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The Market Potential for Fats and Oils in Drying-Oil Uses

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PREFACE

This study of potential uses of fats and oils in drying-oil products had its inception early in 1953. It is well known that drying oils in recent years have encountered increased competition from synthetics. This raises a question as to the nature and strength of the competition from synthetic materials and of how drying oils can best meet it.

The present study is aimed at finding out the following: (1) The factors affecting the use of various fats and oils in the drying-oil industry; (2) the difficulties that drying-oil users are encountering and the modifications desired to make the oils more useful in these industries; (3) the reasons why synthetic materials, nonoil paints, and tall oil, a byproduct of the alkaline paper pulp industry, have captured an increased share of the protective-coatings market; (4) the price and supply conditions under which one drying oil might be substituted for another; and (5) the present and probable future supply and price situation for materials used in the production of the synthetics. This information helps provide a basis for efforts to maintain or improve the competitive position of drying oils.

The primary aim of this study was to gather information and ideas that would ultimately benefit the farmer-producer of the crops from which drying oils are obtained. However, it necessarily follows that any knowledge of how to process and use drying oils more effectively would also be of benefit to the industries that supply these oils or consume them in their manufacturing processes. While this study suggests areas in which further research appears desirable as a means of strengthening the competitive position of drying oils, it does not spell out the particular chemical or physical research techniques that should be employed.

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SUMMARY

In spite of intensive research and effective promotion of synthetic materials, drying oils are still the staple raw materials for film-forming industrial products. Although drying oils have and are likely to retain an important position, they are meeting with substantial competition which will increase unless research finds new uses for them, new ways to overcome their inherent weaknesses, or new methods to produce both the oils and their derivatives more cheaply. This study showed that:

1. Linseed oil continues to dominate the drying oils because of its unique adaptability to exterior house paints for wood. So far, no satisfactory substitute for linseed oil has been developed for this use.

Soybean oil finds maximum usefulness in alkyd vehicles, particularly for paints, because of its semidrying nature, its color-retention properties, and its relative cheapness. Tung, oiticica, and dehydrated castor oils, usually chemically modified, are being exploited for the unique properties of each oil. Rapid drying, color retention, water resistance, and similar desirable properties are typical reasons cited by users of these oils for particular applications. Safflower oil, a relative newcomer to the drying-oil field, is being used principally as a replacement for soybean or linseed oil in the production of alkyd resins and in other uses. Fish oils and tall oil are being used because of their relative cheapness, primarily in products of second- or third-grade quality.

2. The difficulties encountered in the use of drying oils and the properties desired in drying oils are as diverse as the products manufactured from them. Drying oils have been accepted and used with only minor modifications for a great many years. Certain characteristics, such as the yellowing and relatively slow drying of linseed-oil films, have been recognized and tolerated because of other valuable properties. Every film--whether a protective coating, printing ink, core oil, or other type--represents

1/ These men belong to the Engineering Economics Division of the Battelle Memorial Institute.

a compromise between the ideal characteristics and those attainable at the price the ultimate consumer is willing to pay.

3. Synthetic materials (vinyl coatings, vinyl sheet, "steam-set" inks, phenolic shell molding resins, etc.) are taking a growing share of the respective markets for protective coatings, floor coverings, printing inks, and core oils. This is true because the synthetics have desirable properties for certain uses not now found in drying oils. The synthetic materials have been "tailor-made" for specific applications. The possibility of drying oils recapturing a large share of these specialty markets appears remote, except as methods are developed for using drying oils as chemical raw materials for making film formers with improved properties.

4. Rubber and water-mix paints have been taking a larger share of the protective-coatings market because of a combination of factors. Chief among these are the trend toward amateur home maintenance, customer acceptance based on the ease of application and cleanup, and effective promotion. There are indications that the protective-coatings industry is in the process of developing new oil-based protective coatings (primarily one-coat alkyd-flat paints) and the necessary promotional techniques to compete with rubber and water-mix paints.

5. Tall oil, a byproduct of paper manufacture, has taken a larger share of the protective-coatings market chiefly because of its relatively low cost. It has no unique advantages except price. Drying oils will have to meet this challenge to maintain or improve their present position in competition with tall oil.

6. A majority of the companies interviewed indicated the existence of alternate formulas for at least one product that permit them to substitute one oil for another. In general, the properties of the various drying oils differ significantly enough that reformulation of the product is a necessary consequence of any change in oil constituent. Furthermore, inflexible specifications for industrial protective coatings and producer-imposed quality standards for most products limit substitutions among the oils for slight economic advantages. Certain conditions, such as oil supply or product quality, may force the substitution of one drying oil for another. However, such substitutions are the exception rather than the rule in the industries that consume drying oils.

7. The drying oils, or simple chemical modifications of them, enjoy widespread use in protective coatings and other products because they are inexpensive raw materials that have film-forming properties adequate to meet the needs of many applications. In some specialty applications, the oils or their simple modifications do not meet the needs. There is a definite possibility that

they could be used in these applications too, provided that the oils are looked upon as raw materials for making other film formers and that enough research and development work is done to yield products that can do the job. Such film formers derived from drying oils may not be as inexpensive as the oils themselves, but they would have the necessary properties to make them attractive even at a higher price.

8. Technological and developmental research on the drying oils should center on the fundamental chemistry of the drying oils and their component parts. Despite extensive research and study, there are still definite gaps in the basic understanding of drying oils. Some of the questions that still need answering are: What is the fundamental cause of poor color retention, poor water or chemical resistance, poor drying? What is the basic relationship between the composition of the oil and the particular properties it exhibits? What is the basic mechanism by which drying oils dry? Given the answers to these and similar fundamental questions, American producers and consumers of drying oils would feel better qualified to make effective use of them through developmental research.

HISTORICAL DEVELOPMENT AND RELATIVE IMPORTANCE OF DRYING-OIL USES

Highlights in the Development of Drying-Oil Usage

Although drying oils are of ancient origin, the major developments in their industrial use date from less than 200 years ago. Until 1763, protective coatings were the only recognized outlet for the drying oils. In that year the technology of bulk oxidation of drying oils was perfected, resulting in the manufacture of floor coverings. The other uses of drying oils appear to have developed during the industrial revolution, about the middle of the nineteenth century.

Uses of Protective and Decorative Coatings

The use of protective and decorative coatings, as such, can be traced back to prehistoric man. However, it was not until the eleventh century A.D. that the materials known today as protective coatings started to emerge. The first commercial varnish factory was established in England in 1790. Linseed oil became the standard oil of paint and varnish manufacture and remained the standard until 1870, when tung (or China wood) oil was introduced in the United States. Fish oils became available in quantity shortly before 1900, and perilla oil was introduced in this country just prior to World War I.

Given the impetus of a more adequate supply of nitrocellulose and fermentation-produced solvents, lacquer began to be a significant factor in the protective-coatings field in the period following World War I. This same period also saw the introduction of phenolic-formaldehyde resins, which replaced the natural resins in varnishes. (For a description of the major synthetic resins in protective-coating uses see Glossary, page 121.)

In 1928, the development of the water-thinned, casein-protein type of paint made available a product with film properties markedly superior to previous water-thinned paints. They found a ready market as low-cost, semidurable interior finishes.

By 1930, the protective-coatings industry could offer oil-based paints, quick-drying varnishes, lacquers, and calcimine-type finishes. The raw materials for the industry included linseed oil, tung oil, perilla oil, fish oils, natural resins, phenolic resins, nitrocellulose, and casein and protein materials.

In the mid-1930's phthalic-glycerol resins emerged as a competitor for the natural and phenolic resins. Moreover, it was soon discovered that formation of the resin in the modifying drying oil--rather than dissolving the resin in oil--produced some startlingly unexpected and desirable properties in the ultimately formed film. For example, soybean oil, previously unsuited for paint use, could be upgraded to produce a satisfactory film. Since soybean oil was cheaper than linseed oil, the development of these materials called alkyd resins caught the attention of cost-conscious paint chemists.

The mid-1930's also witnessed two other developments--one, new oil raw material, and the other, a new lacquer-type film-forming material. The new oil was oiticica oil, a true drying oil. The new lacquer-type material was polyvinyl chloride, a completely synthetic film former.

Polyvinyl chloride as a protective-coatings material has not approached the importance of the cellulosic lacquers. However, its development marks an important milestone in the history of protective coatings and chemistry. Polyvinyl chloride was among the first commercial products of the technology known as polymer chemistry. The effects of polymer chemistry have been as marked, if not more so, on the drying-oil-based coatings as the effects of the lacquers.

In the late 1930's, resin emulsion paints and dehydrated castor oil were introduced to the protective-coatings industry. Resin emulsion paints were the outgrowth of an attempt to adapt the alkyd resins to the water-thinned casein coatings. They offered film properties that were better than the casein-protein paints, approaching the durability characteristics of oil-based films. In addition, they were easy to apply and had less "paint odor" than oil paints. In spite of these advantages, their growth was slow until after World War II. Dehydrated castor oil was the most successful of many attempts to modify chemically a nondrying oil to a drying oil. It approached tung oil in drying characteristics and had significant advantages over linseed oil in color retention. By 1941, it was being hailed as one of the most significant advances in drying-oil technology.

Until the oil-short period of World War II, paint technology had undergone remarkably little change. True, lacquers, phenolic varnishes, and phthalic alkyd vehicles had been introduced, and the proportion of ready-mixed paint had increased tremendously. But the ordinary exterior house paint consisted essentially of lead, zinc, or titanium pigments and extenders ground in linseed oil. In 1941, the weight of linseed oil per gallon of all oil-containing paint and varnish products was 3.07 pounds. The comparable figure in 1914 was 4.50 pounds. This change reflected the growing importance of industrial and architectural enamels that contain less oil per gallon. In 1941, the ordinary exterior house paint still contained between 4.25 and 4.50 pounds of linseed oil per gallon. During World War II, the Government cut this house paint ratio to 3.75 pounds of oil per gallon to conserve the drying oils.

Reformulation to comply with this regulation led a considerable number of companies to re-examine the classical theories of required pigment-to-binder ratio. Higher pigment ratios and the use of processed oils for part of the binder resulted in further decreases in the average oil content per gallon of paint and stimulated interest in the possibility of substituting other processed oils for processed linseed oil.

The post-World War II period saw the introduction--in 1948--of styrene-butadiene latex emulsion paint, the use of which has been growing lustily since then. A good share of the success of latex emulsion paints must be ascribed to the effective promotion they received from the paint manufacturers. Nevertheless, they have continued to find usage because of their ease of application and clean-up and relative lack of odor. Furthermore, their introduction coincided with the rise of the so-called "do-it-yourself" trend in home maintenance. This change from professional to amateur painter was sparked by a combination of factors including a population increase not matched by a comparable increase in the number of professional painters, a substantial growth in housing starts and an increasing number of owner-occupied dwellings, a greater amount of leisure time available to the average homeowner, and the rapidly inflating cost of labor in contracted maintenance and repair work.

The "do-it-yourself" trend focused manufacturers' attention on materials that would be easy and pleasant for the consumer to use. Quality of product and adaption of product to a specific end use will continue to be inherent in paint manufacture, but the outstanding consideration in future paint sales to the amateur consumer--i.e., trade paint sales--will be convenience.

The pendulum of drying-oil usage seems to be swinging in shorter arcs. Whereas the development of oil-modified alkyd materials followed the major introduction of lacquers by some 10 years, the styrenated alkyds that may be a competitive answer to the latex emulsions appeared less than 5 years after the latter's inception. Although it is too early to have gained perspective, styrenated alkyds are the latest technological advance in the long developmental history of drying oils.

Other Major Uses of Drying Oils

The major uses for drying oils other than protective coatings are of comparatively recent origin. For the purposes of this study, floor coverings, printing inks, core oils, table oilcloth, fabric wall coverings, thermal and electrical insulations, and friction materials are considered to be the other major sales outlets for drying oils.

Floor Coverings.- The floor-coverings (or floorcloth) industry was started in 1763. It was made possible by the development of techniques for handling and thermally processing appreciable quantities of linseed oil.

The first floorcloth appears to have consisted of an oxidized linseed oil spread on a cloth or fiber base. Little was added to the art until 1860 when Fredrick Walton developed and applied his procedures for making and handling oxidized oil gels. The product of Walton's genius was linoleum. Linoleum manufacture is unchanged in principle today, although improved in mechanical manipulation.

Linseed oil has been the basic oil material since the inception of the floor-coverings industry. Other oils account for about 10 percent of the total oil used in floor coverings, even in periods of adequate linseed oil supply. During World War II, the world-wide shortage of oils and fats forced the use of substitute oils, particularly tall oil, with varying degrees of success.

Among the synthetic materials that have encroached on linoleum and floorcloth, rubber, asphalt, and plastic tile should be mentioned. Early attempts to duplicate the properties of linoleum with a rubber composition were not markedly successful. A compromise in the form of small (9 by 9 inches square) tiles, producible in a steam-heated press, has become a significant part of the floor-coverings market.

Asphaltic materials have found considerable favor. Like the rubber floorings, a small-sized segment, called a "tile," is the accepted form. Asphalt tile is distinguished by the fact that it will soften on the application of heat and recover its inherent resilience on cooling. This property simplifies the laying of the tile in irregularly shaped rooms and around permanent projections through the floor.

Until 1939, the price of plastic resins (vinyl resins in particular) that could be rolled into large or continuous sheets was too high to permit wide-scale competition with linoleum or felt-based coverings. The durability, color, and color-and-gloss-retention properties of these materials were superior to linoleum, so that a certain acceptance was gained. Following World War II, improvements in the production of the basic resins and in the compounding technology for the sheets or films lowered the price to the consumer sufficiently that vinyl floor coverings are encroaching on markets formerly held by linoleum.

Printing Inks.- Printing inks based on drying oils trace their development from the invention of the movable-type printing press by Gutenberg about 1440. He is believed to have been the originator of ink made of lampblack thickened with linseed oil. This type of printing ink is still regarded as being the best for certain processes.

The technological advances of printing inks cannot be separated from the development of the art of printing. Each form of printing--Gutenberg's raised type, lithography, engravure, and silk screen--required special properties in the inks used with them. The rapid advance of mechanical printing since 1900 and the use of a greatly expanded number of media, such as newsprint, cellophane, and paper-board, have forced printing-ink makers to produce thousands of different inks, each designed for a particular printing job. The complexity of ink making is staggering.

Until the advent of the rotary high-speed press, printing inks depended on the oxidation of a thin film of pigmented drying oil on the surface of the paper. Linseed was the major oil used. But the slow drying of linseed-based inks was poorly suited to rotary-printed newspapers. The less expensive and faster-drying mineral oil inks were used instead.

Later printing developments--coated and glossy papers, metals for lithography, waxed paper, cellophane and other synthetic films--were made possible by the use of a wide range of synthetic chemicals that were developed after the first World War.

Oils other than linseed have entered the printing-ink industry as chemical modifying agents became available. Phenolic resins facilitated use of tung oil, and alkyd resins allowed the use of softer oils such as soybean and fish oils. However, linseed oil remains the chief drying oil in printing inks.

Core Oils.- Core oils are a part of the larger field of core binders used in sand molds in foundries. Core binders fall into four general classifications: (1) Binders that become firm on freezing, (2) binders that become firm at room temperature, (3) binders that become firm on baking, and (4) clays. Group 3 is further subdivided: (a) binders that dry on heating; (b) binders that harden on cooling after being heated, and (c) binders that adhere on heating. Core oils are used in cores for molds of Group 3, Subgroup a.

Most of the vegetable, mineral, and marine animal oils have been used at one time or another as core binders. It is probable that linseed oil was among the first oils used as a core binder. It has many desirable properties and survived as the principal core oil until the ready availability of tall oil.

The supporting art--in this case, foundry technique--was again the controlling factor in the development of core oils. Individual consumers specified the requirements that the oil must meet, thus developing a complex assortment of formulas. However, unlike printing inks, the core oils have been dominated by economic considerations that have fostered a continual search for cheaper, adequate materials.

At least as early as 1916, some synthetic materials, for example phenolic resins, had been investigated as substitute binders. Since then, a wide variety of compounds have been tried and some of these have found applications in specific foundry practices.

Other Drying Oil Uses.- Table oilcloth and fabric wall coverings are the surviving members of a group of products classed as fabrics made waterproof by oil. The art of rendering fabrics waterproof has been practiced for centuries. The development of cloth weaving, particularly in the more severe climates of Northern Europe, led to the application of drying-oil films to garments. It is probable that floorcloth and linoleum were direct outgrowths of this practice. Oil-treated garments have given way to synthetic materials--first, rubber coatings, and later, plastic films. However, the low cost of oil-based table oilcloth and fabric wall coverings has preserved them as substantial consumers of drying oils, notably linseed oil.

Electrical insulations were developed from the varnishes available at the time that the electrical industry started its growth. Specialized varnishes with good electrical insulating properties and water resistance were based on variations of a phenolic tung-oil varnish. Rubber sheathings, and later polyvinyl and polyethylene extrusions have replaced part of the varnish insulation; but are not applicable where space is at a premium, as in motors and coils. Silicone alkyd resins, the most recent development, have particularly attractive electrical and water-resistance properties but have found only limited applications because of their high cost.

Fabricated building materials having high heat and sound insulation values are the outgrowth of wood-waste utilization that got its start prior to World War II and advanced to prominence during the building boom that started in 1946. In addition to drying-oil-based impregnants and binders, a number of synthetic plastic materials have been used. No revolutionary developments are known to have occurred in this field, so far as drying oils are concerned.

Friction materials, such as those for brake linings, containing small proportions of drying oils, followed the rise of the automotive industry. Their influence on the drying-oil industry has been negligible.

Relative Importance of the Drying-Oil-Consuming Industries

Historically, the protective-coatings industry--the manufacturers of paints, varnishes, and lacquers--was the first large nonfood user of the drying oils. Prior to 1931, paste forms of paints (in preference to ready-mixed paints) predominated, making quantitative assessment of the relation of drying oils in protective coatings to the other industrial uses difficult. Estimates based on the average amount of linseed oil assumed to be added to paste paints by professional and amateur painters indicate that protective coatings were the largest consumer of drying oils. Statistics published for 1931 by the Department of Commerce, Bureau of Census, confirm this indication.

Table 1 details the consumption by major product type in millions of pounds of oils, fats, and tall oil. Paint and varnish products continue to consume the bulk of the fats and oils used in drying-oil products. To the paint and varnish totals listed in table 1 can be added 90-95 percent of the fats and oils contained in synthetic resins. Synthetic resins have increased in importance in recent years, and rank second to paints and varnishes as drying-oil consumers. Linoleum and oil cloth continue to be an important consumer of drying-oil products.

Table 1.- Utilization of oils, fats, and tall oil in drying-oil products, by type of product, United States, 1931-54 1/

Year	Paint and varnish		Other products: Linoleum and oilcloth		Core oils 2/		Printing inks 3/		Insulation 2/		Linings, packings and hydraulic fluid 2/		Synthetic resins 2/		Miscellaneous 4/		Total		Total
	Quantity	Percentage of total	Quantity	Percentage of total	Quantity	Percentage of total	Quantity	Percentage of total	Quantity	Percentage of total	Quantity	Percentage of total	Quantity	Percentage of total	Quantity	Percentage of total	Quantity	Percentage of total	
	Million pounds	Percent	Million pounds	Percent	Million pounds	Percent	Million pounds	Percent	Million pounds	Percent	Million pounds	Percent	Million pounds	Percent	Million pounds	Percent	Million pounds	Percent	Million pounds
1931	524	84.6	73	11.8											22	3.6	95	15.4	619
1932	405	84.6	58	12.1											17	3.3	72	15.4	479
1933	459	83.4	70	12.8											21	3.8	91	16.6	550
1934	506	84.2	68	11.3											27	4.5	95	15.8	601
1935	611	84.7	81	11.2											30	4.1	111	15.3	721
1936	654	82.4	101	12.8											38	4.8	139	17.6	793
1937	702	82.5	101	11.9											48	5.6	149	17.5	852
1938	563	82.6	84	12.3											35	5.1	119	17.4	682
1939	673	81.9	108	13.1											41	5.0	149	18.1	822
1940	652	80.8	112	13.9											43	5.3	155	19.2	807
1941	875	81.0	137	12.7											68	6.3	205	19.0	1,079
1942	775	79.6	116	11.9											82	8.5	198	20.4	973
1943	700	78.6	76	8.6			23	2.6							91	10.2	190	21.4	890
1944	694	75.6	85	9.3			31	3.4							107	11.7	223	24.4	917
1945	644	73.7	79	9.0			38	4.4							113	12.9	230	26.3	874
1946	683	73.3	88	9.4			34	3.6							128	13.7	250	26.7	934
1947	706	69.3	142	14.0			24	2.4							145	14.3	311	30.7	1,017
1948	766	70.8	167	15.4			22	2.0							127	11.8	316	29.2	1,081
1949	655	67.2	148	15.2	35	3.6	19	2.0	8	0.8	10	1.0	5/82	8.4	17	1.7	319	32.8	974
1950	761	64.3	153	12.9	38	3.2	21	1.8	11	.9	13	1.1	105	8.9	84	7.1	422	35.7	1,183
1951	743	64.6	134	11.6	46	4.0	20	1.7	11	1.0	11	1.0	156	13.5	30	2.6	408	35.4	1,151
1952	691	67.0	125	12.1	42	4.1	20	1.9	10	1.0	6	0.6	128	12.4	10	1.0	341	33.0	1,032
1953	750	69.0	117	10.8	40	3.9	22	2.2	10	1.0	6	.6	128	11.8	15	1.4	337	31.0	1,087
1954 6/	686	65.9	112	10.8	2/	2/	3/	3/	2/	2/	2/	2/	132	12.7	111	10.7	355	34.1	1,041

1/ Totals computed from unrounded numbers.
2/ Not available prior to 1949 and in 1954. Included in "miscellaneous" category prior to 1949.
3/ Not available prior to 1943 and in 1954. Included in "miscellaneous" category prior to 1943.
4/ Includes coated fabrics other than oilcloth, and miscellaneous unspecified products.
5/ The major portion (90-95 percent) of the oil utilized in synthetic resins finds end use application in paint and varnish. Statistics are not available that would permit an assignment of drying-oil consumption to synthetic resins prior to 1949.
6/ Preliminary.

U. S. Department of Commerce, Bureau of Census, Facts for Industry, Series M-17.
U. S. Department of Agriculture, Agricultural Marketing Service, Fats and Oils Situation.

Since 1931, consumption of oils in paint and varnish has declined steadily from about 85 percent to a low of a little less than 65 percent in 1951. By 1953, this usage had increased to nearly 70 percent but fell off to 66 percent in 1954 as a result of a general decline in industrial activity. Consumption in linoleum and oilcloth varied between 11 and 14 percent from 1931 until 1943 to 1946, when it fell below 10 percent. From a peak of 15 percent in 1948, consumption has leveled off in the 11 to 12 percent range.

Maximum utilization of fats and oils in paint and varnish products was in 1941, when 875 million pounds were consumed. Following World War II, a distinct recovery was noted until 1949, when an inventory adjustment period at the dealer level combined with the peak of resin-emulsion paint production to limit oil usage. The years 1951-53 reflect the increasing sale of latex and emulsion paints, while the trend upward in 1953 can be attributed to the resurgence of interior oil-based paints, in the form of flat alkyd formulations.

The category of linoleum and oilcloth was the only other major outlet for drying oils identified in the statistical reports until 1949. Maximum consumption, on both a poundage and percentage basis occurred in 1948, when 167 million pounds of oil, representing 15.4 percent of the total, were used. The decrease since then has been attributed to the rise of nonoil floor coverings, including asphalt and rubber tile and vinyl materials.

In 1949, synthetic resins and plastic materials were first separated in available statistics as a class of drying-oil consuming products. In prior years, oil consumption in synthetic resins had been listed separately, but only as it related to secondary fat and oil materials. An examination of production and sales figures for synthetic resins as reported by the Tariff Commission indicates that oil consumed by paint and varnish companies in the production of resins for protective coatings has been included in the paint and varnish utilization category. Thus, oil listed by the Bureau of Census as consumed in synthetic resins represents only the oil content of resins produced by companies other than paint and varnish manufacturers.

The Tariff Commission's notation is that 95 to 99 percent of the major class of oil-bearing resins, the alkyd resins, finds application in paints and varnishes. Although there are no statistics available to support the belief, it is likely that the bulk of the oil (90-95 percent) consumed in synthetic resins as listed by the Census Bureau is used in the manufacture of protective coatings.

In descending order of importance, core oils, printing inks, linings and packings and hydraulic fluids, insulations, and miscellaneous other products affect the utilization pattern of the drying oils. The only significant pattern change evident in the available statistics is the gradual decline of oil consumption in printing inks from a high of 4.4 percent in 1945 to about 2 percent from 1948 on. In the aggregate, the minor uses of drying oils account for about 10 percent of the total consumption.

DESCRIPTION OF COMPANIES CONTACTED

The future prospects for drying oils are important to a number of industries as well as to the agricultural producer of those oils. To be meaningful, a study of this type must attempt to collect and integrate the opinions of representative groups of producers of the following: (1) End-use products containing drying oils, (2) intermediate materials formulated with drying oils, (3) drying-oil raw materials, and (4) materials that compete with drying oils. Additionally, groups in a position to influence either the use of the drying-oil-containing products, or the technical aspects of processing and use of drying oils--i.e., Government laboratories and trade associations--should be included.

In planning this study, it was decided that personal interviews with key men from selected companies in the drying-oil industry would be the most effective method of gathering the needed information. To get a good cross section of opinion, officials of the following were interviewed: 46 paint, varnish, or lacquer manufacturers, 15 other major users of drying oils and 11 producers of synthetic resins or basic raw materials for them, 9 oil suppliers, 8 trade associations, and 2 Government laboratories. The opinions of manufacturers of nearly all types of drying-oil-containing end products, suppliers of drying oils and synthetics raw materials, and producers of intermediate products utilizing these materials are represented in the survey.

A detailed list of questions concerning current use, technical difficulties, and probable future trends of drying oils and competitive materials was formulated for each of the four major industrial categories--paint and varnish, other major uses, synthetic resins, and oil suppliers. The questionnaire forms were used for all interviews, except those with Government laboratories and trade associations. While a great deal of useful information was obtained with respect to the opinion sections of the questionnaires, only limited data were obtained in the statistical sections. Rather than attempt to extrapolate to an industry-wide basis the few complete answers received, the statistical data that were received have been used as supporting evidence for the opinions expressed. No tabulation of the data collected is included in this report.

Protective-Coatings Manufacturers

Introduction

In the broadest sense, protective coatings could refer to most of the applications in which drying oils are a normal constituent. For the purposes of this report, protective, or protective and decorative, coatings refer only to the products of paint, varnish, or lacquer manufacturers; and the designations have been used interchangeably.

Opinions were gathered from 46 paint and varnish companies out of an original selection of 49. Forty-three of the 46 are American companies, 2 are the Canadian affiliates of American companies, and 1 is an independent Canadian manufacturer. Forty-two separate corporations have been included. And because of the corporate structure, the specific product line of a subsidiary, or other factors, 4 affiliates of 3 corporations have been treated as independents.

Geographically, these companies' products are sold throughout the United States, Canada, the Hawaiian Islands, and parts of Mexico, and Central and South America. All types of service conditions for trade-sales paints are represented from tropical to arctic, humid to semiarid.

This list of 43 interviews with American establishments (not including the 3 Canadian interviews) represents the opinions of far more than the indicated 1.7 percent of the estimated 2,500 American paint establishments in operation at the present time. Multiplant operations were covered by 1 interview in a majority of the cases with the data secured representing from 2 to 8 separate manufacturing installations.[a]

A size distribution of the companies interviewed has not been attempted. However, 14 of the 15 largest American paint companies responded, as well as 32 smaller concerns. No attempt was made to include a numerically representative group of the many small paint companies.

A distribution of the companies interviewed by the major categories of trade and industrial paints has been made. Failure of certain companies to report their individual statistics and the absence of individual paint-sales volumes precludes the possibility of determining the trade-to-industrial sales ratio of the total sample. Eighteen of the 46 companies have been classed as predominantly trade sales (less than 30 percent industrial sales), 12 have been classed as predominantly industrial-product-finishes sales (less than 33 percent trade sales), and the remaining 16 have been identified as prominent in both fields.

Prior to 1952, estimates of the dollar value of trade and industrial sales of protective coatings were reported to the Census Bureau by 580 establishments, representing between 75 and 85 percent of the total of such sales. In January 1952, the base of calculation was shifted to 250 companies, with 385 establishments, and the reports were adjusted to represent total sales in the United States. Later, the reports for 1951 were recalculated on the new base. There are indications that the proportion of trade to industrial sales on an industry-wide basis might differ slightly from the identifiable sales of the 580 establishments. However, correction to total sales for the period 1936-1950 is impractical. Therefore, figure 1 presents the known proportion of trade and industrial sales for these years, and estimates on total United States sales for 1951-54.

The calculation of a trade-sales-to-industrial sales ratio for the companies interviewed is impractical. Three companies, each large enough to influence the ultimate ratio, did not specify their own company ratio. Assuming these 3 to have 50-50 ratios, the arithmetic average ratio (disregarding differences in size of companies) has been calculated to be 58 percent trade sales to 42 percent industrial-product finishes. This compares favorably to the weighted industry ratio of 60 percent trade to 40 percent industrial calculated from reports of the Bureau of Census (table 2).

Total sales of the American paint, varnish, and lacquer industry have been estimated by the Bureau of Census and the National Paint, Varnish and Lacquer Association. Figure 2 and table 3 indicate the growth of the industry since 1931 in actual and deflated dollar value of sales. It is evident from this graph that the dollar volume of paint sales in this country has been rising for the past 20 years--slowly during the thirties and early forties, sharply in the immediate postwar period, and again slowly since 1950. A sizable share of this increase can be attributed to rising paint prices. Paint gallonage sales, as is evident in the same figure and table, have not increased as markedly as have sales in terms of dollar value.

Statistics of the physical volume of protective-coatings products are fragmentary. Starting with the known quantities shipped in census years (1931, 1935, 1937, 1939, 1947), the estimates of figure 2 are presented as possible gallonages.

The products of the companies interviewed cover the complete range of paint, varnish, and lacquer materials as well as many items outside the field of protective and decorative coatings. 2/

2/ The types of paint products made by the companies contacted may be listed as follows: by end-use pattern, starting with the Bureau of Census designations of trade and industrial sales:

Seven of the 42 corporations have substantial, if not predominant, sales in nonpaint lines. The balance of 35 corporations are known primarily as paint manufacturers but have varying proportions of

2/ (Continued)

Trade-Sales Products

Architectural finishes

- Exterior paints
- Exterior enamels
- Interior paints
- Interior enamels
- Varnish and oil stains

Floor varnishes and enamels

Barn paints

Industrial maintenance finishes

Putties and caulking compounds

Paste paint products

Industrial-Product Finishes

Automotive

Truck, tractor, and implement

Appliances

Marine

Other metallic

Furniture

Railroad

Toys

Other wood

Another useful method of classifying protective and decorative coatings is by type of vehicle. This study includes companies that make one or more of the following types of vehicles:

Oil-base paints

Varnishes

- Oleoresinous
- Alkyd
- Phenolic

--Continued

nonpaint income. For this study, answers and opinions were confined to the paint manufacturing operations of each corporation.

In summary, the companies interviewed have experience in formulating all types of protective coatings from a wide variety of vehicles for all types of service conditions.

