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FLAXSEED PRODUCTION, COMMERCE, AND MANUFACTURE IN THE UNITED STATES.

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INTRODUCTION.

Evidently impressed with the vicissitudes that flax culture has undergone in the United States, some one has aptly remarked that the flax crop is one of the curiosities of agriculture. The remark is peculiarly suggestive. For, although there is nothing strange or unusual in the present method of cultivating flax in this country, the crop being drilled, harvested, thrashed, and marketed under natural and mechanical conditions almost identical with those of cultivating, garnering, and marketing the small grained cereals, spring wheat, spring rye, and oats, nevertheless, there are other features connected with its history that make the flax crop unique among agricultural products.

The flax plant is the source of two extremely valuable economic products—the one a fiber derived from the straw and noted from time immemorial the world over for its strength, beauty, fineness, and length of staple; the other, a seed rich in an oil of such superior drying qualities as render it an indispensable ingredient in paint and varnish, and in the manufacture of linoleum, oilcloth, printer's ink, patent leather, and a few other products. The full value, however, of both straw and seed from one and the same crop has never been realized on a large scale in practical agriculture. The cultivation of flax for fiber, requiring, as it does, the sowing of from 2 to 4 bushels of seed to the acre and the pulling up of the plant by the roots by hand a little before the seed is fully ripe, impairs the quality and reduces the quantity of the crop of flaxseed. The cultivation of flax for the seed, on the other hand, requires a seeding of but 2 to 3 pecks to the acre, and results in an increased yield of seed but a coarser straw; and the subsequent mowing and thrashing of the crop by machinery tends to destroy the value of the straw for textile uses. As a business proposition, therefore, flax is almost universally raised either chiefly for the fiber or exclusively for the seed, either as a source of raw material for the linen factory or for the linseed oil mill. And, with the exception of Russia, which is an important producer of both seed and fiber, the principal flax-producing countries of the world have become distinctly

divided along these lines. In the European countries, with Russia as the prime factor, flax is cultivated chiefly for the fiber; in the United States, Argentina, and British India, which with Russia produce the world's commercial crop of flaxseed, the plant is cultivated almost exclusively for the seed. In the United States, as will be seen further on, there has been a gradual conversion from one system of cultivation to the other. Many hundred gallons of oil from the seed of this valuable plant have been utilized in making the printer's ink used within the past half century in demonstrating the possible utility and theoretical value of the thrashed and tangled straw. The Department of Agriculture, through its Office of Fiber Investigations, in 1898, published a report^a on the possible utilization of flax straw. Nevertheless the economic value of the flax crop of the United States to-day is represented almost entirely by the seed; the straw, with a few unimportant exceptions, is a total waste.

THE GROWTH AND DEVELOPMENT OF FLAXSEED PRODUCTION AND MANUFACTURE.

Flax was originally introduced upon this continent solely for its fiber, and bears the distinction of being among the first agricultural products transplanted from the Old to the New World; chance records of its culture occur within a few years after the landing at Plymouth. For a period of more than 150 years thereafter, or until cheaper cotton fabrics began to supplant linen ones, the extensive culture of flax for fiber played an especially important part in the material progress of the country, becoming, as it did, the basis of that famous household industry whose homespun products were necessities of life second only to food. The seed, for which there was obviously a limited domestic demand, gradually developed into an important article of export, and in 1791 exports of flaxseed from the United States amounted to 292,460 bushels, a larger quantity, it is curious to note, than was exported in any year thereafter until 1892.

