., San Francisco, California.
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 saleable. 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 which the industry does not possess. Finally, wool grease is normally the cheapest and best material available.

At present prices of thirteen to fifteen cents per pound, wool grease is still from two to three cents cheaper than the nearest single competitive product and is five to eight cents per pound cheaper than any effective mixture which might replace it in the fur industry. However, an assured supply is even more important than price.

Fur dressers are not direct purchasers of wool grease as are some tanners. The wool grease which they use is supplied to them in fur dressing oils compounded principally by four manufacturers. The largest of these firms used approximately one 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. If the supply of wool

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9 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 two years.
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 find the supply of common degras usually scarce and its price generally higher.

Wool Grease in Belt Dressing

Most 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 production of 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

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10 It is produced by only three mills in the United States.
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 the natural pulley gripping
qualities of the leather. Belts may accumulate mineral oil and
grease from the drive motor or nearby machinery which 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 in sticks, containing about 50
percent wool grease, is a temporary expedient used simply to increase
the coefficient of friction between the belt surface and the pulley.
Rosin, with small amounts of beeswax, neatsfoot or castor oil is 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 applica-
tion 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 criti-
cal. 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 past two years due to the scarcity of domestic supplies of this quality but have bought it through United States refiners or importers acting as brokers or merchant middlemen. It is estimated that approximately 400,000 pounds of crude wool grease are used annually in belt dressing.

Some of the leather belting manufacturers either manufacture 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 combing and drafting operation. Cordage oil enables the rope to stretch and bend easily without producing internal friction and/or fiber breakage. Cordage oil constitutes 11 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. Since 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 the 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 per 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; i.e., 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. Mr. David Himmelfarb, Master Ropemaker of the Ropewalk at the Boston Navy Yard, believes that wool grease in cordage oil acts as a wetting agent, gives better lubricity in the drafting operation, and delays deterioration of the rope in use. The effect of wool grease as a fiber softener and a plasticizer for other greases is debatable.

About twenty 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 Arlington Mills. Typical comments were as follows:

11 Interview with Mr. H. R. Landwehr, Purchasing Agent, New Bedford Cordage Company, New Bedford, Massachusetts, April 24, 1953.
12 Interview, Boston, Massachusetts, April 27, 1953.
"We formerly purchased our wool grease from the Arlington Mills located in your state at Lawrence. We use very little at the present time."

"In the past we have used Arlington Mill's Wool Grease, Barre Desulphurized Degras, and occasionally, imported wool grease."

Apparently a substantial portion of the Arlington 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 supply when Arlington Mills closed in 1950 that led to the use of refined tallow and other greases and waxes with the basic mineral oil.

Present use of wool grease in cordage oil by commercial establishments is very limited because of its high price. The following extracts are typical of those received from questionnaire respondents:

"However, we are limited as to what we can afford to pay for it for this purpose, and material meeting our requirements at approximately 10¢ per pound would permit the use of an estimated 10,000 pounds per month."

"Wool Grease, commonly known as Degras, is used somewhat in the manufacture of cordage, but for several years we have practically stopped its use because of high price."

"We used to buy Degras for 1¢ or 5¢ per pound, but when it gets up to around 20¢ there are other things that work better and give better results."

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. Under Government Specification MIL-R-16060 (Ships), 15 April 1951, a combination of copper naphthenate and GH$_1^{13}$

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$^{13}$A potent fungicide and bactericide, 2,2'-dihydroxy - 5,5'-dichlorodiphenylmethane manufactured by Sindar Corporation, New York City.
is prescribed for all cordage manufactured for the Navy. GU is easily soluble in wool grease; and although the Navy specification does not designate that wool grease shall be used, the Master Ropemaker adds 15 percent by weight to the cordage oil used in the Manila rope produced at the Boston Navy Yard and recommends its use in all Manila rope manufactured by commercial establishments for the Navy, first as a solvent for the GU compound and second as a good lubricant and preservative for the rope. The Boston Navy Yard produces about five million pounds of rope and uses approximately 100,000 pounds of wool grease annually. This wool grease is purchased by bids submitted by the refinners under Navy Department Specification 14-G7a, February 15, 1946 as follows:

<table>
<thead>
<tr>
<th>Grease, Wool, Rope-lubricant Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melting point, degrees C.</td>
</tr>
<tr>
<td>Minimum</td>
</tr>
<tr>
<td>Maximum</td>
</tr>
<tr>
<td>36</td>
</tr>
<tr>
<td>42</td>
</tr>
<tr>
<td>Ash (percent)</td>
</tr>
<tr>
<td>Minimum</td>
</tr>
<tr>
<td>Maximum</td>
</tr>
<tr>
<td>1.00</td>
</tr>
<tr>
<td>Water (moisture)(percent)</td>
</tr>
<tr>
<td>Minimum</td>
</tr>
<tr>
<td>Maximum</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>Flash point, degrees C</td>
</tr>
<tr>
<td>Minimum</td>
</tr>
<tr>
<td>Maximum</td>
</tr>
<tr>
<td>175</td>
</tr>
<tr>
<td>Acid number</td>
</tr>
<tr>
<td>Minimum</td>
</tr>
<tr>
<td>Maximum</td>
</tr>
<tr>
<td>15</td>
</tr>
<tr>
<td>25</td>
</tr>
<tr>
<td>Saponification number</td>
</tr>
<tr>
<td>Minimum</td>
</tr>
<tr>
<td>Maximum</td>
</tr>
<tr>
<td>115</td>
</tr>
<tr>
<td>130</td>
</tr>
<tr>
<td>Iodine number (Hanus)</td>
</tr>
<tr>
<td>Minimum</td>
</tr>
<tr>
<td>Maximum</td>
</tr>
<tr>
<td>25</td>
</tr>
<tr>
<td>32</td>
</tr>
</tbody>
</table>

Although no actual data exist as to the number of pounds of Manila Rope manufactured annually in the United States, it is estimated that average annual sales are about 75 million pounds excluding sales to the Federal Government. Annual sales to the United States Government.

Letter from Cordage Institute, dated May 6, 1953.
ment 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 free fatty acid maximum of 15 percent and not too dark a color. The sulphur content is not important. 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. Since 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 price of 15 to 16 cents per pound 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 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."15

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. The following comments showing how wool grease and lanolin are used are typical of those received from a cross section of the industry.

"We wish to advise that wool grease and lanolin are used by us in the production of Oil Type Letterpress and Lithographic Inks. While not universally used in all formulations, they do find their way into approximately 50% of the tonnage we produce. They are added in small quantities ranging from one half to two per cent of the pounds produced."

"Wool grease, when it is used in ink, is approximately 10% of the weight. It improves the printability of the ink by serving as a lubricant without materially changing the body of the ink."

"Both wool grease and lanolin are used and their two defects from a production standpoint are odor and price. Strong odor is objectionable from a sales viewpoint. When the price goes up, the amount is reduced or omitted entirely, though the proportion is only 5% of the total weight."

"The usage of wool grease in printing inks has been dropping. Usually only one grade is used, this being a pale neutral lanolin. The amount which might be used in certain inks will vary probably 2 to 5%. Some of the good points about it is that it works well lithographically. It tends to relieve tack and still maintain a good body. On the other hand it also tends to retard drying and weakens the binding. For this reason it has been frequently replaced by other materials without these defects."

"We use small amounts, about 3% by weight, of Technical Grade Lanolin in Lithograph Ink."

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 which it adds to their product and feel that it is indispensable in this use.

"Our mimeograph ink contains 8% wool grease by weight. We know of no substitute for the wool grease for use in mimeograph ink having a castor oil base."

"They give a smoothness of flow to the ink and in some cases they add to the sheer of the finished product. Neither item can be substituted with any known petroleum product mainly because wool grease and lanolin have length while petroleum products are generally short and buttery."

"It has no substitute in inks. It is used in lithograph inks for two reasons. First, it absorbs moisture during the process of lithoprinting and resists further additional water so that it does not go to paste. Second, it helps to wet surfaces better than other materials and makes ink adhere better to metals. Both of these qualities are based on its property as a surface active agent."

"Actually, we do not wish to discuss all the details of its uses, but I might say that we have used petrolatum as a substitute when shortages have forced us to do so."

In this industry, as in many others which produce formulated compounds, the exact proportion of wool grease used by each company is a closely held secret. From interviews with a number of manufacturers
of printing inks, the following formulae (quoted by permission of the publisher, MacNair-Dorland Company, New York) are judged to be typical of current practice in the industry. They come from a source recommended as "the best available public information" by the National Association of Printing Ink Makers.  

### Dry Offset Bronze Blue

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lithographic varnish</td>
<td>37 lbs, 0 oz.</td>
</tr>
<tr>
<td>Lithographic varnish</td>
<td>7 lbs, 8 oz.</td>
</tr>
<tr>
<td>Wool Grease</td>
<td>2 lbs, 12 oz.</td>
</tr>
<tr>
<td>Alumina hydrate, dry</td>
<td>7 lbs, 0 oz.</td>
</tr>
<tr>
<td>Bronze blue, dry</td>
<td>1 lb, 12 oz.</td>
</tr>
<tr>
<td>Total</td>
<td>100 lbs, 0 oz.</td>
</tr>
</tbody>
</table>

### Dry Offset Red for Lake C

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lithographic varnish</td>
<td>3 lb, 0 oz.</td>
</tr>
<tr>
<td>Lithographic varnish</td>
<td>12 lbs, 0 oz.</td>
</tr>
<tr>
<td>Gloss white, dry</td>
<td>23 lbs, 0 oz.</td>
</tr>
<tr>
<td>Barium red for lake C, dry</td>
<td>2 lb, 0 oz.</td>
</tr>
<tr>
<td>Paste drier</td>
<td>3 lbs, 0 oz.</td>
</tr>
<tr>
<td>Wool grease</td>
<td>1 lb, 0 oz.</td>
</tr>
<tr>
<td>Total</td>
<td>100 lbs, 0 oz.</td>
</tr>
</tbody>
</table>

### Mimeograph Ink

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Castor Oil (heated to 300°C and cooled)</td>
<td>40 lbs</td>
</tr>
<tr>
<td>Blown castor oil</td>
<td>20 lbs</td>
</tr>
<tr>
<td>Free-flowing carbon black</td>
<td>2 lb, 6 oz.</td>
</tr>
<tr>
<td>Victoria blue base (dissolved in oleic acid)</td>
<td>1 lb</td>
</tr>
<tr>
<td>Benzine</td>
<td>8 lbs</td>
</tr>
<tr>
<td>Neutral wool grease or lanolin</td>
<td>3 lbs</td>
</tr>
<tr>
<td>Milori blue ink (1:1 in litho varnish)</td>
<td>1 lb</td>
</tr>
<tr>
<td>Alumina hydrate, dry</td>
<td>1 lb</td>
</tr>
</tbody>
</table>

---

16 Extract from a letter from Mr. Herbert Livesey, Secretary dated March 30, 1953.

17 Wolfe, op. cit., p. 284.

18 Ibid., p. 332.
Typewriter Ribbon Ink

16 lbs. Commercial oleic acid
5 lbs. Free-flowing carbon black
2 lbs. Blown castor oil
1½ lbs. Methyl violet base dye
1 lb. Lanolin
26½ lbs.

Offset Milori Blue

½ lbs. 8 oz. #00 Lithographic varnish
32 lbs. 0 oz. #1 Lithographic varnish
4 lbs. 0 oz. Alumina hydrate, dry
4 lbs. 0 oz. Blanc fixe, dry
49 lbs. 0 oz. Milori blue, dry
4 lbs. 4 oz. Refined wool grease
1 lbs. 4 oz. Offset ink compound

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 eight percent wool grease by weight.