2/ (Continued)

Gloss paints

Architectural gloss and semigloss
Industrial, baking
Industrial, air dry

Flat paints

Architectural flat
Primers
Sanding sealers

Lacquers

Nitrocellulose
Vinyl
Other

Water-thinned paints

Resin emulsion
Latex emulsion
Casein

Wash primers

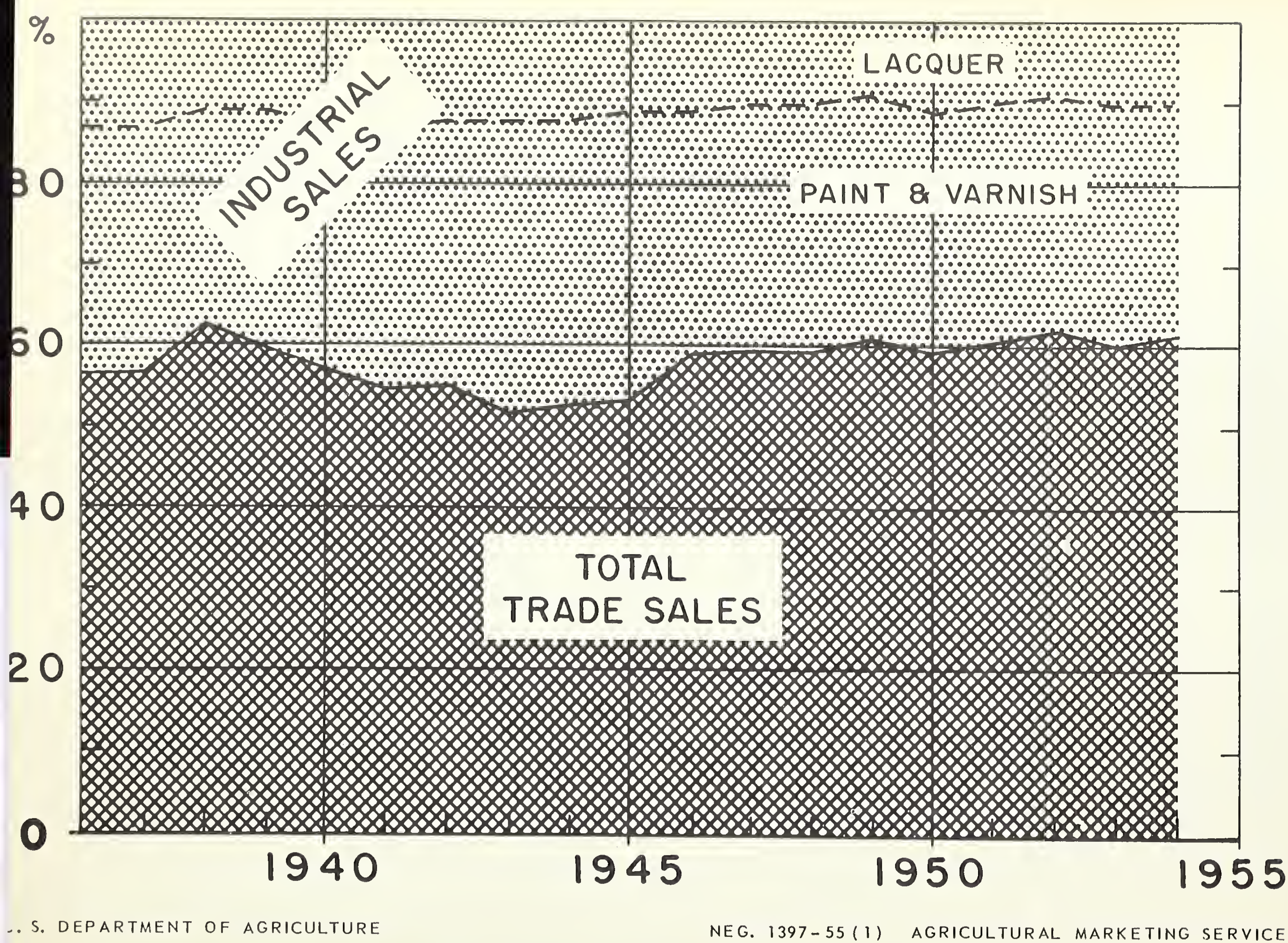
Plastisols and organosols

Table 2.- Value of trade and industrial sales of identifiable paint, varnish and lacquer, 1936-54

Year	Trade		Industrial						Total value of sales 1/
	Value	Percentage of total	Paint and varnish		Lacquer		Total		
			Value	Percentage of total	Value	Percentage of total	Value	Percentage of total	
	Million dollars	Percent	Million dollars	Percent	Million dollars	Percent	Million dollars	Percent	Million dollars
1936	203.1	56.3	111.0	30.7	47.1	13.0	158.1	43.7	361.2
1937	215.9	56.8	115.3	30.3	48.9	12.9	164.2	43.2	380.1
1938	196.0	62.6	81.2	26.0	35.8	11.4	117.0	37.4	313.0
1939	213.7	59.7	102.4	28.6	41.7	11.7	114.1	40.3	357.8
1940	214.2	57.0	111.7	30.0	48.3	13.0	160.0	43.0	374.2
1941	276.2	54.8	162.6	32.3	64.8	12.9	227.4	45.2	503.6
1942	260.5	55.1	155.9	33.0	56.2	11.9	212.1	44.9	472.6
1943	265.2	51.6	186.2	36.2	62.7	12.2	248.9	48.4	514.1
1944	294.2	52.8	197.1	35.4	65.9	11.8	263.0	47.2	557.2
1945	307.4	53.2	204.7	35.5	65.3	11.3	270.0	46.8	577.4
1946	420.8	59.0	216.9	30.4	75.3	10.6	292.2	41.0	713.0
1947	551.8	59.3	289.5	31.1	89.4	9.6	378.9	40.7	930.7
1948	560.5	59.1	296.0	31.3	91.2	9.6	387.2	40.9	947.7
1949	516.3	60.9	250.6	29.6	80.0	9.5	330.6	39.1	846.9
1950	605.3	59.1	305.3	29.9	112.0	11.0	417.3	40.9	1,022.6
1951	807.4	60.3	396.3	29.6	135.4	10.1	531.7	39.7	1,339.1
1952	830.9	62.0	387.6	28.9	122.3	9.1	509.9	38.0	1,340.8
1953	840.4	59.9	420.5	30.0	141.8	10.1	562.3	40.1	1,402.7
1954 2/	838.0	61.6	388.9	28.6	134.2	9.8	523.1	38.4	1,361.1

1/ Derived as the sum of industrial and trade sales reported by 580 establishments from 1936-50, not adjusted to total sales. 1951-54 are estimates of total industry sales.
2/ Preliminary.

U. S. Department of Commerce, Bureau of Census.



'Figure 1.- Identifiable proportion of trade and industrial paint, varnish, and lacquer sales, United States, 1936-54

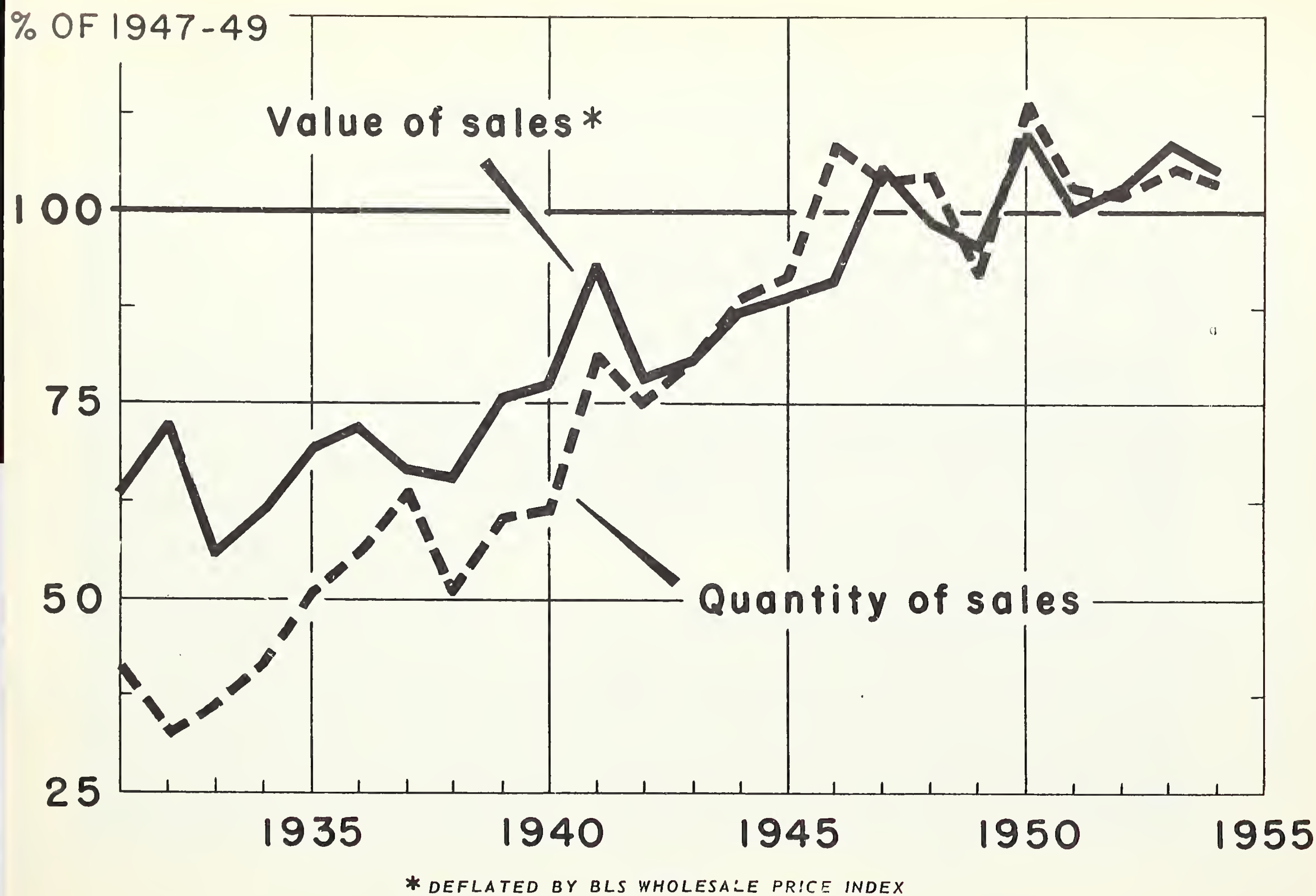
Table 3.- Estimated quantity and value of sales of paint, varnish, and lacquer, United States 1931-54

Year	Quantity 1/		Value 2/		
	Actual	Index 1947-49 = 100	Actual	Actual deflated 3/	Index 1947-49 = 100
	Million gallons		Million dollars	Million dollars	
1931	218	41.4	352.1	742.8	63.5
1932	172	32.7	357.3	848.7	72.5
1933	193	36.7	279.4	652.8	55.8
1934	220	41.8	349.8	718.3	61.4
1935	267	50.7	423.5	814.4	69.6
1936	297	56.4	443.8	845.3	72.2
1937	336	63.8	468.8	835.7	71.4
1938	270	51.3	391.6	766.3	65.5
1939	319	60.6	443.9	886.0	75.7
1940	324	61.6	463.8	907.6	77.6
1941	428	81.3	617.1	1,086.4	92.8
1942	395	75.0	588.6	916.8	78.3
1943	423	80.4	631.2	942.1	80.5
1944	464	88.2	687.0	1,016.3	86.8
1945	481	91.4	716.0	1,040.7	88.9
1946	570	108.3	833.2	1,058.7	90.5
1947	545	103.5	1,193.7	1,238.3	105.8
1948	549	104.3	1,207.3	1,156.4	98.8
1949	485	92.1	1,106.9	1,115.8	95.4
1950	599	113.8	1,326.8	1,286.9	110.0
1951	542	103.0	1,339.1	1,166.5	99.7
1952	536	101.8	1,340.8	1,201.4	102.7
1953	556	105.6	1,402.7	1,274.0	108.9
1954	545	103.6	1,361.1	1,234.0	105.5

1/ 1931-50 estimates by Stanford Research Institute, Chemical Economics Handbook. 1951-54 estimates accumulated during this survey from numerous diverse sources.

2/ 1931-50 estimates by National Paint, Varnish and Lacquer Association, based on the Bureau of Census reports, corrected to include those not reporting and those reporting and not classifying sales. 1951-54 estimates by the Bureau of Census.

3/ Deflated by Bureau of Labor Statistics wholesale price index 1947-49 = 100.



U. S. DEPARTMENT OF AGRICULTURE NEG. 1398-55(1) AGRICULTURAL MARKETING SERVICE

Figure 2.- Index numbers of estimates of quantity and value of sales of paint, varnish, and lacquer by manufacturers, United States, 1931-54

Recent Price History of Principal Products

For the protective-coatings industry, cost of production and selling prices have tended upward. Thirty-four companies indicated that paint prices had risen from 4 to 17 percent, depending on the particular item. The most general agreement was that a 10 to 15 percent price increase between 1949 and 1952 would be descriptive of the experience of the industry as a whole. Eleven companies claimed no significant price adjustments but complained about increasing costs. The replies to the question on prices are shown in table 4. Significantly, the companies stating that prices were not up are not among the top 15 American companies.

Rising raw-material costs and labor wage-rate increases were the most frequently mentioned reasons for the price increases. Raw materials, usually dry pigments or synthetic vehicles, were given prime importance by 30 companies. Two cited labor as the major cause, 3 said that materials and labor were equally effective, 4 specified packaging costs, and 7 did not reply. In view of the proportion of sales price represented by raw materials (about 60 percent), this distribution is not considered unusual.

Figure 3 presents the wholesale price indexes of prepared paints and paint raw materials as collected by the U. S. Department of Labor, Bureau of Labor Statistics. Previously published indexes have been converted to the base of 1947-49 = 100.

The answers summarized in table 4 are in agreement with the trends indicated in figure 3. Between 1949 and 1952, prepared paint prices dipped in 1950 and recovered strongly in 1951 and 1952. The 1952 index shows a net gain of 10 percent over 1949. During the same period, paint raw-material prices increased by about the same percentage. Since the Bureau of Labor Statistics revised its calculations of paint raw materials during 1950 to include titanium pigments for the first time, the indexes of 1949 and 1952 are not strictly comparable.

Furthermore, the effect of formulation changes on the raw-material requirments probably accounts for the emphasis given by the paint manufacturers to material costs as the reason for product-price advances. This effect of formulation would not be apparent in price indexes without drastic revisions.

Vehicle Processing Experience of the Protective-Coatings Manufacturers

Historically, the paint maker had his own secret formulas handed down from one generation to the next; but the rise of the chemical industry and the scientific approach to paint formulation have had an increasing influence on the protective-coatings industry.

Table 4.- Number of replies of paint and varnish manufacturers to the question on significant changes in prices of their principal products from 1949 to 1952 1/

Type of company	Replies on prices		
	Significantly up	Not significantly up	Total
	Number	Number	Number
Predominantly			
Trade			
Large 2/	5	0	5
Medium	10	2	12
Industrial			
Large	0	0	0
Medium	8	4	12
Prominent in both			
Large	8	0	8
Medium	4	4	8
All companies	35	10	45

1/ Question: Were there any significant changes between 1949 and 1952 in the price of your principal products? Were changes in the price of raw materials, either natural or synthetic, a major factor in these product-price changes?

2/ One company among the top 15 American paint, varnish, and lacquer manufacturers, classified as predominantly trade sales, did not answer this question.

Table 5.- Index numbers of wholesale prices of prepared paints and paint raw materials, 1940-54 1/

(Base 1947-49 = 100)

Year	Prepared paints	Paint raw materials
1940	65	44
1941	66	49
1942	68	58
1943	68	60
1944	68	64
1945	68	66
1946	71	76
1947	102	105
1948	98	105
1949	100	90
1950	97	82
1951	106	98
1952	110	100
1953	111	96
1954	113	96

1/ Based on U. S. Department of Labor, Bureau of Labor Statistics reports. 1940-51 indexes of prepared paints and paint raw materials calculated by adjusting 1926 = 100 series to a 1947-49 base. 1952 and 1953 indexes are from Bureau of Labor Statistics reports. These indexes are not official, but have been calculated to point out the trends in prices from 1940-54 on a continuing scale.

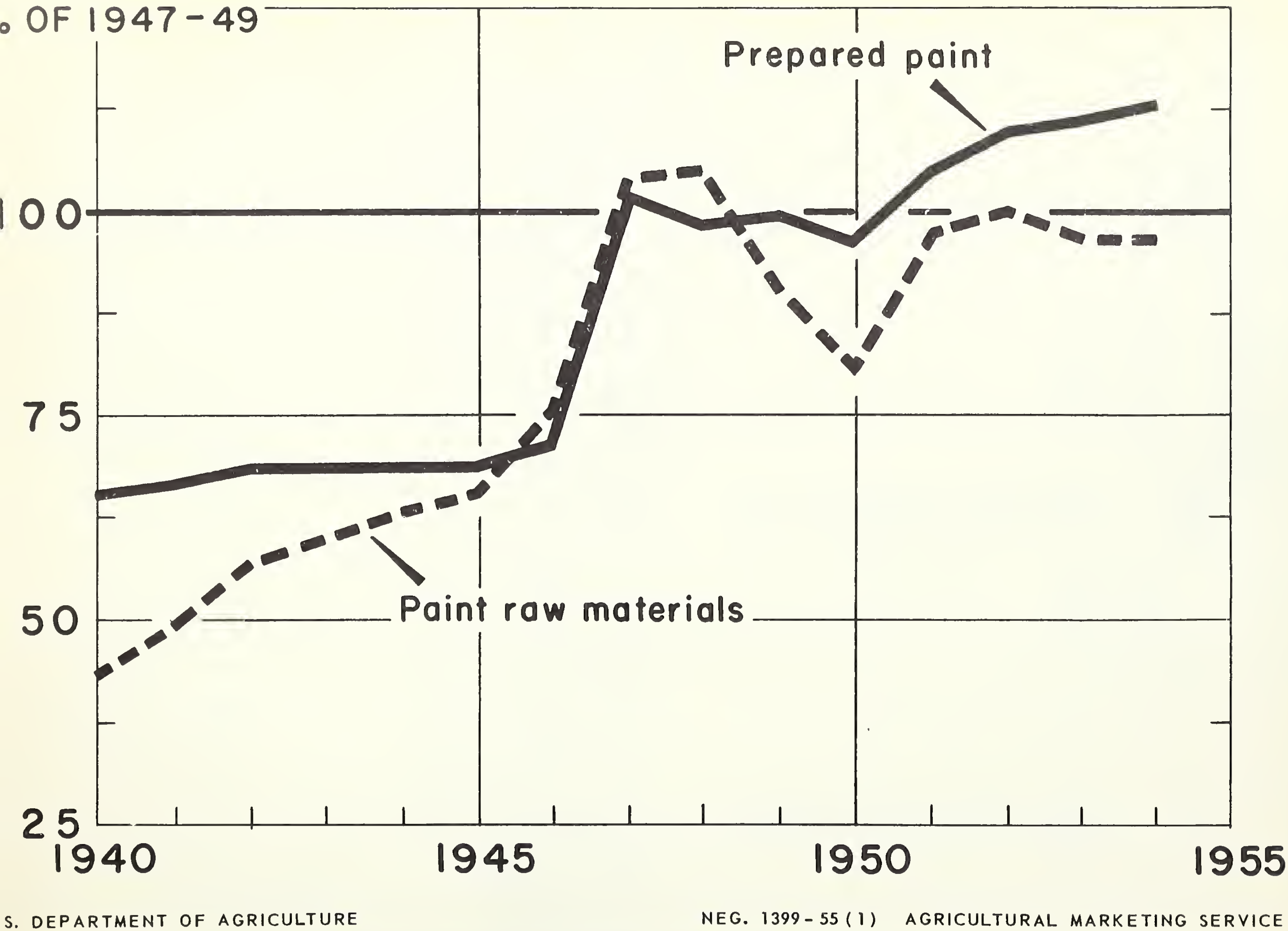


Figure 3.- Index numbers of wholesale prices of prepared paints and paint raw materials, 1940-54.

Experience in processing protective coatings' vehicles is widespread among the paint companies interviewed. Nine of the 46 make more than 95 percent of their total vehicle requirements. Thirty make more than 10 percent of their requirements, and seven buy almost all their vehicles, maintaining no vehicle processing facilities. Among the top 15 companies, only one relies on other manufacturers to supply the bulk of his vehicles.

For the larger companies, outside vehicle purchases center on the specialty materials such as latex epoxy resins, vinyls, and acrylics. The smaller companies purchase these specialties and varying proportions of the other common vehicles, usually alkyds and styrenated alkyds. Plant location within the urban area and close proximity to a large resin vehicle producer appear to be the determing influences.

Of the 7 companies that produce a minimum of their vehicle requirements, 2 specialize in industrial finishes, 4 concentrate on trade sales, and 1 produces both categories of materials. The industrial firms are located near the center of the industrialized East Coast and have ready access to a number of vehicle manufacturers. Both indicated familiarity with alkyd processing, since they specify the type of oil, polyol, and disbasic acid and their respective proportions for all purchases.

The trade-sales companies are located in 4 different cities, and management decision is the primary factor in their lack of vehicle processing equipment. The remaining firm has been restricted in vehicle manufacture by their downtown location in a large city. Within a few years they anticipate a more suburban plant site and the installation of cooking facilities.

A majority--28 of the 46 companies--make and purchase vehicles for their own use only. Six others sell minor amounts of vehicles, usually to a smaller, local paint mixer. In each case, no attempt is made to build up the volume of such sales. Only one large firm admits to a policy of supplying vehicles for the industry.

Other Major Users of Drying Oils

Introduction

While the principal market for drying oils has been and will probably continue to be the paint and varnish industry, a representative group of other major users of drying oils was included in the study. This was done with two objectives in mind. First, it serves to provide a more complete picture of the overall market outlook for drying oils. Second, it directs attention to those end uses that may in the future represent a relatively more important outlet for these oils if consumption of oil for protective coatings continues to decline.

A total of 15 other major users of drying oils are represented in the study. Included in this group are 4 manufacturers each of (1) linoleum and floor coverings, (2) printing inks and printing-ink vehicles, and (3) core oils. The remaining 3 companies produce a variety of products containing drying oils--table oilcloth, fabric wall coverings, thermal insulations, brake linings, varnished cambric electrical insulation, and impregnants for electric coils.

In general, these companies market their products nationally. For the most part, they are also among the leading manufacturers of the several products--linoleum, printing ink, etc.--with which this phase of the study is concerned.

Products Manufactured

Most of the companies that have been included in this "other-major-users" category make a large number of products, the bulk of which do not use drying oils. No exhaustive listing of the product lines of the companies is included in this report, except for mention of products that contain drying oils.

In the floor-coverings industry, drying oils are important raw materials in the production of linoleum and printed or enameled felt-base floor coverings. These oils are used also as plasticizers for asphalt tile and for roofing materials. Drying oils are likewise an ingredient of table oilcloth, fabric wall coverings, brake linings, clutch facings, electrical insulation, and electric-coil impregnants; and they are being used both as a binder and an impregnant for thermal insulations. The oils find use in the manufacture of letterpress and offset inks and in vehicles used in making such inks. Finally, drying oils are a basic raw material in the production of core oils.

Admittedly, limited amounts of drying oils are being consumed in industrial end uses other than protective coatings and the above list of products. Total oil consumption in such products is relatively insignificant, however, and the scope of the present survey precluded contacts with manufacturers for these materials.

Statistics of drying-oil utilization in nonprotective-coatings products are incomplete prior to 1949. Floor coverings and oilcloth (identified in table 1, page 10, as "linoleum and oilcloth") has been an identifiable category in statistical reports since 1931, accounting for 9 to 15 percent of total drying-oil usage. Printing-ink consumption of drying oils can be traced statistically from 1943, but, at best, represents less than 5 percent of the drying-oil market. Core oils (less than 5 percent), insulations (about 1 percent), linings and packings (also about 1 percent), and other miscellaneous products (a maximum of 7 percent) make up the balance of the drying-oil markets.

Oil-containing synthetic resins, a category listed separately in 1949-54, find application in protective coatings, floor coverings, and printing inks. If a statistical distribution were made of this synthetic-resins total among its ultimate end-use product, the proportionate shares going into each product would probably approximate the percentage figures cited above.

Table 1 shows the percentage relationship of floor coverings, printing inks, core oils, linings and packings, and insulations as users of drying oils. The percentage of total drying-oil consumption in floor coverings and oilcloth, printing inks, and linings and packings show a declining trend. Usage in core oils and insulations shows slight gains.

Recent Price History of Principal Products

There was no uniform trend between 1949 and 1952 in the prices of the various nonpaint products in which drying oils are used. Price fluctuations in general were greater and more frequent for those products in which the oil constituent was subject to relatively little processing in the manufacture of the product. . Likewise, prices of products containing a relatively high percentage of drying oil fluctuated more widely than those in which the oil was a minor ingredient. Prices of core oils--manufactured by a one-step process--and printing-ink vehicles fluctuated as the prices and price relationships of the oils changed. Prices of floor coverings and other major oil-containing products remained relatively stable. The prices of printing inks moved upward between 1949 and 1952, from very slightly for some products to about 10 percent for others.

Raw materials, competition, and labor appear to affect prices of drying-oil products in approximately that order. However, in relatively few instances are the effects of raw materials and competition completely divorced. For example, raw-material costs are the dominant factor in core-oil prices; competition forces a continual adjustment of prices as costs vary. These same factors stimulate the search for the lowest cost material that will perform statisfactorily. Based on fluctuating raw-material costs, core-oil prices followed a similar pattern within narrower limits with profits shaded to meet competition.

In floor coverings, varnished insulation, and thermal insulations, raw-material costs were important also; but the oil constituent occupies a less dominant position. Other raw materials--dry colors, supporting media, etc.--claim a varying share of production costs and must be considered in price adjustments. Increased labor costs have exerted a further modifying influence, although technological improvements in production methods and products may minimize this factor.

For printing inks, oil and other raw-material costs were given almost equal weight, while labor costs were secondary. Printing ink-vehicles tended to follow the course of linseed-oil prices--generally downward between 1949 and 1952--but marked increases in the costs of pigments more than counterbalanced the oil drop for 2 of the 3 ink makers.

Drying-Oil Suppliers

Introduction

The drying-oil suppliers interviewed in this study fall into 3 general classes. One group extracts or recovers the various oils and applies no purification or refining processes before sale. A second group extracts and refines the oils before sale, and the third group processes a part of their oil production to semifinished or finished vehicles. The distribution among the 3 groups of the 9 companies interviewed is indicated as:

Group 1 - Crude oil only	- 1 company
Group 2 - Crude and refined oil	- 5 companies
Group 3 - Crude and refined oils, vehicles	- 3 companies
Total	9 companies

The processing plants of the companies visited are located in all sections of the country. Since the emphasis of this study was placed on linseed and soybean oils, companies processing them predominate. Headquarters offices of the interviewees are distributed as follows: 5 in the Midwest, 3 on the East Coast, and 1 on the West Coast.

Products and Markets

Products sold by the companies interviewed include crude, refined, and processed oils, and various oil and resin combinations commonly designated as vehicles. Linseed, soybean, tung, oiticica, safflower, perilla, dehydrated castor, fish, and tall oils were considered by this study to be the "usual drying oils." Although used in the manufacture of protective coatings, printing inks, and other nonedible products, the non-drying oils, such as cottonseed, coconut, palm kernel, and castor oil were not covered by this study.

In addition to the usual drying oils (see above), walnut seed, sunflower seed, grapeseed, and rapeseed are processed or sold by at least 1 of the 9 companies.

Five of the nine companies process or sell oils from a variety of sources. Two additional firms specialize in oils from single vegetable sources, and two recover and sell oils normally considered to be derived from industrial sources.

The products of the suppliers of drying oils are sold to all the consumers of them. Excluding the company of Group 1 (crude oil only), the distribution of sales of these companies would approximate the percentages by end uses given by the Bureau of Census in the Fats and Oils "Facts for Industry" series.

Linseed oil has been and continues to be the most important drying oil. The other oils that make up the drying-oil group have shifted positions for a variety of reasons. Historically, tung oil ranked second in importance to linseed oil. World War II, the development of dehydrated castor oil, and the cultivation of the nut that produces oiticica oil combined to relegate tung oil to its present position behind soybean and tall oils. The establishment of a domestic industry for tung oil has failed to halt this decline in importance. Perilla oil, at times the third most important drying oil, became another casualty of World War II and has been unavailable since 1948.

Soybean oil, currently in second place, owes its ascendancy to the alkyd-resin mechanism that adapts a semidrying oil to drying-oil uses. Cheap sources of raw material and effective application of research have promoted tall oil from obscurity in 1942 to the third-ranking drying oil used in 1954. Fish oil has shown the least fluctuation in volume of usage among the minor oils but has varied from third to sixth in position of importance. In recent years it has ranked sixth.

Poundage consumption of linseed, soybean, tung, tall, and other drying oils in all drying-oil products is shown in table 6 for the period 1931 to 1954. Figure 4 illustrates the relative importance of the major drying oils (linseed, soybean, tung, and tall oil) by percentage consumption. Similarly table 7 shows, on a percentage basis, the fluctuations among major drying oils and minor drying oils, and portrays the steady rise of tall-oil consumption. The "other fats and oils" category includes safflower oil, cashew nut shell liquid, rapeseed oil, sesame oil, and an increasing amount of segregated fatty acids.

Table 6.- Consumption of fats and oils in drying-oil products by kind of oil, 1931-54

Year	Linseed oil	Soybean oil	Tung oil	Fish oil	Castor oil	Oiticica oil	Perilla oil	Tall oil	Other fats and oils	Total
	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds
1931	475	10	91	27	2	-	12	-	1/	619
1932	356	13	75	20	2	-	12	-	2	479
1933	376	16	104	23	2	-	27	-	2	550
1934	414	15	115	26	3	-	25	-	4	601
1935	467	19	128	34	4	2	64	-	4	721
1936	481	19	119	41	5	3	112	-	14	793
1937	583	19	148	46	8	3	43	-	4	852
1938	485	22	91	31	6	4	42	-	2	682
1939	556	33	106	44	12	17	52	-	4	822
1940	585	46	67	47	25	15	20	-	4	807
1941	807	62	69	57	46	27	9	-	3	1,079
1942	819	33	12	32	63	9	3	-	3	973
1943	757	39	12	36	22	4	2	2	16	890
1944	688	37	10	47	90	11	1/	7	27	917
1945	627	46	23	58	60	19	1/	7	35	874
1946	663	67	36	48	35	25	1/	15	47	934
1947	567	159	106	47	44	13	1/	32	50	1,017
1948	595	162	130	40	53	13	1/	36	53	1,081
1949	428	220	103	26	51	12	-	53	81	974
1950	575	213	109	33	66	12	-	75	100	1,193
1951	665	194	65	28	38	12	-	84	65	1,151
1952	536	209	51	36	41	11	-	87	61	1,032
1953	529	134	51	34	39	10	-	94	82	1,087
1954 2/	493	221	50	28	38	8	-	111	91	1,041

1/ Less than 500,000 pounds.
2/ Preliminary.