The invention of the cotton gin in 1792 placed a check upon the production of flax for fiber in the United States from which it never recovered, and indirectly gave the first slight impetus to the cultivation of flax for seed that has culminated in the present century in making this the leading flaxseed producing country of the world. In the absence of positive historical evidence, it can not be far wrong to assume that from about this time dates the manufacture of linseed oil in the United States, at least on anything like an important scale. In 1810 there were 283 linseed oil mills in existence in fourteen States of the Union, 171 of them in the single State of Pennsylvania. Small affairs they were, it is true, probably operated under pressure obtained from the most primitive appliances of mechanical power; their total annual

^aReport No. 10, Office of Fiber Investigations, U. S. Dept. of Agr., "Flax culture for seed and fiber in Europe and America."

output of oil amounted to only 770,583 gallons, representing doubtless not 300,000 bushels of seed—a smaller quantity than could be crushed in a like period by a single modern mill of less than average capacity. But they are of interest as illustrating the early conditions of a minor industry in which the United States was afterwards to lead the world.

In 1839 the first cargo of flaxseed ever brought into the United States was imported from Russia. A few years later ships carrying ice to India found it profitable to load return cargoes of flaxseed. By 1850 India had practically monopolized this trade, and for a period of twenty years thereafter shipped annually a larger quantity of flaxseed into the United States (larger by fourfold in some years) than the States themselves produced.

Flaxseed production in the Atlantic coast States had declined, and excepting in New York, Pennsylvania, Virginia, and North Carolina had practically disappeared altogether. The culture of the crop had migrated across the Alleghenies, and from 1850 to 1860 half the entire crop of the country was grown in Ohio and Kentucky. Linseed oil mills, moreover, were being established in these States with a capacity capable of crushing the Western-grown crop, and the only alternative of many mills in the East had been to go out of business or to import seed. From this state of affairs arose a division of the industry, in the parlance of the trade, into Eastern and Western mills, a division not merely geographical, but founded upon essentially different commercial conditions that continued in greater or less force until the great increase of flaxseed production in the United States in 1891. The Eastern mills, though still crushing the seed grown in the Atlantic coast States, became dependent for supplies principally upon seed imported from India. The Western mills were the primary markets for seed grown almost at their very doors. The apparent advantage of the latter in being near the base of their supplies was largely offset by the fact that the seed from India was larger of grain and yielded oil greater in quantity and of better quality than did seed of American origin. The location of the Eastern mills on or near tide-water also gave them superior advantages for exporting the valuable by-product, linseed oil cake.

Under these conditions imports increased rapidly from a little over a half million bushels in 1850 to almost 4 million bushels in 1875. Production in the Western States, expanding into new territory, gradually increased beyond the crushing capacity of the Western mills, and larger and larger quantities of the surplus of good years found its way annually to the Eastern crushers. Naturally the relative cheapness of Western seed favored its substitution for the imported product. But the supply was unequal to the demand, and imports from India continued to figure in the Eastern markets, usually to the extent of from a half million to $2\frac{1}{2}$ million bushels a year, until 1892. In that year the United States for the first time took rank among the

surplus flaxseed producing nations of the world, and became an exporter of some importance and permanency; regular importations on a large scale ceased; the flax crop had virtually disappeared from the Eastern States, and the Eastern mills, in so far as they had been dependent upon foreign seed, changed their base of supplies from Calcutta and other points to the domestic markets at Chicago and Duluth. On only two occasions since have foreign importations of large proportions been renewed. The short crop of the United States in 1894 was followed by imports amounting to over 4 million bushels. And a speculative condition in the flaxseed trade in the crop year 1900-1901 resulted in an importation of over 1½ million bushels, the imports of the latter year being of especial interest in that they came almost wholly from a new source of supply—Argentina. For the past dozen years, therefore, with but two exceptions, the linseed oil mills of the East have been run almost entirely on domestic seed, a condition that had not existed in two consecutive years before for over a half century.