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 one and two thousand 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."
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 formulae. 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

Information for this section was obtained principally by a questionnaire sent to every refiner and manufacturer of lubricating oils and greases and to all of the manufacturers of oil rust preventives listed in Thomas's Register of American Manufacturers. A sample of large and small firms was selected on the basis of the questionnaire returns, and representatives of these firms were interviewed. An extensive correspondence with technically qualified individuals and trade associations developed additional information on the nature and extent of current uses. Recent technical literature and patents
were searched for current information.

The petroleum industry uses more wool grease than any other and offers the greatest potential market for any additional amounts which might be recovered in the United States or imported from abroad. The Bureau of the Census reported the use of wool grease in lubricants and greases for five years as follows:

**TABLE 21**

Proportion of Wool Grease Used in Lubricants and Greases, 1944-1948

<table>
<thead>
<tr>
<th>Year</th>
<th>Amount of Wool Grease Available for Consumption (000 pounds)</th>
<th>Wool Grease Used in Lubricants and Greases (000 pounds)</th>
<th>Percent of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1944</td>
<td>17,077</td>
<td>5,200</td>
<td>30</td>
</tr>
<tr>
<td>1945</td>
<td>18,812</td>
<td>4,387</td>
<td>23</td>
</tr>
<tr>
<td>1946</td>
<td>19,959</td>
<td>3,457</td>
<td>19</td>
</tr>
<tr>
<td>1947</td>
<td>22,329</td>
<td>5,983</td>
<td>27</td>
</tr>
<tr>
<td>1948</td>
<td>19,164</td>
<td>5,583</td>
<td>29</td>
</tr>
</tbody>
</table>


Census data are not available for more recent years, but it is estimated that approximately six million pounds of wool grease were used by the petroleum industry in 1952 out of a total available supply of fourteen million pounds. Considering the increase in price which took place between those years, the use of wool grease in the petroleum industry is quite steady. The industry uses wool grease in four classes of products as shown by the following estimates (in millions of 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 excludes moisture from the metal. They can be easily displaced from the metal surface by water. The protection which petroleum oils afford can, however, be increased by the addition of lanolin and petroleum sulfonates.

In tests carried out by Bell Telephone Laboratories 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.\(^{23}\)

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, Cover 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, (e.g., 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. Having a long chain molecule with a polar group on one end, it adsorbs 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 by one company, as Alox 1727, as a
suitable replacement for wool grease, to inhibit the rusting of steel plates after descaling. Its price is 18.5 cents per pound in drums, f.o.b. Niagara Falls, New York, drums included. A 5 percent blend of this material in a light oil has been found equivalent to a 10 percent blend of lanolin in the same oil. It is therefore 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 microcrystalline waxes from crude petroleum fractions, and spermaceti wax, which has some merit in this use. Sperm oil, which has a chemical structure similar to that of lanolin, 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 four to five million pounds went into this use. It decreased to not more than one and one half 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 semi-solid stiff paste form. The conditions of use determine the relative proportions 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 in
Tables 19 and 20. The metallic components are usually sodium, lithium,
calcium, potassium, aluminum, or barium, depending on the length of
fiber and resistance to high temperatures and water desired. Lubri­
cating 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 which 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 under conditions of extreme pressure, form 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. They are not often used alone since most of them contain a small amount of natural fatty acid of the glyceride type which increases upon exposure to air and becomes rancid. 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 listed in Appendix E which have similar properties. In some cases the supply of these oils is almost unlimited, and some of them are cheaper in price than wool grease. The physical and chemical properties of these fatty oils and their use in compounded metalworking lubricants are given in Appendix E.

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Lubricant Additives

The use of wool grease in mineral oils for lubrication purposes has long been known, but only in recent years has it been used to improve

The following U.S. Patents cover various kinds of lubricant additives using wool grease and lanolin: 2,331,923; 2,346,357; 2,357,346; 2,365,209; 2,383,495; 2,385,832; 2,399,234; 2,413,332; 2,415,836; 2,415,837; 2,415,838; 2,439,819; 2,422,206; 2,422,630; 2,439,820; 2,439,822; 2,468,031; 2,566,211; 2,606,182.
lubrication in internal combustion engines under high temperature conditions. Typical concentration of additives in crankcase 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, coconuts oil, or babassu oil,) with an unsaturated hydrocarbon and a phosphorus sulphide. An example of this involves the mixing of twenty-three parts of phosphorus pentasulphide, by weight, with thirty parts of a diluent neutral oil and one hundred parts of wool grease. The mixture is agitated for an hour at 300°F. and filtered. Another example of a 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 eight to ten 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 five to six million pounds of wool grease could be marketed at prices up to ten cents per pound for lubricant additives. Present consumption in this use approaches two million pounds annually.

In addition to the uses in petroleum products in which they compete with other fats and oils, there are certain uses in which the unique qualities of wool grease and lanolin make them 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 the reasons given above. Lanolin may be used as the lubricating base plus 10 percent flake or powdered graphite which serves as a carrier, or in accordance

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with the following formula:

- 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.

There are two distinct sizes of firms that 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 which 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 nation-wide.

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 which a small manufacturer can offer to a nearby customer will often offset any small savings which 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 the Arlington Mills was operating and a large supply was available. However, it is the scale of their requirements which 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, it is the certainty of supply and the uniformity of
the product which only the refiners can furnish which override the
savings which 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 very 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 quite 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 special-
ized; e.g., 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 a trained technical staff
at a centrally located manufacturing plant such as Chicago, Cleveland,
or Philadelphia and distribute over a wider area by means of branch
offices staffed with one or two 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", i.e., 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 sterilized 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. A survey of the industry indicates 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 two to three 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 formulae 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; and 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 which meets the tests for identity and purity given in the United States Pharmacopeia (see Appendix D) is designated as U.S.P. lanolin, Wool Fat or Adeps Lanae. Hydrous Wool Fat or Adeps Lanae Hydrossus contains not less than twenty-five percent and not more than thirty 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 which 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 five to ten 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.

Prior to 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 hydrophillic ointments because they are more acceptable aesthetically and because their antiseptic power is more readily available; i.e., it can be absorbed more readily from a hydrophillic ointment than from one with a higher grease content. The latest development in this field is 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, and nonirritating and do not support bacterial or mold growth.

The use of lanolin in the preparation of ointments by pharmacists has declined drastically since 1950. In that year it was omitted from the fourteenth edition of the United States Pharmacopeia.

The following statement in a paper entitled "Dermatologic Pharmacuti-


27 The Revision Committee of the United States Pharmaceutical Convention consists of twenty dermatologists and forty physicians.
cals of the Future," by Louis C. Zopf, is the official explanation for the omission.

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 dermatologists 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% 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.29

There were eighteen ointments which contained lanolin 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. Wool Fat was also deleted from The National Formulary, Ninth Edition, in 1950; and it was its omission from these two compendia which decreased its use in prescriptions.

The lanolin refiners took no notice of this action at the time.

29 Drug Standards, May-June, 1951, p. 98.
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 from one of the largest lanolin manufacturers in-
dicates his views on the subject.

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.

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 emollient. 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 stand-
point particularly when the incidence of positive skin reactions
even under such circumstances is so small? Opinions and conclu-
sions on any product, including lanolin, to be valid, must
necessarily be based on a much broader and more substantial
basis.30

30 Extract from a letter from Mr. A. Wagner, Robinson-Wagner
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. A proprietary ointment vehicle sold under the trade name Eucerin is said to consist of three percent of the free alcohols from lanolin, incorporated with petrolatum. A similar product, Aquaphor, is also used, and it is claimed that this vehicle will not reduce metallic oxides but is capable of suspending large proportions of water.

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 22 shows that U.S.P. lanolin varied in price only twelve

\[ \text{The U.S. Army Medical Corps used 10,560 pounds of U.S.P. lanolin in 1952.} \]

<table>
<thead>
<tr>
<th>Year</th>
<th>High Price (cents)</th>
<th>Low Price (cents)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1941</td>
<td>29</td>
<td>29</td>
</tr>
<tr>
<td>1942</td>
<td>30</td>
<td>29</td>
</tr>
<tr>
<td>1943</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>1944</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>1945</td>
<td>32</td>
<td>27</td>
</tr>
<tr>
<td>1946</td>
<td>27</td>
<td>21.5</td>
</tr>
<tr>
<td>1947</td>
<td>21.5</td>
<td>21.5</td>
</tr>
<tr>
<td>1948</td>
<td>28</td>
<td>20</td>
</tr>
<tr>
<td>1949</td>
<td>30</td>
<td>28</td>
</tr>
<tr>
<td>1950</td>
<td>34</td>
<td>34</td>
</tr>
<tr>
<td>1951</td>
<td>33.5</td>
<td>33.5</td>
</tr>
<tr>
<td>1952</td>
<td>33.5a</td>
<td>33.5a</td>
</tr>
<tr>
<td>1953</td>
<td>34</td>
<td>34</td>
</tr>
</tbody>
</table>

a Up to June, 1953


cents over the decade 1941-1951. The relatively small proportion of lanolin used in each product and the wide profit margin which is common in this field decrease the significance of price changes on the manufacturer's demand for lanolin. Price increases up to forty cents per pound can be absorbed without increasing the established selling price or changing to a cheaper material. Between forty and fifty 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 a physical shortage developed. Above fifty 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. Since there is very little difference in the material produced by the different refiners and prices are competitive, the manufacturers of pharmaceutical products tend to make contracts with one refiner which are renewed annually with prices adjusted to delivery dates. In some cases the size of 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 22 shows the prices received by refiners since 1941.

U.S.P. lanolin sold to drug stores to be used in prescriptions or sold in bulk over the counter is bought from the refiners in drums by three companies, who package and sell it in one, five, ten, twenty-five, and one hundred pound containers to druggists along with a full line of drugs, proprietary products and sick room supplies. It is estimated that 700,000 pounds of lanolin were consumed in this use during 1952. This is about one-fourth of the amount used four years ago. Lanolin is distributed more efficiently and economically through a wholesaler than from the refiner directly to the retailer. One of these distributes approximately eighty percent of the total.
The largest drug stores seldom carry an inventory of more than twenty-five pounds of U.S.P. lanolin, and small ones do not carry more than five 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.

**TABLE 23**

**U.S.P. Lanolin Prices and Margins, June, 1953**

<table>
<thead>
<tr>
<th>Received By</th>
<th>Anhydrous, Price per Pound (dollars)</th>
<th>Distributor's Margin per Pound (dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Producers</td>
<td>0.22</td>
<td></td>
</tr>
<tr>
<td>Refiners</td>
<td>0.12</td>
<td>0.20(^a)</td>
</tr>
<tr>
<td>Wholesalers</td>
<td>0.81</td>
<td>0.39</td>
</tr>
<tr>
<td>Retailers</td>
<td>1.21</td>
<td>0.40</td>
</tr>
</tbody>
</table>

\(^a\) Refiners' margin includes lanolin manufacturing costs of seven to eight cents per pound.

There is a possibility in this field for the wool scourer to produce and market simple proprietary ointments and salves which contain up to fifty percent of lanolin. It is estimated that one ounce tubes or tins of these products could be produced at ten to fifteen cents to retail for forty-nine to fifty-nine cents. A part of this margin would go to the wholesalers, either local or regional, through whom the products would be distributed to drugstores. This project
would require a considerable investment not only in production facil-
ities but also in advertising to ultimate consumers, to build up a
demand which would persuade wholesalers to undertake the distribution.

**Lanolin in Cosmetics**

as "(1) articles intended to be rubbed, poured, sprinkled or sprayed
or, 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 com-
ponent 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 with
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.

[^1]: Act approved June 25, 1938, 75th Congress, 3rd Session,
52 Stat., 1040, 21 U.S.C. sec. 301 et seq.; amended June 23, 1939,
See Appendix D. 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.