U. S. Department of Agriculture, Agricultural Marketing Service. The Fats and Oils Situation, FOS-165.

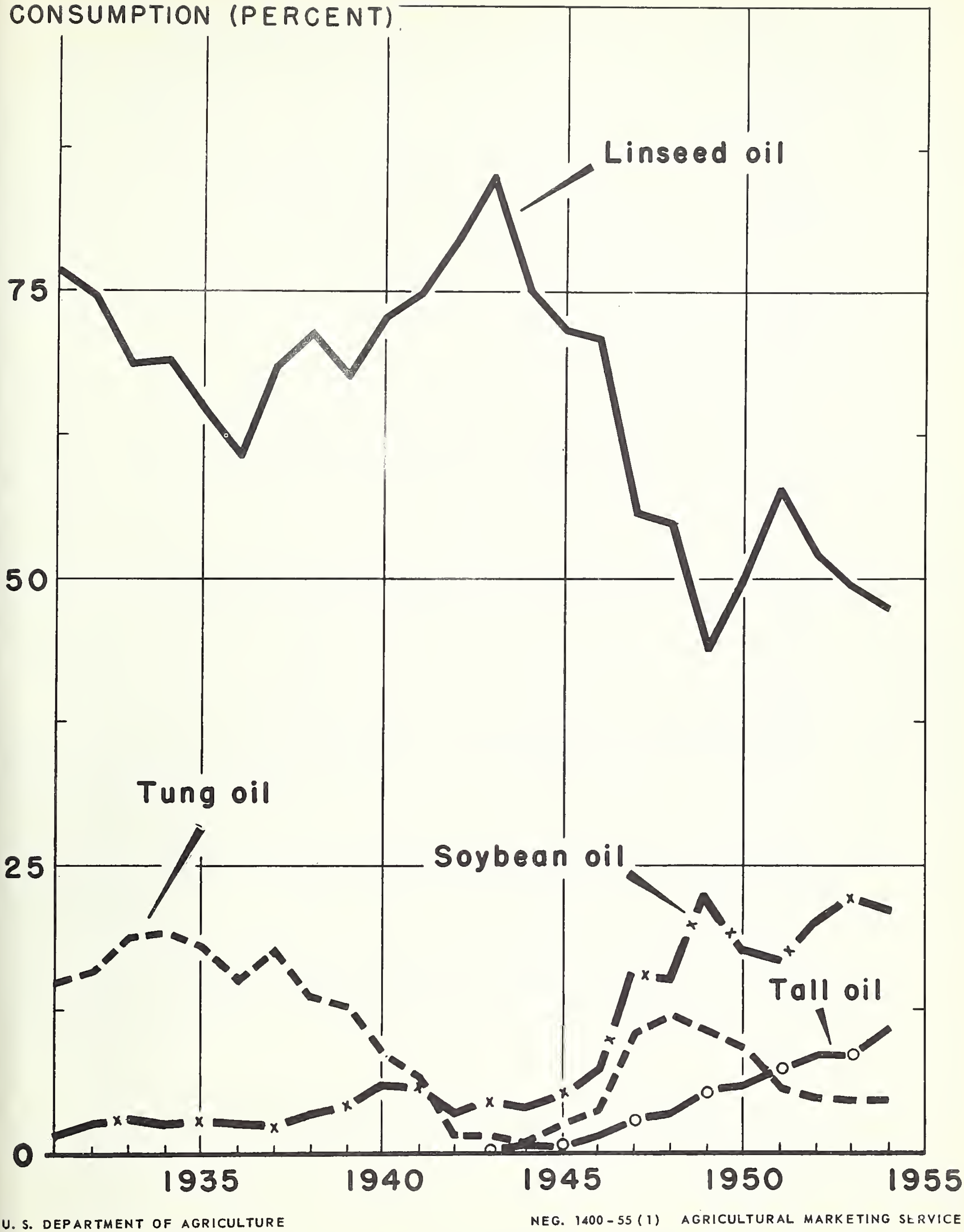


Figure 4.- Percentage distribution of consumption of fats and oils in all drying-oil products, by major oils, 1931-54

Table 7.- Percentage distribution of consumption of fats and oils in all drying-oil products, by kind of oil, 1931-54 1/

Year	Linseed oil	Soybean oil	Tung oil	Fish oil	Castor oil	Oiticica oil	Perilla oil	Tall oil	Other fats and oils
	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
1931	76.8	1.6	14.7	4.4	0.3	-	1.9	-	2/
1932	74.4	2.7	15.7	4.2	.4	-	2.5	-	0.4
1933	68.4	2.9	18.9	4.2	.4	-	4.9	-	.4
1934	68.9	2.5	19.1	4.3	.5	-	4.2	-	.7
1935	64.8	2.6	17.8	4.7	.6	0.3	6.9	-	.6
1936	60.6	2.4	15.0	5.2	.6	.4	14.1	-	1.8
1937	68.4	2.2	17.4	5.4	.9	.4	5.1	-	.5
1938	71.2	3.2	13.4	4.5	.9	.6	6.2	-	.3
1939	67.6	4.0	12.9	5.4	1.5	2.1	6.3	-	.5
1940	72.4	5.7	8.3	5.8	3.1	1.9	2.5	-	.5
1941	74.8	5.7	6.4	5.3	4.3	2.5	0.8	-	.3
1942	79.7	3.2	1.2	3.1	6.5	.9	.3	-	.3
1943	85.0	4.4	1.3	4.0	2.5	.4	.2	0.2	1.8
1944	75.0	4.0	1.1	5.1	9.8	1.2	2/	.8	2.9
1945	71.8	5.3	2.6	6.6	6.9	2.2	2/	.8	4.0
1946	71.0	7.2	3.9	5.1	3.8	2.7	2/	1.6	5.0
1947	55.8	15.6	10.4	4.7	4.3	1.3	2/	3.1	4.9
1948	55.0	15.0	12.0	3.7	4.9	1.2	2/	3.3	4.9
1949	43.9	22.6	10.6	2.7	5.2	1.2	-	5.4	8.3
1950	49.2	17.8	9.1	2.8	5.5	1.0	-	5.9	8.4
1951	57.8	16.9	5.6	2.4	3.3	1.0	-	7.3	5.6
1952	52.0	20.3	4.9	3.5	4.0	1.1	-	8.4	5.9
1953	49.3	22.3	4.7	3.1	3.6	.9	-	8.6	7.5
1954 3/	47.4	21.2	4.8	2.7	3.6	.8	-	10.7	8.7

/ Computed from rounded numbers, totals may not add to 100.
/ Less than 0.05.
/ Preliminary.

. S. Department of Agriculture, Agricultural Marketing Service, Fats and Oils Situation, FOS-165.

In 1949, the 974 millions of pounds of drying oils consumed in drying-oil products were distributed as follows: 44 percent linseed; 23 percent soybean; 11 percent tung; 5 percent tall; 5 percent dehydrated castor; 3 percent fish; 1 percent oiticica; and 8 percent all others. Within recent history--since 1912--linseed has never accounted for such a low proportion of the total drying oils used. By 1952, the 1,051 millions of pounds of drying oils consumed were distributed as follows: 52 percent linseed; 20 percent soybean; 8 percent tall; 5 percent tung; 4 percent dehydrated castor; 4 percent fish; 1 percent oiticica; and 6 percent all other oils. While linseed oil regained 8 percent of the total drying-oil products market, tall oil and tung oil traded positions in the order of importance.

Prices of the various drying oils, as well as technological advances in their production, purification, or application, influence their consumption. Referring to figure 5 and table 8, the data show that individual oils have unique patterns of price history. This chart and table attempt to eliminate the factor of diverse geographic origin of the oils and the attendant difference in shipping costs by selecting a specific market and size of purchase. With the exception of tall oil, all prices are the annual average prices for drying oils on the New York wholesale market. Grade of oil--"refined"--is roughly equivalent for all but linseed oil. Current refining charges would increase the price of linseed oil by approximately 2 cents per pound, but an accurate history of processing charges is not available to this study.

In addition to the relatively high price of linseed oil in 1949 possibly accounting for the low proportional consumption in that year, the relative stability of tall-oil prices in comparison to the price fluctuations of other oils is noteworthy.

Contract-quantity purchases of any oil will affect the cost of that oil for an individual company. Figure 5 and table 8 do not attempt to assess this factor in terms of the relative importance of the various oils to the drying-oil-consuming industries as a whole. For example, linseed, soybean, tall, and possibly tung oils are likely to be purchased in tank carlots because of their wide use. But a specific company might purchase tank car quantities of castor oil, and drum lots of linseed oil to fit its particular operations.

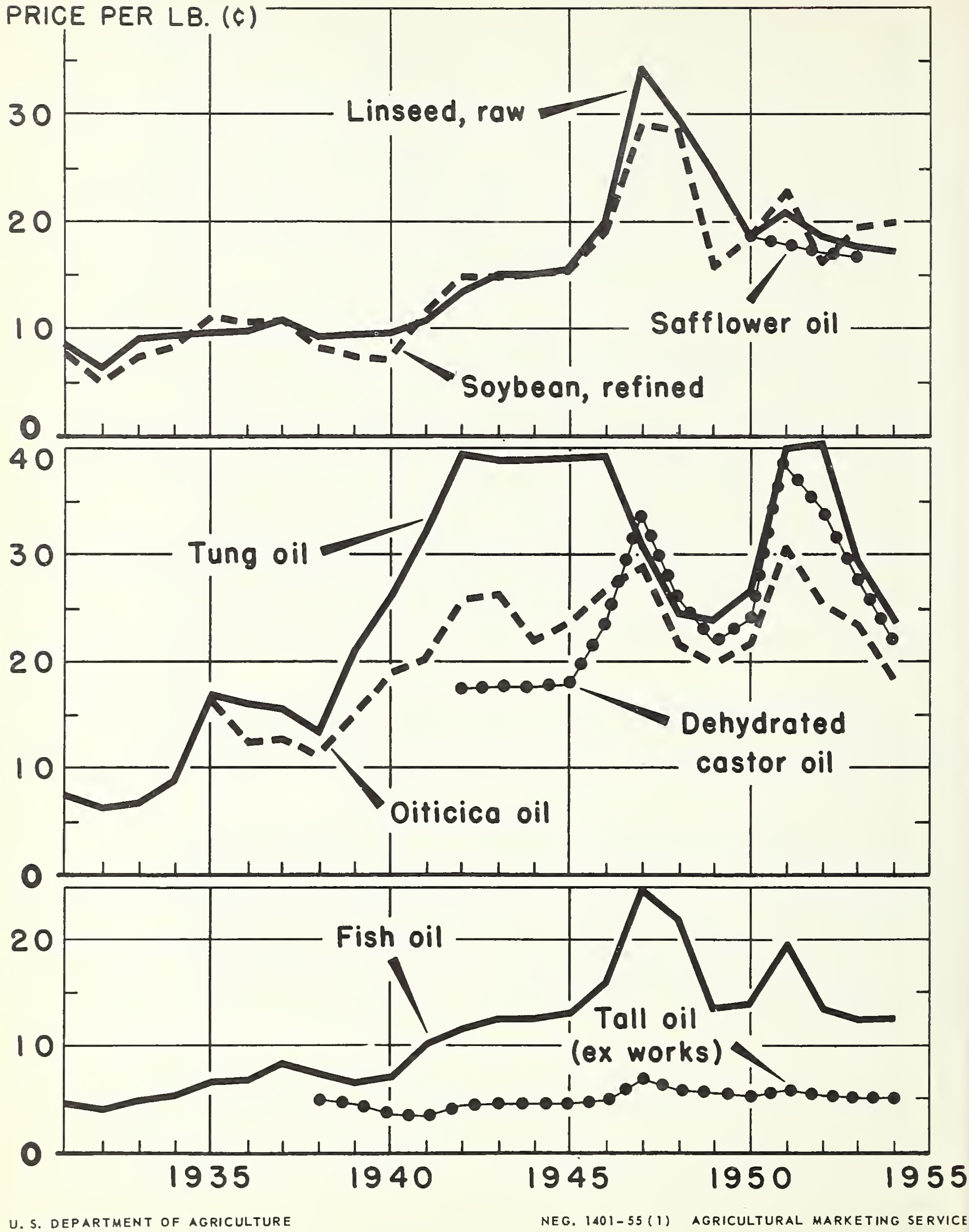


Figure 5.- Fats and oils: Wholesale prices per pound at New York, 1931-54.

Table 8.- Fats and oils: Wholesale price per pound at New York, 1931-54

Year	Wholesale price per pound							Revised Index numbers of wholesale prices of drying-oil uses 1947-49 = 100 8/
	Linseed oil raw 1/	Soybean oil refined 2/	Tung oil 3/	Fish oil refined 4/	D. C. O. 5/	Oiticia oil 6/	Tall oil refined 7/	
	Cents	Cents	Cents	Cents	Cents	Cents	Cents	
1931	8.4	7.6	7.4	4.6	-	-	-	29
1932	6.3	4.9	6.3	4.1	-	-	-	22
1933	9.0	7.4	6.8	4.9	-	-	-	31
1934	9.3	8.2	8.9	5.3	-	-	-	32
1935	9.4	11.0	17.0	6.7	-	16.3	-	36
1936	9.8	10.4	16.1	6.8	-	12.6	-	37
1937	10.8	10.7	15.7	8.3	-	12.9	-	40
1938	9.1	8.1	13.5	7.4	-	11.1	5.0	34
1939	9.3	7.4	21.0	6.7	-	15.0	4.6	37
1940	9.7	7.2	26.3	7.1	-	18.9	3.6	41
1941	10.7	11.7	32.2	10.1	-	20.2	3.5	46
1942	13.3	14.9	39.6	11.6	17.4	25.6	4.3	57
1943	15.1	14.9	39.0	12.4	17.7	26.2	4.5	64
1944	15.1	15.1	39.0	12.6	17.7	21.9	4.5	64
1945	15.5	15.4	39.2	13.0	17.8	23.7	4.5	64
1946	19.9	19.1	39.3	15.9	23.3	26.8	4.9	78
1947	34.3	29.1	30.5	24.9	33.8	28.9	6.9	118
1948	29.7	28.3	24.6	21.8	25.8	21.5	5.8	102
1949	24.7	15.8	23.9	13.3	21.6	19.8	5.4	80
1950	18.4	18.5	26.7	13.9	24.0	21.7	5.1	73
1951	20.9	22.8	40.0	19.4	38.7	30.7	5.8	95
1952	18.5	16.0	40.4	13.2	34.0	25.4	5.2	83
1953	17.7	19.4	29.3	12.3	27.7	23.5	5.0	72
1954	17.3	19.9	23.9	12.4	21.8	18.3	5.0	66

1/ Barrels before June 1940; drums, carlots, returnable basis since 1940. Charges for processing to "refined" grade will vary from 1.5 to 2.5 cents per pound, depending on the year. 2/ Quoted as barrels before 1934, after 1934 as drums. This is primarily an edible series and consequently is somewhat higher than the series that should be used for drying oil purposes. 3/ Barrels before June 1934; drums since 1934. 4/ Menhaden oil. Barrels before June 1934; drums, carlots, June 1934-November 1944; less than carlots, December 1944-December 1948; drums, light pressed since January 1949. 5/ Beginning May 20, 1942, quoted as "bodied oil" tanks. 6/ Drums. 7/ Ex works, tanks. 8/ Seventeen major fats and oils, leading markets.

Synthetic-Materials Manufacturers

Introduction

Synthetic materials used in conjunction with or to replace drying oils range from basic industrial chemicals to finished vehicles. One or more intermediate steps may be necessary to convert a raw material into a product salable to drying-oil users. At any point on this raw-material-to product scale, sales may be made to other manufacturers who carry the processing further toward finished paint.

The multiplicity of materials, variations in the number of steps between basic chemical and end product, and sales at any step complicate any attempt to analyze the "synthetic-materials industry." Furthermore, many of the same synthetic materials used by the drying-oil-consuming industries are being used by other industries.

This summary is based on the replies received from 11 manufacturers of synthetic resins or their intermediates. For purposes of analysis the manufacturers have been assigned to 1 of 3 groups:

Group 1 - Manufacture of basic chemicals, either for modification of oils or for production of synthetic resins

Group 2 - Manufacture of vehicles involving no use of drying oils

Group 3 - Manufacture of vehicles involving considerable use of drying oils

It must be recognized that assignment of a company to any one of the above groups does not necessarily imply that their sales fall entirely within that classification. This is particularly true of Groups 2 and 3.

According to this grouping, the 11 respondents are arranged as follows:

Group 1 - 3 companies
Group 2 - 2 companies
Group 3 - 6 companies

No differentiation between sizes of companies has been attempted. All the respondents market their products on a nation-wide basis, several have world-wide operations, and possibly only

2 of the 11 would not be considered major companies. The relative proportions of each respondent's products that are sold to drying-oil-consuming industries and to other industries was not disclosed by the replies received. In the companies with multiple departmental or divisional organization, the interview was restricted to the segment most directly concerned with drying oils.

Products and Markets

The products sold to the drying-oil-consuming industries are essentially the same, whether the customer is a producer of protective coatings, printing inks, floor coverings, or core oils. Minor variations in raw-materials ratios, processing techniques, or solvents were noted; but the chemical reactions involved are identical. The major deviation is found in the latex emulsions that are, to date, restricted to the protective-coatings field.

A complete listing of the materials produced and sold by the respondent companies is impractical. Outstanding examples, arranged by company group, follow.

Group 1 - Basic Chemicals (3 companies)

Phthalic anhydride
Pentaerythritol
Urea and melamine resins
Cellulosic compounds
Monomeric chemicals (styrene, vinyls, acrylonitrile)
Phenolic resins
Chlorinated rubbers

Group 2 - Nonoil Vehicles (2 companies)

Latices (butadiene-styrene, vinyl, styrene)
Substituted phenolic resins
Polyethylene
Dispersion resins

Group 3 - Oil-Bearing Vehicles (6 companies)

Alkyd resins of all types
Oil-soluble and oil-modified phenolic resins

The protective-coatings industry is the major market for the products of 9 of the 11 resin manufacturers. The others sell primarily to the plastics industry.

Although varying from company to company, floor coverings, printing inks, core oils, and thermal insulation materials usually follow the protective-coatings industry in that order as markets for these resin materials. The distribution among end uses suggested by the Bureau of Census for drying oils would appear applicable to the resins as well.

Until 1947, two separate sets of statistics on synthetic resins and plastics were maintained, one by the Bureau of Census and the other by the Tariff Commission. Starting with 1948, all statistical reports have been integrated under jurisdiction of the Tariff Commission. The rapid growth of the synthetic resin and plastic segments of the chemical industry, the lack of standardization of nomenclature within it, and the reluctance of companies to divulge production statistics have complicated the task of reporting meaningful figures. No one doubts that synthetic resins have found increasing application in the protective-coatings and other drying-oil-consuming industries.

The attempt to quantify, year by year, the actual consumption of the resins is difficult. Figure 6 and table 9 present a summary of available information for total synthetic-resins production for protective coatings, and for certain types of resins that are included in the total. Reports of the Tariff Commission form the basis for these data, sometimes modified by the publicly expressed opinions of experts in the fields of paints and varnishes, and plastics. No data about the consumption of cellulosic materials in lacquers have been discovered.

Raw Materials and Their Effect on Synthetic-Resin Prices

Considering only the materials that eventually find their way into the drying-oil-consuming industries, the distinction between synthetic-resin manufacturers and the suppliers of their basic raw materials is obvious. The companies of Groups 1 and 2 are basic suppliers, and those of Group 3 are the resin producers. The latter group buys a minimum of 75 percent of its raw materials, whereas the others purchase 25 percent or less.

Sales of basic chemicals to other manufacturers who make products for the drying-oil-consuming industries depend on the capacity of the individual company's plant for processing the basic materials. A number of the respondents have capacity in excess of their own needs for phthalic and maleic anhydride, pentaerythritol, styrene and acrylic monomers, and phenol. Where this condition exists, they sell these materials.

Between 1949 and 1952, prices of products varied significantly, largely as a result of raw-materials price shifts. One company, very basic in raw materials, dissented from this consensus. In this instance, processing economies allowed gradual product-price decreases while raw material costs remained stationary.

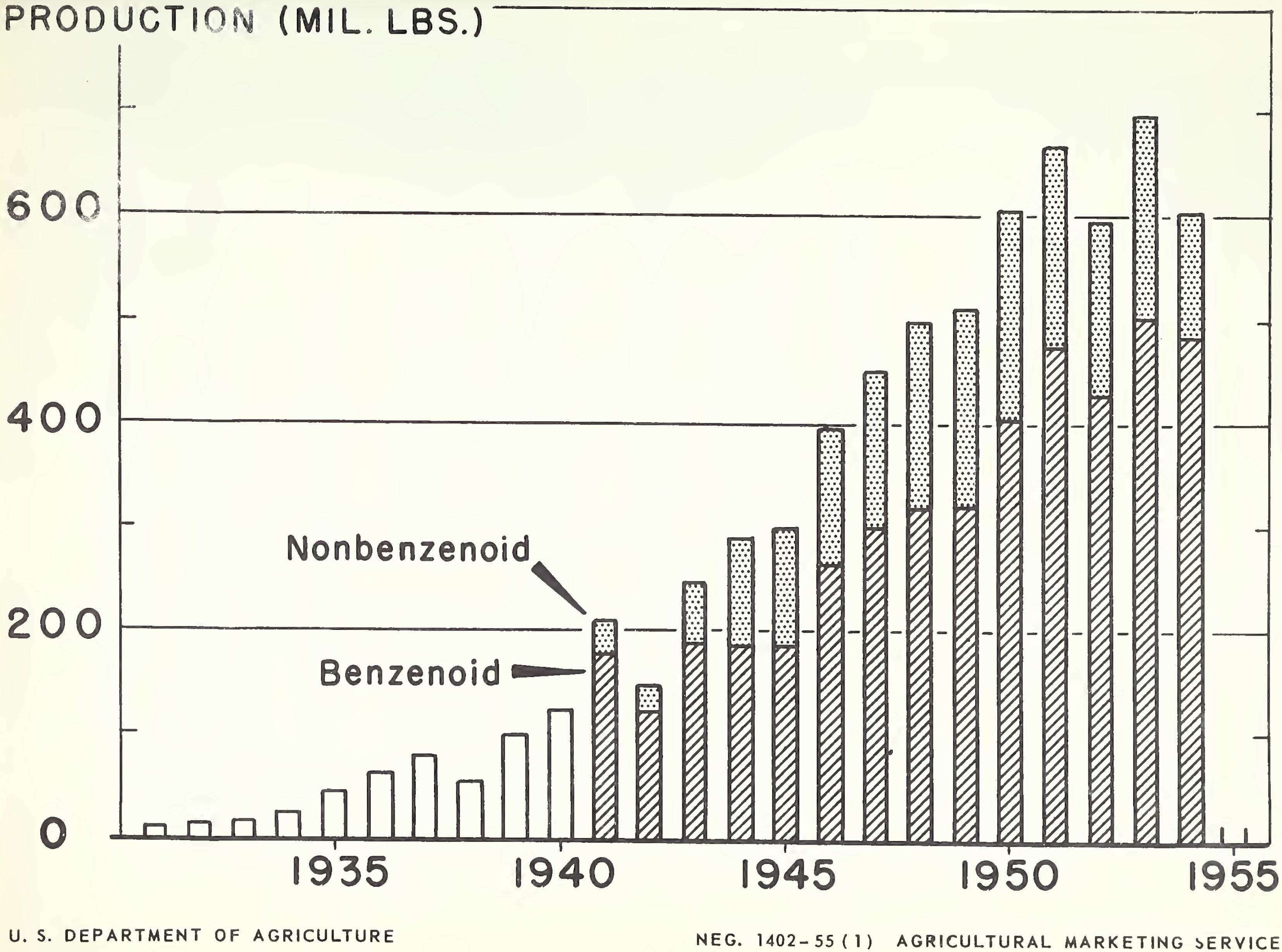


Figure 6.- Production of synthetic resins for protective-coating uses, by major chemical types, United States, 1931-54.

Table 9.- Production of synthetic resins for protective coatings, by types, United States, 1931-54 1/

Year	Benzenoid types				Nonbenzenoid types						Grand total
	Phthalic alkyds	Tar acid resins	Styrene resins 2/	Total	Rosin esters and adducts	Urea and melamine resins	Vinyl resins	Non-phthalic alkyds	All others 3/	Total	
	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds
1931	7.3	4.3			38.4				0.5		12.1
1932	11.4	3.0			28.4	0.2			1.0		15.6
1933	9.9	6.3			48.0	.4			1.0		17.6
1934	15.2	10.0			69.5	.5		0.1	1.0		26.8
1935	34.3	10.4			98.2	.5		1.0	1.5		47.7
1936	45.6	14.0			96.0	1.0		1.4	1.5		63.5
1937	58.5	16.0			99.6	1.5		2.8	2.0		80.8
1938	37.6	12.5			96.7	1.0		3.4	2.0		56.5
1939	70.2	19.2			116.6	2.5		6.3	2.0		100.2
1940	91.5	19.9			114.0	3.0		6.5	2.0		122.9
1941	124.3	37.2	4/	178.0	5/	6.6	4/	4/	44.0	34.1	212.1
1942	89.2	28.0	4/	123.3	5/	2.7	4/	4/	28.4	25.0	148.3
1943	153.6	17.5	4/	191.1	17.9	4/	4/	4/	60.4	58.3	248.4
1944	127.1	31.2	4/	188.7	5/	3.4	4/	4/	129.1	102.1	290.8
1945	137.3	21.4	4/	188.7	83.8	5.6	4/	15.8	45.3	120.5	309.2
1946	191.0	28.7	4/	266.8	104.6	4/	4/	13.6	60.2	131.3	398.1
1947	222.0	63.0	17.9	302.9	115.6	4/	4/	14.7	20.6	150.1	453.0
1948	239.3	57.6	24.2	321.1	83.8	23.6	10.9	40.3	20.2	178.8	499.9
1949	263.1	40.5	17.9	321.5	60.4	18.7	4/	53.3	60.1	192.5	514.0
1950	6/333.0	46.4	25.8	405.2	74.4	29.8	20.1	69.0	9.5	202.8	608.0
1951	368.4	53.9	51.4	477.3	72.3	25.5	22.1	50.6	22.0	192.5	669.8
1952	337.3	26.7	68.7	429.1	95.1	24.1	21.0	3.6	24.5	168.3	597.4
1953	389.2	28.2	84.2	501.6	103.4	30.4	22.3	20.9	17.5	194.5	696.1
7/1954	325.0	25.0	85.0	435.0	90.0	25.0	25.0	20.0	10.0	160.0	605.0

1/ Prior to 1948, poundage given as net resin content, excluding fillers, plasticizers and diluents. 1948 and after, poundage given as "dry basis" including fillers and plasticizers, but not water or liquid diluent. 2/ Includes styrene for oil or alkyd addition, styrene polymers, and copolymers containing styrene. 3/ Includes benzenoid and nonbenzenoid types not classed elsewhere. 4/ Included with "all other." 5/ Not included in "all other" category. 6/ Beginning with 1950, alkyd category includes virtually all alkyd manufacturers, an increase in coverage of 10 to 15 percent. 7/ Preliminary.

U. S. Tariff Commission Reports.

Variations in the prices of the drying oils, phthalic anhydride, benzene, and glycerine were mentioned as causes of product-price changes. Ten of the eleven companies stated that raw materials costs were the determining factor in product-price fluctuations.

Between 1949 and 1952, benzene and glycerine increased in price, while phthalic anhydride dipped in 1950 and recovered in 1951 and 1952. These are annual average prices. Glycerine showed the greatest fluctuation, jumping from 16.7 cents per pound in 1949 to 44.1 cents per pound in 1951, and falling to 23.9 cents per pound in 1952. Figure 7 and table 10 show the price histories of benzene, phthalic anhydride, glycerine, and drying oils as a group as index numbers on the 1947-49 = 100 base. Drying oils and glycerine were the most variable in the 1949-52 period.

Résumé

While the companies selected for interviews for this study are not the only manufacturers in their respective fields, they represent a good cross section of the industries interested in the future of drying oils. Producing and consuming industries are represented from the first nonagricultural contact with drying oils to the manufacture of an end product. Producers and consumers of competing materials are also included. The collected opinions are believed to be based on a selection that is large enough to be considered representative of the current and probable future position of the drying oils.

It must be emphasized that the diversity of interests represented by a large number of end uses, and hence end products, tends to obscure the development of anything except major trends. Each interviewee has his own place to fill in the mosaic that constitutes the drying-oil picture in the United States. His opinions and ideas will be limited by the boundaries of his interests and must be interpreted with this in mind. Also, each interview must be taken at face value, until a preponderance of contrasting opinions indicates that a particular company is out of step.

CURRENT PATTERNS OF DRYING-OIL USES

In attempting to evaluate the future market prospects for fats and oils in drying-oil uses, it is a prerequisite that one determine what has happened to the pattern of drying-oil consumption in recent years, and what changes are still in progress. Simultaneously, it is necessary to find out what the reasons have been for the changes that have occurred in these years. A major share of the effort in this study was directed toward gathering

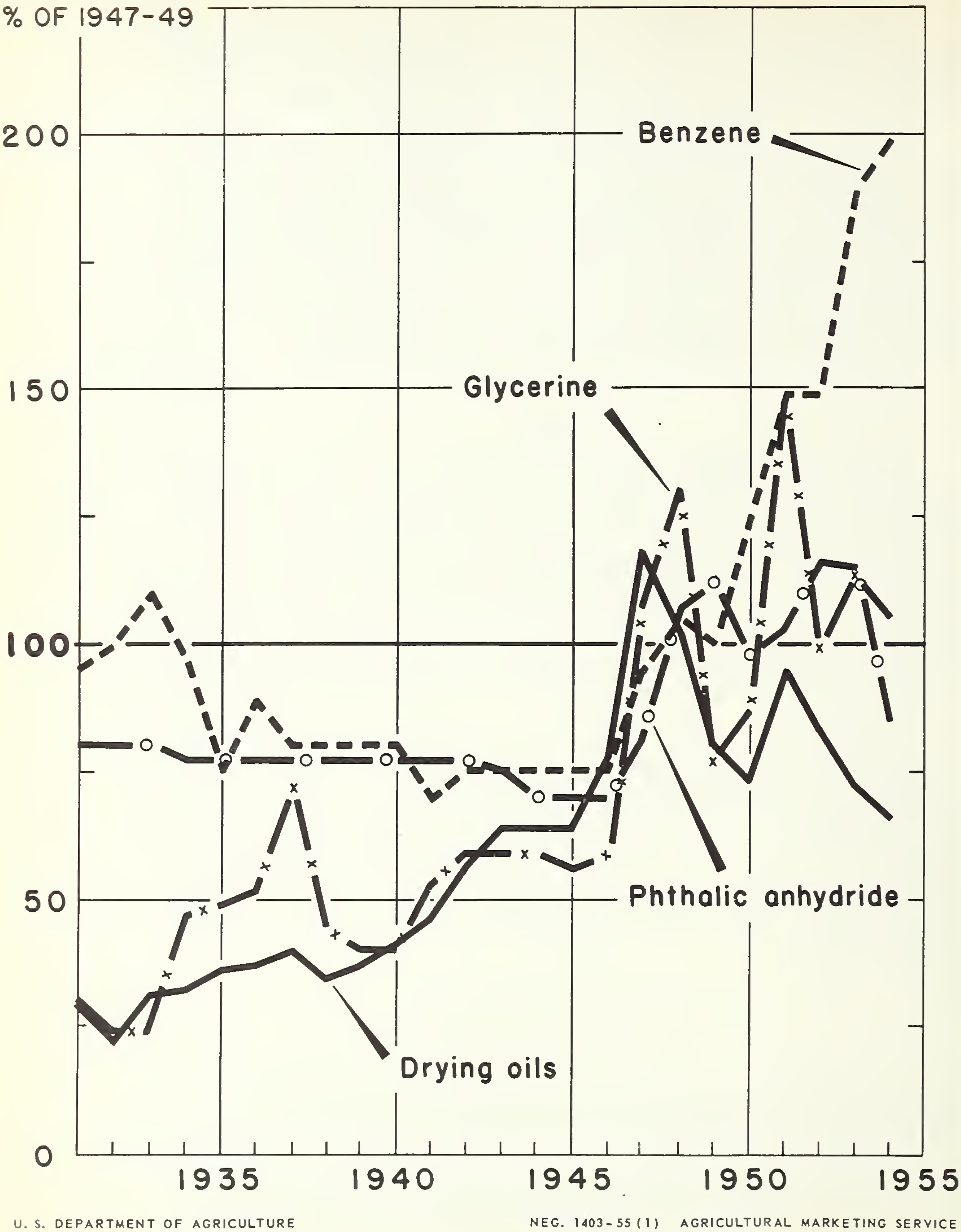


Figure 7.- Index numbers of wholesale prices of selected chemicals and drying oils, 1931-54

Table 10.- Index numbers of wholesale prices of selected drying oils and chemicals, 1931-54

(1947-49 = 100)

Year	Drying oils	Benzene	Phthalic anhydride	Glycerine
1931	29	95	80	30
1932	22	100	80	24
1933	31	110	80	24
1934	32	96	77	47
1935	36	75	77	49
1936	37	89	77	52
1937	40	80	77	72
1938	34	80	77	44
1939	37	80	77	40
1940	41	80	77	40
1941	46	70	77	53
1942	57	75	77	59
1943	64	75	75	59
1944	64	75	70	59
1945	64	75	70	56
1946	78	75	70	59
1947	118	95	81	107
1948	102	105	107	130
1949	80	100	112	77
1950	73	125	98	87
1951	95	149	103	148
1952	83	149	116	99
1953	72	189	115	113
1954	66	199	85	105

U. S. Department of Agriculture, Agricultural Marketing Sercice; U. S. Tariff Commission.

and analyzing such information, and the section of the report that follows presents the findings in this regard.