During that half century the linseed oil industry had been revolutionized. In the East the disappearance of flaxseed from cultivation had annihilated the small local mills; the importation of seed from abroad and the construction of new transportation lines at home had forced others to change their location from the old to new and more economical bases of operation; improvements in linseed oil machinery, moreover, had enabled the remaining mills greatly to enlarge their crushing capacity. And, later, the concentrative spirit of the age tended steadily toward the embodiment within the limits of a few establishments, and the localization at a few points of commercial vantage, of an industry that had formerly been widely dispersed. The thirty-odd mills that as late as 1870 had existed in the Atlantic coast States from North Carolina to Massachusetts, and inland as far as the Alleghenies and the western boundaries of New York and Pennsylvania, are at present represented by 13 mills of large capacity as a rule, located generally with reference to the bases of seed supply or to the advantageous sale of the manufactured products. The two principal crushing centers of the Eastern States now are Buffalo, with 4 mills, and New York, with 2 mills, the former city possessing the advantages of all-lake transportation from the great primary market, Duluth-Superior,^a the latter that of being the center of a great consumptive market for linseed oil, and of having exceptional advantages for the importation of flaxseed, when necessary, and for the exportation of linseed oil cake. Philadelphia, with 3 mills, ranks next as an Eastern manufacturing center, with a crushing capacity about one-third that of the city of New York. The only other Eastern cities of noteworthy importance in this industry are Amsterdam, N. Y., and Pittsburg, Pa. Two mills of limited capacity, located,

^a Cited in trade journals as one port.

respectively, at Troy, N. Y., and Allegheny, Pa., complete the list of Eastern mills. The combined crushing capacity of the mills located at the above-named points may be estimated, approximately, at from about $10\frac{1}{2}$ million to $12\frac{1}{2}$ million bushels of flaxseed a year, although it is likely that their actual annual crush has never exceeded three-fourths of the lesser quantity.

MIGRATORY CHARACTER OF THE WESTERN CROP.

In the West the history of flaxseed production and linseed oil manufacture presents some especially interesting features. As to the crop itself, the most remarkable characteristic is that it has been migratory. Always a minor crop and specialized almost in entirety within the area of a few States, it has, within the past half century, migrated from one area of production to another, increasing enormously in volume at every stage of its progress, until it has traversed the entire country, almost State by State, from its original home in Kentucky and southern Ohio to its present area of principal production in North Dakota, Minnesota, South Dakota, Iowa, and Wisconsin. The product of this area is known as the Northwestern crop. A diversion of a portion of the crop from the general direction of migration has resulted in another smaller but distinct area of production in Kansas, Missouri, and Nebraska, Oklahoma and Indian Territory. The product of this area is known as the Southwestern crop. Strange as this migration seems, its causes are in no wise peculiar. The flaxseed crop of the West has been distinctively a "pioneer" crop. It has the common reputation when fertilizers are not used, as they seldom are on pioneer crops, of being, in so far as the reproduction of flaxseed is concerned, quickly exhaustive of the soil. From this and minor causes the flaxseed crop in the West seems simply to have abandoned in succession old areas upon which it had ceased to yield profitable returns and to have sought the rich, fertile lands of newly settled States.

In 1849 the flaxseed crop of the United States amounted to about a half million bushels, and Ohio, with about one-third of the total crop, was the leading producing State. In what is now the principal area of production—that is, the Dakotas, Minnesota, Iowa, and Wisconsin—flax culture, with the exception of an insignificant area in Iowa and Wisconsin, was absolutely unknown. For the next decade the total production of the country remained about stationary, and although Ohio retained her supremacy relative to the total crop, a slight tendency toward migration was manifest in a heavy increase in the small crop of Indiana. By 1869 the flax crop of the entire country had trebled; Ohio was still the leading producing State, and Indiana a close second, but a decided tendency toward further migration was manifest in a heavy increase in the flaxseed area of Illinois. From this date flax cultivation in Ohio began a steady decline. Ten years later the area of principal production had expanded until it embraced Iowa, and