The Toilet Goods Association has published specifications for many of the substances used in cosmetics. The latest for lanolin is their #29, published in May, 1948.

**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 of 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 one per cent 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.

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 which are used in various combinations. Lanolin is used as an emulsifier in water-in-oil combinations, commonly used in emollient creams, hand creams, baby products, lipsticks, and other preparations intended to impart or maintain softness of the skin, hair, and nails. An extremely valuable property is its tendency 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, and/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. As it is a rare substance that never causes an unfavorable reaction in some individual under some circumstances, a few studies have shown 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 of many kinds of cosmetic products used on the skin, — creams, lotions, powders, and 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 facial creams a small proportion of it has a notable softening effect. In cleansing creams it removes watery dirt while other greasy ingredients remove greasy dirt. In emollient creams (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 formulae for these creams are as follows:

<table>
<thead>
<tr>
<th>Cleansing Cream</th>
<th>Emollient Cream</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid petrolatum 40 parts</td>
<td>Lanolin anh. 20 parts</td>
</tr>
<tr>
<td>Ceresin 16</td>
<td>White petrolatum 40</td>
</tr>
<tr>
<td>Lanolin 4</td>
<td>Water, to make 100</td>
</tr>
<tr>
<td>White petrolatum 30</td>
<td></td>
</tr>
<tr>
<td>Water, to make 100</td>
<td></td>
</tr>
</tbody>
</table>

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 1 percent.

Lotions which contain lanolin are more exactly liquid creams, with composition similar to that of solid or semi-solid creams, of oil-in-water and water-in-oil type emulsions. They have a large water content. Lanolin is included in amounts of from two to ten percent.

Face powders which 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 five 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 ten 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 five to thirty-five 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, approximately one 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. In the increasing use of so-called soapless shampoos, based on synthetic detergents and other surface-active agents, if a small amount of lanolin is left on the hair after the usually drastic 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:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lanolin anh.</td>
<td>25</td>
</tr>
<tr>
<td>Benzoin Tincture</td>
<td>5</td>
</tr>
<tr>
<td>Petrolatum</td>
<td>70</td>
</tr>
</tbody>
</table>

Lanolin can also be used with cacao 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; and the mixtures are applied both to the scalp and to the lengths of hair, for local improvement. Lanolin is commonly the animal fat used, incor-
porated 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: By hair dressings are understood the oily or waxy preparations used to impart brilliance to the hair and hold it in place. 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:

<table>
<thead>
<tr>
<th>Product</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toilet soaps</td>
<td>0 to 2%</td>
</tr>
<tr>
<td>Shaving creams</td>
<td>0 to 1%</td>
</tr>
<tr>
<td>Baby oils</td>
<td>0 to 5%</td>
</tr>
<tr>
<td>Zinc creams</td>
<td>0 to 3%</td>
</tr>
<tr>
<td>Face creams</td>
<td>0 to 15%</td>
</tr>
<tr>
<td>Lipsticks</td>
<td>0 to 15%</td>
</tr>
<tr>
<td>Shampoos</td>
<td>0 to 2%</td>
</tr>
</tbody>
</table>

Substitutes for Lanolin in Cosmetics

In efforts to get away from the disadvantages of lanolin — the stickiness, the characteristic odor — derivatives of lanolin con-

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Extract from letter from Mr. Moody L. Crowder, Treasurer of the Society of Cosmetic Chemists, dated March 17, 1953.
taining a part of the cholesterol rich fraction have been used increas ingly 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 and/or other fats and waxes. Some of the names by which these proprietary products are known in the trade are: Aquaphor, Almecerin, Boerocerin, Cefatin, Cremogene, Emulgel, Falba, Hydrocerin, Lameform, Lanochol, Nimco, Parachol, Protegin, Protegin X, Sorbotex, Thoreps. Manufacturers or distributors of all 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 2. 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 which make lanolin a desirable ingredient in cosmetic formulae.
TABLE 24

Wholesale Prices of Lanolin and Lanolin Substitutes in Cosmetics

<table>
<thead>
<tr>
<th></th>
<th>Price per Pound</th>
<th>Price per Pound</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>In Drums</td>
<td>10 lbs. or less</td>
</tr>
<tr>
<td>Lanolin, cosmetic quality</td>
<td>$0.38</td>
<td>$0.48</td>
</tr>
<tr>
<td>Ceramol, Lanette Waxes</td>
<td>.78</td>
<td>1.50</td>
</tr>
<tr>
<td>Atlas Powder Co. modified lanolins</td>
<td>.59</td>
<td>.69</td>
</tr>
<tr>
<td>Carbowaxes: 400 (liquid)</td>
<td>.29</td>
<td>.49</td>
</tr>
<tr>
<td>1500 (liquid)</td>
<td>.32</td>
<td>.52</td>
</tr>
<tr>
<td>4000 (solid)</td>
<td>.34</td>
<td>.51</td>
</tr>
<tr>
<td>Modulan</td>
<td>1.25</td>
<td></td>
</tr>
<tr>
<td>Amerchol L-101</td>
<td>1.20</td>
<td></td>
</tr>
</tbody>
</table>

Among the most successful (commercially) of the synthetic waxes used instead of (or substituting for some proportion of) lanolin in cosmetic preparations are:

Lanette Waxes (also called Ceramol, Cera Emulsificans). These consist of nine parts of cetyl alcohol (flakes) plus one part of sodium lauryl sulfate.

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

The polyethylene glycols of 400 and 4000 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 and/or mineral oil and wax 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 are offered by the Atlas Powder Company under code numbers, C1425, C1431, C1441. 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 formulae.

Cold Cream

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beeswax</td>
<td>15%</td>
</tr>
<tr>
<td>Mineral Oil</td>
<td>50%</td>
</tr>
<tr>
<td>C1431 (polyoxyalkylene sorbitol-lanolin)</td>
<td>3%</td>
</tr>
<tr>
<td>Borax</td>
<td>1%</td>
</tr>
<tr>
<td>Water</td>
<td>31%</td>
</tr>
</tbody>
</table>

### Cold Cream (Soap Free)

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mineral Oil 65/75</td>
<td>50.0%</td>
</tr>
<tr>
<td>Beeswax, white</td>
<td>15.0%</td>
</tr>
<tr>
<td>Spermaceti</td>
<td>2.0%</td>
</tr>
<tr>
<td>Lanolin, (anhid.)</td>
<td>0.5%</td>
</tr>
<tr>
<td>C-14H1, (polyoxyalkylene sorbitol-lanolin)</td>
<td>4.0%</td>
</tr>
<tr>
<td>Arlacel 60 (sorbitan mono-stearate)</td>
<td>4.0%</td>
</tr>
<tr>
<td>Arlacel 83 (sorbitan sesquioleate)</td>
<td>0.5%</td>
</tr>
<tr>
<td>Vee gum Gel (magnesium aluminum silicate)</td>
<td>0.5%</td>
</tr>
<tr>
<td>Water</td>
<td>23.5%</td>
</tr>
<tr>
<td>Preservative</td>
<td>q.s.</td>
</tr>
<tr>
<td>Perfume</td>
<td>q.s.</td>
</tr>
</tbody>
</table>

### Oil in Water Hair Dressing

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Petroleum</td>
<td>7.5%</td>
</tr>
<tr>
<td>Mineral Oil 65/75</td>
<td>37.5%</td>
</tr>
<tr>
<td>Beeswax</td>
<td>2.0%</td>
</tr>
<tr>
<td>C-14H25 (polyoxyalkylene sorbitol-lanolin)</td>
<td>4.5%</td>
</tr>
<tr>
<td>Arlacel 83 (sorbitan sesquioleate)</td>
<td>2.0%</td>
</tr>
<tr>
<td>Water</td>
<td>46.5%</td>
</tr>
<tr>
<td>Preservative</td>
<td>q.s.</td>
</tr>
<tr>
<td>Perfume</td>
<td>q.s.</td>
</tr>
</tbody>
</table>

Modulan and Amerchol L 101 are modified lanolin products manufactured by American Cholesterol Products, Inc. Their use is shown in the following formulae:

### Vanishing Cream

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modulan</td>
<td>2 parts</td>
</tr>
<tr>
<td>Amerchol CAD</td>
<td>5 parts</td>
</tr>
<tr>
<td>Stearic acid</td>
<td>25 parts</td>
</tr>
<tr>
<td>Triethanolamine</td>
<td>1.4 parts</td>
</tr>
<tr>
<td>Glycerin</td>
<td>5 parts</td>
</tr>
<tr>
<td>Water</td>
<td>70 parts</td>
</tr>
<tr>
<td>Perfume and preservative</td>
<td>q.s.</td>
</tr>
</tbody>
</table>

### Hair Treatment Cream

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modulan</td>
<td>3.5 parts</td>
</tr>
<tr>
<td>Amerchol L-101</td>
<td>9.5 parts</td>
</tr>
<tr>
<td>Glyceryl mono-stearate</td>
<td>13.5 parts</td>
</tr>
<tr>
<td>Spermaceti</td>
<td>1.5 parts</td>
</tr>
<tr>
<td>Mineral oil (70 vis.)</td>
<td>8.5 parts</td>
</tr>
<tr>
<td>Glycerin</td>
<td>4.5 parts</td>
</tr>
<tr>
<td>Water</td>
<td>59.5 parts</td>
</tr>
<tr>
<td>Perfume and preservative</td>
<td>q.s.</td>
</tr>
</tbody>
</table>

**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 made by Glyco Products Company, one of the earlier promoters of this type of compound in cosmetics.

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 one hundred forty 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.

It is estimated that approximately two million pounds of lanolin are used in cosmetics annually. Most of this amount, but not all of it, is of cosmetic quality, i.e., 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 formulae. This industry has not felt the recurring shortages of lanolin experienced by industry using the lower grades. During periods when the raw material has been
scarce the refinners 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 (1930-1953) 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 chapter 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 refinners.

---

Charles Antell of Baltimore and Lanolin-Plus of Chicago
Apiculture

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. 38

It has also been found that dipping pine seedlings in lanolin, forty grams per liter of water, at transplanting time greatly increased their survival rate by reducing transpiration until the root systems became established. 39

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. 40 A survey of paint manufacturers, made by the author in 1952, indicated that only one company was using (one drum per month) wool grease as a paint vehicle.

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40 U. S. Patent 2,450,615.

Tape

It is estimated 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, which gives satisfactory results in the field and can be removed by ordinary soap and soda scouring. The formula is as follows:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lanolin</td>
<td>30 lbs.</td>
</tr>
<tr>
<td>Gum rosin</td>
<td>10 lbs.</td>
</tr>
<tr>
<td>Stearic acid</td>
<td>6 1/2 lbs.</td>
</tr>
<tr>
<td>Triethanolamine</td>
<td>2 lbs.</td>
</tr>
<tr>
<td>Water</td>
<td>16 gal.</td>
</tr>
<tr>
<td>Solvent naphtha</td>
<td>1 lb.</td>
</tr>
<tr>
<td>Pigment concentration</td>
<td></td>
</tr>
<tr>
<td>Blue</td>
<td>25 lbs. per 100 gal.</td>
</tr>
<tr>
<td>Red</td>
<td>25 lbs. per 100 gal.</td>
</tr>
<tr>
<td>Black</td>
<td>50 lbs. per 100 gal.</td>
</tr>
<tr>
<td>Green</td>
<td>25 lbs. per 100 gal.</td>
</tr>
</tbody>
</table>

The consumption of lanolin in this use probably does not exceed 5,000 pounds annually.
**Veterinary Salves and Ointments**

Medications used by veterinaries are often the identical products used by physicians 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 quite steady.