The end-product designations of the industries that consume drying oils or their substitutes are as follows:

Paint, varnish, and lacquer, including putty
Floor coverings, i.e., linoleum and printed felt-base coverings
Printing inks and printing-ink vehicles
Core oils
Table oilcloth and fabric wall coverings
Varnished cambric (electrical) insulations
Thermal insulations
Friction materials, including brake linings and packings
Other products having minor drying-oil usage.

The industries that supply drying oils or competitive materials include synthetic-resins manufacturers and oil processors. Admittedly, some of the interviewees could be considered to operate in more than 1 category--i.e., companies producing 2 or more end products or companies acting as both a supplier and end-product manufacturer. In general, interviewees were assigned to the industry in which their experience with drying oils predominates.

For the balance of this report, the data collected from interviewees have been segregated into two major categories of end uses. Protective-coatings uses are considered separately because of their preponderant control of drying-oil consumption. All other uses of drying oils are collected into an "other major uses" category. Data from synthetic-resins manufacturers and oil processors have been distributed to these two categories where applicable.

Protective-Coatings Manufacturers

Recent Changes in Paint Formulations

In the final analysis, the formulations used in making paints, varnishes, and lacquers are the major determinant of demand for various paint raw materials. A knowledge of recent trends in paint formulation practice and the reasons underlying these trends is essential to an understanding of shifts in demands for these raw materials. The influence of these trends on the oil suppliers and synthetic-resin manufacturers who supply the raw materials or partially processed intermediates is equally important. In this section, a detailed analysis is made of the formulation changes that have occurred, the reasons for them, the related changes in practice of raw-material suppliers, and the influence of Government purchases on the overall paint-formulation picture.

Changes in paint formulation can affect any of three major elements of protective-coatings--vehicles, pigments, or thinners. Since drying oils or their substitutes normally enter paint formulations as vehicles, the emphasis of this study centers on vehicles and the constitution of vehicles.

Aside from the historical evidence of decreasing consumption of drying oils because of constantly increasing paint sales, a glance at the technical literature of protective coatings suggests substantial changes in paint formulation in recent years. At the beginning of the period--1949--a typical publication (Official Digest of the Federation of Paint and Varnish Production Clubs) carried 30 articles dealing with paint formulations. The pigment-volume relationships in white house paints and the properties and potentialities of vinyl resins, styrenated oils and alkyds, silicones, styrene-butadiene copolymers, fatty acid esters, chlorowax, tall-oil varnishes, and several unusual oils were investigated and reported. In the intervening years, maleic-treated soybean oil, styrene copolymers, dimer acids, amino resins, copolymers ("the new paint vehicles"), modified phenolics, and epoxy resins have entered the paint picture. It was inevitable that some formulation changes would result from this research effort on the part of paint makers, resin manufacturers, and oil processors.

Between 1949 and 1952, many changes in formulations were effected by the paint companies interviewed for this study. Forty-one indicated that the changes were significant, that is, involved an addition of a new line, an upgrading of an existing line, or a shift in major raw materials to meet price competition. There are 5 firms, including 2 of the top 15, still using the same formulations.

The outstanding changes may be summarized as:

New line additions

- Latex emulsion vehicles (all types)
- Epoxy resin vehicles
- Styrenated alkyd vehicles

Quality improvement changes

- Alkyd flat vehicles
- Water-thinned industrial primers

Price competition changes

- Alkyd vehicles replacing oleoresinous vehicles
- Increased use of tall oil in alkyds
- Synthetic baking enamels replacing lacquer

The net result of these changes has been to decrease slightly the oil content per gallon of protective coating.

Reasonably accurate calculation of the oil content of paints and varnishes is possible only for the years for which the Department of Commerce compiled a Census of Manufactures. Compilations have been made in 1931, 1935, 1937, 1939, and 1947. The gallonage of paint and varnish produced in these years can be related to the consumption of drying oils as reported by the Department of Agriculture to derive an average oil content per gallon of paint.

Using the estimates of gallonage paint production from table 3, page 17, and the consumption of fats and oils in protective coatings (except those oil-bearing resins produced by companies other than paint and varnish manufacturers) from table 1, page 10, the estimates of average oil content in table 11 (charted in fig. 8) have been developed. Figure 8 shows a fairly steady decline in the oil content of all paints, varnishes, and lacquers, and of oil-bearing paints and varnishes as well, between 1931 and 1941.

Between 1941 and 1946, the general shortage of fats and oils resulted in a rapid decline in the oil content of these products. Since 1947, the more conservative paint companies have been gradually increasing the amount of oil, particularly in outside house paints. so that a slight gain over 1946 is evident. Variations from year to year, evident in the 1947 to 1952 period, may be the result of shifts in the proportion of trade and industrial sales recorded in a dynamic economy.

As stated on page 11 it is estimated that 90-95 percent of the fats and oils used in synthetic resins ultimately go back in protective-coating uses. If these quantities are included in the totals for paints, varnishes, and lacquer (protective coatings), the decline in the average oil content is not as great as otherwise noted. These data are also shown in figure 8 for the years 1949-54, the only years these data are available.

Most of the formulation changes that occurred during the 1949-52 period related to trade-sales lines, influencing interior coatings primarily. Formulas for industrial-product finishes remained relatively stable, major changes having been effected prior to 1949.

Two factors influencing formulation changes should be mentioned. First, consumers of industrial-product finishes are reluctant to shift from successfully used materials unless significant quality improvements or cost reductions can be demonstrated. This tends to minimize minor modifications by the manufacturer to achieve

Table 11.- Consumption of oils in paint and varnish and estimated production of oil bearing paint and varnish and total paint and varnish, 1931-54

Year	Consumption of oils, fats and tall oil 1/	Estimated production of paint and varnish: Containing drying oils: Quantity 2/	Containing drying oils: Oil content per gallon 3/	Total: Including lacquer 2/	Total: Oil content per gallon
	Million pounds	Million gallons	Pounds	Million gallons	Pounds
1931	524	4/152	3.5	4/218	2.4
1932	405	120	3.4	172	2.4
1933	459	135	3.4	193	2.4
1934	506	154	3.3	220	2.3
1935	611	4/186	3.3	4/267	2.3
1936	654	208	3.1	297	2.2
1937	702	4/234	3.0	4/336	2.1
1938	563	189	3.0	270	2.1
1939	673	4/223	3.0	4/319	2.1
1940	652	231	2.8	324	2.0
1941	875	303	2.9	428	2.0
1942	775	291	2.7	395	2.0
1943	700	313	2.2	423	1.7
1944	694	349	2.0	464	1.5
1945	644	358	1.8	481	1.3
1946	683	413	1.7	579	1.2
1947	706	4/399	1.8	4/545	1.3
1948	766	396	1.9	549	1.4
1949	655	349	1.9	485	1.4
1950	776	432	1.8	599	1.3
1951	743	389	1.9	542	1.4
1952	691	374	1.9	536	1.3
1953	750	381	2.0	556	1.4
1954	686	375	1.8	545	1.3

1/ U. S. Department of Agriculture, Agricultural Marketing Service.
2/ Estimates by Stanford Research Institute, Chemical Economics Handbook, Battelle Memorial Institute.
3/ See footnote 5, table 1, p. 10. Application of the 90-95 percent synthetic resins going into paints and varnishes are shown for the years 1949-54 in figure 8. The data used are as follows:

Year	Estimated production of paints and varnishes containing drying oils: Oil content per gallon	Estimated production of total paints and varnishes: Oil content per gallon
1949	2.1	1.5
1950	2.0	1.5
1951	2.3	1.6
1952	2.2	1.5
1953	2.3	1.6
1954	2.2	1.5

4/ U. S. Department of Commerce, Census of Manufactures.

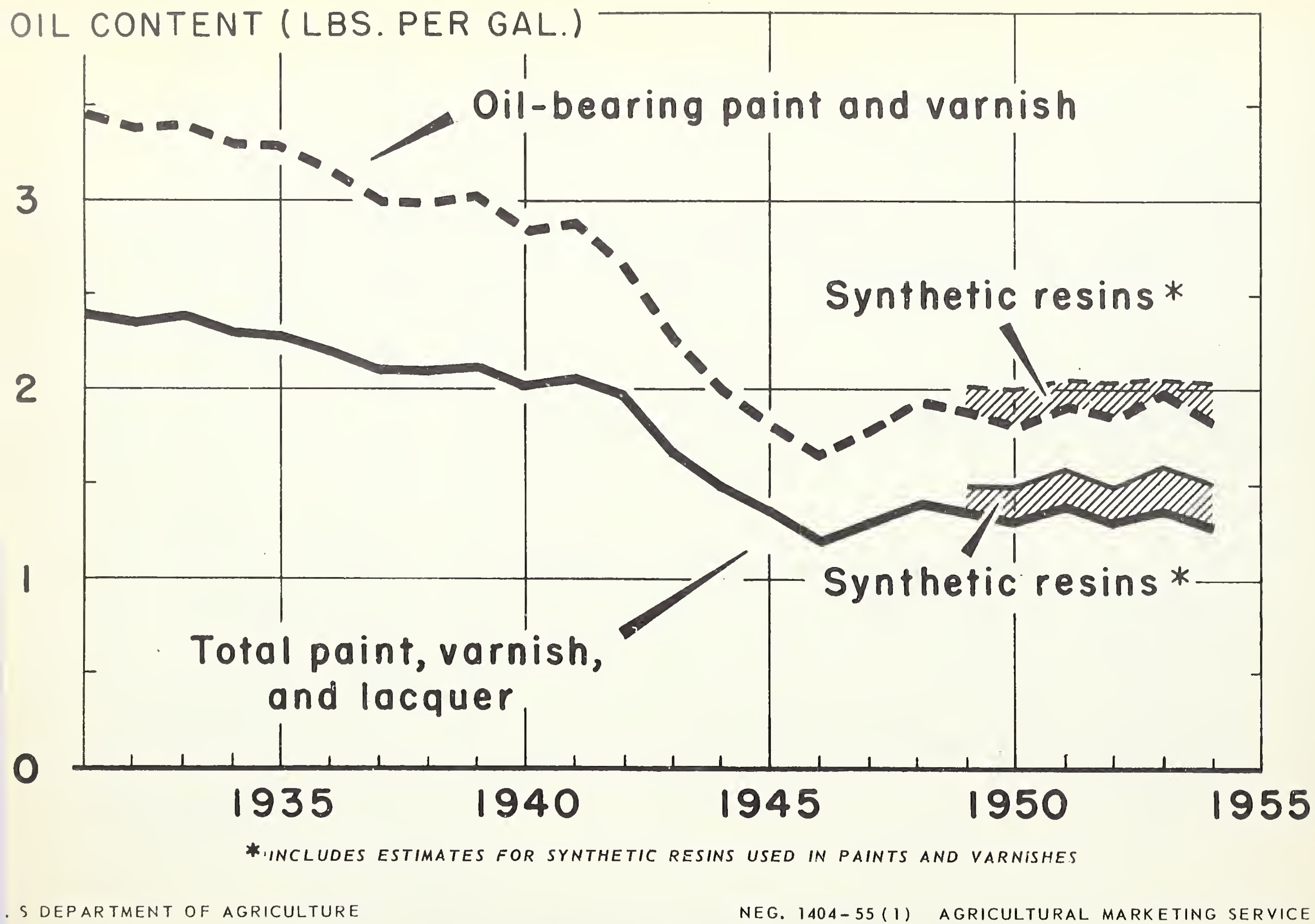


Figure 8.- Oil content per gallon of all paint, varnish, and lacquer production, and oil-bearing paint and varnish production, 1931-54.

economic sales advantages. The trade-sales consumer is less critical of changes that influence application of the coating, but desirous of optimum quality in the end result. Thus, maintenance of the paint manufacturer's reputation in performance of product is more important than the specific formulation employed. Second, both quality and price enter into any formulation change. This factor will be weighted in varying degree by each company, and few generalizations are warranted.

In view of the changes recorded in paint-vehicle formulation, changes in the resins and chemicals used by the protective-coatings industry would be expected and did take place. The oil-bearing resins and nonoil vehicles changed more than the basic chemicals from which are they constructed. Three resin companies of Group 1 (3 basic chemical producers), 1 company of Group 2 (2 nonoil vehicle manufacturers), and 1 company of Group 3 (6 oil-bearing resin makers) reported no significant change in formulation of resins between 1949 and 1952. However, during 1953, 3 of these 5 companies started commercial production of new materials that would shift their answer into the category of "significant change."

New types of vehicles or chemicals introduced during the two periods, 1949-52 and 1953, are:

1949-52

Silicone alkyd resins
Interior flat alkyds
Epoxy-modified oils and alkyds
Polyvinyl acetate resins
Styrenated alkyds
Pentaerythritol in adequate supply

1953

Acrylic resin emulsions
Polyethylene materials in adequate supply

Improvement of some property, or combination of properties, was cited as the reason behind these changes. The silicone alkyds were developed for coatings with higher heat resistance. Interior flat alkyds replaced oleoresinous vehicles in order to compete with latex emulsions. Epoxy resins add chemical and mar resistance to finished films. Styrenated alkyds speed drying time and increase durability. Pentaerythritol, available and priced more realistically than glycerine, allowed the development of a series of improved alkyds. According to their producers, the new materials of 1953 increase the range of film-formers available and will have improved characteristics over the materials in use during 1952.

New developments for future introduction include a long-oil alkyd vehicle for exterior wood finishes and nonoil polyester resins with general utility.

Eight of the eleven synthetic-resin respondents use drying oils in one or more formulations, six to a major degree. Oil-containing products of the two minor oil users are specialty items in which specifications restrict changes in formulation. Among the synthetic-resin manufacturers classed as major oil users, numerous minor shifts and a very few significant formulation changes took place between 1949 and 1952. Alkyd vehicles--a combination of drying oil, a dibasic acid, and a polyhydric alcohol--retained their lead among the synthetic resins.

Variations in the proportions of the ingredients and substitutions among the acids and alcohols used in the alkyds were listed as changes that occur regularly. One company indicated a tendency to swing between several combinations of oils as oil prices changed, but soybean oil remained the primary oil raw material. Phthalic and maleic anhydrides were the major acids, while pentaerythritol started to challenge glycerine as the principal alcohol constituent. No specific formulations were divulged that might illustrate a change made during the 1949-52 period. However, there was a general replacement of hard resins by new alkyds, and a trend toward a lower oil content was noted by one company. The development of alkyd vehicles for odorless flat wall paints was also mentioned.

The use of chemical modifying agents for alkyds became more popular during this period, and resulted in formulation changes in the direction of lower oil content. In particular, silicone- and epoxy-resin-modified alkyds and copolymerized styrene alkyds were added to the sales lines of some of the companies.

Improved film properties, involving either application or performance characteristics, were the motivating force for the majority of the changes. Economic considerations prompted some, such as the increased use of pentaerythritol and the one company's shifts among the oils. An unusual, but possible important, reason suggested by one company was that alkyd vehicles are advantageous for the paint companies since they require less skilled labor, less equipment, and fewer raw materials--in general a less complicated procedure.

The absence of any mention of styrene-butadiene latex vehicles on the part of the resin manufacturers is not considered unusual. These materials were available prior to 1949, and the basic formulation was introduced to the paint industry in 1948. The rapid adoption of this vehicle type by the paint industry--from an estimated 2 million pounds in 1949 to about 40 million pounds in 1952--is significant, so is the fact that each gallon of paint produced from this material requires only 1.5 pounds of film-forming constituent.

Turning to the oil suppliers, 8 of the 9 interviewees process oils beyond the crushing stage. Among these, processing of oils was greater in 1952 than in 1949 for 7 companies. Chemical modifications of the oils have increased as demands for specialized oils or vehicles has increased. The changes include upgrading of the oils by improved refining or by chemical modifications such a conjugation, increasing the value of production by conversion to higher-priced products, and utilization of low-grade starting materials for products acceptable to other manufacturers. Some of these changes resulted from intense research effort on the part of the oil suppliers, while others followed the demands for specialized materials. Still other changes occurred because the oil supplier could develop a large enough market to produce the necessary material economically.

The exception to this trend, the company whose processing has remained stable, foresees an adequate market for its current products; and management has decided to "freeze" the process.

In large measure, the new products, formulations, and techniques that came into being in both the synthetic-resin industry and the oil-supplying industry during the 1949-52 period resulted from demands made on these companies by their customers.

Between 1949 and 1952, the resin producers noted a change from a seller's market to a buyer's market that intensified attention to specifications, performance, and price. Again, the chemical raw materials (phthalic and maleic anhydride, glycerine, pentaerythritol, styrene, vinyl monomers, and phenol) have been least affected because of their relative chemical purity as normally produced. The synthetic resins, butadiene-styrene latices, and vehicles of all types are continually under pressure of consumer demands for greater uniformity and price reduction. Improvement in performance of these products, however, usually requires the development of new lines.

Nine of the 11 resin companies agreed that improved performance demands were more insistent than demands for price concessions but that neither could be ignored. In response to these demands, all the respondents have developed new products, and four admitted that new processing techniques were involved. Nonoil-containing products accounted for the majority of the new processes developed between 1949 and 1952 or cited as being in the development stage since then.

The oil suppliers have noted an increase in the chemical modifications of oils, stemming from several of the demands of the paint industry. Improved properties of paint products, utilization of cheaper raw materials, and faster processing of vehicles were given as the major reasons for the development of chemical modifications of oils. Of course, the alkyd formulations are the best known and most used means of improving the properties or upgrading an oil. Epoxy resins and styrene-oil alkyd copolymers are others that illustrate this trend. One oil company stressed the fact that chemical modification of oils will go beyond present practice.

In the final analysis, the ultimate consumer will determine the relative importance of chemical modifications of oils or substitution of nonoil film-forming materials through his purchases of paint materials. This has been proven by the acceptance of styrene-butadiene latex paints, and, more recently, the increasing acceptance of the so-called "odorless flat alkyd" wall paints.

Since the Government of the United States, at both Federal and State levels, has been a major consumer of paints and paint materials in recent years, an attempt was made to determine the effect of Government specifications on paint manufacture.

The consensus of the paint company interviewees is that Government paint specifications have had very little carry-over into general paint-manufacturing practice. The vinyl wash primer, a styrenated alkyd shell coating, and traffic paints were noted as exceptions. Most of the companies feel that Government specifications are designed for minimum acceptable quality and low prices and are deficient in not specifying processing procedure as well as raw materials. There was some slight indication that the specifications are improving, but general acceptance is not expected.

Magnitude of Government purchases affected seven of the companies interviewed. Five are American firms; two are Canadian. Only 1 of the top 15 is included. Four additional companies indicated that past (1948 or 1949) volume was significant but they no longer sell their products to the Government.

Starting with customer requirements, protective-coatings manufacturers have built a sprawling, multiproduct industry with the help of research on the part of everyone connected with it, producer or supplier. The advancement of chemical technology has been frequently cited as the motivating force for the current importance of synthetic materials at the expense of the classical drying oils. However, sociological changes and the rediscovery of the value of promotion have made important contributions. The "do-it-yourself" fad and "week-end decorator kit" are the result of social change assisted by applied science. An understanding of this relationship is basic to the understanding of the present market for drying oils in paints and varnishes.

Flexibility of Paint Formulations and Substitution Among Drying Oils

The extent to which substitutions can be made in paint formulations is necessarily limited. In general, factors of raw-material quality, availability, and price must be balanced against factors of product quality, processing techniques, and competitive conditions. The nature of this balance, the character of the substitutions that have been and can be made, and the limitations involved in such substitutions--either in finished paints or paint intermediates--are considered here.

Throughout the years of paint history, certain combinations of materials have been recognized as indispensable to a particular coating use, or, at least, as the best available materials for that use. Current instances of such technological requirements could be expected to explain partially the present consumption pattern of the drying oils. Further, an examination of the formula types might lead to valuable conclusions regarding future consumption patterns.

Formulations maintained for technological reasons represent a minority of the formulations made by the protective-coatings industry. Although small in actual number, these formulations do account for a substantial proportion of the total volume of paint produced. Specifically, most of the companies are reluctant to change their premium grade outside house paints, waterproof varnishes, insulating varnishes, internal can coatings, or certain highly specialized baking enamels.

Considerations other than technological irreplaceability weigh far more heavily on the industry. First, there is the necessity to maintain the company reputation, and, in some instances, the label identification of ingredients. Second, many industrial-product finishes have protective functions that involve liabilities far in excess of the cost of the paint. Third, industrial consumers insist on comparable application techniques as well as comparable or better quality. Fourth, a good many companies are reluctant to change because of raw material storage, production scheduling, equipment use problems, or the possibility of human error in mixing. All these factors tend to limit the use of "substitute" formulas, or replacement formulas based on a temporary cost discrepancy.

The changes that occurred between 1949 and 1952, both in interior trade-sales lines and industrial-product finishes, were based on the following: Marked superiority to any existing coating, adequate performance at a much lower cost in below-top-quality products, or continued nonavailability or excessive price of an important ingredient.

In spite of the resistance to change by most of the companies, eight firms indicated that they are not bound by the restrictions listed above. With 1 exception, they are not among the top 15 companies, and this answer is subject to conditions peculiar to each company.

The synthetic-resin manufacturer is faced with a slightly different problem in formulation. First, the specifications describing his products can be expressed in more concrete terms than can the specifications for paint. Chemical constitution, exact boiling ranges, and chemical purity can be applied frequently, in addition to the comparative physical tests of color and viscosity. Second, the definiteness of the chemical makeup of many synthetic resins precludes as wide a variety of starting raw materials as that available to the paint manufacturer.

Shortages of key raw materials would tend to disrupt the synthetic-resin industry. Many products have specific raw-material requirements that preclude substitution. Within the past 5 years, this vulnerability of the industry has been mitigated by the construction of additional processing facilities to assure a continuing supply of essential materials. Productive capacity for phthalic anhydride, pentaerythritol, and vinyl monomer has greatly increased since 1949.

Substitutes have been developed for a number of raw materials, but, frequently, the substitute results in new resins rather than an alternate material for an old resin. Isophthalic and terephthalic acids, trimethylolethane and trimethylolpropane, and acrylic monomers were mentioned in this connection.

The synthetic film formers, based on petrochemicals, appear to offer a wider choice of starting material than either the lacquers or alkyd-and oleoresinous vehicles. Natural gas, petroleum refining byproducts, or even coal liquefaction fractions can be used to produce vinyl, acrylic, styrene, and butadiene monomers.

Another major difference between the resin producers and the paint manufacturers lies in the nonprotective-coatings uses to which the resin producer can put his current products or minor modifications of them. Perhaps the most pertinent illustration of this would be the shift possible between styrene-butadiene latex paint vehicles and synthetic rubber. Not all the resin companies interviewed have such a ready substitute market. However, the development of new markets for adequately available raw materials has been one of the chief factors in the growth of the chemical industry of which the resin makers are a part.

The shortage of drying oils during World War II led to some intensive research into the possibility of substituting an oil in good supply (regardless of source) for one in short supply. Again, the effect on current paint and vehicle formulations can be related to either the paint or synthetic-resin industries.

For the protective-coatings industry, direct substitution of one oil for another is the exception rather than the rule. In the majority of cases, a complete reformulation, at least of the vehicle, is necessary. Technical comparability of the end-products, delivered price of the various oils, and other economic factors enter into the consideration of any particular substitution.

The majority, 36 of 45 companies responding, said that each formulation change has to be studied in the light of the current price differentials and the probable duration of the differential. The other 9 companies, including 4 of the top 15, have tested and established alternate formulas for 1 or more product, and shift at varying specific differentials between certain oils. The specific price differential at which alternate formulas are used was stated by only 2 companies, at 6 cents and 10 cents per pound. Two others said that variations of one-half cent in the current differential was enough to institute substitutions.

Availability of the oils, disregarding price discrepancies, is admittedly a legitimate basis for change. However, two companies insisted that they had, and would, withdraw products from the market rather than attempt to reformulate.

The answers received from the 45 respondents may be classified into 3 groups. The first group would change formulations only under extreme provocation, and are identified in table 12 as "No Change." The second group has some formulations that are subject to rather ready changes, and are identified as "Some Change." The third group changes most or all of their formulations rather readily, and is identified "Free Shift." The respondents are arranged by company group according to product line and size.

The most significant difference appears to be the relative inflexibility of industrial formulations. Four of the 10 companies prominent in both trade and industrial sales and classified as "Some Change" stated that the changes would be in trade-sales lines only. This would indicate that 12 of the 28 companies with substantial industrial production maintain these formulations if at all possible. Nine more of the 28 limit their shifts to 1 or 2 sets of alternate oils--e.g., treated soybean for linseed, oiticica for tung, safflower for soya, or safflower for dehydrated castor.

Table 12.- Paint respondents' answers to questions regarding substitutions among drying oils

Type of company group	No change	Some change	Free shift
	Number	Number	Number
Predominantly trade sales	3	11	3
Prominent in both	2	10	4
Predominantly industrial sales	6	4	2
Total respondents	11	25	9
Respondents among top 15	3	8	3
Others	8	17	6
Total respondents	11	25	9

The comparison of answers by size of company distribution is interesting in that no apparent difference is to be noted between the large and smaller companies.

The practices of companies that produce oil-containing resins compare closely with those of paint companies making industrial-product finishes in their reluctance to make substitutions. Seven of the eight resin producers of oil-bearing vehicles do not change oils in an established formulation. If price or availability indicate replacement of an oil, a new product or a complete new line is introduced under its own name or number identification. For the eighth company, substitution of certain oil combinations for others is relatively easy in their alkyd vehicles, and variations of 1 cent per pound in the price of oils is enough to justify a change.

One of the seven companies that do not change suggested strongly that a reasonable assurance of price stability of the oils is an important prerequisite to the decision to add a new product or a complete line of products based on a certain oil.

Statistics of the consumption of the various drying oils in paint and varnish products are not, of themselves, indicators of the substitutability of the oils. The per capita increase in paint consumption tends to cloud the picture. But the evidence is clear that certain oils have replaced others, either because of shortages or economic advantages (table 13). Figure 9 records the consumption of certain drying oils as a percentage of total drying oils consumed in protective-coatings products for the years 1931 to 1954.

Several features of this chart are significant. First, consumption of linseed oil has declined from prewar and wartime percentages of total drying-oil consumption in protective coatings, but it appears to be leveling off at about 55 percent. Second, tung oil usage has declined from a prewar peak of almost 19 percent in 1937 to only 6 percent of the total in 1954 and presently seems destined to rank as a secondary, or minor, drying oil. Third, soybean oil is emerging as the most serious threat to linseed oil, accounting for almost 22 percent of the consumption in 1954. Fourth, the balance of drying-oil consumption is split among a number of sources, including tall oil and other fatty acids. The consumption of none of these oils consistently approaches 10 percent. In other words, linseed oil still dominates the drying-oil scene, challenged by soybean (in place of tung), and losing some ground to the sum total of all the other drying oils.

Since formulation of paint vehicles varies so widely, no attempt has been made to reconcile the consumption of individual oils with the gallonage of paint produced from each oil. Linseed oil is used in oil paints in the form of raw, refined, and bodied oil. Also, it is modified by the addition of chemical reagents to form paint and varnish vehicles. On the other hand, soybean oil primarily enters alkyd vehicles, in which it may constitute 40 to 85 percent of the total weight of the film-forming materials (an oil-modified alkyd resin). Consequently, it is probable that more gallons of paint products are produced from 100 pounds of soybean oil than from an equivalent weight of linseed oil. In other words, the percentage of total oil consumption attributed to soybean oil (17.4 in 1952) is not a true measure of the importance of soybean oil in paint manufacture. More than 17.4 percent of the oil-bearing paint products produced in 1952 were based on soybean oil.