the three States, Indiana, Illinois, and Iowa, were producing two-thirds of the country's 7 million bushel crop—Illinois first with a crop of 1,812,438 bushels, and Iowa second with 1,511,131 bushels. Flaxseed cultivation in Indiana and Illinois, however, soon underwent a rapid decline and within the next ten years lost its importance altogether. This crop in all States east of the Mississippi soon afterwards became practically a thing of the past. Minnesota in the meantime had become the leading producing State, surpassing even Iowa. Flaxseed cultivation had also been taken up on an extensive scale in South Dakota, and of the crop raised in the United States in 1889 (10,250,410 bushels) Minnesota, Iowa, and South Dakota produced almost exactly the same proportion as Indiana, Illinois, and Iowa had of the smaller crop of ten years previous. Next came the final stage in the migratory progress of the crop—the remarkable expansion of the area of principal production into North Dakota. Between 1889 and 1899 the yield of that State increased from 164,319 bushels to 7,766,610 bushels, and in the latter year the five States, North Dakota, Minnesota, South Dakota, Iowa, and Wisconsin, producing what is now known as the Northwestern crop, were credited with a combined yield of 17,668,672 bushels, or over 88 per cent of the entire crop of the United States. Flaxseed production in the Northwest, notably in North Dakota, has since increased with giant strides. In 1902 the entire crop of the United States amounted to a total of 29,284,880 bushels, and of this 15,552,000 bushels, or over 53 per cent, was the product of that single State. The crops of Minnesota and South Dakota also showed a marked increase, the older flaxseed producing State, Iowa, as might now be expected, showing a decline. The present importance of the five so-called Northwestern States with reference to this crop is illustrated by the fact that in 1902 their combined product amounted to 26,966,600 bushels, or over 92 per cent of the entire crop of this country.

Naturally arises the question of further migration. Does the small but increasing acreage now devoted to this crop in Idaho and Montana forecast a movement in that direction? Or will the area of principal production expand into the new lands of Manitoba and the Northwest Territories of Canada?

The Southwestern crop is distinguished from the Northwestern not so much by geographical limitations as by a difference in the oil content of its seed. Up to the time of the expansion of flaxseed production into Minnesota and South Dakota the entire crop of the United States had been, from the crushers' point of view at least, all of one variety, characterized by being smaller of grain and less rich in oil than that imported from foreign sources. Occasional attempts to transplant seed from British India had resulted only in its rapid reversion to the old American type. Soon after flaxseed cultivation

had been taken up on an extensive scale in South Dakota, however, the introduction of a foreign variety (by Russian emigrants, according to some authorities, and as an agricultural experiment according to others) resulted in a seed which, though not retaining all the characteristics of the original stock, was larger of grain and richer in oil than the old American seed. To the successful issue of this experiment was doubtless due in part the subsequent extensive development of flaxseed cultivation in the Northwest, that crop now consisting entirely of this kind of seed. But in the Southwest the improved variety has either not been cultivated at all, or when sown experimentally has not retained its original characteristics. As a consequence there are two different varieties of flaxseed produced in the United States, the small-grained seed of the Southwest, usually credited by crushers with yielding an average of 16 or 17 pounds of oil to the bushel (56 pounds) of seed, and the larger-grained seed of the Northwest, credited by the same authorities with a yield of from 18 to 20 pounds of oil to the bushel, the yield in all cases, of course, varying greatly with the climatic conditions under which the crops are grown and harvested. Under these adverse competitive conditions and from other causes flaxseed cultivation in the Southwest, as a whole, has naturally shown a tendency to decline, and the decline has been both absolute and relative. From 2,846,062 bushels in 1889 the crop fell in 1899 to 2,104,162 bushels, and in 1902 to 1,856,240 bushels; or, relatively, from about 27 per cent of the entire crop of the United States in 1889 to a little over 6 per cent of the total in 1902.

STATISTICAL HISTORY OF FLAXSEED CULTIVATION IN THE UNITED STATES.

The history of flaxseed cultivation in the entire flax belt of the United States for the past fifty-odd years, the rise and fall of its culture in certain States, the migratory progress of the crop, the enormous increase in the total production, and the specialization of the crop almost entirely within the area of a few States, are excellently illustrated by the following statistical statement, which gives the production by States in decennial years, according to the reports of the United States census, and also the yield in 1902 according to the initial number of a series of annual estimates recently undertaken by the Division of Statistics of the Department of Agriculture. For many years the flaxseed crop of the United States has practically all been produced in the Western States; hence only those States are given specifically in the statement. They are divided according to the custom of the trade into Northwestern and Southwestern, the now almost obsolete crops of Kentucky, Ohio, Indiana, and Illinois being included under the former classification only to illustrate more fully the migration of this crop.