Following is a typical veterinary ointment:

**Pickrokain Ointment**

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benzocaine benzoate</td>
<td>1%</td>
</tr>
<tr>
<td>Picric acid</td>
<td>1%</td>
</tr>
<tr>
<td>Lanolin anhydrous</td>
<td>42%</td>
</tr>
<tr>
<td>Petrolatum</td>
<td>50%</td>
</tr>
<tr>
<td>Alcohol</td>
<td>6%</td>
</tr>
</tbody>
</table>

It is estimated 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 whose volume of production 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 one 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:

<table>
<thead>
<tr>
<th>Year</th>
<th>Pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>1944</td>
<td>184,000</td>
</tr>
<tr>
<td>1945</td>
<td>505,000</td>
</tr>
<tr>
<td>1946</td>
<td>598,000</td>
</tr>
<tr>
<td>1947</td>
<td>422,000</td>
</tr>
<tr>
<td>1948</td>
<td>313,000</td>
</tr>
</tbody>
</table>

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 which have special problems in removing grime and soil from workers' 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 five to ten percent of lanolin for its emollient quality. Many of the industrial hand cleaning soaps for general use are now made from the following formula:

\[ L. \text{Schwartz and D.J. Birmingham, "Skin Cleaners for Industry," Safety Engineering, May, 1949, p. 62.} \]
Neutral toilet soap 30 parts
Colloidal clay (bentonite or kieselguhr) 30 parts
Synthetic detergent 10 parts
Lanolin 5 parts
Perfume 1 part

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, non-stratifying mixture in powder form of clean cornmeal, thoroughly saponified soap, and/or active, salt-free synthetic detergent, and lanolin (five 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 crying.

Industrial workers whose jobs bring them into contact with irritating 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:

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>65-70%</td>
</tr>
<tr>
<td>Wax</td>
<td>16-20%</td>
</tr>
<tr>
<td>Glycerine</td>
<td>8-11%</td>
</tr>
</tbody>
</table>

These protective ointments are of five 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 ointments.

Fatty mixtures cover the skin with a harmless material which repel water soluble irritants and screen 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 three parts petrolatum and one part of lanolin. A synthetic wetting agent may be added to facilitate removal.

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

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Parts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lanolin</td>
<td>70</td>
</tr>
<tr>
<td>Castor oil</td>
<td>30</td>
</tr>
<tr>
<td>Wetting agent,</td>
<td></td>
</tr>
<tr>
<td>such as DuPont's</td>
<td>2</td>
</tr>
</tbody>
</table>

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.

A protective cream for hands in prolonged contact with soapy water, since it has a pH of 5.4, uses lanolin as follows.45

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>White wax</td>
<td>10%</td>
</tr>
<tr>
<td>Hydrous lanolin</td>
<td>5%</td>
</tr>
<tr>
<td>Glycerol monostearate</td>
<td>12.5%</td>
</tr>
<tr>
<td>Stearic acid</td>
<td>2%</td>
</tr>
<tr>
<td>Petrolatum</td>
<td>75.5%</td>
</tr>
</tbody>
</table>

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.46

- Polyoxyethylene sorbitan, monostearate: 5% (Tween 61, manufactured by Atlas Powder Co.)
- Lanolin: 25%
- Castor oil: 25%
- Ceresin wax (Melting point 60°C): 5%
- White petrolatum to make 100%

Lanolin is also used in a cream for protection against chlorine bleach.47

Photosensitizing agents derived from coal tars may be screened out by including chemical or physical light screens in preparations like the following:48

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lanolin</td>
<td>58 parts</td>
</tr>
<tr>
<td>Castor oil</td>
<td>30 parts</td>
</tr>
<tr>
<td>Titanium dioxide</td>
<td>5 parts</td>
</tr>
<tr>
<td>Menthol salicylate</td>
<td>5 parts</td>
</tr>
<tr>
<td>Synthetic detergent</td>
<td>2 parts</td>
</tr>
</tbody>
</table>

---

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

<table>
<thead>
<tr>
<th>Ink Removing Cream</th>
<th>Carbon Paper and Ink Stain Remover Cream</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbowax 4000</td>
<td>Lanolin</td>
</tr>
<tr>
<td>Water</td>
<td>Carbowax 4000</td>
</tr>
<tr>
<td>Propylene glycol</td>
<td>Carbowax 1500</td>
</tr>
<tr>
<td>Triethanolamine</td>
<td>Triethanolamine</td>
</tr>
<tr>
<td>Oleic acid</td>
<td>Oleic acid</td>
</tr>
<tr>
<td>Lanolin</td>
<td>Water</td>
</tr>
<tr>
<td>Terpineol</td>
<td>Terpineol</td>
</tr>
<tr>
<td>Mild abrasive</td>
<td>Multi-cel 1000</td>
</tr>
<tr>
<td>(multicel 1000)</td>
<td>Sodium bisulphite</td>
</tr>
<tr>
<td>Sodium bisulphite</td>
<td></td>
</tr>
</tbody>
</table>

Since lanolin is usually a small proportion of industrial hand cleaners and protectants, it is estimated that the present and potential market for lanolin in this use is not over ten to twelve thousand pounds annually. Many of these products are distributed by the manufacturers of the equipment or materials against which protection is needed. For example, the manufacturers of Ditto office duplicating equipment sell a protective cream which 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 and has no significance beyond its advertising value.
CHAPTER VII

FUTURE OF THE WOOL CREASE AND LANOILN INDUSTRY IN THE UNITED STATES

The small size of this 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 it 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 the upward trend in domestic wool grease production. Pollution abatement is rarely 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 which 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, as shown in Table 25. 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, further, because of the geographical concentra-
<table>
<thead>
<tr>
<th>Industry</th>
<th>Number of Establishments</th>
<th>Value Added by Manufacturers ($ thousands)</th>
<th>Number</th>
<th>Units</th>
<th>Gallons</th>
<th>Million Gallons Year 1947</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel (Finished)</td>
<td>419</td>
<td>2,659,250</td>
<td>61,857,241</td>
<td>Tons</td>
<td>65,000</td>
<td>1,020,721</td>
</tr>
<tr>
<td>Oil Refining</td>
<td>437</td>
<td>1,494,474</td>
<td>1,887,890,000</td>
<td>Bbls</td>
<td>770</td>
<td>1,453,675</td>
</tr>
<tr>
<td>Gasoline</td>
<td>-</td>
<td>(1)</td>
<td>791,325,000</td>
<td>Bbls</td>
<td>357</td>
<td>791,325</td>
</tr>
<tr>
<td>Wood Pulp</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sulphate</td>
<td>-</td>
<td>(1)</td>
<td>5,356,710</td>
<td>Tons</td>
<td>64,000</td>
<td>342,329</td>
</tr>
<tr>
<td>Sulphite</td>
<td>-</td>
<td>(1)</td>
<td>2,755,960</td>
<td>Tons</td>
<td>60,000</td>
<td>167,756</td>
</tr>
<tr>
<td>Soda</td>
<td>-</td>
<td>(1)</td>
<td>491,580</td>
<td>Tons</td>
<td>85,000</td>
<td>11,784</td>
</tr>
<tr>
<td>Groundwood</td>
<td>-</td>
<td>(1)</td>
<td>2,019,810</td>
<td>Tons</td>
<td>5,000</td>
<td>10,249</td>
</tr>
<tr>
<td>Paper</td>
<td>-</td>
<td>(1)</td>
<td>10,646,833</td>
<td>Tons</td>
<td>39,000</td>
<td>165,226</td>
</tr>
<tr>
<td>Paper Board</td>
<td>-</td>
<td>(1)</td>
<td>9,186,810</td>
<td>Tons</td>
<td>15,000</td>
<td>137,802</td>
</tr>
<tr>
<td>Coke</td>
<td>167</td>
<td>(1)</td>
<td>79,148,000</td>
<td>Tons</td>
<td>3,600</td>
<td>281,493</td>
</tr>
<tr>
<td>Beer</td>
<td>440</td>
<td>808,946</td>
<td>88,027,000</td>
<td>Bbls</td>
<td>170</td>
<td>11,373</td>
</tr>
<tr>
<td>Whiskey</td>
<td>226</td>
<td>172,357</td>
<td>266,485,000</td>
<td>Gals</td>
<td>80</td>
<td>21,155</td>
</tr>
<tr>
<td>Milk, Cream and Butter (2)</td>
<td>-</td>
<td>(1)</td>
<td>7,444,000,000</td>
<td>Lbs</td>
<td>.31-.25</td>
<td>11,286</td>
</tr>
<tr>
<td>Canning and Preserving (3)</td>
<td>2,255</td>
<td>609,939</td>
<td>39,154,000,000</td>
<td>Cases</td>
<td>7.5-25</td>
<td>8,5204</td>
</tr>
<tr>
<td>Manufactured Ice (4)</td>
<td>3,423</td>
<td>226,584</td>
<td>36,100,000</td>
<td>Tons</td>
<td>243,85</td>
<td>8,302</td>
</tr>
<tr>
<td>Soft Drinks</td>
<td>5,618</td>
<td>121,000</td>
<td>927,700,000</td>
<td>Cases</td>
<td>.35</td>
<td>6,250</td>
</tr>
<tr>
<td>Woolens and Worsted Fabrics</td>
<td>435</td>
<td>599,534</td>
<td>451,563,000</td>
<td>Lbs</td>
<td>70</td>
<td>3,252</td>
</tr>
<tr>
<td>Wool Scouring</td>
<td>74</td>
<td>54,166</td>
<td>210,172,000</td>
<td>Lbs</td>
<td>1,26</td>
<td>2,648</td>
</tr>
<tr>
<td>Tanning</td>
<td>561</td>
<td>403,783</td>
<td>238,731,000</td>
<td>Lbs</td>
<td>8</td>
<td>1,910</td>
</tr>
<tr>
<td>Soap</td>
<td>249</td>
<td>450,721</td>
<td>413,001,000</td>
<td>Lbs</td>
<td>.25</td>
<td>1,034</td>
</tr>
<tr>
<td>Meat Packing (hogs)</td>
<td>2,153</td>
<td>(1)</td>
<td>51,678,017</td>
<td>Hogs</td>
<td>11</td>
<td>568</td>
</tr>
<tr>
<td>Cane Sugar (5)</td>
<td>75</td>
<td>98,112</td>
<td>358,000</td>
<td>Tons</td>
<td>1,000</td>
<td>358</td>
</tr>
<tr>
<td>Rayon (All Types)</td>
<td>38</td>
<td>447,900</td>
<td>746,900,000</td>
<td>Lbs</td>
<td>.16</td>
<td>119</td>
</tr>
</tbody>
</table>
Footnotes for Table 25

(1) Value added by manufacture is not given on the same basis as production on which water consumption is based.

(2) Based on U.S. Department of Agriculture's figures for creamery butter, liquid milk and cream sold in communities. No other milk products subject to water consumption estimates.

(3) Estimate of 8,520 million gallons includes water used in processing only fruits and vegetables for which consumption factors are available. This accounts for 177,321,000 cases. Total water used by this group is probably two or three times as high.

(4) Includes filling cans and pulling cores.

(5) Includes refining only.