Table 13.- Utilization of selected oils, fats, and tall oil in protective-coatings products, 1931-54 1/

Year	Linseed oil		Soybean oil		Tung oil		Crude and dehydrated castor oil 2/		Fish oils		Oiticica oil		Perilla oil		Tall oil		Other fats and oils 3/		Total paint and varnish
	Quantity	Percentage of total	Quantity	Percentage of total	Quantity	Percentage of total	Quantity	Percentage of total	Quantity	Percentage of total	Quantity	Percentage of total	Quantity	Percentage of total	Quantity	Percentage of total	Quantity	Percentage of total	
	Million pounds	Percent	Million pounds	Percent	Million pounds	Percent	Million pounds	Percent	Million pounds	Percent	Million pounds	Percent	Million pounds	Percent	Million pounds	Percent	Million pounds	Percent	Million pounds
1931	410	78.2	6	1.1	82	15.6	2	0.4	12	2.3	-	-	11	2.1	-	-	1	0.2	524
1932	311	76.8	7	1.7	66	16.3	1	.2	8	2.0	-	-	9	2.2	-	-	3	.7	405
1933	329	71.7	9	2.0	89	19.4	2	.4	9	2.0	-	-	19	4.1	-	-	2	.4	459
1934	363	71.8	10	2.0	97	19.2	2	.4	12	2.4	-	-	19	3.8	-	-	3	.6	506
1935	408	66.8	13	2.1	112	18.3	3	.5	19	3.1	2	0.3	50	8.2	-	-	4	.7	611
1936	411	62.8	14	2.1	106	16.2	4	.6	24	3.7	3	.5	86	13.1	-	-	6	.9	654
1937	481	68.6	16	2.3	134	19.1	7	1.0	28	4.0	3	.4	32	4.6	-	-	1	.1	702
1938	406	72.2	15	2.7	82	14.6	6	1.1	16	2.8	4	.7	33	5.9	-	-	1	.2	563
1939	462	68.6	22	3.3	97	14.4	11	1.6	26	3.9	16	2.4	38	5.6	-	-	1	.1	673
1940	473	72.5	30	4.6	62	9.5	24	3.7	31	4.8	14	2.1	16	2.5	-	-	2	.3	652
1941	649	74.2	42	4.8	63	7.2	44	5.0	41	4.7	26	3.0	7	0.8	-	-	3	.3	875
1942	654	84.4	25	3.2	11	1.4	50	6.5	23	3.0	8	1.0	2	.3	-	-	2	.3	775
1943	610	87.2	20	2.9	10	1.4	17	2.4	27	3.9	3	.4	2	.3	2	0.3	9	1.3	700
1944	516	74.4	19	2.7	8	1.2	83	12.0	38	5.5	9	1.3	4/	-	7	1.0	14	2.0	694
1945	465	72.2	26	4.0	18	2.8	52	8.1	43	6.7	17	2.6	4/	-	7	1.1	16	2.5	644
1946	502	73.4	30	4.4	32	4.7	30	4.4	36	5.3	20	2.9	4/	-	11	1.6	22	3.2	683
1947	419	59.4	89	12.6	87	12.3	35	5.0	34	4.8	10	1.4	4/	-	13	1.8	19	2.7	706
1948	440	57.4	100	13.1	102	13.3	48	6.3	27	3.5	8	1.0	4/	-	22	2.9	19	2.5	766
1949	321	49.0	124	18.9	84	12.8	39	6.0	15	2.3	5	.8	-	-	18	2.7	49	7.5	655
1950	428	57.1	117	15.1	92	11.9	47	6.1	21	2.7	10	1.3	-	-	20	2.6	26	3.4	761
1951	483	65.0	88	11.8	54	7.3	26	3.5	22	3.0	10	1.3	-	-	34	4.6	26	3.5	743
1952	396	57.3	120	17.4	44	6.4	17	2.5	32	4.6	9	1.3	-	-	32	4.6	40	5.8	691
1953	405	54.0	161	21.5	43	5.7	17	2.3	31	4.1	7	.9	-	-	34	4.5	51	6.3	750
1954 5/	359	52.3	149	21.7	43	6.3	17	2.5	25	3.6	6	.9	-	-	34	5.0	54	7.9	686

1/ Computed from rounded numbers. Percentages may not add to 100 because of rounding.
2/ Dehydrated castor oil appears first in 1942. Since 1942, the ratio of dehydrated to crude castor oil has been 4.5: 1.
3/ Includes coconut, cashew shell, safflower, and other primarily oils, as well as fatty acids other than tall oil.
4/ Less than 500,000 pounds.
5/ Preliminary.

U. S. Department of Agriculture, Agricultural Marketing Service.

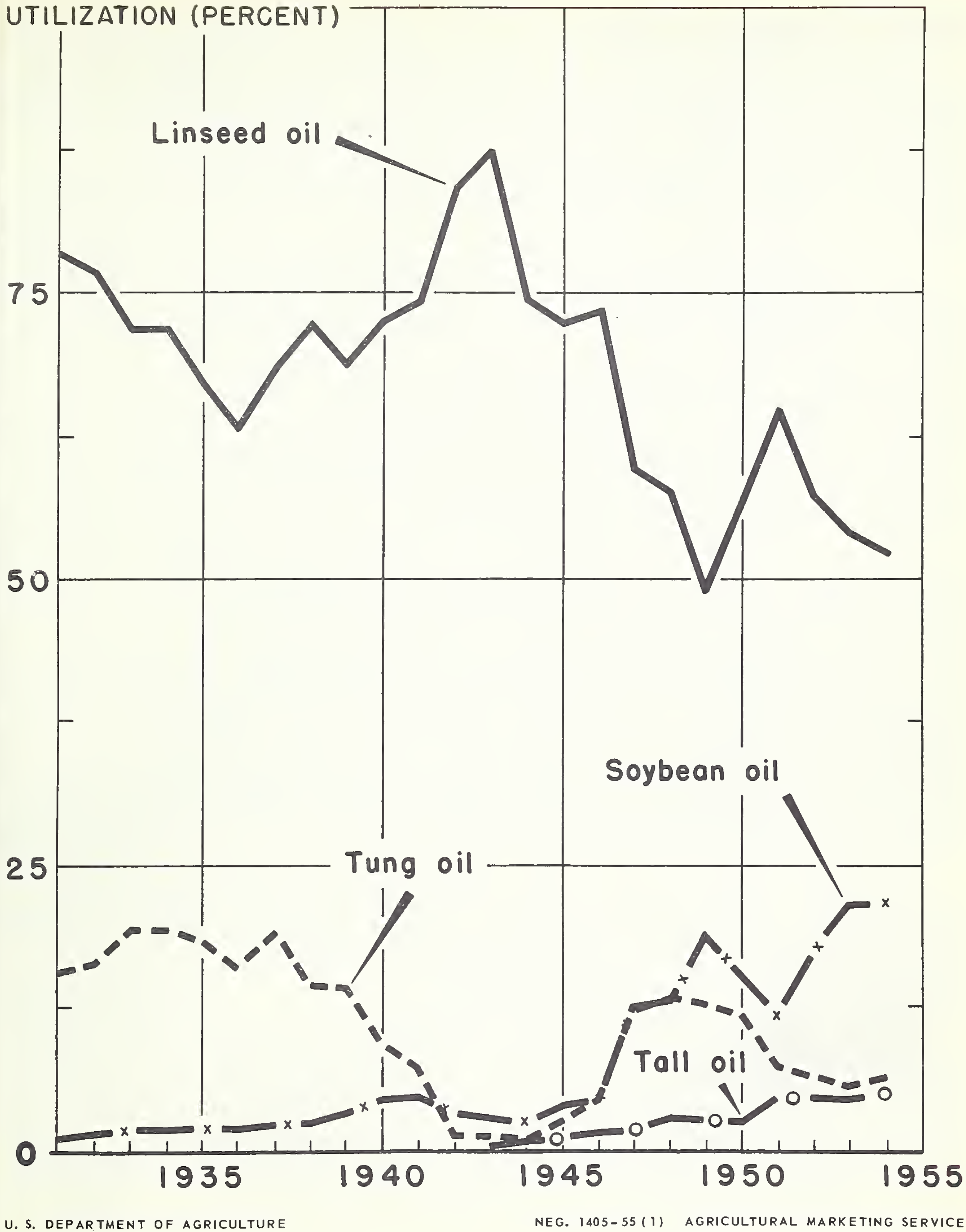


Figure 9.- Percentage distribution of utilization of selected oils, fats, and tall oil in protective-coatings products, 1931-54.

Tall Oil in Protective Coatings

Tall oil is a nonagricultural product that appears to compete directly with the drying oils. As indicated previously, relatively few direct substitutions of one oil for another are found in current paint technology. Tall oil is not an exception to this statement. However, several factors suggest the value of attempting to determine its present position and the reasons for that position.

Tall oil is a mixture of fatty and rosin acids that, in itself, does not have the drying characteristics necessary for paint-film formation. Combined with a polyfunctional alcohol, tall oil can yield a vehicle that is suitable for some protective-coatings applications. More frequently, it is used in conjunction with other oils in the manufacture of varnish vehicles. In general, the protective-coatings industry regards tall oil as an inexpensive ingredient for second- or third-quality lines of paint products. But segregation of the fatty acid constituent of tall oil upgrades the material sufficiently to make it directly competitive in quality with soybean fatty acids.

The use of tall oil in protective coatings increased between 1949 and 1952. The extent of the increase is not subject to calculation from the statistics collected during the company interviews. Of the 46 paint companies, 17 did not use any tall oil in 1952, although 5 are working with it experimentally. Sixteen additional companies used varying quantities, described as "negligible," "minor," or less than 2 percent of total oil consumption. Three companies--two industrial and one in both trade and industry--recognize it as an important oil, with their usage of it increasing substantially between 1949 and 1952. Whatever increase actually was recorded for the industry as a whole, the universal reason given was tall oil's low price.

The three major users of tall oil specialize in industrial wood varnishes. The minor users indicate that it appears in their trade-sales lines, in either a second- or third-quality line. Two companies of this group have discontinued the use of tall oil since 1949 and do not anticipate returning to it.

Beyond the price consideration, the upgrading of tall oil by continuing research effort on the part of the producing companies was mentioned by eight consumers. Ten additional consumers bought out specific points of superiority, such as "quite durable alkyds," "tall-oil varnishes perform better than tung-oil-limed rosin varnishes," "best oil in certain uses, e.g., in an epoxy ester," "stable in dip tanks," "good alkali and acid resistance," and "good weathering." However, in all cases price was given as the primary reason for tall oil's use. Unlike a number of synthetic film-forming materials, tall oil does not impart superior film qualities that would cause it to be used in place of other lower-priced or equally priced materials.

A minor use of tall oil as a prime oil was suggested by one company and may hold true for others. In the one instance, a tall-oil alkyd is the vehicle used to make the tube colors for tinting base formulations to a customer's shade specification. The quantity of tall oil entering this market is small but does illustrate the point of superior properties--in this case package stability and ease of pigment dispersion--that some manufacturers claimed for tall oil.

Even the suppliers of tall oil admit that its increasing usage is based on its relative cheapness compared to the drying oils. Although the wording was different, five of the oil suppliers agreed that tall oil has no technical advantages as a film-forming agent. However, films with satisfactory service performance that contain tall oil offer an economic advantage over films containing only vegetable oils. According to one large oil supplier, a major demand for cheaper coating materials exists, and tall oil helps meet that demand.

Secondary reasons advanced for tall oil's increased usage in the past were its availability during periods of vegetable oil scarcity, research that has adapted it to new applications, and its price stability.

The Department of Agriculture (Fats and Oils Situation) reports that protective-coatings consumption of tall oil increased from 18 million pounds in 1949 to 32 million pounds in 1952. This represents a gain of 78 percent, the result of price, price stability, and continued research.

Unusual Oils in Protective Coatings

In order to get a complete picture of drying-oil usage in protective coatings, one must consider not only the conventional, long-established oils but also those that are classified as "unusual" at the present time because of the limited application they have had to date. Such oils, although admittedly unimportant at the moment in the overall drying-oil situation, may at some future time play a major role in the protective-coatings industry. Thus, an evaluation of their past and current positions is a helpful indication of their possible future importance.

Around the fourteenth century walnut oil was prized by artists for the light color of varnishes that could be prepared from it. The advent of quantity production of oil varnishes seems to have focused attention on the more readily available oils such as linseed oil. However, the present development of vehicles with specific and limited properties warrants an inquiry into current usage.

Linseed, soybean, tung, oiticica, dehydrated castor, safflower, fish, perilla, and tall oils are considered to be the usual drying oils. Drying oils other than these appear to have minor usage in the protective-coatings field. Three of the 46 companies expressed interest in but did not see commercial importance, in oils like corn oil, citrus seed and peel oils, stilingia oil, and sunflower oil. One of the top 15 companies admitted using unusual oils commercially, but did not reveal either the oils or the type of vehicle in which they appear.

Safflower oil was frequently mentioned in the discussion of "unusual" oils. Seven companies said they were investigating it at the time of the interview, and were very much interested in it. Nine firms are using safflower oil in commercial quantities. Geographic location (West and East Coasts) can be considered to be the determining factor for 6 of the 9, while the remaining 3, in inland locations, appreciate its qualities in spite of high transportation costs.

Limited availability of the unusual drying oils appears to be the biggest stumbling block to their development. To a certain extent, this is true also of safflower oil, which has attained commercial importance only in the past five years. One large paint company said that they would be happy to experiment with any unusual oil that could be made available in commercial quantities.

Eight of the nine oil suppliers sell only the usual drying oils. The geographic location of the ninth company may account for its broader range of oils sold. The unusual oils constitute a minor part of total oil sales by this supplier, and the large number of drum-lot consumers precludes analysis of end use. None of the companies process the unusual oils.

Although interest in the unusual oils is academic, it appears that fatty acids, including tall-oil fatty acids, are offering increasing competition to the normal drying oils.

Five of the oil suppliers produce vegetable fatty acids and tall-oil fatty acids either for use in vehicle manufacture or for sale. In addition to linseed and soybean fatty acids, cottonseed, coconut, and castor, as well as low-rosin-content tall fatty acids, are isolated. Two of the companies indicated that fatty acids separation represents a large share of their processing of oils.

Other Major Users of Drying Oils

Recent Changes in Formulation of Products

As in the case of protective coatings, product formulations have a major part in determining raw-materials usage by companies that make drying-oil-containing products other than protective coatings. New chemicals, new processing methods, and changed consumer demands in recent years have resulted in significant changes in formulations for many of these products. What the changes were and why they were made are discussed in this section.

Technological change typifies the American industrial scene, particularly since the end of World War I. All branches of industry have been affected to a degree. Since the drying oils exhibited changes in their principal application, the secondary applications should be examined for changes in the comparable period, i.e., 1949-52.

As indicated previously, the applications reviewed in this section have not accounted for a large share of drying-oil consumption, either collectively or individually. The possibility exists, however, that one or more of them might have changed in recent years, or be about to undergo changes that would drastically revise the pattern of drying-oil consumption in the future.

Table 14 presents the consumption patterns of drying oils and fats in nonprotective-coatings products for the period 1949-53. Other than floor-covering products and oilcloth, which account for roughly 10 percent of drying-oil consumption, printing inks and core oils are recognized as important drying-oil consuming products. Fabric wall coverings, varnished cambric (electrical) insulations, impregnated building material (thermal) insulations, impregnated friction materials, and all other drying-oil consuming products constitute such a minor percentage of drying-oil consumption that they have been grouped together. However, each of the above products has its own technical problems in the use of drying oils.

Among the companies producing a given product--printing ink, for example--there was considerable uniformity in the responses to the question of formulation changes. There was little consistency, however, in the replies from manufacturers of different products.

Table 14.- Utilization of drying oils and fats in products other than protective coatings used in paints and varnishes, by type of product and type of oil, 1949-53 1/

Year	Linseed oil	Tung oil	Oiticica oil	Castor oil: No. 1 and No. 3	Castor oil: Dehydrated	Fish oils	Soybean oil	Tall oil	Other primary and secondary	Total
	Mil. lbs.	Mil. lbs.	Mil. lbs.	Mil. lbs.	Mil. lbs.	Mil. lbs.	Mil. lbs.	Mil. lbs.	Mil. lbs.	Mil. lbs.
	Floor coverings and oilcloth									
1949	76	10	2/	1	2	4	37	16	2	148
1950	90	5	0	3	3	4	29	16	3	153
1951	101	1	2/	2/	2/	2	10	15	4	134
1952	89	2/	2/	1	2/	1	17	13	3	125
1953	86	2/	2/	1	2/	1	12	15	1	117
	Resins									
1949	6	2	0	2	1	0	44	6	21	82
1950	22	4	0	4	1	0	45	8	21	105
1951	32	4	0	7	2	0	82	11	18	156
1952	16	3	0	17	2	0	62	15	13	128
1953	21	4	0	14	2	0	58	13	17	129
	Others 3/									
1949	25	7	6	4	3	7	16	12	7	87
1950	35	8	2	3	3	8	22	26	50	157
1951	49	6	2	0	3	5	14	24	15	118
1952	34	3	2	3	2/	3	9	27	6	87
1953	36	1	0	8	0	0	10	35	4	93
	Grand total									
1949	107	19	6	8	6	11	96	34	31	317
1950	147	17	2	10	7	12	97	50	73	415
1951	182	11	2	7	5	7	106	50	38	408
1952	140	6	2	21	2	4	88	55	22	340
1953	143	6	0	23	2	1	80	63	22	339

1/ Estimates based on rounded figures.
2/ Less than 500,000 pounds.
3/ Includes protective coatings (other than paint and varnish), printing ink, core oil, insulation, other coated fabrics, hydraulic brake fluid, linings and packings.

U. S. Department of Agriculture, Agricultural Marketing Service; U. S. Department of Commerce, Census Bureau.

All four producers of printing inks and printing-ink vehicles stated that there had been no significant changes in the formulation of their drying-oil-containing products during the period between 1949 and 1952. In each instance, major shifts in product formulations had occurred prior to 1949. Perhaps the most important of these was the shift from oleoresinous varnishes to alkyd vehicles. Improved product quality was the basis for this shift. Alkyd-based letterpress and offset inks were found to dry more rapidly, thereby facilitating the use of high-speed packaging machinery. These inks also produce a more durable film with greater rub-resistance, and reduced the odor problem that is of particular concern in the printing of food-packaging materials.

A second major change in printing-ink formulation during the 1940's was the introduction of "heat-set" and "steam-set" inks. The former inks, based on a resin-mineral oil combination, have very rapid drying properties and have become prerequisite to the operation of the high-speed presses essential to the existence of widely distributed national magazines. "Steam-set" inks, based on a solution of a resin in diethylene blycol, have become equally important in the printing of bread wrappers. These inks have little or no odor and permit the waxing of bread-wrapping paper within a very brief time after printing. As a result, the printing and waxing of these wrappers has been reduced from a 2-step operation to one that is virtually continuous. In essence, these two types of inks, which contain no vegetable drying oil, have been found capable of performing printing jobs that previously used linseed-based inks could not do.

A third shift in printing-ink formulation, currently in progress, is evident in the increasing production of aniline- and gravure (alcohol-shellac)-type inks.

In contrast to the responses given by printing-ink producers, all four floor-covering manufacturers who were interviewed indicated that there had been significant changes between 1949 and 1952 in the formulation of their products. A considerable variety of changes was cited, but 1 or both of 2 causes--improvement of product quality or economy in raw material purchases--appeared to underlie all of them.

One company stated that it had shifted from oleoresinous vehicles based on linseed oil to alkyd-type vehicles based on soybean and tall oil. In so doing, they were able not only to improve product quality (especially gloss retention), but also to use less expensive oils. A second company increased its usage of modified oils, maleic anhydride, and fractionated oils when dehydrated castor and tung oils were in short supply and relatively high priced.

At the third company, major shifts in formulation were made to improve product quality. An alkyd-type finish for printed floor coverings was introduced, since it produced a surface with better color retention and greater resistance to alkali and abrasion and, at the same time, permitted faster processing in the manufacturing plant. For the same reasons, this company also changed from lacquer to a melamine finish in making decorative interior wallboard. The fourth company substituted both esterified tall oil and safflower oil for linseed oil in making floor coverings. Quality improvements resulted in both cases, as well as raw-material economies.

Responses from producers of core oils were conflicting. Two of them indicated that they had made no significant changes in their core-oil formulations during the 1949-52 period. A third stated that lower-priced materials--both oils and other ingredients--had been substituted in order to maintain the company's position in a highly competitive field. The fourth company reported that it had made more changes in core-oil formulations between 1949 and 1952 than in any other 4-year period. Different metals and sands came into common use, customers requested changes in product specifications, and the company's technical laboratory developed better methods for making core oils. Two important resulting changes were the increasing use of chemically modified oils and the virtual abandonment by some companies of petroleum polymers (i.e., clay polymers) as raw materials in core oil production.

For the other products included in this category, only brake linings and related friction materials and varnished cambric insulation showed no significant changes in formulation during the 1949-52 interval. Economic and product-quality considerations led to formula changes in the remaining products. As linseed oil prices declined from their peak levels, the use of this oil as a normal ingredient in table oilcloth, wall coverings, and thermal insulations was resumed--in large measure displacing the styrene-butadiene and tall oil that had been previously substituted for linseed for price reasons.

There were three indications of the trend away from drying oils. First, production of competing lines of table and wall coverings based on synthetic materials was increased. Second, synthetic resins were substituted for drying oils in wallboard impregnants (to eliminate an odor problem). Finally, synthetic materials were used more and more in the manufacture of electric-coil impregnants.

In another instance, an inorganic material was substituted for linseed oil in thermal insulations, because it provided greater resistance to fire. In all these cases, the shifts to synthetic materials were made because the resulting products had superior qualities to those based on drying oils.

During this same 4-year period, silicone-coated glass was developed commercially as a substitute for varnished cambric in electrical insulation. This is a very high-priced material, however, and the United States Navy is the sole customer for the product at the present time.

The new oils and resins required to effect the changes enumerated above had far less effect on the resin manufacturers and oil suppliers than did the reformulations of the protective-coatings industry. In the majority of cases, the nonprotective-coatings consumers of resins and oils represent a minor part of the supplier's business.

Specifically, the absence of change in printing-ink formulations, particularly those containing drying oils, is reflected in the absence of new resins and oils developed by the respective manufacturers. The changes in composition of floor coverings were made on the basis of established materials (chiefly vinyl resins) or slight modifications of materials (chiefly alkyd resins) developed for use in protective coatings. The effect of nonoil materials in this instance is readily seen in table 14. Core-oil manufacturers adapted phenolic resins and tall oil rather than search for new materials, and oil consumption remained fairly stable. Electrical-insulation manufacturers maintained the previously used formulations, but added a silicone-glass insulation for a special application where expense is secondary in importance. Producers of the other products had no basic changes in formulations.

In part, the low level of interest in nonprotective-coatings uses for synthetic resins and highly processed oils stems from the desire shown by the manufacturers of the end products to process all raw materials. In general, the companies that make floor coverings, printing inks, core oils, etc., start with raw ingredients in making these products. Five of the 15 firms indicated that they buy no semimanufactured materials (vehicles or varnishes) from other companies; 8 stated that they purchase between 5 percent and 20 percent of the total vehicles they use; the remaining 2 companies quoted figures of 80 percent and 90 percent in response to this question. Only 4 of the companies--2 printing-ink makers, 1 core oil producer, and, obviously, the manufacturer of printing-ink intermediates--sell any semimanufactured materials to other companies.

Furthermore, several of the drying-oil consumers stated that the drying oils that enter their products frequently require treatments markedly different from the processing that fits an oil for application in protective coatings. Linoleum-type floor coverings, for example, involve controlled bulk oxidation of the drying oil, whereas oxidation of the oil in a paint film occurs some time after the preparation of the paint. On the other hand, core-oil- and thermal-insulation-impregnant films are developed economically from the whole oils, rather than the chemically modified or treated oils.

Flexibility of Product Formulations and Substitution Among Drying Oils

Formulations for drying-oil-containing products other than protective coatings vary widely in their flexibility. Some of these formulations can be changed readily to take advantage of new, more available, or lower priced ingredients. Others are highly resistant to change and substitution. The degree of this flexibility determines in large measure the current and future prospects for drying-oil consumption in these products.

Printing inks, thermal and electrical insulations, friction materials, some floor-covering products, and a few core oils resist changes in formulations. Printing inks are considered to be tailor-made materials for an individual customer who is reluctant to try a product he has not used previously. Consequently, the printing-ink makers wind up with thousands of formulations (90,000 in the case of one company) each of which is sacrosanct. Customer specifications for electrical-insulating varnishes and certain core oils are quite rigid because of quality requirements and product liability involved. Processing limitations account for the reluctance of manufacturers to change formulations of linoleum (either oil-based or synthetic), friction materials, and thermal insulations. The net effect in each case is the same--stable formulations regardless of price shifts in the oils.

The majority of core oil, table oilcloth, fabric wall covering, and felt-based floor covering formulations can be shifted rather readily.

Shortage of a particular oil is recognized as reason to change to another or combination of other oils. None of the respondents suggested that they would withdraw a product from the market rather than use substitute oils. Two companies did say that the resulting substitute product would not bear the same identification as the normal one. Substitutions cited as the result of past shortages included:

Normal Oil	Substitute
Linseed	Tung plus fish
Linseed	Tung plus soybean
Linseed	Linseed diluted with tall
Linseed	Modified soybean
Linseed	Soybean plus fish
Soybean	Safflower
Tung	Linseed
Tung	Oiticica
Tung	Maleic soybean
Tung	Dehydrated castor

Oil substitutions made for economy reasons are restricted to core oils, table oilcloth, fabric wall coverings, and felt-based floor coverings. The general practice is to assess each situation as it arises and change if desirable. The contrasting position--set-price differentials--is represented by two floor-covering manufacturers. For them, a deviation of one-half cent per pound from normal price differences is enough to cause them to use alternate formulas.

The general attitude toward substitution among the users of drying oils has three major divisions and as many minor subdivisions as the number of companies interviewed. The principal categories range from "no change" to "change if necessary" to "change based on economic advantage." The products of any particular industry may fall into any of these classes.

The factors influencing a decision on oil substitution in any one product include the following: (1) The relationship of oil cost to total product cost, (2) function of the oil, (3) liability that may be involved in the consumer product containing the oil-bearing material, (4) customer specifications, and (5) complications introduced into the normal process. Obviously, core-oil and linoleum manufacturers will stress factors 1 and 5, whereas brake-lining manufacturers are influenced by factor 3. Printing-ink and electrical-insulation manufacturers tend to favor factor 4, and thermal-insulation and fabric wall-covering manufacturers consider factors 2 and 5. Customer specifications and liability are the factors that limit or preclude substitution of one drying oil for another.

Tall Oil in Other Major Drying-Oil Uses

Tall oil and its derivatives have found a place in the manufacture of nonpaint products. The ways in which it is being used, its importance as a raw material, and the reasons for its use in these products are detailed in the following paragraphs.

Tall oil, of itself, is not an oil in the accepted sense of a glyceride of fatty acids. Either the fatty acid or the resinous acid fraction can be the important part for the tall-oil consumer. However, segregation of either fatty-acid or resin-acid constituent, or conversion to an oil-like form by esterification is necessary to exploit fully the advantages of tall oil.

Tall oil was used in core oils, floor coverings, and thermal insulations in the years 1949 to 1952, but not in table oilcloth, fabric wall coverings, printing inks, friction materials, and electrical insulations. Between 1949 and 1952, the amount of tall oil consumed by the respondent companies increased. Two of the four floor-coverings companies reported "increased" and "substantially increased" usage; the others reported about the same. All four core-oil producers indicated that more tall oil was used. However, its usage in termal insulations decreased.

Esterified tall oil (usually the crude grade) offers economic advantages with adequate performance for certain core oils. As a part of felt-base floor coverings, tall oil is cheaper than soybean alkyds and exhibits better gloss retention, but it cannot be used as the only oil-bearing material. As in the protective-coatings industry, the major reason for the use of tall oil is price. Its increasing adaptation to new applications and its price stability undoubtedly have also played a part in its use in products other than protective coatings.

Unusual Oils in Other Major Drying-Oil Uses

By the definition of this study, unusual oils are those that are presently being used in relatively small quantities. Availability, reasonable price, and specific unique properties are the factors that determine the use of such an oil in preference to the normal drying oils.

Among the major drying-oil products, friction materials are the only consumers of unusual oils. A cashew-nutshell liquid having unique friction properties is incorporated in the resinous binder of brake linings. Consumption of the liquid was reported as "substantial."

The oil suppliers contacted during this study do not process the cashew-nutshell liquid. For this application, they had no pertinent comments.

Résumé

Between 1949 and 1952, the consumption pattern of drying oils was affected externally and internally. Synthetic film formers appeared and captured part of the market previously held by drying oils. In addition, there was a rearrangement in the relative positions of the various drying oils.

By far the greatest single influence in the drying oils-synthetics controversy was the far-reaching and rapid spread of styrene-butadiene latex paint technology. Vinyl resins showed the biggest gain among the synthetics used in floor coverings. Minor inroads were accomplished by phenolic resins in core oils, and acrylic and vinyl latices in paints.

Among the various drying oils, soybean oil in protective coatings and tall oil in both protective coatings and core oils increased their percentage share of the market at the expense of linseed and tung oils. Furthermore, segregated fatty acids increased to the extent that they attained recognition as a separate class of competing materials.

Expansion of the general economy and of the particular industries under study complicates any attempt to interpret the current consumption pattern of drying oils. There is no common denominator for all the materials that compete with drying oils or that extend their function in the variety of uses to which they are put. From the fragmentary and imperfect data on paint gallonage, drying oils as a group are barely holding their own in the face of a slight decline in paint volume production. In protective coatings, linseed oil is being used to the extent of about 400 million pounds per year--nearly 60 percent of all drying oils in this field. In nonprotective-coatings products, linseed oil accounts for approximately 125 million pounds or 36.5 percent of total drying-oil consumption in these uses. In fact, linseed oil remains the dominant drying oil and the major raw material for paint vehicles.

The decline of oil consumption in drying-oil use and the shifts in use patterns among the oils can be attributed to two factors:

(1) Quality improvement. Examples are latex paint, vinyl wash primer paint, vinyl food-can linings, vinyl floor coverings, phenolic resins in shell molding, "heat-set" and "steam-set" printing inks, and epoxy-modified paint.

(2) Cost reduction. Examples are soybean alkyds, tall-oil varnishes, tall-oil-based core oils, and alkyds in enameled floor coverings.

These two factors are recognized by the industries that produce and consume drying oils and have stimulated some research on upgrading the drying oils. But the major deterrent to adequate research has been the continued economic advantage of drying oils, in their presently modified forms, as film-forming agents.

PROBABLE FUTURE TRENDS IN DRYING-OIL USE

The question of future trends in drying-oil use was approached from several angles. The individual companies contacted, protective-coatings manufacturers and other major users of drying oils, were asked to estimate the probable future use of oils and synthetics in their products, and the probable production trend for those various products. They were also asked to indicate the products in which they believed different synthetic materials would be likely to show their greatest future gains in lieu of drying oils. Conventional exterior house paint was singled out and given special attention. The interviewees were asked to suggest how drying oils might maintain their competitive position against tall-oil and nonoil coatings. Finally, the possible effect of lower oil prices on their consumption in paints and other products was explored.

Each question asked in this analysis of future trends presupposed the following: (1) That business conditions would remain stable; (2) that the total volume production of the individual company would remain at 1952 levels; (3) that drying oils would decrease in price relationship to other materials; or (4) that consumers of drying oils would be interested in increasing their usage of these materials. Specific questions, such as the probable change in outside house paint, were included because of the importance of the individual product in the overall consumption of drying oils. Taken together the answers received from companies should define the probable situation of drying oils 5 years from now.

The several drying-oil-consuming products again form a logical basis for grouping the opinions concerning future trends. Paint and varnish, including the oil-bearing synthetic resin intermediates, use a majority of the drying oils. Drying-oil suppliers have looked to this market for a good many years and have opinions resulting from contact with it and from the development of products for it. The paint and varnish, synthetic-resins, and drying-oil industries form one division of this section. Other industries that consume drying oils make up a second division that includes pertinent contributions from the synthetic-resins and drying-oil industries. A third division accumulates the ideas that do not fall logically into the two preceding categories.

Protective-Coatings Manufacturers

Drying Oils and Synthetic Materials in Paints

Two factors are involved in estimating future usage of drying oils or synthetic materials in protective coatings: (1) The quantity of oil or synthetic material going into a given volume of end products, and (2) the probable trend in production for the various end products. The first factor is considered in the following section. The second factor is discussed in the section following that.

The probable trends in oils and synthetics usage in protective coatings logically divides into three categories: Oil usage in trade sales, oil usage in industrial sales, and synthetic-material usage. According to the classification of the 46 respondents by trade and industrial categories, 34 answers should typify trade sales and 28 represent industrial sales. Sixteen companies prominent in both fields are common to both categories, as previously outlined.

Assuming no change in the volume of paint produced in the next 5 years, more than half of the respondents believe that drying-oil usage will decline. A greater percentage (76 percent) expect the use of synthetic materials to increase. A breakdown of the replies is shown in table 15. (It should be stressed that the basic assumption in this question is stable paint production volume, not necessarily stable dollar sales of paint.)