Sources: Data from 1947 Census of Manufacturers
tion 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 forty-six percent of the pollution load produced by all of the industries combined and discharge eighty percent of it to streams in an untreated condition.¹

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 which permits the exercise of police power through the courts to abate local nuisances. Vigorous enforcement of these laws would, in eliminating stream pollution, eliminate the firms which 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 which requires uniform waste treatment by all mills on a given waterway, this is 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.2

Since 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 streams are classified as follows:

2 Interview with Mr. W. H. Taylor, Massachusetts Department of Public Health, July 15, 1953, Boston, Massachusetts.
New England Interstate Water Pollution Control Commission
Tentative Plan for Classification of Waters
(As Revised and Accepted December 8, 1950)

<table>
<thead>
<tr>
<th>Class</th>
<th>Stability for Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Suitable for any water use. Character uniformly excellent.</td>
</tr>
<tr>
<td>B</td>
<td>Suitable for bathing and recreation, irrigation and agricultural uses; good fish habitat; good aesthetic value. Acceptable for public water supply with filtration and disinfection.</td>
</tr>
<tr>
<td>C</td>
<td>Suitable for recreational boating, irrigation of crops not used for consumption without cooking; habitat for wildlife and common food and game fishes indigenous to the region.</td>
</tr>
<tr>
<td>D</td>
<td>Suitable for transportation of sewage and industrial wastes without nuisance, and for power, navigation and other industrial uses.</td>
</tr>
</tbody>
</table>

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, for example, from the mill owner's viewpoint 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. 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 might be debated. 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 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 effect of the Federal Water Pollution Control Act, Public Law 845, on wool grease recovery has been, and in its present form will continue to be, negligible. 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 cooperate with it, and none has filed a complaint since the enactment of the law in 1948. The Federal Law contains inadequate enforcement provisions, and funds allocated to the agency are all encumbered for other uses. Moreover, present administrators are not interested in enforcing the provisions of the Federal law as much as they are in working through the state authorities on a long range program of technical assistance and education.

The degree of enforcement of stream pollution laws upon an industry cannot be accurately assessed from the pronouncements or written statements of public officials but can best be discovered by interviewing a representative sample of firms. From this procedure it has been 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

Approximately eighty percent of the domestic production of wool grease is recovered by centrifuges and is suitable for refining into lanolin. With present commercially available equipment this is an economic solution to the production of wool grease for the wool scourer at the present prices.

However, the market shortage of wool grease is in the lower grades with higher fatty acid content, not suitable for refining into lanolin. Even during the period of shortage of the past two years, the cosmetic and pharmaceutical manufacturers did not experience a shortage of lanolin, although the price increased. By using their refining facilities to the utmost, i.e., by refining to the higher grades all of the suitable wool grease they could buy, the refiners derived the maximum return from their operations. Thus many industrial users of degras, crude and neutral wool grease were forced to use other available fats and oils that were cheaper. At present, the greatest potential market demand is for the lower grades of wool grease. These
must be marketed at lower prices than centrifugal grades.

Research should therefore be directed toward increasing the amount of wool grease recovered from the effluent from the present (emulsion) method of scouring or toward devising a new method of scouring (e.g., solvent degreasing) which will recover a greater proportion of the grease content of apparel wool. These are technical problems. Both are admittedly difficult. It is unusual in the recovery of by-products of this type for increased amounts to be produced at a lower unit cost. In the second case a literature and patent survey as well as the experience of the staff at the Lowell Technological Institute indicate that no economical method of solvent scouring has yet been devised since Arlington Mills closed in 1950. Fundamentally, the wool grease industry is still suffering the readjustment occasioned by the loss of that huge source of supply.

Current Research Projects and Organizations

The U.S. Department of Agriculture (Mr. J.T. Scanlan) and the two largest refiners are the only ones now actively engaged in chemical research on wool grease in the United States. Following is a list of research activity in this field elsewhere in the world.

Saponification of wool wax. - Dr. E. V. Truter, Department of Textile Industries, The University, Leeds 2, England.


Investigation of the acidic fraction of the wool grease ester.

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3
Wool wax alcohols. - Research Department, Croda, Ltd., Croda House, Snaith, Nr. Goole, Yorkshire, England.


Wool scouring and grease recovery. - Mr. J. Lindberg, Director of Research, Swedish Institute for Applied Textile Research, Gothenburg, Sweden.


Wool grease recovery, saponification of wool wax. - Division of Industrial Chemistry, Commonwealth Scientific and Industrial Research Organization, Melbourne, Victoria, Australia.

Saponification of wool grease. - D. A. Sutton, Senior Research Officer, National Chemical Research Laboratory, Visagie Street, Government Buildings, P. O. Box 395, Pretoria, Union of South Africa.

Sources of Data on Wool Grease

The United States Government is the only agency which collects and issues statistical data on wool grease. The data are for production, stocks held by wool scourers, the wholesale price of common degras, and imports. The following are sources of United States Government data on wool grease:

A. Department of Agriculture
   Bureau of Agricultural Economics

   The Fats and Oils Situation, published each alternate month, contains the following data on wool grease:

   1. Wholesale prices (it is listed as Degras, common) in barrels in New York for recent months. Prices are the average of weekly prices quoted by the Oil, Paint and Drug Reporter.
2. Production. - Data is obtained from Census reports and is compiled for current and recent years.

3. Stocks. - Data on stocks held by wool scourers on December 31 for current and recent years.

4. Imports. - Data is for current and recent years.

5. Exports. - Data is available for years 1949, 1950, and 1951 only. See Tables 16 and 17.

B. Department of Commerce

Bureau of the Census, Industry Division

Facts for Industry: Animal and Vegetable Fats and Oils contains the following data on wool grease:

1. Factory production and stocks. Monthly data for current year and annual data for recent years. Stocks are the amounts held by wool scourers at the end of the month or year. This information is collected on the Bureau of the Census Form M17A.

2. U.S. imports for consumption. Monthly data for current year and annual data for recent years.

U.S. Imports for Consumption of Merchandise, Report No. FT-110 lists the amount and value of each grade of the three classifications for wool grease by country of origin.

U.S. Exports of Domestic and Foreign Merchandise, Report No. FT-110. Beginning in 1952 wool grease is included in the classification "Inedible Animal Grease and Fats, n.e.c.," commodity number 085898. Prior to 1949 wool grease was included under "Hog Grease and Wool Grease," commodity number 085805.

From January 1, 1949, to January 1, 1952, wool grease had a commodity number (085810) in the Statistical Classification of Domestic and Foreign Commodities Exported from the United States (Schedule B), so that the amount exported annually could be compiled. Since January 1, 1952, it has been grouped with inedible animal fats and greases, and therefore the amount of wool grease exported cannot be determined.
Appendix F contains an account of the methods and policies of the Bureau of the Census in the collection and use of data on wool grease.
CHAPTER VIII

CONCLUSIONS

Many of the problems presented in this study are typical of those found in industries based on a by-product. Although the wool grease industry is relatively small, it has a social significance due to the importance of wool grease as a stream pollutant; a military significance because the Armed Forces have been unable to find satisfactory substitutes for wool grease in some important uses; and an economic significance because it is widely used in many industries and is indispensable to a few. Chemically, many of its fractional parts and their properties are still unknown, and it has many interesting potential uses which could be developed if an adequate supply could be assured.

This is the first comprehensive survey of the wool grease industry. The study being the first of its kind, and because of the technical nature of wool grease production, refining, and industrial uses, it was unusually difficult to assemble, analyze, and present economic data which would be useful to those engaged in the industry and still be intelligible to the layman.

The marketing channels and functions as well as the structure and characteristics of the wool grease industry have been described and analyzed in some detail. (Wool grease presents some special problems and is of particular interest because it is a by-product.) Its production by the wool scouring industry and its competitive
situation relative to other fats and oils made it necessary to discuss
the economic and technical aspects of its production and consumption.
Because the market demand for wool grease is dependent to a substan-
tial degree upon the price and supply situation of other fats and oils,
it has been necessary to examine their physical and chemical properties
compared to wool grease and the extent to which they could replace it
in each industry.

Several other objectives were attained by this study. The average
per unit cost of scouring grease wool and recovering wool grease were
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 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?"

The major and minor conclusions derived from this study and
their implications for the wool grease industry are presented as
follows.

Major Conclusion

The wool grease industry has experienced alternate periods of
oversupply and shortage because the production of wool grease fluc-
tuates with the mill consumption of apparel wool while the demand for
it remains relatively steady. This uncertainty of supply has resulted
in a search by industrial users for other materials which in specific
uses can be substituted for wool grease (and lanolin). This has led periodically to a progressive diminution of the demand for wool grease and severe fluctuations in its price. The fluctuations in price in turn discourage investment in grease recovery equipment by mills for which the recovery of wool grease would be economically profitable in the long run.

The most significant conclusion derived from this study is that this cycle of events must be broken and some measures taken to stabilize the supply and price if the industry is to improve its marginal status, make profits, and attract the capital necessary for expansion. These measures would at the same time establish stream pollution abatement on a sound economic basis in those states where the wool scouring mills are concentrated.

The wool grease producers can alter the sequence of events described above, first, by investing in additional grease recovery equipment; second, by adopting price policies which maximize long run profits instead of emphasizing short run profits; and third, by cooperating with the refiners in a research program to find improved recovery methods and new uses for their product and its derivatives.

It is not claimed that an increased supply of wool grease will solve all of the industry's problems or particularly that fluctuations in supply (and consequent fluctuations in price) can be eliminated by the producers. The point here is that the same fluctuations around a higher mean annual production figure, e.g., twenty million pounds, would substantially benefit all segments of the industry. Reductions below a low level of wool grease production in the United States can
cause severe financial loss to industrial users, who experience not only a price increase but an actual physical shortage. With a high level of wool grease production assured, the technology of wool grease usage is such\(^1\) that adjustments in consumption can be made that are in accord with normal production practice.

When average annual production is high, the margin for adjustment by users is much greater than it is when wool grease production is at a low level. In the former situation all users by making adjustments in the amounts used can meet absolute needs. In the latter situation, however, a decrease in supply is more likely to deprive some users of an absolute minimum amount of wool grease.

There is also reason to believe that price fluctuations would be less at the higher production figure since industrial users would be less likely to experience non-deferrable demands. Enough wool grease would be available to meet the needs of marginal users with only minor changes in the market price.

The refiners have been concerned heretofore almost exclusively with their manufacturing processes and marketing functions. Individually, since each is a small part of the total wool grease industry and each is smaller than any of the producers, they have been ineffectual in promoting any changes in the industry. The refiners, like all middlemen, can reduce or amplify supply and price fluctuations. They

\(^1\) A large part of the wool grease consumed in the United States is used with other fats and oils, e.g., in leather tanning, fur dressing, lubricating oils and greases, cosmetics and pharmaceuticals. The proportion of wool grease used can be and is easily varied without materially affecting the process or end product.
can, for example, accentuate price changes by refusing to buy their normal requirements at regular intervals. They can refuse to cooperate in the stabilization program outlined above. Their long-run interests, however, are in harmony with those of the wool grease producers, and most of them see this clearly.

**Minor Conclusions**

Certain other significant conclusions have been derived from the analysis of the wool grease industry. These are summarized in the following statements:

1. The domestic production of wool grease is variable because it is a by-product. The amount produced depends upon the mill consumption of apparel wool rather than upon the demand for wool grease.

2. The gap between domestic production of wool grease and the demand for it is bridged by imports as long as foreign grease is available. Thereafter, increases in the price of wool grease make it economically advantageous to substitute other fats and oils.

3. The consumption of apparel grease wool is a function of the demand for clothing. This in turn is dependent chiefly upon the level of general prosperity in this country, as reflected by the national income and level of employment. In the long run, consumption of apparel wool tends to be high when disposable income is high, and vice versa.
The amount of wool grease recovered annually in the United
States is a small proportion of the amount which theoretically could be recovered. This is partly due to technology, but mostly to economics; e.g., it does not pay to recover grease in small mills. Increasing amounts of wool grease could be recovered at a small additional cost, but mills are reluctant to undertake the greater investment because of the uncertainty of the market for wool as well as the fluctuating price for wool grease.

The forecast of domestic wool grease production for the years 1955 and 1960 is approximately eleven million and twelve million pounds, respectively. This is based on a per capita consumption of apparel wool between the 1935-1939 and 1949-1952 averages and the official population forecast. This means that there is no chance of increasing the supply of wool grease except through a change in scouring methods and/or a significant improvement in recovery techniques.

The great variation in the character and amount of impurities in grease wool and the relatively large amounts of cheap materials used in the emulsion process make wool scouring more an art than an exact science, and its efficiency is not likely to be increased. Because this is the most economical method of scouring wool and because it can be easily adapted to the great variety of wools scoured, an increased supply of wool grease is more likely to come
from improved wool grease recovery techniques until a revolutionary change is made by United States mills in the scouring process.

7. Wool scouring costs are difficult to assess for the industry as a whole because of the unique conditions under which wool is scoured in each mill, but they are of interest to this study in order to know the proportion of the cost which can be defrayed from the sale of the by-product, wool grease. Scouring cost for a commission scourer of average size in the United States is $2.39 per one hundred pounds of grease wool. For integrated mills scouring costs per one hundred pounds of grease wool range from $2.56 for mills scouring annually one million pounds to $1.31 for mills scouring twenty million pounds. Differences in scouring costs are to be explained by differences in equipment, materials, method of operation, location, degree of integration, and size.

8. Emulsion scouring is the most economical method at present. Many other methods of scouring are known and have been tried. Solvent scouring offers the greatest promise for ultimately lowering net costs, decreasing noilage, abating stream pollution, and yielding a greater net return from by-product recovery.

9. Wool grease recovery is currently profitable in the United States by both centrifugal and acid cracking methods. However, the latter can be economically operated only when there
is a large and continuous supply of scouring effluent.

10. Lanolin manufacturing has been established in the United States since 1915. It is a highly competitive industry, and distribution is carried on economically and efficiently.

11. Wool grease refiners perform all of the marketing functions in distributing over ninety percent of the wool grease and all of the lanolin in the United States.

12. As usual for industrial goods, the marketing channel for wool grease is short. Direct sale of wool grease from producer to industrial user is possible in a few industries but for technical and historical reasons is not common enough to be economically significant.

13. The market price for wool grease is chiefly affected by the available supply and the price and supply situation of other fats and oils which are substitutes for it in specific uses. In the long run its price is determined by the general level of industrial activity and to a minor degree by defense production. This is confirmed by practical experience, although it cannot be corroborated by statistical techniques. There is no other by-product which is used in as many industries and for which the demand (and price) is affected indirectly by so many factors.

14. Although there were some inequities in the ceiling price regulations of 1952 which favored the producers of higher quality grease, they created no significant production or marketing disturbances.
15. Wool grease and lanolin are useful in a great variety of industrial products and processes. Their elasticities of demand vary in each use, and there are few industries in which they are considered indispensable.

16. A forecast of the average price at which domestic scourers can sell their wool grease output is possible only with an intimate knowledge of:

A. The supply of wool grease available for the year.
B. The price and supply situation of other oils and fats which are good or close substitutes for wool grease in specific uses.
C. The general level of industrial activity for the year, including defense production.

17. Stream pollution laws, both state and Federal, will have little effect on the amount of wool grease recovered by scourers in the immediate future. The laws of those states in which there is the largest amount of apparel wool scoured are not enforced vigorously enough to induce wool scourers to install additional or more effective grease recovery equipment. Federal laws apply only to interstate water pollution disputes, and the United States Public Health Service does not have the funds or facilities for vigorous enforcement.

18. Research in this industry should be directed primarily toward solving the technical problem of increasing the amount of wool grease recovered from the scouring operation.
These conclusions have several implications for the wool scourers and grease refiners, some of which are already being considered by the industry.

Implications of the Industry

An economist's view of the future of this industry is less optimistic than that of the chemist. The latter knows of many uses for the alcohol portion of the wool grease ester and sees many possibilities for the acidic fractions. The economist sees that the supply and price characteristics of wool grease over a number of years have restricted its use in many industrial compounds and processes. Even when its price has been competitive with other animal and vegetable fats and oils, the uncertainty of its supply has persuaded many first to seek less satisfactory but more plentiful substitutes.

There is no panacea for all of the technical and administrative difficulties in the production and distribution of wool grease. However, an analysis of this industry indicates that there are several ways in which the wool scourers and refiners can in the long run increase the supply of wool grease and decrease its cost.

Wool Scourers

While there is no immediate prospect that all apparel wool scourers will be required to treat their waste effluent before discharge it is inevitable that the increasing pressures of population and public opinion will eventually make some form of treatment necessary. Riparian owners downstream have already forced several mills in
Massachusetts to recover their grease to avoid the formation of unsightly sludge banks.

The following points are the results of an analysis based on the assumptions that for mills scouring at least three million pounds of apparel wool annually wool grease recovery by centrifuge is economically sound and that for others waste water treatment is as justifiable an expense as payment for treatment of intake water.

A. Increase in supply. Since an increased supply of wool grease is a partial solution to the problem of a more stable price structure and an increased demand, all apparel wool scourers not recovering grease should reexamine the technical and economic possibilities of grease recovery for their mills.

B. Scouring research. The wool scourers collectively should subsidize research to develop a practical method of solvent scouring. The consensus of opinion in the industry is that aqueous scouring, having reached the peak of its efficiency, still offers serious disadvantages not inherent in the solvent method. The ideal method should combine efficient, low cost scouring with stream pollution abatement and maximum grease recovery.

C. Cooperative enterprises. Until an improved method of solvent scouring is developed, the following suggestions could decrease the net cost of scouring, contribute to the present cost of waste treatment, and increase the net return from the sale of wool grease. One of the possible ways for the smaller wool scouring establishments to decrease their costs
for both scouring and waste treatment is through cooperative action. Where technically and geographically feasible, cooperation by these mills might include one or more of the following operations.

1. Cooperative scouring. Since cost studies in this industry indicate that the lowest costs are achieved by large scale, three-shift operation, cooperative enterprises might be set up near the ports of Boston, New York, and Philadelphia. Because of the technical difficulties of their acting as a commission scourer to many small mills, the success of these enterprises would depend upon their managements' 'know how' as much as upon their ability to lower costs. Only in this way could small mills achieve the cost advantages in their operation which are at present available only to the large firm. Cooperative scouring would also make possible the economic recovery of wool greases and treatment of the waste effluent.

2. Polling of scouring liquors. Because of the putrescibility of scouring liquors and their great volume relative to their wool grease content, they cannot be economically transported except over short distances by pipeline. Where a number of small scouring establishments are located within a five mile radius on one waterway or its branches, an economical grease recovery and/or waste treatment operation might
be possible. 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.

3. Cooperative refining and marketing of wool grease.

This would be an alternative to any combination of the refiners resulting in lower prices to the scourers. It is doubtful that a cooperative refining and marketing enterprise could realize net returns for the scourers greater in the long run than those which they now receive from individual refiners. Competition keeps their margins reasonably low. An aggressive selling organization would be required, and the expense of setting up an adequate technical and administrative staff and equipment would require an investment that present management in the wool textile industry would be reluctant to make.

D. Government subsidies. It has been suggested that subsidies to marginal producers are another possibility for increasing the production of wool grease. This might be applicable during wartime if the federal government considered wool grease a strategic material important for its use in leather, cordage, rust preventives, and lubricants. Granting accelerated depreciation on recovery equipment installed during wartime might also increase production.
Refiners

It has been suggested that a trade association might be formed by the nine wool grease refiners to help the industry by assuming the following functions:

1. Promoting the use of wool grease, lanolin, and derivatives.
2. Acting as spokesman for the industry.
3. Promoting research on uses.
4. Setting up trade standards.
5. Collecting data from all sources and making it available in one place.
6. Exchanging general information among members.

If a trade association cannot be formed, it has been suggested by one of the refiners that a research project on the technical aspects of wool grease uses be financed collectively by the refiners on the basis of the tonnage handled. The project could be placed with a textile school or a commercial laboratory with the proper facilities and personnel. Owing to the potential supply and demand for wool grease, lanolin and derivatives, there is an adequate incentive for even the larger refiners, who maintain their own laboratories, to join in this project. For the smaller refiners it would be an economical way of keeping abreast of new technical developments in the industry.

If through such action as that outlined above the wool grease industry is stabilized and expanded many of the potential uses for wool grease envisioned by the chemist can be realized. In addition the problem of stream pollution will be progressively reduced, and
both the Armed Forces and those industries in which it is essential can be assured of a supply of wool grease.
APPENDICES
LOWELL TEXTILE INSTITUTE RESEARCH FOUNDATION
Lowell, Massachusetts

WOOL SCOURING QUESTIONNAIRE

1. Please check your appropriate classification
   - Commission scourer
   - Wholly owned subsidiary
   - Partially controlled subsidiary
   - Fully integrated mill
   - Other (explain) ..........................................................

2. Indicate the method of scouring employed in your plant
   - Emulsion
   - Organic solvent
   - Other (explain) ..........................................................

3. Indicate which chemical or chemicals are used in your scouring process
   - Soda ash
   - Soap
   - Synthetic detergent
   - Trichloroethylene
   - Other (explain) ..........................................................

4. If applicable
   A. (1) How many scouring trains do you have in your plant? ..............................................
      (2) How many are in active use? ........................................................................
      (3) Does each train have the same number of scouring bowls? Yes. No. ..............................................
      (4) If yes, how many? ........................................................................
      (5) If no, please show breakdown per train ..................................................

   B. Do you use equipment other than a scouring train in your scouring operations? 
      Yes □ No □
      If Yes, describe. (e.g., batch emulsion) ..................................................

5. (a) How many pounds of grease wool did you scour in 1951? ..........................................
   (b) What would be the maximum yearly capacity of your plant? Please break figures down by grades as closely as possible.

<table>
<thead>
<tr>
<th>Grade</th>
<th>(a) 1951</th>
<th>(b) Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine (64's - 80's)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium (48's - 58's)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coarse (Less than 48's)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6. In the past four or five years has the percentage of grease recovered from your scouring operations been constant in terms of the volume of grease wool scoured?
   Yes □ No □
   If no, explain. ..................................................
Wool Scouring Questionnaire

7. Did you recover any wool grease products from scouring operations during 1950 or 1951?  Yes[ ]  No[ ]

(a) How much of the following wool grease products did you recover during 1950 and 1951?

<table>
<thead>
<tr>
<th>Product Recovered</th>
<th>Amount in Pounds</th>
<th>Product Recovered</th>
<th>Amount in Pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1951</td>
<td></td>
<td>1950</td>
</tr>
<tr>
<td>Common grease</td>
<td>. . .</td>
<td>Wool grease alcohols</td>
<td>. . .</td>
</tr>
<tr>
<td>Neutral grease</td>
<td>. . .</td>
<td>Cholesterol</td>
<td>. . .</td>
</tr>
<tr>
<td>(technical lanolin)</td>
<td>. . .</td>
<td>Other (explain)</td>
<td>. . .</td>
</tr>
<tr>
<td>Fertilizer</td>
<td>. . .</td>
<td></td>
<td>. . .</td>
</tr>
<tr>
<td>Lanolin</td>
<td>. . .</td>
<td></td>
<td>. . .</td>
</tr>
<tr>
<td></td>
<td>. . .</td>
<td></td>
<td>. . .</td>
</tr>
<tr>
<td></td>
<td>. . .</td>
<td></td>
<td>. . .</td>
</tr>
<tr>
<td></td>
<td>. . .</td>
<td></td>
<td>. . .</td>
</tr>
<tr>
<td></td>
<td>. . .</td>
<td></td>
<td>. . .</td>
</tr>
<tr>
<td></td>
<td>. . .</td>
<td></td>
<td>. . .</td>
</tr>
<tr>
<td></td>
<td>. . .</td>
<td></td>
<td>. . .</td>
</tr>
</tbody>
</table>

(b) Indicate the grease recovery system employed in your plant.

- □ A. Centrifugal
  - □ 1. Sharples
  - □ 2. DeLaval
  - □ 3. Duhamel
  - □ 4. Other centrifugal system
    (explain).