Over the next 5 years in trade-sales lines, the proportion of oil per gallon of paint (average oil content per gallon in all paints) is expected to continue the downward trend of the past several years. Most of the companies believe that the decrease will be minor, probably less than between 1949 and 1952. Latex emulsion interior paints nationally, and other emulsion exterior paints on the West Coast, may be responsible for the biggest drop in oil content. However, many manufacturers are expecting that an increasing volume of flat alkyd paints will tend to maintain the current average oil content of interior wall finishes. In general, the shift from oleoresinous to alkyd vehicles was completed by 1952, and relatively little change is anticipated for the future. One major company, prominent in trade and industrial sales, indicated that a 10-percent decrease in oil proportion would be the maximum at current oil prices but doubted that this percentage would be realized.

Table 15.- Summary of paint company opinions on future trends in drying-oil and synthetic-materials usage

Type of company	Trend direction				
	Down	Stable	Up	No reply	Total replies
	Number	Number	Number	Number	Number
	Trade sales, oil usage				
Large companies	10	3	0	1	14
Medium companies	11	5	2	2	20
Total	21	8	2	3	34
	Industrial sales, oil usage				
Large companies	2	5	0	1	8
Medium companies	12	7	0	1	20
Total	14	12	0	2	28
	All sales, synthetic-materials usage				
Large companies	0	3	10	1	14
Medium companies	0	7	25	0	32
Total	0	10	35	1	46

A few companies mentioned the possible replacement of whole oils by fatty acids in alkyd-vehicle production. Such a change is not likely to affect total oil usage in a drastic manner, since the fatty acids are derived from oils. However, tall-oil fatty acids could increase at the expense of both soybean and linseed whole oils. Similarly, soybean-oil fatty acids could increase at the expense of linseed oil. Any trend in this direction will be secondary in importance to the effect of the emulsion-flat alkyd competition.

Industrial-product finishes, relatively less subject to reformulation than the trade lines, appear more stable in the proportion of oil to be used during the next 5 years. Of course, the present oil content per gallon is already less than the average of trade-sales items--a trend that began in 1939 and has been amplified by the continued development of chemical materials for oil-modifying agents or synthetic film formers. The continuing industrial demand for specialized finishes, coupled with the appearance of new raw materials, indicates slight changes in the direction of a lower oil content. Finishes for structural metals, ships, automobiles, and wooden furniture are expected to remain as is. Finishes for appliances, metal furniture, aircraft and guided missiles, farm machinery, railroad cars, and industrial machinery are the most likely to change.

Among the synthetic materials, the epoxies, acrylics, vinyls, and emulsions are mentioned most frequently. The latex emulsions, based on butadiene-styrene, polyvinyl acetate, and, very recently, acrylic resins, are used primarily in trade-sales lines. The epoxies, the lacquer-type vehicles based on acrylic, polystyrene, or vinyl resins, and the chlorinated rubber-type vehicles find their major application in industrial finishes. One of the newest developments in this latter field, too new to assess fully, is the water-thinned industrial primer based on a variety of synthetic film formers.

In brief, many of the companies interviewed recognize the tremendous research effort being put into synthetic materials. A few expressed the hope that improved oils will be available to maintain the relative position of the oils in protective coatings.

It seems probable that research will be the key to future drying-oil usage. While the paint and varnish manufacturers, the oil-bearing resin producers, and the drying-oil suppliers spend large sums of money on research, the bulk of it goes to solve specific problems. Even the development of new vehicle types, such as the oil-resin emulsion that several companies are working on, is applied research. In the case cited, the problem is to combine the quality of the alkyd flat-wall-finish film with the ease of application of the latex emulsion paints. But research of this nature is like the scatter-gun technique. If enough tries are made, one may find the mark. Fundamental, or basic, research on films and the drying oils might shorten the interval between a recognized need and the successful solution.

Trends in Protective-Coatings Production

The intent of this subdivision is to indicate, if possible, the production potential for protective coatings whose vehicles contain, respectively, only oil, part oil, or no oil. Business conditions over the next 5 years are assumed to be similar to 1953 conditions. Population growth and economic expansion are expected to continue. Within this framework, the answers of paint manufacturers and drying-oil suppliers may indicate meaningful trends.

In discussing this question, the three classes of paints were illustrated by specific examples in each category. None of the illustrations is intended to include all the possible vehicle types that might be included in a given category.

Vehicle Type	Specific Example
Exclusively oil	Linseed exterior house paint
Part oil	Alkyd enamels
Nonoil	Latex emulsions, vinyl or acrylic emulsions

The consensus of the paint manufacturers is that the exclusively oil coatings will decline percentagewise. However, 13 companies are expecting the expanding economy and the "do-it-yourself" trend to maintain or possibly increase the gallonage produced. The variation from present conditions will be less marked for total gallonage production than for the percentage distribution. On either a percentage or gallonage basis, both the part-oil and the nonoil finishes should experience increases. The answers are summarized in table 16.

Confirming previous information, trade-sales lines will be affected more than industrial lines for the part-oil coatings. Three medium companies dissent from the majority opinion about the nonoil coatings, claiming that the synthetics, particularly latex, reached their peak during 1953 and will tend to level off.

The drying-oil suppliers support the majority views of the paint manufacturers. Although 4 oil suppliers claimed their opinions would represent "secondhand observation" and declined to comment, the other 5 responded on the basis of their knowledge of customers' thinking.

Table 16.- Summary of paint company opinions on future production trends for specific vehicle types

Type of company	Respondents	5-year production trend		
		Up	Stable	Down
	Number	Number	Number	Number
		Exclusively oil coatings		
Trade	17	2	4	11
Both	16	4	2	10
Industrial	8	1	3	4
Total	41	7	9	25
Among top 15	14	2	3	9
Others	27	5	6	16
		Part-oil coatings		
Trade	17	10	4	3
Both	16	14	2	0
Industrial	10	4	5	1
Total	43	28	11	4
Among top 15	14	10	2	2
Others	29	18	9	2
		Nonoil coatings		
Trade	18	16	1	1
Both	15	14	1	0
Industrial	9	8	1	0
Total	42	38	3	1
Among top 15	14	13	1	0
Others	28	25	2	1

In the opinion of the oil suppliers, coatings based exclusively on oil are expected to decrease, those based partly on oil and on the nonoil materials to increase. One major company explained the decrease in the exclusively oil-based coatings by saying that modification of the oils removes them from this category to the part oil-based coatings, and that less and less unmodified oils will be used. All the respondents anticipate increased alkyd or other chemical modification usage, with emphasis on fatty acid starting materials. The use of oil-based derivatives in latex emulsions to improve adhesion and pigment incorporation was mentioned bv two companies, although all the respondents believe that the non- and low-oil-content coatings will increase.

Significantly, one important supplier indicated that the downward trend in average oil content may be reversed at the same time that total oil consumption is rising through expanded paint sales. New chemical modifications of oils for greatly improved properties and promotion of the flat alkyd-vehicle types were cited as the basis for this optimism.

Since the interviews for this study were conducted in late 1953 and early 1954, the experience of 1953 colors the opinions of many companies. For example, a number of the paint manufacturers recorded marked increases in odorless flat alkyd wall paints during the last 6 months of 1953. None of the interviewees cared to guess the percentage distribution of interior wall coatings between latex and flat alkyd, but several indicated that the growth curve of latex was leveling off.

In the minds of most of the paint companies, two reasons are apparent for the growth of nonoil coatings. The first is the fact that these coatings meet service conditions not attainable with the oil-based coatings. This reason applies to industrial finishes, for which little change is expected within 5 years. The second is customer acceptance, because of ease of application and cleanup. This reason relates to trade-sales finishes, a field in which the ultimate consumer can be influenced.

The promotional buildup of latex emulsion paints is a unique occurrence in the history of trade-sales finishes. No other product has received so much publicity and advertising. The rise of the amateur painter and home decorator may well have stimulated it. But promotion alone did not sell the latex paints; they filled a need that the consumer was quick to realize and appreciate.

As paint makers push odorless flat alkyds during the next 5 years, quality of finish as well as ease of application and cleanup is likely to be the subject of paint promotion.

The annual reviews for 1953 in leading trade magazines are slightly more optimistic regarding the future of latex paints than the paint companies interviewed for this study. They estimate that during 1953 these coatings accounted for 40 to 50 percent of all interior trade sales. Oil-based wall paints, enamels, and varnishes for woodwork and floors make up the balance. Further, they intimate that 1954 will be the test year for latex formulations in exterior applications.

On the basis of these bits of information, it may be concluded that the oil-vehicle paints will remain fairly steady in total volume, decreasing slightly as a percentage of total paint, varnish, and lacquer production. Part-oil-vehicle paints will increase both in gallonage and percentage of total, particularly in trade-sales lines. Industrial part-oil coatings will retain their present percentage of the total, with small increases in gallonage indicated. Nonoil vehicle paints (e.g., latex) also will gain in gallonage and percentage, but will contain an increasing amount of oil-based resin (e.g., alkyds) to improve quality.

In the 5-year picture, a slight decline in oil content per average gallon of all paints is expected, together with increased paint sales.

Extending the projection beyond this 5-year period, the synthetic-resin producers were asked to estimate the total market that synthetic film formers might capture. All percentage figures cited by them were qualified in terms of time. The most common answer was that within 20 years the synthetic film formers will have captured 30 percent of the total film market. Others said that the present percentage (no figure stated) would be doubled within the 20-year period.

A detailed analysis by one basic-materials supplier indicates the possible future position of the synthetic film formers as follows:

Vinyl films (not emulsion)	1-2 percent
Epoxy resins, oil modified	25 percent maximum
Latex emulsions (vinyl, acrylic, and butadiene-styrene)	60 percent of interior finishes in 1953, less in 1954, and much less if alkyd emulsions are perfected
Oilless alkyds and polyesters	10 percent within 10 years
Core binder resins	2 percent in 1952, more later

Complete replacement of drying oils by synthetic film formers is not foreseen. Price differentials are too great to allow this within 50 years. Better performance of the synthetic film formers in certain applications justifies their higher price (and more applications will be found). However, the performance requirements of many films are such that oil-based materials are a satisfactory economic answer.

No universal replacement for drying oils has been discovered by the resin producers. A miscellany of products are expected to have some share of the drying-oil market, including vinyls, epoxies, polyesters, phenolics, and oil-free alkyds. Epon resins, urea- or ethylene diamine-modified, pose the biggest threat to drying oils in the opinion of one of the respondents. Considering their current price, a drastic reduction (more than can be expected) will be needed before they replace all the drying oils. Technologically, 3 companies believe that complete replacement is or will be possible within 50 years.

Several contradictory factors are apparent in the thinking of the resin manufacturers. Against the newness of the synthetic film formers that would argue extension of their use as their technology improves, must be balanced their higher price. The higher price of the better films attainable with synthetics allows an upgrading of the oils or oil-bearing materials that may bring them back into competition. The remarkable gains made by latex paints in 5 years did not eliminate oil-based interior coatings, and none of the current developments appear capable of doing so, in spite of a lot of wishful thinking.

Although this specific question was not asked of the paint manufacturers or oil suppliers, the reasoning evident among the resin producers applies to them as well. Drying oils remain the cheapest film formers. With one exception (the epoxy-modified oils), even the chemical modification of drying oils produces reasonably priced film materials. So long as the drying oils maintain their present price relationship to synthetic materials, they may expect to retain a good portion of the film-forming market.

Exterior House-Paint Formulation

Exterior house paint based on linseed oil is one of the staple formulations of the protective-coatings industry. Until World War II, it contained about 4.25 pounds of oil per gallon--the highest oil content of any major paint product. Since World War II, two changes in formulation have been accepted by most of the industry:

(1) A lower oil content--between 3.75 and 4.0 pounds per gallon--and (2) the replacement of part of the raw linseed oil with a processed linseed oil. Relatively little change in formulation was experienced between 1949 and 1952. However, the importance of this one product to the drying oils--linseed oil in particular--justified the inclusion of this specific question to attempt to chart the near future.

Competition for the ordinary exterior house paint is already present. Brick, stone, stucco, concrete block, and asbestos shingle construction have reduced the potential market for house paint. In this sense, they represent competition. Counterbalancing this factor, there are more wooden houses to be painted or repainted today than there were 5 years ago. None of the 34 companies with trade-sales lines has a proven paint competitor for linseed-based paints.

Looking 5 years ahead, 17 believe some replacement will be made; 15 say no significant changes will occur; and 2 major companies refused to commit themselves. Twelve answers were received from the 15 largest American companies; 6 feel that replacement is possible, 6 do not. In a further attempt to clarify the position of the various companies, 16 firms with substantial trade-sales lines were segregated. Of these, 2 were noncommittal, 7 foresaw a possible replacement, and 7 anticipated no change.

The butadiene-styrene, polyvinyl acetate, and acrylic emulsions, being used currently on masonry construction, are given the best chance to invade the exterior wood house paint field. Two companies admitted having formulations of exterior latex emulsions in field test now. Two others said that "everyone is working on them" and that 2 to 3 years' experience has been accumulated. The West Coast, with its higher proportion of masonry construction using emulsion exterior paints, appears to offer the best possibility for initial commercial trials of nonlinseed-based paints.

Long-oil alkyds are accorded the second best chance as linseed's replacement. Eight companies mentioned them specifically, citing poor adhesion to a partially deteriorated paint film as the major problem to be solved. Three medium companies claim to have technically equivalent exterior wood finishes based on a combination of linseed oil and maleinized soybean oil. At current oil prices, there is no economic advantage, so the formulations are not in present production schedules.

The extent of replacement, if accomplished, with the next 5 years is problematical. The estimates received ranged from slight to substantial. The majority of the companies indicated that thorough testing, including repainting, would be necessary before commercial production reaches sizable proportions. Although the field tests of currently proposed nonlinseed exterior paints are reported to be satisfactory, at least 2 to 7 years' additional testing may be expected before these paints are introduced. The degree of acceptance by the buying public and the professional painter will determine the rate of changeover and, consequently, the production volume. Most of the companies believe that a definite trend toward new exterior formulations will be established within 10 years.

The oil suppliers are less divided on the question of a replacement for linseed-based house paint than the paint manufacturers. The majority believe that present formulas are safe for at least 5 years. Only one oil supplier foresees an encroachment of nonlinseed formulas, possibly to the extent of 10 percent of the house-paint market.

On the question of the most likely successor to linseed house paint, the oil suppliers agree with the paint manufacturers, citing vinyl and acrylic emulsions and long-oil alkyds.

Exterior wood house paint formulation has received a lot of research attention for a long time. Many answers to specific problems have been discovered. Some answers are still to be found, including the ideal film-producing material. It is recognized that linseed oil is not the ideal film base.

Paint formulation has been described as a series of compromises. The good qualities of a raw material--oil, pigment, thinner--are always accompanied by some properties that are not so desirable. A successful formulator minimizes the undesirable properties with the least sacrifice of the good characteristics. For example, hardness of film is attainable only at the expense of elasticity. A paint film capable of withstanding the weathering effects of the northern regions of the United States has so little stretch that the expansion and contraction of the wood underneath it soon cause the film to peel off in flakes or sheets. The film has more cohesion than adhesion. At the opposite extreme, a film with good flexibility and adhesion has poorer weather resistance.

Current white house-paint formulations effect the compromise between adhesion and cohesion with what are known as "controlled chalking" films. Vehicle and pigment are matched to attain this end. The film deteriorates a little bit at a time, and the weather removes the residue, presenting a fresh surface to start the cycle over again. Eventually, there is no film--and no protection for the wood--left. This type of paint has several outstanding values prior to complete failure. Properly compounded, the white color remains nearly the same throughout the life of the film. Perhaps most important, though, is the fact that the deteriorated film is a good base for fresh painting and does not have to be removed.

Since the life of a house-paint film is about 5 years, it can be seen readily that 6 to 10 years of testing is necessary to demonstrate the initial and repainting properties of a new formulation. Failure of the second film application in the ninth year of the test can be just as fatal to the formula as premature failure of the first film application. In view of the experience of one of the large paint companies with alkyd-type outside house paints during the 1930's, paint companies today want to be sure of any new formulation.

The time and expense of this long testing procedure is a deterrent to the quick replacement of an accepted formulation. However, paint companies are testing many new formulations for exterior house paints. As one medium-sized firm said, "if and when and replacement for linseed oil house paint is announced, one of the large companies will make the announcement. We couldn't afford to be the first on the market with such a product."

None of the companies contacted in this study could be expected to reveal a successful new formulation that it intended to market within a year or so. But the tenor of all the answers received indicates that a new outside house paint for wood will be announced before 1957, and that by 1962 it will be established in considerable production volume. Unfortunately, the opinions of the paint manufacturers and oil suppliers are not conclusive enough to identify the replacement by type of vehicle at this time.

Synthetic Materials in Specific Coatings Types

This question was asked in an attempt to cross-check the answers received to previous questions concerning probable future trends in paint manufacture. Replies were sought from paint, synthetics, and oil companies.

Replies to this question are not strictly comparable in terms of the synthetic materials and end-use products. Several companies did not specify the film former when discussing either trade or industrial items. Others failed to identify the particular end-use type of paint in which the specific synthetics would be used.

Within the broad classifications of trade-sales and industrial-finishes lines, many specific types of paint products were suggested as being vulnerable to further encroachment by the synthetic film-forming materials. Again, either through the inclusion of 34 companies interested in trade-sales lines or because these lines are less subject to rigidly enforced specifications, references to trade-sales items predominate.

Specific end products (with the pertinent synthetic film formers in parentheses) included:

Trade-Sales Lines

- Interior wall (latex, vinyls, flat alkyds)
- Interior enamels (alkyds)
- Floor finishes (epoxy resins)
- Exterior, wood (vinyls, acrylics, or alkyds)
- Exterior, other (vinyls, acrylics, or latex)
- Industrial maintenance, anticorrosive, and chemically resistant (vinyls, epoxy resins)

Industrial-Finishes Lines

- Exteriors, anticorrosive (vinlys)
- Interiors (nonoil baking enamels)
- Farm implements (latex)
- Freight cars (latex)
- Airplanes (vinyls, acrylics)
- Appliances (epoxy resins, epoxy esters)
- Venetian blinds (copolymers)

In the above listing, the terms "latex," "vinyls," and "acrylics" refer, respectively, to styrene-butadiene latex emulsions, vinyl emulsions, and acrylic emulsions.

The comprehensiveness of this list of paint types in which synthetic materials may show significant future gains results largely from the diversity of individual opinion that it represents. There is not sufficient evidence to support the assumption that synthetic materials will capture a major share of the market in all these paint types or even a large proportion of them.

Of course, the oil suppliers are interested in the drying oils and recognize the competition from synthetic film-forming materials. Their answers to this question reflect the general optimism they hold for the prospects of drying oils. All but one of the oil suppliers expect the flat alkyd-vehicle type of paint to show great gains in the next 5 years. These would be used in interior trade-sales lines. For industrial finishes, the epoxy-modified oils were mentioned most frequently. One major supplier hinted that they have other chemically modified oils, the nature and application of which the respondent was not at liberty to disclose. The company is optimistic about one product already on the market and another to be announced soon.

Among the nonoil coatings, the oil suppliers felt that interior industrial maintenance coatings would consume more butadiene-styrene and acrylic emulsions, while vinyl resins would be adapted for anticorrosive and chemical-resistant finishes.

The listing as given for the paint companies parallels the answers received from the synthetic-resins producers. All types of protective coatings are included. In each instance, the products of the individual company are used primarily in a particular field. Producers of pentaerythritol and other polyols and phthalic anhydride and its homologs expect growth in alkyd manufacture, although they are little concerned about the ultimate use of the final paint product. Basic monomer producers anticipate growth both in copolymerized alkyds and latex emulsions--the former for industrial and the latter for interior and exterior trade-sales uses. Alkyd manufacturers foresee gains in flat wall finishes, industrial heat-resisting enamels, other specialty industrial finishes, and quick-drying architectural enamels.

To pick a specific protective-coating type of formulation in which the synthetic resins will show their greatest gain in the next 5 years is difficult. There was no consistent pattern in the replies from paint makers, resin producers, or oil suppliers, either individually or in combination. Certainly, both trade-sales and industrial-finishes lines will be affected. However, the customer-specification aspect of industrial finishes argues for a slower change, and hence less effect, on these products than on trade-sales finishes.

Among the three categories of trade items--interior, exterior, or industrial maintenance (a variety of interior finish)--the industrial-maintenance finishes would seem to be the logical first choice. For one reason, less change has occurred in prior years. A second factor would be the intensive sales effort that the latex paint makers might apply in a tradionally oil-paint market. A third aspect is the not-so-gradual shift in industrial installations toward the South and Southwest where climate differences may require revised maintenance paint formulations. Although this choice cannot be justified on the strength of the answers from respondents, hints of it were evident in a number of interviews, including those with the Government laboratories.

Drying Oils Versus Tall-Oil and Nonoil Films

Competition among the film-forming materials is clearly evident. Tall oil, considered to be an industrially rather than an agriculturally derived product, is as much a part of that competition as the chemically produced plastic films. The intent of this subdivision is to indicate changes from current conditions that might increase the relative use of drying oils. The basic assumption has been made that cost and quality equivalence in the paint end product would be sufficient reason to change to the drying oils. This is not necessarily true, but the assumption establishes the minimum conditions under which the change could take place. Consumers and producers of the drying oils are equally qualified to comment on this question.

Drying oils will improve their position in relation to tall oil when the price differential has been decreased. This is the opinion of 33 of the paint companies interviewed. The balance said that tall oil offered no competition to drying oils in their company, or they had no opinion. Since tall oil is a unique combination of fatty and rosin acids, several respondents suggested that competitive pricing on a combination of oil and rosin would be necessary, rather than on the oil alone. The specific price at which drying oils would compete with tall oil was not revealed in the answers received. The implication is that individual companies have widely differing uses for tall oil, and pay between 5 and 12 cents per pound, depending on grade.

Accordingly, soybean or linseed oil at 10 cents per pound might, or might not, be an economic replacement for tall oil. Each formula would require study on the basis of the following: (1) Performance requirements of the finish, (2) comparative costs, and (3) production problems introduced.

One large company intimated that tall oil will remain an insignificant factor and that price competition by the drying oils is not worth while. This opinion was unique and may be based on this company's nonproduction of second-quality lines.

With lower prices, the oil producers believe that vegetable drying oils would tend to maintain or improve their position with respect to tall oil. Because of the necessity of using different agents to modify either tall oil or the vegetable drying oils, the prices of these materials must also be considered. This factor complicates any attempt to specify a price for the vegetable oils that would offer serious competition to tall oil. One supplier guessed that "nine-cent linseed would do some good in recapturing part of the tall-oil usage." The others (6 out of 8) did not mention specific prices.

Price stability was suggested by three oil companies as a factor that could influence their acceptance of the vegetable drying oils in place of tall oil. Since 2 of the 3 vehicle manufacturers specifically mentioned this, it may be indicative of pressure for price stability originating with the paint manufacturers, or possibly the large industrial paint consumers.

The failure of this question to develop a unity of opinion about the specific price at which drying oils could recapture part or all of the tall-oil usage is indicative only of the complexity of costing methods used by the paint and vehicle formulator. Each formula has a peculiar relationship to its major ingredients, so that the exact level of economic replacement for one major element differs from formula to formula. There seems to be little doubt, however, that linseed oil priced at 9 cents per pound instead of 14 cents per pound would materially change the pattern of tall-oil usage.

Previous references (see section on Current Patterns in Drying-Oil Uses) to specific good qualities of tall oil are interpreted to mean that some companies might continue to use tall oil in spite of equivalent cost for linseed oil. A separate study of a number of specific formulas would be required to estimate the possibility of eliminating tall oil as a competitor for the vegetable drying oils.

Concerning the competition of drying oils with synthetic film-forming materials, a well-known industrial-finishes manufacturer said, "The trend (toward synthetic materials) will be hard to buck because the other coatings have improved properties that command a higher price." Properties comparable to the synthetic film formers--the ease of application and cleanup of latex emulsions, the speed of drying of the phenolic baking enamels, the chemical resistance of the epoxies--have not been duplicated with the oils to date. Eleven companies, including 6 of the top 15, feel that the oils cannot be improved enough to compete with the specialty materials on a quality basis. However, it must be remembered that the present oils or their modifications already have a substantial position among the film-forming materials and are likely to retain much of the current volume in an expanding market. Nevertheless, upgrading the oils to "mimic" the best properties of the synthetics should be attempted.

In general, the oil companies believe that improvement in properties at an economic cost can be achieved through research and realistic pricing of the raw materials from which the oils are derived. Many of the synthetic materials mentioned contain some oil or oil-based ingredient now. But to compete with them directly will require considerable upgrading of the oils through chemical modification. The resulting products will no longer be identified as oils, but the oils will be a major raw material.

Suggested means of accomplishing the improvement in film properties included extension of alkyd technology, further use of segregated fatty acids, and other chemical reactions that the interviewees were not free to identify. Economic factors, such as the vegetable-oil-price "umbrella" and oil-price fluctuations, also will influence the competition. Customer acceptance of oil-based materials may be increased by use of odorless solvents, better application properties, and more publicity.

Drying-Oil Prices and Oil Usage in Paints

Throughout this study, reference has been made to the economics of the protective-coatings industry--the effect of raw-material prices on paint prices, the reasons for current oil-consumption patterns, and the competition of drying oils with tall oil and other synthetic film materials. This question was asked in an attempt to specify the effect that marked changes in the economics of drying oils might have on their future usage. The interests of oil suppliers, as well as those of resin producers and paint manufacturers, were considered. It was recognized that price adjustments might affect oil usage in three ways: (1) Change the oil content of oil-bearing paints; (2) change the ratio of oil-bearing to nonoil-bearing paints; and (3) change the per capita consumption of paints in general.

Seven of the nine oil suppliers feel that a generally lower price level for the drying oils would tend to increase their usage. Maintenance of the current price relationships among the oils at lower levels should increase their attractiveness as chemical raw materials and might displace some tall-oil usage. In turn, present products at lower prices (no change in oil content) or improved products at equivalent prices (change in oil content possible but not mandatory) might displace some of the synthetic materials like latex emulsions.

With synthetic resins marked reductions in the prices of drying oils may be expected to have two effects. First, the same types of resins, with different oil contents, might be sold. Second, oil-bearing resins might replace some or all of the synthetic film formers. Either of these could affect over-all oil usage in the drying-oil-consuming industries.

The effect of oil-price reductions on alkyd vehicles would tend to be greater for trade-sales products than for industrial materials. Basically, this difference stems from the film performance specifications required for each class of vehicle.

Trade-sales finishes are not subjected to the severe service conditions or the mass-production application requirements of industrial finishes. Thus, variations in oil content of trade-sales finishes are less critical, provided reasonable similarity of application and service characteristics can be maintained by formulation. Initially, oil-price reductions would tend to reduce the cost of alkyd vehicles and the paints produced from them. Evenutally, the oil content would rise to take advantage of the cheaper raw materials of the alkyd vehicle. Only this eventual shift, dependent on increasing the cost differential between oils and resin-forming materials, would improve the relative position of the oils.

Industrial finishes would be likely to retain the current ratio of oil content since performance is critical. No one anticipated a change here except in the price of the finished product.

The secondary effect of oil-price reductions (replacement of synthetic film formers) also would be most noticeable in trade-sales finishes. For the majority of industrial finishes properties are the paramount issue, and oils do not provide the necessary properties.

In the final analysis, a sizable number of synthetic film formers have technologic advantages that will enable them to hold a portion of the market regardless of the price of oils.

A similar philosophy is evident among the paint manufacturers. According to all but one of the interviewees, oil prices do not affect their over-all use of oils. Performance is much more important than price. Even the one company that believes lower prices would increase usage of oils expects that the additional oil would be used as raw materials for improved film formers.

One possible increase in vegetable-oil usage through price reduction has been mentioned previously, i.e., linseed or soybean oil at 9-1/2 or 10 cents replacing tall oil. In certain companies this could cause a major shift, but the over-all effect might not be great.

While these replies appear to be pessimistic in inferring that even price reductions will not help the drying oils, such pessimism is not warranted. As the oil suppliers suggested, reasonable pricing of the drying oils will enhance their attractiveness as chemical raw materials. By suitable modification, successful research can develop products comparable in quality to some of the synthetic film formers. It is in this direction that a number of forward-looking companies believe the drying oils should move.

Another aspect of the pricing of drying oils has been mentioned previously. It can be summarized as price stability. To date, price stability does not exist among the vegetable drying oils. Actually, a minority of the interviewees have strong feelings on this question. Most of the companies contacted feel that oil price instability has relatively little influence on drying-oil consumption. At the opposite extreme, a resin producer believes that stable oil prices are the cure-all for the ills of the drying-oil industry.

The paint manufacturers have an intermediate viewpoint. Nine of the 12 paint companies that mentioned price stability feel that stable pricing of drying oils would be desirable but would not affect the amount of oil used. The other three believe that present pricing practices are desirable, since they expect to develop a slight competitive margin through proper purchasing. There is no unanimity of opinion that would justify a recommendation of stable pricing for the drying oils.

Other Major Users of Drying Oils

Drying Oils and Synthetic Materials in Nonpaint Products

As with the parallel question in the protective-coatings section, the basic assumption for this question was stability of current production. The assumed maintenance of present production volume, regardless of the unit of measurement, tends to highlight the competition between the drying oils and other materials.

Changes in the relative proportions of oil-bearing and synthetic materials to be used by the respondents during the next 5 years depend on the industry. Since none of the various industry groups expect an increase in oil usage, the consensus would be that the oil content of these products, as a group, will decline. Printing inks, core oils, thermal insulations, and friction materials are expected to remain relatively stable in composition. The output of various nonoil inks and nonoil core resins may increase slightly, but no significant developments are foreseen. Floor coverings, table oilcloth, fabric wall coverings, and electrical insulations are expected to continue the swing toward synthetic materials--vinyls for the first three uses and phenolic resins for the fourth. The trend will be most pronounced in floor coverings and least in table oilcloth and fabric wall coverings.

The implication inherent in these answers is that the lines of competition are established. To increase their proportion of these markets, the drying oils will have to be improved in relation to known products. However, as with certain of the synthetic materials for industrial paints, sufficient improvement of the drying oils is likely to be difficult of attainment. Vinyl floor coverings and heat-set and steam-set printing inks represent the qualities of a product not attainable with the current drying oils. These qualities are accepted as standards today. No development presently on the horizon seems likely to change these standards within the next 5 years. This, then, does allow opportunity for research to upgrade the drying oils to maintain or improve their present position.

Trends in Production of Nonpaint Products That Use Drying Oils

The intent of this subdivision is to delineate, if possible, the market potential for drying oils for the next 5 years in products other than protective coatings. Production volume is free to follow population growth or other economic trends that are meaningful to the individual industries.

Estimates of production trends over the next 5 years for the various industries range from "stable" to "very optimistic." As a group, these industries expect a decline in oil content per unit of their products and stable or slightly greater total consumption of the products themselves.

Printing-ink volume should be increased, assuming that there is no serious interference with normal business trends, but any increase will go to the synthetic heat-set and steam-set types. Population increase, greater use of newspaper and magazine advertising, and the trend toward display advertising on product containers were mentioned as factors responsible for this probably increased volume.

Floor coverings present a more confused picture. First, linoleum and felt-base materials have been displacing rugs as floor coverings. One company expects a 10-percent growth in the next 5 years. Second, maintenance of a high standard of living has shifted, and will continue to shift, sales from the low-priced felt-base materials to linoleum. The same company anticipates that oil-based and vinyl linoleum will account for half the nonrug floor-coverings market in 5 years. Here again, the synthetic materials are expected to show gains, while the drying-oil products decline or at least taper off at present levels.