- □ B. Acid cracking process

- □ C. Hypochlorite process

- □ D. Solvent evaporation

- □ E. Other (explain)

8. If you do not recover any by-products, please check pertinent reason(s) below.

- □ A. Majority of wool scoured of low grease content.
- □ B. Recovery systems too costly to employ.
- □ C. Amount of wool scoured too small to warrant investment.
- □ E. Market for wool grease too unstable.
- □ F. Other (explain).

9. If not currently recovering grease:

(a) Have you ever recovered it in the past?  Yes[ ]  No[ ]

If yes, indicate by letter relating to statement in Question 8 which of the reasons caused you to stop. If other reason(s), please explain.

(b) Do you plan to recover grease in the near future?  Yes[ ]  No[ ]

(1) If yes, reason for shift.

(2) Method of recovery to be employed.

(3) Expected volume of wool grease to be recovered (in pounds).

Please Print

Name of concern..........................................................
Address.................................................................

Party to be contacted for further information........................................

Person answering this questionnaire........................................

APPENDIX A - QUESTIONNAIRE
Appendix A

LOWELL TEXTILE INSTITUTE RESEARCH FOUNDATION

WOOL GREASE RECOVERY COST FORM
(Based on lbs. of clean wool scoured)

Period __________________________ (last fiscal year)

I Direct labor on grease recovery only

<table>
<thead>
<tr>
<th>Man-days</th>
<th>Item</th>
<th>Ave. Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Machine Operator</td>
<td>$________</td>
</tr>
<tr>
<td></td>
<td>Supervisor</td>
<td>$________</td>
</tr>
<tr>
<td></td>
<td>General handy man</td>
<td>$________</td>
</tr>
<tr>
<td></td>
<td>Total man-days in department</td>
<td></td>
</tr>
</tbody>
</table>

Total $_______

II Materials used for grease recovery

Total $_______

III Supplies directly charged to grease recovery

Such as: Drums, Materials for repairs, Testing materials, Lubricating oils and greases, Cleaning utensils

Total $_______

IV Royalty paid

Total $_______

V Sum of I, II, III, and IV

$_______

Formula for computing overhead to be charged to grease recovery:

Total number of man-days in grease recovery department - %

Total number of man-days in plant

VI Total overhead charged to department

$_______

VII Book value of equipment

Make ____________________

Year installed ____________________

VIII Total pounds of grease recovered

_____________________

IX Selling price per pound

_____________________


Appendix A

LOWELL TEXTILE INSTITUTE RESEARCH FOUNDATION

WOOL SCOURING COST FORM

Period (last fiscal year)

Grease
Clean Lbs. of wool scoured (last fiscal year) ____________

I Estimated average total cost per lb. of scouring (1947 - 1952)

II Direct Labor

<table>
<thead>
<tr>
<th>Man-days</th>
<th>Item</th>
<th>Ave. Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>From storage to machine</td>
<td>$ _______</td>
</tr>
<tr>
<td></td>
<td>Feeder of machine</td>
<td>_________</td>
</tr>
<tr>
<td></td>
<td>Train operator</td>
<td>_________</td>
</tr>
<tr>
<td></td>
<td>Dryer operator</td>
<td>_________</td>
</tr>
<tr>
<td></td>
<td>Bagger (Comm. only)</td>
<td>_________</td>
</tr>
<tr>
<td></td>
<td>Supervisor</td>
<td>_________</td>
</tr>
<tr>
<td></td>
<td>General handy man</td>
<td>_________</td>
</tr>
<tr>
<td></td>
<td>Total man-days in department</td>
<td>_____</td>
</tr>
</tbody>
</table>

III Materials

Soap - Quantity used _______ lbs.; Cost $_______
Soda Ash "  " _______ lbs.; Cost $_______
Cost of other materials $_____ 

IV Supplies directly charged to scouring

Such as: Materials for repairs, Chemicals for testing, Belting, Lubricating oils and greases, and Cleaning utensils.

Total $_____

V Sum of Items II, III, and IV. Total $_____

Formula for computing overhead to be charged to scouring.

\[
\text{Total number of man-days in scouring dept.} = \% \\
\text{Total number of man-days in plant} \\
\]

VI Total overhead charged to department $_____

VII Book value of Equipment

Make ____________________
Year installed ____________________
Appendix B

TABLE 26

Variations in Grease Content of Wool due to Age Differences in Sheep

<table>
<thead>
<tr>
<th>Age of Ewes (years)</th>
<th>Average Weight of Greasy Fleece (pounds)</th>
<th>Average Weight of Grease (pounds)</th>
<th>Grease in Greasy Fleece (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9.12</td>
<td>1.18</td>
<td>12.9</td>
</tr>
<tr>
<td>2</td>
<td>10.13</td>
<td>1.10</td>
<td>13.5</td>
</tr>
<tr>
<td>3</td>
<td>11.59</td>
<td>1.73</td>
<td>14.9</td>
</tr>
<tr>
<td>4</td>
<td>11.11</td>
<td>1.60</td>
<td>14.4</td>
</tr>
<tr>
<td>5</td>
<td>11.20</td>
<td>1.71</td>
<td>15.3</td>
</tr>
<tr>
<td>6</td>
<td>11.12</td>
<td>1.75</td>
<td>15.7</td>
</tr>
<tr>
<td>7</td>
<td>10.22</td>
<td>1.50</td>
<td>14.7</td>
</tr>
</tbody>
</table>


TABLE 27

Average Distribution of Grease in the Fleeces of Wurtemburg Sheep

<table>
<thead>
<tr>
<th>Region</th>
<th>Grease Content Per cent of Grease Wool Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoulder</td>
<td>8.24</td>
</tr>
<tr>
<td>Neck</td>
<td>8.83</td>
</tr>
<tr>
<td>Legs</td>
<td>10.20</td>
</tr>
<tr>
<td>Sides</td>
<td>10.52</td>
</tr>
<tr>
<td>Belly</td>
<td>12.42</td>
</tr>
<tr>
<td>Back</td>
<td>15.41</td>
</tr>
</tbody>
</table>

Appendix C

FACTORS AFFECTING SCOURING COSTS

1. **Equipment.** Scouring trains vary from 2 to 7 bowls (see Table 8), and in age from one to thirty years. This causes differences in depreciation and maintenance. Depreciation among scourers ranges from 0 to $4,000 on a new six foot wide train. Labor costs vary widely depending on the type of equipment. Labor costs are less for one six foot wide train than for two four 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 6000 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 twenty-three 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 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.

The following statement is typical of the relationships
existing between various types of wool scoured and the amounts of materials used.

We would like to caution you against arbitrarily assuming that the amounts of soda ash and soap needed is a function of the grease content of the wool only. This relationship may be true in general, however, we have seen many exceptions to this. One of the most glaring examples of this exception occurred one time when we were scouring Cape combing wools. Everything was proceeding nicely until there was a switch over to Patagonian wools of the same grade or type. This Patagonian wool came up dirty and it was found necessary to double the additions of soap and soda ash in order to obtain satisfactory cleanliness. As soon as the wool was changed back to Cape again we were able to go back to the regular additions.

It is an established fact that wools from different geographical areas require different amounts of scouring agents, and it depends more upon the particular wool than its grease content.1

It is apparent that materials used in scouring could double in cost in a mill using the same grade of wool.

3. Method of Operation. The method of operation is principally a function of size and varies from a steady three shifts per day, five days per week, through two shifts, three days per week, to one shift per day seasonal operation. Continuous operation means substantial savings in water, steam, and soap and soda ash costs. 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 this is dependant

---

1 Letter dated December 19, 1952, from Mr. B. A. Ryberg, Textile Research Department, the Procter & Gamble Company.
on the 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

\[
\begin{align*}
275.8 \text{ lbs. of wool} & \quad \text{to} \quad 1 \text{ pound of soap} \\
23.6 \text{ lbs. of wool} & \quad \text{to} \quad 1 \text{ pound of soda ash}
\end{align*}
\]

to

\[
\begin{align*}
51.3 \text{ lbs. of wool} & \quad \text{to} \quad 1 \text{ pound of soap} \\
26.0 \text{ lbs. of wool} & \quad \text{to} \quad 1 \text{ pound of soda ash}
\end{align*}
\]

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 chemical consumption 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, multi-story, multi-tenant 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, Massachusetts, areas. Other scourers of various sizes are housed in wooden and cinderblock buildings in
rural areas on streams so small\textsuperscript{2} that they must treat all of their waste waters and hold them in lagoons until high water periods. 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 is a factor in costs. Steam costs for scouring are much less in a yarn manufacturing plant or a fully integrated mill than those of a commission scourer or commission comber because of the use of feed-back water in a heat exchanger. Electricity is also less because of lower rates on increased amounts. Only the commission scourer has the extra costs of bleaching, controlled drying, re-bagging, and storing clean wool. The others produce clean fiber which is fed directly to the cards or is blown into bin storage. Indirect labor costs tend to decrease with the degree of integration, but these vary more directly with the size of the operation.

6. Size. There are economies in scouring due to the scale of operation. Since it is a continuous process, more productive time can be realized on a two or three-shift operation. On a one-shift operation an extra hour of unproductive labor is needed at the

\textsuperscript{2} One scourer is unable to get sufficient water to scour during August if the summer has been a dry one.
beginning to make ready and at the end to clean up.

Direct labor costs for the twenty-three mills in this study vary from $.009 per grease pound for a one-shift operation scouring approximately two million pounds of wool annually to $.001 for a two-shift operation with three trains scouring twenty 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 non-union 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 two 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, of 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 representative sample of firms in this industry who contributed their costs to this study have been used as benchmarks in determining costs for several Model Scourers. Certain assumptions have been made in setting up these Model Scourers 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 multi-story, multi-tenant 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 thirty-eight cents per square foot. Warehouse storage space is figured at thirty-four cents per square foot. This rate is for Lowell, Massachusetts. Rates for similar facilities in Lawrence, Massachusetts, are slightly lower. The annual rentals per square foot for other areas are as follows:

- **Boston, Mass.**: $0.50
- **Paterson - Passaic, N. J.**: $0.31
- **Providence, R. I.**: $0.30
- **Philadelphia, Pa.**: $0.65 - $0.75

**Direct Labor:** Costs are based on the following personnel and base rates:

**TABLE 28**

**Labor Costs of Scouring, Southern New England, 1951**

<table>
<thead>
<tr>
<th>From storage to machine</th>
<th>Hourly Rate</th>
<th>Number of Personnel per Shift</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>$1.51</strong></td>
<td>1 train 2 trains 3 trains</td>
</tr>
<tr>
<td>Feeder of machine</td>
<td><strong>1.47</strong></td>
<td>1</td>
</tr>
<tr>
<td>Train operator</td>
<td><strong>1.53</strong></td>
<td>1</td>
</tr>
<tr>
<td>General Handyman</td>
<td><strong>1.45</strong></td>
<td>1</td>
</tr>
<tr>
<td>Supervisor</td>
<td><strong>2.50</strong></td>
<td>½ ½ ½</td>
</tr>
</tbody>
</table>

Total cost per hour

<table>
<thead>
<tr>
<th></th>
<th>1 train</th>
<th>2 trains</th>
<th>3 trains</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>$5.76</strong></td>
<td><strong>$11.72</strong></td>
<td><strong>$16.23</strong></td>
<td></td>
</tr>
</tbody>
</table>

---

3 Lowell Development Company, 95 Bridge Street, Lowell, Massachusetts.
These are union rates for the southern New England area and include a six cent per hour cost of living bonus. The rates for the northern New Jersey and the Philadelphia areas are approximately the same.

Production per hour is based on 1200 pounds per hour of grease wool. This period allows for starting up, running out, cleaning, and repairs and is estimated to be eight hours per week. The production while running is 1500 pounds per hour. The difference between fine, medium, and the 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 used.