Relatively stable markets and oil usage are foreseen in core oils, table oilcloth, and wall fabric. Increased production is forecast for thermal and electric insulations and friction materials, with a greater potential for oils in both thermal and electric insulations.

The drying-oil suppliers in general are a little more optimistic than their customers. However, no outstanding trends are anticipated in floor coverings, printing inks, core oils, coated fabrics, insulations, or other minor uses.

The anticipated market for drying oils in these industries varies with the company interviewed. The companies in which a single oil predominates are optimistic about its prospects. The other firms are more conservative, projecting no major changes for the drying oils as a group. If anything, total drying-oil use is expected to be slightly lower in the future.

Among the individual oils, safflower and tall-oil suppliers foresee increased sales (in one instance as much as 100 percent) to linoleum and core-oil producers. In the near future castor-oil markets are likely to remain stable, but, with an adequate supply and reasonable pricing, the potential might include all the present linseed-, tung-, and soybean-oil markets.

Inasmuch as floor coverings represent the largest drying-oil-consuming industry outside the protective-coatings field, trends in this industry are likely to be significant. The 1952 market for the floor-coverings industry was estimated by one company at 425 million square yards, exclusive of tile products. The distribution was 66 percent in enameled or printed felt-base products, and 34 percent in linoleum-type products. In the linoleum-type products, oil-based and vinyl-based materials each accounted for half of the yardage. This company expects that, within 5 years, the market will increase 10 percent to 470 million square yards. At the same time, linoleum-type coverings will increase their share to one-half of this market, or 235 million square yards. Vinyl-based coverings are expected to account for 75 percent of linoleum-type yardage sales at that time.

The other floor-covering manufacturers also anticipate an increase in the production of the vinyl coverings. Two companies foresee decreases in oil-based linoleum, while the third hopes for an increase. All three expect stable production conditions for felt-based or enameled coverings.

On an over-all basis, synthetic materials should increase their share of the floor-coverings market, while the oil-containing materials should decrease but not fall drastically from their present production levels.

None of the other uses for drying oils appear capable of a rapid expansion that would revise the present importance of these industries to the drying-oil suppliers. This is particularly true, since the only two industries that forecast increased drying-oil usage (producers of thermal and electrical insulations) do not anticipate growth to the status of major drying-oil consumers.

Synthetic Materials in Specific Nonpaint Products

Predictions of where synthetic materials will show their greatest growth may serve to establish the areas in which drying oils could be improved to prevent the loss of markets. Additionally, this question attempts to cross-check the previous estimates of the future potential for drying oils in nonprotective-coatings applications.

The replies to this question confirm the indication of lower drying-oil consumption in nonprotective-coatings products. Slightly differing viewpoints are held by the consuming industries, the resin-intermediate industry, and the oil-supplying industry. All agree that vinyl-resins consumption in linoleum will increase. The oil suppliers and printing-ink manufacturers believe that offset inks will suffer most from nonoil products. Other possible points of growth for synthetics were suggested in the manufacture of table oilcloth, electric-coil impregnants, and core oils.

Also confirming previous trends, none of the drying-oil suppliers felt that the increase in synthetic-materials usage would be great. Further support can be found in the absence of any specific reference to products in which nonoil materials might capture the entire market.

Again, linoleum floor coverings, the largest nonpaint consumer of drying oils, can be expected to be the most serioulsy affected market.

Drying Oils Versus Tall-Oil and Nonoil Materials

Consumption of tall oil in products other than protective coatings is greater than the combined consumption in resins and paint and varnish products. Synthetic film-forming materials also account for a higher percentage of the consumption of film materials in products other than protective coatings than they do in products of the paint and varnish industry. For the drying oils to recapture a part or all of this market, either economic or technical changes from the current status are indicated. This question was designed to discover the specific changes that might improve the position of the drying oils in competition with tall-oil and nonoil materials.

Where tall oil competes with drying oils, the oils could maintain or improve their present position by price reductions. No indication of the price level necessary to improve the oils' position was given by the other major users of drying oils.

Both floor-coverings and core-oil manufacturers treat tall oil as a combination of rosin and fatty acids that reduces the need to purchase additional hardening resins. Thus, the oils and resins necessary to produce a satisfactory vehicle would have to be competitive, pricewise, with the currently used oil-esterified tall-oil-resin combinations. One floor-coverings producer indicated that stabilization of vegetable oil prices would aid their position. Another suggested that a continuation of research on tall oil and the lack of such research on drying oils will accelerate the present trend toward increased tall-oil usage.

Disadvantages of tall oil that eliminate it from consideration in printing inks, table oilcloth, fabric wall coverings, electrical insulations, and friction materials are all concerned with quality. The relationship of tall oil to drying oils in these fields is similar to the relationship of drying oils to synthetic film formers in industrial-product finishes, except that tall oil has never had an established position as did the drying oils.

The comments of the drying-oil suppliers are as applicable to these uses of tall oil as they are to the protective-coatings uses. Even the processors of tall oil admit that its increasing usage is based on its relative cheapness compared to other drying oils. Although the wording was different, 5 of the 9 companies agreed that tall oil has no technological advantage as a film-forming agent. However, films with satisfactory service performance that contain tall oil offer an economic advantage over films containing only vegetable drying oils. According to one large oil supplier, a major demand for cheaper film formers exists, and tall oil helps meet that demand.

In competition with other synthetic materials, the drying oils will maintain or improve their present position by improvement of properties through chemical modifications. This reply was universal among the various industries interviewed. Such modifications and improvements of the oils are considered prerequisite to their recapturing markets lost to synthetic materials. The extent to which this recapturing may occur, and in turn the volumes of oil that might be involved, varies considerably, however, among the several industries concerned.

Floor coverings represent the largest potentially recapturable market for two reasons. First, this industry is a large one. Secondly, there is a concurrent spread, in both price and quality, between drying-oil-based and synthetic-based materials. Table oilcloth and fabric wall coverings might represent additional recoverable markets. The incursion of synthetic materials in core oils has been relatively minor. In certain thermal insulations, printing inks, and electrical insulations the improvements necessary to recapture markets are considered to be beyond economic feasibility.

Thus, both price and quality improvement are necessary to improve the position of the drying oils. Price reductions alone will suffice for the competition with tall oil. With other synthetic film-forming materials, price reductions in oils will make more attractive the upgrading by chemical modifications that is necessary.

Drying-Oil Prices and Drying-Oil Usage in Other Products

Pricing of drying oils has a greater effect on their usage in products other than protective coatings than it does in the case of paints and varnishes. Producers of floor coverings and core oils keep a much closer watch on the prices of the various oils, and shift more readily with small price differences. This question represented an attempt to quantify the price levels of drying oils that would be effective in recapturing part or all of the lost markets.

Price levels for linseed oil in the neighborhood of 9 to 10 cents per pound might be expected to recapture a part, if not all, of the core-oil market lost to tall oil. These same levels--or a 20 to 25 percent drop from current levels--could also be expected to maintain or improve the consumption of linseed oil in both linoleum and felt-based floor coverings. They would also increase the amount of oil used in thermal insulations.

In all the other major uses--table oilcloth, fabric wall coverings, friction materials, electrical insulations, and printing ink--price reductions would have relatively little effect on per-unit consumption of drying oils. Only in table oilcloth and fabric wall coverings would increased sales be anticipated with cheaper oils.

General Supply and Market Prospects for Drying Oils and Synthetic Materials

In addition to the questions on future trends in drying-oil usage covered in the previous section, other factors that might exert an influence were considered. The information received in response to these additional questions serves to broaden and clarify the market-prospect picture drawn from previously discussed questions.

Adequacy of Raw Materials and Processing Facilities for Synthetic Resins

Since Synthetic resins find application in many fields outside the industries that consume drying oils, the factors of raw-material supply and production facilities for resins can have an important effect on the consumption of drying oils. One needs only to consider the recent experiences of the alkyd-resin industry in this regard to recognize the importance of these interrelationships. Until fairly recently alkyd-resin production has been hampered by shortages of phthalic anhydride. Even though facilities were expanded and re-expanded, production of phthalic anhydride was unable to keep pace with mounting demand for this chemical in the manufacture of both alkyd resins and plastics.

Future shortages of raw materials are not anticipated by the majority of the resin manufacturers. Production facilities are being expanded for the materials that normally enter either the oil-bearing or the synthetic film formers. Two exceptions were noted. Raw materials from which fatty acids are derived are plentiful in supply. However, due to present price relationships, production of fatty acids has been limited to levels which are being fully utilized in a variety of products. As a consequence, the supply of these acids available for use in protective coatings may be tight on some occasions. Also, the acrylic monomer--basis of the recently developed acrylic latex emulsions--is likely to be scarce until new facilities are installed.

Increased production facilities are anticipated within 5 years for alkyds, alkyd emulsions, butadiene-styrene latices, phthalic and maleic anhydrides, isophthalic acid, acrylic latices, epoxies, polyethylene, and polyvinyl acetate. Phenolics and pentaerythritol are specifically mentioned as requiring no new facilities. Eight of the eleven respondents said "Yes" in reply to this question.

Within 10 years, 10 of the 11 companies believe that population growth will necessitate further expansion of production facilities for all the products mentioned above, with the possible exception of phenolics.

Sources close to the chemical industry claim that alkyd resins have not reached their ultimate utility because of insufficient phthalic anhydride. In spite of this, alkyd resins--of which more than 95 percent goes into paint, varnish, and lacquer uses--have been the largest single class of plastics reported by the Tariff Commission in 3 of the past 5 years. Expansion planned for these resins indicates a continued demand for the drying oils that are used with them. Soybean oil will likely continue to predominate as the oil raw material.

The situation regarding the synthetic film-forming materials may be spotty, viz., the acrylic monomer shortage. In general, the drying oils can expect continued pressure of competition from nonoil materials so far as future supply of basic chemicals and adequacy of processing facilities are concerned.

Synthetic-Materials Prices Versus Drying-Oil Prices

The rise of the chemical industry as it is known today can be traced, in part, to a policy of volume production accompanied by price reductions. There are exceptions to this rule, several of which impinge on the field of protective coatings. Benzene and naphthalene are outstanding examples of chemical raw materials that have increased in price in the last 5 years. It has been suggested that removal of the synthetic rubber plants from Government ownership would exert a similar influence on styrene-butadiene raw-material prices. This question explores the possible effect of shifts in the prices of synthetic materials as a group on their ability to compete successfully with drying oils.

All of the resin manufacturers believe that their products can continue to compete with drying oils. The film properties that are unattainable with oils are cited as the basis for this statement. In the realm of the improbable, one basic producer said that an increase in the current price of butadiene-styrene latex paint might have a slight effect on the proportion of this material used on interior wall. Another producer believes that prices for a number of the synthetic materials can be cut if oil price decreases necessitate it.

Significantly, a number of the paint and varnish manufacturers feel that the price of latex paints can be reduced from present levels if such action is necessary to maintain production volume in the face of flat alkyd competition. This is further indication that latex is not likely to price itself out of the market.

Again, the total field of synthetic competition for drying oils appears healthy and vigorous. Continued development of the drying oils will be necessary if they are to find a firm basis for maintaining their present competitive position.

Relative Promise of New Synthetic-Resin Developments

There is no general agreement about the synthetic-resin development that holds the most promise for the next 5 years. A number of the resin companies offered alternate choices from as many as four items. Tabulation of all the answers reveals:

Synthetic-Resin Development	Number of Companies Mentioning
New alkyds	2
Alkyd emulsions	2
Epoxies	4
Copolymers of oil and various monomers	4
Vinyl acetate emulsions or dispersions	2
Acrylic polymers	2
Silicone alkyds	1
Polyester resins	1
Fatty alcohols	1

The epoxies, first introduced in 1948, have been restricted in application because of their high price. Many of their properties are known, and there is a feeling that their cost will decrease during the next 5 years, thus broadening their economic utility. The copolymers of oils and various monomers represent a recent development that has been incompletely explored. Styrenated alkyds have found a number of applications, but the use of vinyltoluene, divinylbenzene, dichlorostyrene, and acrylonitrile as copolymer materials is still in the developmental stage. In the opinion of a number of the resin manufactueres, the probability of improved film properties from these materials is excellent.

The net effect of combining or replacing oils with synthetic materials will be a decrease in the average oil content of protective coatings. The extent of the decrease is expected to be minor by all 6 of the resin manufacturers and 3 of the 5 basic suppliers of chemicals. Two basic suppliers foresee drastic reductions in oil use. The factors that will influence the future trend of oil consumption include the following: the probable growth of the protective-coatings industry (with synthetic film formers accounting for most of the increase), the possible replacement of current synthetic film formers with oil-bearing copolymers or epoxies, and the hoped-for success of alkyd emulsions to compete with latex emulsions.

The oil suppliers were asked specifically about the prospects for styrene and vinyltoluene, materials that may be used to modify the properties of the drying oils. Styrene has been available for some time, with the reactions reasonably well known. Vinyltoluene is a recent chemical introduction. In terms of commercial application, it is not yet out of the laboratory stage.

The outlook for styrenated oils is poor in the opinion of all the oil suppliers that answered the question. They have bad odor characteristics, poor compatibility with other materials, and are limited to specialty-finishes applications. Vinyltoluene, in the same use as a modifier of oils, is too new to be evaluated properly, but seems to have many of the same disadvantages.

Copolymerization of alkyds with either styrene or vinyltoluene appears to have a greater chance of success. Depending upon polymerization conditions, a range of products has been produced with fast-drying, good color-retention, and acceptable odor characteristics.

Formulations of trade-sales products, industrial-maintenance paints, and industrial specialties, such as hammer finishes for steel, are expected to absorb most of the copolymers of this type. Again, experience is limited, and the full potential of these materials is difficult to a[illegible]

Outlook for Drying Oils as Plasticizers

Six of the nine oil suppliers interviewed believe that oil-based plasticizer materials offer a good potential. Research, aimed at both compound development from the oils and use in the plastics, appears to be the key to this market. Work of the Eastern Regional Research Laboratory on vinyl plastics was mentioned favorably, and three companies indicated that they also are doing research on this problem.

Potential New Markets for Drying Oils

In the face of a highly competitive situation in established uses, it is logical to inquire whether new uses might be found for drying oils that would alleviate the current stress on them. That was the objective in raising this question in interviews with drying-oil suppliers.

Potential new uses for drying oils are not known to the three biggest oil suppliers. They say that they would have been working on them if a potential existed.

For drying oils in general, the only specific suggestion was to use them as impregnating agents to develop new construction materials. Tall oil has some promising (but undisclosed) new uses according to one company, while another sees synthetic detergents as a large potential market for this oil. Castor-oil derivatives in lubricants and synthetic fibers were also mentioned.

In connection with the new construction materials, an interesting application was mentioned by one of the paint companies. This application, currently in pilot-plant trial, consists of deresinifying Southern pine and impregnating it with linseed oil. Originally, the process was developed to impregnate fence posts with wood-preservative chemicals. Later, the linseed-oil impregnation was attempted to upgrade the lumber to kiln-dried quality. The apparent success with this on a laboratory scale indicated that upgrading to trim-quality (competing with Western soft woods) might be possible.

Officials of the company are optimistic about the process, but caution that full-scale operation is several years in the future. Pending further tests they prefer not to estimate either the potential for the treated lumber or the probable consumption of linseed oil in this use.

According to one official of the company, oils other than linseed might be used. Comparative tests have not been made to determine the differences between impregnating oils.

Résumé

During the next 5 years, total consumption of drying oils is expected to continue to decline, probably at a slower rate than was evident between 1949 and 1952. This decrease will come about because many future protective-coatings products will be coatings containing both oils and synthetic resins or only synthetic resins, rather than coatings based entirely or almost entirely on oils. New oil-containing materials, e.g., alkyd flat resins, in protective-coatings resins will be responsible for slowing down the rate of decline.

Among the various types of drying oils, soybean oil and tall oil will show increased consumption at the expense of linseed oil and tung oil. Price considerations will govern the extent of the shift, with quality improvement a secondary consideration in the overall picture.

Among the various end uses of drying oils, paints and varnishes (including the oil-bearing synthetic resin intermediates) are expected to consume slightly less or about the same amount of oil, with total gallonage of products rising. Consumption of drying oils in floor coverings will show a decrease on a percentage basis, but actual volume will remain stable or decrease only slightly. Printing inks, core oils, brake linings, and electrical insulations appear to offer stable markets, while other uses will increase slightly.

Lower prices for vegetable oils as a group and maintenance of synthetic-materials prices, would be expected to increase gradually the proportion of drying oils in paints and varnishes, floor coverings, and thermal insulations. A greater effect, percentagewise, would be anticipated in core oils. Other drying-oil-consuming products would remain farily stable in their oil usage.

These trends are predicated on the assumption that research on the drying oils and their applications will be maintained at current levels or increased. Increased research on drying oils, strongly recommended by the majority of the respondents, could well be the answer to maintaining drying-oil consumption near its present level of 1.1 to 1.2 billion pounds per year.

PRESENT TECHNICAL DIFFICULTIES IN THE USE OF DRYING OILS AND RESEARCH NEEDED

In planning this study of the market potential for drying oils, the important role that research would probably play in determining the future course of drying-oil usage was recognized. Research, from one aspect or another, is mentioned in 3 of the 5 major objectives of the study.

As a result, considerable emphasis was given during the course of the study to determining what problems in the use of drying oils are being encountered by producers and consumers of the oils, and to finding out what types of research might best serve to correct those problems.

Three questions were used in seeking information from companies concerning technical difficulties and research needed. The first sought to determine the general attitude of the company toward drying-oil research and the type of research that the company felt would be most helpful. The second tried to discover the technical difficulties encountered in using the oils and modifications in oil properties needed to better fit them to the company's needs. The third question inquired about technical difficulties faced in the use of synthetic raw materials.

The questions were slanted to the operations of the particular company being interviewed--whether a paint manufacturer, producer of other drying-oil-consuming products, or supplier of the oils themselves. Oil suppliers were not questioned about difficulties with synthetic raw materials, even though some of the suppliers use these materials to produce intermediate products for paint and other manufacturers. In interviews with synthetic-materials manufacturers, none of the three questions was asked. But information was sought about the nature of technical problems brought to these companies by their customers and methods used in developing and promoting new products.

It became apparent early in the interview phase of the study that the problems of technical difficulties and needed research could not be divorced from each other. It was usually possible to get a general statement from the interviewee on his attitude toward research and his belief in the relative importance of fundamental versus applied research. However, technical problems and the research needed to solve them were almost invariably combined into a single discussion. This approach--a perfectly natural one--is also evident in the presentation of this section.

However, even though the overlap of problems and research was recognized, an effort still has been made in writing this section to make at least a partial separation of the topics.

Technical Difficulties in the Use of Drying Oils

If one considered all the different drying oils and all the end products in which they find a use, a person could undoubtedly make a list of well over a hundred separate problems in the use of the oils. However, the bulk of these problems could be listed under two headings--properties and price. The problems involving properties are clearly evident in both the preceding sections on current uses and on future trends. Certain product qualities that can be achieved with various synthetic materials simply cannot be attained with drying oils, per se. As a result, drying oils have been displaced by synthetic raw materials in certain applications.

The overall problem of price is not so clear. There is no doubt of the role of price in the competition between tall oil and drying oils; tall oil is being used because it is cheaper. Price is equally, though less obviously, important in the competition between drying oils and synthetic materials. More expensive synthetics are being used in many instances because desired properties cannot be achieved with less expensive drying oils. If these desired properties could be achieved through suitable oil modification, the raw oil price would have to be sufficiently low to permit the necessary modification and upgrading to make it competitive in quality with synthetics. This same "reasonable-price" concept would be equally important in trying to make new products utilizing drying oils as raw materials. The price that would have to prevail is unknown--but there can be no doubt of the close relationship of the two problems of properties and price.

In addition, the initial comment of many interviewees, when asked to cite difficulties with drying oils, amounted to: "We don't have any special problems with oils. We have our troubles with them, of course, but we know what they will and won't do and we just accept them as they are." The frequency of this statement indicates that many drying-oil consumers have pretty much resigned themselves to taking the oils as they come with little hope of improving them.

However, such an attitude virtually invites synthetic-materials manufacturers to keep supplying new products that will give the drying-oil consumer less trouble and better results. The properties of drying oils should really be a ringing challenge to those interested in these oils to do everything possible to develop new raw materials that will be received with greater enthusiasm by producers of paint, varnish, floor covering, and other products.

Difficulties Cited by Protective-Coatings Manufacturers

Among the dozens of individual technical difficulties mentioned by protective-coatings manufacturers, the two problems which appear to predominate and which were most frequently cited were: (1) speed of drying and (2) color retention. In specific applications, other problems--poor chemical resistance, poor durability, etc.--were also mentioned. However, these problems appear to be less general than those of drying speed and color retention.

Drying speed is a problem in both trade-sales products and industrial-product finishes. In both types of products, drying speed may be the key to the success of a given formulation, or particularly with industrial-product finishes for assembly-line operations, may determine whether a given formulation can be used at all. Better color retention, on the other hand, has been one of the underlying factors in the increasing use of soybean oil in place of linseed oil in many applications. The following remarks summarize the hopes of paint manufacturers with regard to drying speed and color retention, "We want a soybean oil that will dry like linseed, and a linseed oil that has the nonyellowing properties of soybean."

Difficulties Cited by Other Major Users of Drying Oils

The other major users' drying-oil use problems are similar to those of the protective-coatings manufacturers. In a number of instances, the specific properties desired by the groups of consumers lie at the extreme opposite ends of the scale. For example, harder, more durable films are requested by the paint companies, while floor covering and oilcloth manufacturers seek durable, flexible films.

The variations in application of film-forming materials within the other major uses are sometimes of little importance to protective-coatings manufacturers. Problems encountered in making printing inks, electrical insulations, and enameled floor coverings resemble those of the paint companies. In the case of linoleum-type floor coverings, table oilcloth, and fabric wall coverings, the problems relate to controlled oxidation of drying oils in bulk. Problems in the manufacture of thermal insulations, core oils, and brake linings involve the production of discontinuous films and a separate set of variables. However, all the other major users of drying oils could profit from fundamental research on the oils.

Difficulties Cited by Drying-Oil Suppliers

Problems arising in the use of drying oils affect drying-oil suppliers at two levels. First, any unusual processing difficulties experienced by a consumer are usually blamed, rightly or wrongly, on the drying oils. The supplier hears about these problems. Second, a number of the larger oil suppliers have entered the field of synthetic-resins manufacture, and have become intermediate consumers of their own drying-oil products. To these must be added the problems encountered in manufacturing and processing the drying oils themselves.

Most of the problems cited by drying-oil suppliers were of a fundamental nature. These companies would like to know more about the basic structure and composition of the oils, the mechanism of film formation, the effect of minor ingredients on film-forming properties, the results of reacting oils and oil constituents with various reagents, the possibilities of developing new products if oils are treated as chemical raw materials, and so forth. If they had the answers to such questions, the oil suppliers would be in a position to develop a considerably broader market for their products.

Technical Difficulties in the Use of Synthetic Materials

The companies interviewed made relatively few references to problems encountered in the use of synthetic raw materials in their manufacturing processes. Specifically, 26 of the 46 paint companies contacted said that they were experiencing little or no difficulty with synthetic modifying agents or film formers.

To some extent, this lack of problems with synthetics is explained by the fact that some paint companies do not use synthetic raw materials but purchase only intermediate materials based on them, such as the alkyd resins. In larger measure, however, this freedom from difficulties is attributed to the following: (1) greater chemical purity and uniformity of these materials, (2) no attempt to use them outside their special fields of application, and (3) the gradual buildup of knowledge concerning them acquired through processing experience.

The latex-emulsion systems were most frequently mentioned among the various materials giving difficulty. Ten companies cited the complexity of these systems and the short working experience with them as the major causes of processing difficulties with synthetic materials. Quality variations in pentaerythritol were mentioned by 3 companies, and 1 company cited a similar problem with phthalic anhydride. Alkyd resins have been somewhat troublesome to 3 companies, 2 of which are not certain whether the constituent oils are responsible or not. Individual companies mentioned maleinized soybean oil, epoxy resins, melamine hardening agents, and compatibility of polystyrene, polyesters, and epoxies as additional sources of bothersome, but not insurmountable, problems.

The comments on this topic of other major drying oils users closely paralleled those made by protective-coatings manufacturers. Here again, problems arising from the use of synthetic materials are few and minor in comparison with those relating to drying oils. Stability of certain resins, difficulties in calendering vinyls, and foaming of emulsions were the only specific problems mentioned. One company was quick to point out that these problems are not insurmountable and that they will not retard the trend away from drying oils as they now exist.

Technical Service and Developmental Activities of Synthetic-Resins Manufacturers

No attempt was made in this study to get the opinions of synthetic-resins manufacturers on the desirability or nature of future research on drying oils. Rather than pass over this question entirely, however, information was sought from these companies on their technical service work with customer companies and their research and development activities in promoting new types of resins or related products.

This information was obtained by asking three questions. The first sought to determine the types of problems relating to the use of the company's products that were brought in by the drying-oil-consuming customers of the company. The second inquired whether, in the development of new products, a specific or general market for the product was sought. In the third question, the resin producers were asked whether the industries consuming drying oils were making the best use of the producer's materials. Taken together, the replies to these questions provide at least a partial picture of the technical service and development work being done by major synthetic-resins producers in this country. (The absence of a parallel discussion of technical service by drying-oil suppliers in no sense implies that they are any less cognizant of their customers' problems or any less diligent in their efforts to solve these problems.)

Types of Problems Brought to Synthetic-Resins Producers

The types of problems presented by consuming industries to the synthetic manufacturer are very similar to those brought to drying-oil producers by their customers. In both instances, the problems center around improved performance of the final film. For both the resin manufacturer and the drying-oil supplier, these problems have necessitated a field of research known as Technical Service--the specific application of the company's products to the consumer's needs.

The extent of laboratory work done by the consuming company has a distinct bearing on the nature and amount of technical service that the resin producer must supply. Larger consumers, with adequate research facilities of their own, frequently are quite specific in their requests and may indicate the properties desired and approximate composition for a new resin. Smaller companies depend on the resin supplier to furnish not only the necessary material but also the paint formulation that will achieve the desired result.

There are many more small than large consumers of synthetic resins. As a consequence, many of the resin producers have learned a good deal about paints and other drying-oil-consuming products. The chemical industry considers this knowledge a desirable part of their own sales-promotion programs. Illustrative of the extent (but by no means unique in the field) to which the chemical companies will go in this direction is a booklet published in 1952 by the Monsanto Chemical Company. Entitled The Chemistry and Processing of Alkyd Resins, it stresses the fundamental chemistry involved in this big-volume resin field. Furthermore, resin producers generally agree that a competent and complete customer service, including publications, is necessary to sell in this highly competitive field.

Market Development for New Resins

The development of new resin products stems from customer requests for help in solving a particular problem and from an abundance of raw materials for which new uses are needed. Developments arising from the first source tend to have specific application, although continued research may suggest modifications to broaden the market for the product. In contrast, developments arising from the second source are likely to result in products having general application, even though a specific use may merit and receive the initial promotional effort. The alkyd flat vehicles represent an outstanding example of specific product development. On the other hand, styrenated alkyds are representative of utilization of a raw material seeking a general market. In essence, the more basic the chemical products manufactured by a company, the greater will be the tendency for these products to have general usage.

Customer Knowledge and Use of Synthetic Resins Materials

In spite of large technical service groups, a technically trained sales force, and heavy advertising expenditures, acceptance of the synthetic resins is not universal. In fact, there are indications that the consuming industries sometimes change the application of a producer-recommended material. The results of such changes are neither universally bad nor good. They illustrate the consuming companies' belief that they still know more about their products than any raw-materials supplier, even though the producer may have expended many times the research effort put in by the consumer.

In this regard, the resin producers were asked whether they felt that their drying-oil-consuming customers were making the best use of the resin materials they purchased. The responses to this question varied with the type of product sold and the emphasis given to technical sales service.

The uses of basic chemicals are quite well known, with the possible exception of the latest materials introduced. While finding wide application in a variety of products, the reactions and possible advantages of these basic chemicals are generally recognized by their purchasers.

The utility of synthetic film formers and oil-containing vehicles depend mainly on physical properties rather than chemical reaction, and each material used with them in a final formulation may have an effect. The possible combinations of materials that may be used in a paint formula are very large. Consequently, a few useful combinations for each specific resin product are about the most that a resin manufacturer can be expected to suggest. Eight of the resin producers contacted concurred in this opinion and added that they try to supplement these basic suggestions with advertising and personal technical service contacts.

No attempt was made to discover the percentage of uses for a product developed outside the producing company. One large basic chemical manufacturer claimed that 70 percent of the uses are the result of work done by the consumer.

Research Recommendations

The intent of this discussion is to evaluate research problems in terms of their potential contribution to maintaining or improving the competitive position of the drying oils.

Previous Drying-Oil Research and the Problem of Dissemination of Results

Before discussing future drying-oil research, one should refer at least briefly to previous research in this field. Actually, the amount of money that has been spent on drying-oil research is considerable.

How it would compare with the sums spent on industrial-chemical research is not known. The major difference seems to lie in the diversity, decentralization, and duplication of effort that characterizes research relating to drying oils. There was strong evidence that many of the research problems cited in this section have already received considerable attention from one or more companies that produce or consume drying oils. The fact that so many references were made to such problems indicates the relatively poor job that has been done to date in disseminating and correlating research results within the industries that sell or use drying oils.

Attempts to correct this situation are now under way. The recently completed study by the Federation of Paint and Varnish Production Clubs is an outstanding example. True, preliminary indications are that the study was unsuccessful in achieving its objectives. However, publication of the results can prevent a lot of future duplication and can be a springboard from which further research--possibly more successful--can arise.

Equally important, the industries connected with the drying oils need to realize that research that fails to accomplish its main objective is not unsuccessful if it prevents future mistakes in seeking the same objective. And the key to mistake prevention is the publication of the results of basic research, successful as well as unsuccessful.

There is hope for the future. The problem of dissemination of research results is recognized by the informal Industry Committee for Protective Coatings, an advisory committee to the U. S. Department of Agriculture. It is possible and even probable that with the cooperation of all segments of the industries concerned with drying oils, fundamental drying-oils research can be coordinated and thereby speeded. Certainly one of the most important future research recommendations that can be made in the drying-oil field is that the results of previous research be pulled together and widely disseminated.

General Attitude of Companies Toward Drying-Oil Research

The companies interviewed in this study were questioned about specific problems needing research attention and about their attitude toward such research generally. Generally, reactions in this respect were favorable. The protective-coatings industry is overwhelmingly in favor of additional drying-oils research. Three of the 46 companies--1 fairly large and the other 2 medium sized--see no direct practical benefits to themselves but would not discourage research in general. The balance of the paint companies support research for the paint industry with varying degrees of enthusiasm. The replies ranged from "research is both desirable and inevitable" to "oil research on behalf of agriculture but not the paint manufacturer" (by way of saying that such research should be done by the oil companies).

Among the other major users, opinion is unanimous concerning the need for and the desirability of research on drying oils. Beyond these points, however, there is a wide divergence of ideas as to the most immediately useful type of research.

The comment of one prominent figure in the protective-coatings field point up the attitude of the majority of persons contacted in this study. In discussing drying-oil research, he stated, "There is still so much to be learned about drying oils, even after all these years of study! If the drying-oil industry would put one-tenth the amount of research money into fractionation of the oils that the petroleum companies have spent, we would have much purer compounds to work with and be a lot farther ahead."

Relative Interest of Companies in Fundamental and Applied Research

Research suggested by the protective-coatings manufacturers falls into two general categories--that directed at improving the oils (without changing their chemical identity), and that designed to improve performance of the final film regardless of the changes required. The latter, which can be characterized as basic or fundamental research, predominates. Application research (the development of specific formulations or economical means of producing improved oils or film formers) was not ignored. However, the majority of the companies feel that these developments will follow the basic research rat quickly and can best be done by either the paint companies or the oil processors.

Fundamental research was also stressed by the other major oils users. This is evident in two prominent research recommendations made by these companies. The first urges fundamental research on the mechanism of drying. The second recommends that the oils be recognized as basic chemical raw materials and that research be done to determine what useful products can be made from them.

The feelings of drying-oil suppliers are very similar. In talking with these companies, there was strong evidence that the Department of Agriculture should confine itself to basic research, at least in the drying-oils field, and leave application research and formulation development to the oil, resin, or paint companies. Fundamental work received favorable mention. Examples of such research are the Northern Regional Laboratory's study of polymeric fatty acids and polyamide resins, the flavor reversion studies on soybean oil, the Eastern Regional Laboratory's investigation of epoxidation of oils, and the establishment of research scholarships for study of fatty acids.

In summation, the consensus of the companies interviewed is that the Department of Agriculture should give major attention to fundamental research in its work with drying oils. Not all the work attempted will result in useful applications for the industries consuming and producing drying oil. However, each piece of knowledge isolated and identified will help to complete the jigsaw puzzle that characterizes the drying oils.

Fitting Future Research to Potential Markets for Drying Oils

The common-sense fact of attempting to recover markets for drying oils where they will be the greatest leads to the conclusion that research on these oils as protective coatings must come first. Granting that, interior flat wall trade finishes would head the preferential list, and linoleum-type floor coverings and core oils would follow in descending order.

Research Recommended by Companies

The numerous individual research recommendations made by persons interviewed in this study can be grouped into eight broad headings. Seven of these eight groups represent collections of specific related recommendations; the eighth category lists general comments and suggestions bearing on the overall drying-oil research problem. The gist of these general comments is presented in the preceding paragraphs of this section of the report.

Five of the other seven groups of recommendations relate to fundamental or basic research. This breakdown provides further evidence of the stress given to fundamental research in the recommendations made by companies. It is also worth noting that the great bulk of the recommendations referred to chemical analysis, chemical reaction, chemical study of films, etc. There can be little doubt of the importance of chemistry in drying-oil research.

1. Fundamental Chemical Research on Drying Oils--There is general agreement that our understanding of the basic nature of the oils themselves or their constituent parts is inadequate to permit their most effective use in making other products. At the same time, it would be helpful to have better analytical methods--particularly a better measure of conjugation--than now exist. A corollary to these studies of basic chemistry and analytical methods, and a probable natural outgrowth of them, would be the development of more uniform, purer, and more readily usable oils.

2. Improved Drying-Oil Processing Techniques--Numerous references were made to the need for improvement of processing techniques, especially as regards the development of faster-bodying oils and improved bodying methods. In essence, this is applied research; but basic research on the properties, composition, and reaction of the oils will be a necessary precursor to the application. Other oil processing problems were also cited--developing oils with lighter color or less odor, improving the blendability of the oils with each other, studying the reactions of oils with drying additives (a possible key to improved shelf stability), and so forth.

In many respects, the recommendations under this heading can be summarized as "chemical engineering research" on drying oils. Very little has been done in this field; for example, little is known about what can be done with oils by applying high heats in the presence of catalysts. While the primary goal would be improved processing techniques, here again basic research would necessarily precede studies of applications.

3. Chemical Modification of Drying Oils--Since a large percentage of the drying oils used today are chemically modified before going into various end products, further research in this field is also indicated. Basically, all of the recommendations in this group boil down to finding out how the oils react with different chemicals, what products are obtained (either modified oils or entirely new materials), what happens during the reaction, and why. Although not specifically mentioned by any company, another logical phase of this modification research would be a study of the effects of introducing or eliminating selected chemical groups in the oils on their compatibility with various chemical monomers.

4. Use of Oils as Chemical Raw Materials--This is perhaps the "newest" category of recommended research, as measured by volume of previous research. Unquestionably, there has been some good work in this field in the past, particularly in the production of fatty acids and fractional distillation of those acids. But relatively little work has been done in segregating oil constituents, rearranging them, and reconstituting them into new products with properties different from the original oil. Furthermore, drying oils have been recognized for what they really are--highly reactive chemical raw materials in relatively few instances. Consequently, very little is known of drying oils ultimate potential as raw materials for improved products in already established uses or as the starting point for products that would find application in entirely new markets.

5. Fundamental Research on Films--There were 48 separate suggestions, the greatest number of references to a single research activity, that research be done on the basic mechanism of film

formation. Some of these suggestions--e.g., "mechanism of drying needs study"--were general in nature. Others related to more specific problems, such as improved color retention, improved gloss, etc. Still others were highly specific. All, however, involved basic research on film formation--the paramount consideration in the use of protective coatings and related products.

6. Application Research on Films--This category was set up as a separate heading to cover eight specific film-formation problems mentioned by various interviewees. The solution to these problems will rest on the successful accomplishment of the fundamental research on films.

7. Miscellaneous Recommendations--This category contains suggestions that could not properly be placed under other headings. More than half of the suggestions falling into this group can be categorized as upgrading each oil to its maximum potential, which actually encompassed research on the basic chemistry of oils and chemical modification. Other miscellaneous recommendations covered the following: Drying-oil agronomy (research aimed at increasing yields of oilseeds and at making them more uniform in composition geographically and from one crop year to another), research to lower the cost of oils, research to find new uses for linseed oil, and the development of drying oils from petroleum and other nonvegetable sources.

Evaluation and Major Research Recommendations

Five recommendations for future research were selected from over 200 separate comments. The primary yardstick used in making this selection was the potential effectiveness of the indicated research in maintaining or improving the competitive position of the drying oils relative to other raw materials.

The major recommendations for future drying-oil research are:

(1) Make a thorough investigation of the basic chemistry of drying oils. As indicated previously, despite all the research that has been done on drying oils in the past, we do not have a thorough understanding of what they are or why they react as they do. Until we have this understanding, most of the work on the use of drying oils in paints and other products must of necessity be done by trial and error, as it has in the past. The drying-oil suppliers and consumers in general are not in a position to do this fundamental analytical work themselves. They must engage in application research in order to keep their customers happy and to maintain their competitive position. The success of this application research would be greatly enhanced if companies selling or using drying oils could be

given a greater fund of basic knowledge of the materials with which they are dealing. Furthermore, this work must be done as a research job, not as a development job. Questions of economic practicability must be ignored.

(2) Use this knowledge of the basic chemical composition of drying oils as a starting point for research in the chemical modification of the oils. This research program represents a logical sequel to the preceding recommendation. There can be little question that the future position of drying oils rests in large measure on the success of efforts to build better properties into them through chemical modification. The potential rewards of such efforts can be clearly seen in the tremendous market that now prevails for alkyd resins. It would be foolhardy to assume, however, that alkyd resins alone can maintain the position of drying oils indefinitely. Further work in this field must be done, and is being done, by drying-oil suppliers and consumers. A major contribution to this work can be made by conducting a thorough study of how drying oils and their constituent parts react with a wide variety of chemicals and under a wide variety of experimental conditions. Nor should this phase of the research program be limited to chemical materials that have been used in reactions with drying oils in the past. There should be a definite seeking for new materials that might serve as modifiers for drying oils by chemists who will be alert to recognize the potential application of a new material.

(3) By the utilization of materials developed through chemical modifications of oils, formulate new products that will serve more effectively as raw materials in established uses or that will find a market in entirely new uses. The ultimate purpose of chemical modification research on drying oils is the development of new products. The former serves as a stepping stone to the latter. In both phases of the research program, several questions must be used as a guide to the research effort. They are: (1) What can be done to improve the drying oils in their present uses? (2) What types of oils, having what properties, will be needed in different uses in the future? (3) What kind of research must be done on the oils to make them attractive raw materials for new uses?

Two points should be stressed here. First, research on developing new products should not have as its objective the finding of a better paint for refrigerators or a better printing ink for paper napkins. The objective should be the development of chemically modified oil-derived materials that can be used more effectively by paint manufacturers to make a better refrigerator paint or by printing-ink producers to make better inks for napkins--or any of a multitude of other end products. Second, although there is little evidence of new markets for drying oils at present, this should not be interpreted to mean that new markets could not be found if suitable raw materials were developed from the oils.

(4) As an important corollary to the above program of research on the drying oils themselves, undertake studies, based on fundamental physical and chemical knowledge, to determine the mechanism by which oil films dry and the factors that affect color retention in protective coatings. A major share of the technical difficulties of protective-coatings and other manufacturers in the use of drying oils revolves around film formation. The chances are that faster-drying, more color-retentive oil-based paints can be developed as a result of research solely on the basic chemistry and chemical modification of the oils. However, these chances would be increased manifoldly if there were a better understanding of the basic mechanism of film formation to guide this chemical research.

(5) Continuation and expansion of long-term breeding research on the agricultural plants from which oils are derived. This again represents a phase of the research program that is probably not essential to maintaining or improving the position of the drying oils. The objectives of this research would be the following: Continuation of the work already under way with special emphasis on the development of plants that would yield more bushels per acre or more pounds of oil per bushel, greater uniformity of oil from one geographic area to another or from one crop year to the next, new and better types of drying oils. In essence, an expanded research program along these lines might result in less expensive, more uniform oils, or entirely new and better oils. The net effect would be more attractive raw materials, pricewise, propertywise, or both, for the drying-oil chemist to use in developing products for drying-oil consumers.

REVIEW OF RESEARCH FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Recent Trends in Drying Oil Usage

An understanding of recent trends in drying-oil usage and of the reasons underlying those trends was considered basic to the other phases of this research effort to find new or expanded uses for the oils. The years 1949 and 1952 were selected as base years, and information was gathered and analyzed on changes in formulation practice and raw-material use patterns within this period.

Significant changes in formulation practice did occur between 1949 and 1952 in the industries that consume drying oils, and many of these shifts are still in progress. Four changes can be singled out during this period that probably were the most important in terms of their effect on drying-oil consumption patterns.

The first of these changes was the introduction and widespread use of styrene-butadiene latex emulsion paints. Sales of latex vehicles in this country increased rapidly from an estimated 2 million gallons in 1949 to about 30 million gallons in 1952 and 40 million gallons in 1954.

A second major change was the increasing use of synthetic materials in the manufacture of both paint and nonpaint products. In the protective-coatings field, silicone alkyd resins, interior flat alkyds, epoxy-modified oils and alkyds, polyvinyl acetate resins, and styrenated alkyds were introduced. Acrylic resin emulsions came into prominence in 1953. Similar developments occurred in the other drying-oil consuming industries. Two examples are the increased use of vinyl resins in making floor coverings and of various synthetic resins in the manufacture of table and wall coverings.

The third significant change was the growing use of tall oils and their derivatives to produce paint and nonpaint products. The fourth was a shift from oleoresinous to alkyd-type vehicles on the part of the smaller paint companies, a shift that had been largely completed prior to 1949 in the bigger companies. In general, this change has meant somewhat less drying oils used in a given quantity of paint and also a switch from linseed to soybean oil.

Most of these changes occurred because the resulting end products were of higher quality or possessed properties superior to those attainable from previously used formulations. Some of them were made because less expensive raw materials could be used to make equally good or better products. Latex paints achieved widespread acceptance and popularity, largely because of their ease of application and cleanup, plus effective promotion on the part of the manufacturers.

Other synthetic materials, in many cases "tailor made" for specific applications, imparted properties to end products that simply could not be achieved with drying oils. Some of these properties are improved durability, better chemical or heat resistance, and faster drying time. Tall oil was used in larger quantities because it cost substantially less than vegetable drying oils and could be effectively used in combination with other oils to manufacture certain intermediate and end products. Production of alkyd resins continued to increase because these resins offered effective competition for latex emulsion interior paints and because they could be made from soybean oil, a less expensive ingredient than linseed.

The increasing use of synthetic raw materials in lieu of drying oils has stemmed from the superior properties that these materials give to various end products and from the relatively greater research effort that has gone into the development of these materials. Drying-oil research to date has been inadequate to maintain the position of the oils in the face of the competition of synthetics. In addition, much of the research that has been done on the oils has not been widely enough known to be of maximum benefit to those interested in the results of that research.

Whatever the basis for a particular shift in formulation practice, the end result was a marked rise in consumption of synthetic materials in lieu of drying oils, and of soybean oil in lieu of linseed during the 1949-52 period.

Conclusions

It is the consensus of those interviewed during this study that unless a significantly greater research effort is applied to the drying oils, the following trends are likely in the future:

1. Synthetic raw materials will continue to replace drying oils in the manufacture of both protective coatings and nonpaint products. However, the resultant decline in drying-oil consumption will tend to be offset by the expansion in the total markets for most of these products, and the making of new combinations of drying oils and synthetic raw materials.

2. Consumption of soybean oil and soybean-oil fatty acids is likely to increase at the expense of linseed oil if soybean oil is cheaper than linseed as it has been in past years, and if the popularity of alkyd resins continues. The linseed oil market may see a further cutback within 10 years if the anticipated development of an exterior house paint of a nonlinseed type becomes a reality.

3. In protective-coatings products, average oil content will continue to decline in trade-sales and industrial-maintenance lines, but will remain relatively stable in industrial-product finishes. The net effect will be a decrease in the production of "exclusively oil" coatings, and an increase in production of both "part-oil" and "nonoil" coatings. Production of floor coverings will continue to increase, but most of the increase will be in the form of vinyl-based coverings and other types in which relatively little oil is used. Prospective production trends for other products consuming drying oils do not appear to offer any significantly greater market for drying oils. On the basis of relative market size and other factors, interior flat wall finishes and floor coverings appear to be the two products in which drying oils, if improved, might hope

to regain lost markets. On the other hand, the present position of the drying oils in exterior house paints is likely to be in jeopardy within a few years unless research on linseed oil keeps pace with developments in the synthetics field.

4. A decline in the price of one drying oil relative to another would undoubtedly result in increased consumption of the lower-priced oil. A major decline in the price of drying oils as a group relative to tall oil would probably cause a displacement of tall oil in favor of the vegetable drying oils. In the absence of such a decline, consumption of tall oil and derivatives of tall oil seems likely to increase in the future, particularly if the quality of these materials continues to improve as it has in recent years. A decline in drying-oil prices, of itself, would not materially improve the competitive position of the oils in relation to synthetic raw materials. The latter are already being used in large quantities even though most of them are premium priced by comparison with the oils. A decline in oil prices would, however, make the oils more attractive for present and potential new uses, and might lead to increased consumption of the resulting less expensive paints and other products that could be made from them.

5. There is no evidence of a shortage of basic chemicals for making synthetic raw materials or of facilities necessary for their processing, either now or in the foreseeable future. At the same time, there is no indication of any significant new technical development in the synthetics field likely to provide further competition for the drying oils beyond the materials already in competition.

6. With the possible exception of lumber impregnation, no new uses for drying oils appear to be in the offing.

On the basis of the above predictions by themselves, the outlook for the future of drying oils appears bleak. However, there is reason to hope that the trends mentioned may be moderated with respect to the overall use of oils. The basis for this hope lies in a concerted research effort directed at modifying and improving drying oils so as to make these raw materials more attractive to their consumers. The possibility of drying oils *per se* recapturing a large share of the markets they have lost to synthetic materials is admittedly remote. Potentially, however, these oils might well serve as raw materials for making other film formers that would yield end products with even better properties than those presently attainable only from synthetic materials. The fact that there has been no significant production from drying oils of a latex emulsion paint or a "steam-set" ink is no proof that such production is impossible.

In the planning of this study, the promise that research might hold for drying oils was fully recognized. For this reason, major emphasis was given during the interview phase to learning the major technical difficulties faced by consumers and processors in their use of the oils, and the types of research that they felt might provide a solution to these problems.

Listed separately, the individual drying-oil problems cited by the company representatives interviewed would total well over a hundred. Measured in terms of their frequency of occurrence, however, this diversity of difficulties can be reduced to a relatively few major problems. Among manufacturers of protective-coatings, the two problems most frequently cited were the need for speed of drying and for color retention. The problems mentioned by other major consumers of drying oils were similar to those listed by paint producers, although in a number of instances, the specific film properties desired are at the opposite end of the scale.

Most of the problems cited by drying-oil suppliers were of a fundamental nature. These companies would like to know more about the basic structure and composition of the oils, the mechanism of film formation, the effect of minor ingredients on film-forming properties, the results of reacting oils and oil constituents with various reagents, the possibilities of developing new products if oils are treated as chemical raw materials, and so forth.

Nearly all of the companies contacted were in favor of additional research on drying oils, and looked upon such research as the only real hope for maintaining or improving the competitive position of the oils. The companies further believed that the greatest need lay in the field of basic or fundamental research.

Recommendations

Out of the multitude of problems and ideas on which research was recommended, those selected for study appeared to offer the most effective starting point in improving the relative competitive position of the drying oils in future years. On the basis of the studies, it is recommended:

Increased recognition should be given to the potential value of drying oils as basic chemical raw materials. Special attention should be given to the need for competitive prices for the drying oils, so as to make them more attractive as raw materials for developing new or better products.

Stable prices for the oils, with drying oil supplies holding at reasonable levels, are also needed. Excessive fluctuation in prices and supplies tend to depress their use in some products currently and would make them less attractive in the future as chemical raw materials.

The fundamental research suggested above should not be regarded as an overnight panacea for the problems facing drying oils. It is of necessity a long-range research program with the promise, however, of offering a sound solution to the present difficulties confronting drying oils. The research that may enable the drying oils to recapture lost markets or find new markets will necessarily take considerable time to become an effective influence on drying-oil consumption.

A research program should be established promptly in which all available information on the results of previous drying-oil research would be thoroughly reviewed, screened, organized, evaluated, and widely disseminated among persons and organizations concerned with the production or consumption of drying oils.

A comprehensive program of fundamental research on drying oils should be initiated, including the following phases:

(a) A thorough investigation of the basic chemistry of drying oils.

(b) Use of this knowledge of the basic chemical composition of drying oils as a starting point for research in the chemical modification of oils.

(c) Utilization of the materials developed through chemical modification of oils to formulate new products that will serve more effectively as raw materials in established uses or that will find a market in entirely new uses.

(d) Studies based on fundamental physical and chemical knowledge, to determine the mechanism by which oil films dry and the factors that affect color retention in protective coatings.

(e) Intensification of long-term breeding research on the agricultural plants from which oils are derived.

In summary, effective research on the drying oils--fundamental research on their nature and chemical possibilities--is the foundation on which their future utiliztion depends.

GLOSSARY OF SYNTHETIC RESINS IN PROTECTIVE-COATINGS USES

The synthetic resins described in the following paragraphs supplement or replace drying oils from agricultural sources. No attempt has been made to define every synthetic resin used in the manufacture of protective coatings. Rather, this glossary follows the nomenclature of the U. S. Tariff Commission's "Annual Report of Synthetic Organic Chemicals," and illustrates the major classes of synthetic resins.

In the protective-coatings industries--paint and varnish, floor coverings, table oilcloth and fabric wall coverings--a wide variety of raw materials may be combined in many different ways by individual producers to achieve similar characteristics in an end product. For example, an interior flat wall paint may be based by one manufacturer on the purely synthetic film former, styrene-butadiene latex emulsion. On the other hand, a competitive product from the same or a different manufacturer is based on an alkyd resin containing drying oils from agricultural sources. Both products serve the same purpose, and usually represent successful formulations for the respective manufacturers. The same competitive situation between drying-oil-based and synthetic resins exists in the printing ink and core-binder industries whose resins differ from protective-coatings resins in degree rather than in kind.

The major protective-coatings synthetic resin terms used in this report follow:

Alkyd Resins--the condensation product of polyhydric alcohols, polybasic acids, and agricultural oils. The principal raw materials include combinations of glycerine or pentaerythritol and phthalic or maleic anhydride with oils or oil-derived fatty acids, such as linseed, soybean, castor, coconut, or tall oil. A wide range of usable characteristics is achieved by varying the ingredient raw materials as well as the amounts of the individual ingredients.

The alkyd resins probably represent the most versatile film-forming agent in use at the present time. They are used in interior architectural finishes, industrial product finishes, exterior trim enamels, and industrial maintenance coatings. With appropriate modifying ingredients the resultant finish may be glossy, semiglossy, or flat, quick or slow drying, hard, tough, or elastic, or self-leveling, water-resistant, or color-fast. In addition, they form the basis of floor covering, printing ink, and core-binder formulations.

Since agricultural oils are included in the protective-coating alkyd resins, these resins may be considered as extenders of the oils. Originally, the alkyd resins reduced the consumption of drying oils by replacing oleoresinous varnishes and oil paints. Later, these resins increased the consumption of drying oils by replacing strictly synthetic materials and nonoil finishes. Among the various drying oils, the alkyd resins have resulted in decreases in the consumption of linseed and tung oils, with corresponding increases in the consumption of soybean, coconut, castor, and tall oils. The future outlook for alkyd resins is good, indicating the probable continuation of present levels of drying-oil consumption.

Copolymer Resins--the product resulting from the chemical interaction of two substances, each capable of forming resinous products when reacted with itself. Depending on the ingredient raw materials, copolymer resins may be purely synthetic film formers or may be modified oil film formers. The principal raw materials include styrene, butadiene, vinyl chloride, vinyl acetate, acrylonitrile, vinyl toluene, divinyl benzene, and alkyd resins. Some copolymer resins are processed to yield emulsion vehicles, such as styrene-butadiene latex, vinyl latex, or acrylic latex. Others yield lacquer-type vehicles, such as dispersion coatings and vinyl films. Oil-bearing copolymer resins containing styrene, vinyl toluene, divinyl benzene, or acrylonitrile may be regarded as modified alkyd resins.

In general, the copolymer resins are specialty materials, each formulation having distinctive usable characteristics. The variety of copolymer resins available accounts for the diversity of applications, like interior wall coatings, exterior masonry finishes, industrial product finishes, metal protective coatings, and industrial maintenance finishes. However, as a group, the copolymer resins do not have the flexibility of application that is associated with the alkyd resins.

The latex emulsion copolymer resins (styrene-butadiene, vinyl, and acrylic) are described separately in this glossary, and their predominant characteristics noted. Vinyl copolymers, lacquer type, are characterized by resistance to chemical corrosion and inertness to the attack of the weak acids found in foods. Alkyd copolymers have been developed to impart chemical resistance combined with good adhesion and flexibility.

As a group, the copolymer resins have replaced drying-oil-bearing materials. Linseed oil and tung oil have been most seriously affected. However, the alkyd copolymers are of fairly recent origin, and have recaptured part of the market lost to lacquers and other copolymers. The future outlook for vinyl copolymers and alkyd copolymers is excellent. The gain in drying-oil consumption due to alkyd copolymers is expected to be more than counteracted by the decrease in oil consumption due to the use of vinyl copolymers in floor coverings and metal protective films.

Dispersion Resins--any of several synthetic resins, including certain oil-bearing resins, capable of being suspended in an inert liquid medium, usually water or a low-solvency organic liquid. Although the ability to form a successful suspension is fundamental to this class of resins, the faculty of forming a continuous film during the evaporation of the suspending medium is also important. The terminology "dispersion" is more descriptive than definitive, since a number of families of synthetic resins contain one or more members suited to the treatment necessary to make them "dispersion resins."

The usual resin materials entering "dispersion resins" include some representatives of the vinyl, acrylic, and alkyd copolymer families. In general, the characteristics of the final film will depend on the resin itself, instead of whether the resin was incorporated as a dispersion or in solution.

They are formulated into interior wall paints and coatings for fabric wall coverings and paper. As a class, they have replaced varnish vehicles based on linseed oil or alkyd vehicles based on soybean oil. Their future is considered to be excellent, although limited by the range of film properties that can be developed from a small number of suitable resins.

Epoxy Resins--the condensation products of such chemicals as epichlorhydrin and bisphenol. In protective-coatings uses, the epoxy resins are dissolved in organic liquids, or products containing similar chemical configurations are made from agricultural drying oils and hydrogen peroxide. Epoxy resins are distinguished for the chemical and water resistance they impart to industrial appliance finishes and architectural enamels.

They have and are replacing alkyd vehicles containing soybean oil, but since a large proportion contain some drying oil, the effect on drying-oil consumption is less than that of purely synthetic materials. The future outlook for epoxy resins is excellent, based on the properties imparted, but must be tempered by the relatively high price that these materials command at the present time.

Latex Emulsions--copolymer resins capable of forming a paint vehicle when dispersed in a water medium. Usually, the film-forming material is produced by reacting the ingredients in suspension in an inert medium. Combinations of styrene and butadiene, vinyl chloride and vinyl acetate, or mixtures of acrylic esters can be reacted to form latex-type vehicles. All forms of latex emulsion are characterized by the ease of application and the ease of clean-up, using water. After the formation of a continuous film, while in place on the surface, the film exhibits good washability and color retention.

Styrene-butadiene latex emulsions are used principally as interior flat wall finishes. Vinyl chloride-acetate latex emulsions and acrylic latex emulsions are used principally as exterior masonry finishes. The latex emulsions have replaced varnish vehicles containing linseed oil and alkyd-resin vehicles containing soybean oil. However, it should be noted that small proportions of oil-bearing alkyd resins have been incorporated in many formulations to improve the properties of the final film.

As a class, the future outlook for the latex emulsions is good. Both vinyl and acrylic emulsions are still relatively new and will require further testing and evaluation by users before their full potential can be assessed. Styrene-butadiene latex emulsions appear to be reaching the peak of their popularity, with competition from odorless flat alkyd paints limiting future expansion of sales.

Melamine Resins--the condensation product of melamine and formaldehyde, the reaction taking place in an organic liquid such as butanol and yielding lacquer-type vehicles. Generally, these vehicles are mixed with alkyd resins to form the protective coating. The finishes are characterized by hardness, mar resistance, and water resistance. Melamine resin formulations resemble urea resin formulations in performance, but their superior properties must be judged in the light of their higher cost. Their principal use is in formulations for automobile and appliance finishes that require baking. While originally developed to compete with nitrocellulose lacquers, they have replaced some alkyd formulations containing soybean oil. Their future outlook is good, but not expected to expand much beyond present applications.

Phenolic Resins--the condensation product of phenol and other tar acids with formaldehyde, often modified by subsequent reaction with rosin or dispersed in an agricultural oil. Certain substituted phenolic tar acids when condensed with formaldehyde yield oil-soluble products. Properly combined with drying oils, phenolic resins impart quick drying, water resistance, and high gloss to the final film. They are used in the formulation of floor and deck varnishes, automotive undercoatings, and toy enamels. Normally, phenolic resins are considered to be supplements rather than replacements for the agricultural drying oils. Their future outlook is fair and is primarily dependent on the relative cheapness of the tar acids and formaldehyde.

Polyester Resins--a specialized variety of alkyd resin, that is, the reaction product of a polyhydric alcohol and a polybasic acid, containing no agricultural drying oil. Developed for plastics use, these materials appear to offer possibilities for self-contained coloring that would eliminate the need for painting. In addition, some laboratory work has been done to adapt these materials to solventless surface coatings. The future outlook is uncertain.

Silicone Resins--the condensation product of organic compounds in which part of the carbon in the chain has been replaced by silicon. The surface-coating resins are generally produced from dialkyl silance and are used in conjunction with drying oils or alkyd resins. The characteristic property imparted by the silicone resins is heat resistance, particularly applicable to insulating varnishes for electrical equipment. Since they are used with drying oils, the silicone resins are not considered as replacements for the oils at the present time. Their high cost has limited their application to specialty products where their unique property is indispensible. Propertywise their future outlook is excellent, but for wider application a lower cost would be necessary.

Urea Resins--the condensation product of urea and formaldehyde, the reaction taking place in an organic liquid such as butanol and yielding lacquer-type vehicles. Generally, these vehicles are mixed with alkyd resins in the formulation of protective coatings for automobiles and appliances. The finishes are characterized by hardness, mar resistance, and water resistance. Urea-resin-based finishes are similar to but less effective than melamine-resin-based coatings. However, their lower cost makes them competitive. Originally developed to compete with nitrocellulose lacquers, the urea resins have replaced some varnishes and alkyd vehicles containing drying oils, principally soybean oil. Their future outlook is good, but their market is not expected to expand much beyond present markets.

Vinyl Resins--copolymer resins based on vinyl chloride, vinyl acetate, or vinylidine chloride. Resinuous products of these materials processed to latex emulsions and dispersion resins have been described elsewhere in this glossary. The lacquer-type compounds are formulated with plasticizers and organic solvents for finishes that are characterized by good metal adhesion and chemical resistance. In addition, self-supporting films for floor coverings exhibit excellent durability, excellent color and gloss retention, and good chemical and water resistance. In all applications, the lacquer-type vinyl films replace drying oils such as linseed and soybean. Their future outlook in metal protective coatings (can linings) and floor coverings is excellent in spite of higher costs.

Core Binder Resins--a generic name designating synthetic and oil-bearing materials used to impregnate and consolidate sand to form self-supporting inserts in metal casting molds. Linseed oil, tall oil, certain soybean alkyds, and phenolic and petroleum-derived resins are the common raw materials from which core binder resins are made. In general, formulations are sought that combine strength in the uncured core, quick curing at elevated temperatures, quick collapse at a predetermined temperature, and low cost. The diverse requirements of the metals and alloys being cast and the size and shape of the cores needed result in a wide variety of core binder resins, each with its own following of users. Linseed oil, previously accepted as the best core binder, has been partially displaced for economic reasons, principally by esterified tall oil and petroleum derivatives. The future outlook for nonagricultural core binder resins is good, based on their lower and more stable price levels.

Shell Molding Resins--principally phenol-formaldehyde compositions, developed in conjunction with a convenient process for the rapid molding of accurately dimensioned metal parts. As its name implies, the shell molding process uses a thin shell of resin-bonded sand to support and form molten metal instead of bulky sand molds. The shell molds are shaped from sand in metal forms, impregnated with the synthetic resin, cured by baking, and assembled prior to pouring of the metal. In general, shell molding resins represent a small loss of market for agricultural oil-based products, because the sand molds used previously contained very little oil-bearing resins. However, the future outlook for shell molding and the constituent resins is good, since the process results in appreciable savings during subsequent machining operations.

"Heat Set" Inks--compositions comprising resin and pigment dissolved or dispersed in a high boiling organic liquid for application to paper or similar media. The film is cured by subjecting the media to high temperatures for short periods of time, generally through the use of a flame. Principal raw materials are zinc and calcium salts of synthetic resins or processed rosins, often including mineral oil, with an organic solvent such as mineral spirits. "Heat set" formulations were developed to speed up the drying time of the ink, allowing faster printing in rotary or lithographic presses. Linseed oil was displaced most frequently, but soybean and castor oil alkyds also were affected. The future outlook for "heat set" inks is excellent, indicating further reductions in the requirements for agricultural drying oils.

"Steam Set" Inks--compositions based on resins which become insoluble when exposed to steam or water vapor. The principal raw materials are synthetic resins capable of being dissolved or dispersed in a water soluble solvent such as ethylene glycol. Wrapping papers that come into contact with foods, for example bread wrappers, are printed with this type of ink to allow mechanical integration of the wrapper-producing and food-processing production lines. The outstanding properties of "steam set" inks include almost instantaneous drying and lack of odor. "Steam set" inks have displaced formulations based on linseed oil and oil-bearing alkyds. Their future outook is excellent for current uses, but they are not expected to encroach on other applications.

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