Depreciation: This current expense is based on 1952 replacement cost for a scouring train four feet wide consisting of a wool opener and automatic feed; two 2½ foot bowls and two 16 foot rinse bowls equipped with squeeze rolls and a seven section dryer thirty feet long. The total cost of this equipment installed is $68,537. Another bowl could be added for $13,652. At a rate of five percent the annual depreciation for a four bowl train is $3,426 and for a five 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, clerical, maintenance, payroll taxes, and fringe benefits. Payroll taxes, and fringe benefits are included for all labor, both direct and indirect. Costs for a commission scourer would be higher.
# TABLE 29

**Indirect Labor Costs of Scouring**

<table>
<thead>
<tr>
<th>Cost Items</th>
<th>Pounds of Grease Wool Scoured</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1,000,000</td>
</tr>
<tr>
<td>Management, clerical and maintenance costs</td>
<td>$6,750.00</td>
</tr>
<tr>
<td>Taxes and fringe benefits, 11% of total labor</td>
<td>$1,320.00</td>
</tr>
<tr>
<td></td>
<td>$8,070.00</td>
</tr>
<tr>
<td>Cost per 100 lbs. of grease wool</td>
<td>$0.807</td>
</tr>
</tbody>
</table>

**Materials:** Cost of materials, both soap and soda ash and synthetic detergents, in common use in the industry was examined and reduced to a common denominator, i.e., the cost per 100 pounds of grease wool scoured. The average cost for the nine different detergents and methods is $.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. The following statements from large soap manufacturers are typical of the opinion of men with training and experience in this field.

It is our opinion as a result of actual experience in the field that soap and soda scouring costs will vary from 6¢ per 100 lbs. of grease wool scoured to as high as 24¢.4

Again the following information is typical of the data from other sources as well as from the mills represented in the cost study.

---

4 Letter dated January 8, 1953, from R. W. Boedecker, Technical Service Division, Colgate-Palmolive-PEet Co., Jersey City, N. J. It is quoted in full in Appendix C.
analyzed to obtain average cost for materials used in scouring.

We find through practical mill experience that Armour's Energetic will do an excellent job of scouring down to a residual grease content of 1% at a cost of 10¢ per cwt. In numerous plant runs using either a 4 or 5 bowl train and operating on a full 8 hour shift and scouring 12,000 pounds of raw wool, a total of 50 pounds of Energetic was used. This cost, of course, does not include soda ash. Our Energetic is packed in 55 gal. drums and the average cost is 30¢ per lb. 5

Electricity: Electric power costs are based on the following schedule of the Lowell, Massachusetts, Electric Company.

<table>
<thead>
<tr>
<th>Million of lbs. Scoured Annually</th>
<th>No. of trains</th>
<th>No. of shifts</th>
<th>No. of weeks</th>
<th>Cost per month</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>2</td>
<td>12</td>
<td>118.92</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>2</td>
<td>50</td>
<td>408.20</td>
</tr>
<tr>
<td>10</td>
<td>2</td>
<td>2</td>
<td>50</td>
<td>722.56</td>
</tr>
<tr>
<td>20</td>
<td>2</td>
<td>3</td>
<td>50</td>
<td>1314.48</td>
</tr>
</tbody>
</table>

Based on Rate C, 2500 kwh of use per month.
Based on Rate G, 60 kw of demand and 22,000 kwh of use per month.
Based on Rate G, 120 kw of demand and 44,000 kwh of use per month.
Based on Rate G, 180 kw of demand and 88,000 kwh of use per month.

Steam: Cost is based on the following schedule: 6

| $1.687 per 1000 lbs. for first 50,000 lbs. per month |
| 1.587 per 1000 lbs. for the next 50,000 lbs. per month |
| 1.487 " " " " " " 100,000 " " " |
| 1.387 " " " " " 300,000 " " " |
| 1.387 " " " " " all over 500,000 " " " |


6 Lowell, Massachusetts rate.
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° and 42°.

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

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

Alkalinity - Dissolve 2 grams of Wool Fat in 10 cc. of other 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 0.5 cc. 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.
Tested 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 N 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 per cent and not more than 30 per cent 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 transparent 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 per cent and not more than 30 per cent of its weight, page 733.

Other requirements - Hydrous Wool Fat complies with the tests for Alkalinity, Chloride, Water-soluble acids or 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 nor 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 E

LUBRICATING MATERIALS AND PROCESSES

**Tallow**: About twelve percent of highly refined acidless tallow is used with mineral oil to increase the load carrying ability of the oil film. It may also be used in its stiff, paste form to lubricate thin, moving stock. It can be easily handled and easily removed from the metal. It is used in steam cylinder oils as a substitute for wool grease, but it does not have the ability to emulsify as quickly. As shown in Table 20, its price has varied from eighteen to four cents during the past five years, and it is available in almost unlimited quantities.

**Lard Oil**: Lard oil is used as a carrier for sulphur in extreme pressure lubricants and in metal cutting oils. It will absorb up to 14 percent sulphur. It is also used with mineral oils in tempering steel and steel alloys and in steam cylinder oils to produce an emulsion in the presence of live steam. Its present price is comparable to that of wool grease although it has been much higher (see Table 20). It is available in nearly unlimited amounts.

**Sperm Oil**: This material does not decrease in viscosity with rising temperatures and can be used to lubricate delicate instruments. It blends easily with mineral oil and absorbs and retains up to ten percent sulphur. It is comparable in price to wool grease at present but is usually higher in price.
Castor Oil: This oil absorbs up to eight percent of sulphur readily and can be used with mineral oil in extreme pressure gear and metal cutting oils. Its price is usually twice the price of wool grease; and this fact, as well as its physical qualities, limits its use in industrial lubricants.

Rapeseed Oil: Blowing air through this oil oxidizes and stabilizes it and reduces its drying qualities. It is usually mixed with mineral oil, up to 20 percent by weight, for marine engine use. It is particularly useful for engine and bearing lubrication subject to contact with water, which creates a tacky emulsion difficult to wash out. Its special physical characteristics do not make it an important competitor of wool grease. Moreover, its supply is limited, and it is usually higher in price.

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 sur-
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 one percent but may range up to three 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 of the fact that 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 characteristics.

Cutting oils should not turn rancid or develop offensive odors. When used as an emulsion, they should not gum or rust the machines or 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 which contain 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 important. 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:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>80%</td>
<td>Mineral oil</td>
</tr>
<tr>
<td>5%</td>
<td>Rosin oil</td>
</tr>
<tr>
<td>2%</td>
<td>Potash</td>
</tr>
<tr>
<td>5%</td>
<td>Wool grease</td>
</tr>
<tr>
<td>8%</td>
<td>Blown rapeseed oil</td>
</tr>
</tbody>
</table>

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:

- 80% Mineral oil
- 1% Sulphur
- 1% Chlorine
- 16% Fatty oil

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 copper and brass molding typical mold coatings are the following:

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 non ferrous 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. Cold extrusion lubricants for steel are applied as a final coating over one of phosphate solution. Tallow, rapeseed oil, and wool grease have been used; 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.
Appendix F

The Bureau of the Census collects data on production, stocks, and consumption in end uses of wool grease on its Form M17A from producers, refiners, and consumers in the United States. Beginning in 1949, the Bureau discontinued publication of data on the end uses of wool grease. In an interview in Washington, D.C., April 28, 1953, Mr. C.V. Danielson, Chief of the Fats, Oils, and Rubber Products Sub-Section, stated that publication of end use data for wool grease was discontinued because it was felt that there was duplication in the reporting. Some respondents were reporting their use of lanolin under the heading of wool grease. This was pointed out to the Bureau in 1947 by Mr. Glen F. Brown, statistician for the National Association of Wool Manufacturers.

One of the things we discussed was the reporting unit. Present forms merely ask for reports in pounds. But the moisture content of wool grease at least at certain stages of measurement may vary anywhere from a negligible amount to a quarter or a third of the weight. Reports should be on an anhydrous basis. Most mills may be reporting this way anyway, but the instruction should be made specific.

Another involves the amount of double counting in the consumption figures arising from including the consumption of "Crude" grease by refiners and then recounting the same grease "Refined" reported by the user of the refined product. Double counting could be eliminated by limiting the measurement to consumption of "Crude" grease or by omitting the consumption by refiners in arriving at a total consumption figure. If the latter were considered, I might say that I believe the consumption by refiners is a useful statistic in itself and its collection should be continued.1

1 Extract from letter from Mr. Glen F. Brown, National Association of Wool Manufacturers, to Mr. Maxwell R. Conklin, Bureau of the Census, dated February 18, 1947.
Mr. Danielson also stated on April 28, 1953, that the Bureau needed a layman's definition that would clearly distinguish between wool grease and lanolin for the consumers reporting on Form M17A.

This had been said six years ago by the Bureau of the Census as follows:

A third possibility would be to revise the several report forms to obtain crude and refined wool grease separately. If the two classes are subject to a clear cut definition, the resulting statistics would provide the desired measurement of consumption of crude in refining as well as an end-use pattern for both crude and refined wool grease. The main problem, of course, is one of definition, i.e., is the distinction between crude and refined wool grease clear enough so that the consuming establishments can report accurately.¹

On March 12, 1952, the Bureau stated in reply to an inquiry by

N. I. Malmstrom and Company.

It is not contemplated to restore wool grease consumption data to the release. To obtain and publish reliable, unduplicated figures it would be necessary to add lanolin to the list of commodities on our survey.

As you know, appropriations granted to the Census Bureau for its regular current statistical program were somewhat less this fiscal year than for previous years. These reductions were imposed upon a budget which had been reduced by more than half over a five year period. This progressive curtailment in funds has forced us to discontinue a number of surveys and reduce the scope and periodicity of others. Obviously we are not now in a position to consider the expansion of the reference list of Form M17A, "Animal and Vegetable Fats and Oils, Monthly Report of Producers and Consumers."²

On May 28, 1953, the Lowell Technological Institute Research

¹ Extract from a letter to Mr. Brown, dated April 3, 1947, signed Maxwell R. Conklin, Chief, Industry Division, Bureau of the Census.

² Extract from a letter signed Conklin, dated March 12, 1952.
Foundation suggested that the distinction between wool grease and lanolin was well enough known in industry so that the addition of the world "lanolin" in the form would eliminate duplication in the returns.

The Bureau's reply was as follows:

As you already know, the Bureau of the Census appropriations for its current statistical program beginning July 1, 1953 will be somewhat less than for previous years. These reductions will be imposed upon a budget which has been reduced by half over a six year period. This progressive curtailment in funds has forced us to discontinue a number of surveys and reduce the scope and periodicity of others. Obviously, we will not be in a position to consider the expansion of the reference list of Form ML7A. Your recommendations concerning the addition of lanolin to the Fats and Oils reference list will be given careful consideration when it is possible for us to expand the detail in this survey.

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4 Letter to Mr. C. V. Danielson, Bureau of the Census, signed Robert S. Raymond.

5 Extract from a letter from Mr. Maxwell R. Conklin, dated June 12, 1953.
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I, Robert Scott Raymond, was born in Kansas City, Missouri, October 10, 1912. I received my secondary school education in the public schools of Kansas City. My undergraduate training was obtained at the University of Kansas, from which I received the degree Bachelor of Science in Business in 1934. After experience in business and service in the Armed Forces, I attended the London School of Economics and Political Science during the year 1947-1948, taught at New Mexico College of Agriculture and Mechanic Arts 1948-1950, and during a series of summer sessions at the University of Kansas completed the requirements for the degree Master of Business Administration, which I received in 1951.

I entered The Ohio State University in 1950 and was admitted to candidacy for the degree Doctor of Philosophy in Business Organization in 1951. After a year of teaching at Washington State College and a year of research for the Lowell Textile Institute Research Foundation, I joined the faculty of Pennsylvania State College in September, 1953.