Production of flaxseed in the United States.

State or Territory.	1849	1859	1869	1879	1889	1899	1902
NORTHWESTERN CROP.	<i>Bushels.</i>	<i>Bushels.</i>	<i>Bushels.</i>	<i>Bushels.</i>	<i>Bushels.</i>	<i>Bushels.</i>	<i>Bushels.</i>
Kentucky	75,801	28,875	14,657	2,192	1,321	10	.....
Ohio	188,880	242,420	631,894	533,217	145,557	29,821	.....
Indiana	33,888	119,420	401,931	1,419,172	17,596	1,394	.....
Illinois	10,787	8,670	280,043	1,812,438	35,013	4,333	.....
Iowa	1,959	5,921	83,621	1,511,131	2,232,359	1,413,380	770,250
Wisconsin	1,191	4,253	112,019	547,104	68,227	149,765	496,100
Minnesota .....	.....	113	18,635	98,689	2,721,987	5,885,479	6,942,000
South Dakota .....	.....	.....	.....	.....	1,801,114	2,452,528	3,206,250
North Dakota .....	.....	.....	.....	26,757	164,319	7,766,610	15,532,000
Total	315,533	499,639	1,547,800	6,019,700	7,237,463	17,704,323	26,966,600
SOUTHWESTERN CROP.							
Missouri	13,636	4,653	10,391	379,535	450,831	611,888	328,500
Kansas .....	.....	11	1,553	513,616	994,127	1,417,770	1,217,280
Nebraska .....	.....	2	404	77,805	1,401,104	54,394	116,000
Indian Territory .....	.....	.....	.....	.....	.....	15,060	42,000
Oklahoma .....	.....	.....	.....	.....	.....	5,050	152,490
Total	13,636	4,669	12,343	970,956	2,846,062	2,104,162	1,853,240
Total Northwest- ern and South- western crops ..	329,262	414,349	1,560,143	6,981,656	10,083,525	19,808,485	28,822,840
Total other States ..	233,110	152,518	170,296	189,295	166,885	171,007	442,040
Total United States	562,312	566,867	1,730,441	7,170,951	10,250,410	19,979,492	29,284,880

^a Crop of Montana, Idaho, Oregon, and California only. The crop of these States moves westward and is manufactured in the two linseed oil mills located, respectively, at Portland, Oregon, and San Francisco, Cal., the only mills in the Pacific Slope States.

THE INTERNAL COMMERCE IN FLAXSEED.

The linseed oil industry in the West first developed into importance in Ohio, and as early as 1860 there were 26 mills in operation in that State, against 8 in all other territory westward to the Pacific Ocean. The Miami Valley, in the southwestern part of the State, was then the great flaxseed producing section of the West, and Dayton, Ohio, the principal crushing center. As, however, the principal area of flaxseed production migrated, decade after decade, northwestward, there occurred the singular phenomenon of the industry following in the path of migration until, checked by the cheap transportation facilities of the Great Lakes, by conditions incident to the sale of the products manufactured from flaxseed, and by other causes, the industry itself became in a manner stationary in its present location in the Lake region, while the principal area of flaxseed production migrated still farther into the now great producing States, North Dakota and South Dakota. The half hundred mills that were in active operation less than a quarter century ago in the interior of Ohio, Indiana, and Illinois, their existence originally dependent almost wholly upon

supplies of local-grown seed, have one after another been dismantled; and two small and irregularly operated mills at Dayton, Ohio, are now the sole relics of the industry in the interior of those three States. The manufacture of linseed oil in the West has become largely localized in cities on and near the Great Lakes, and in 1902 an annual active crushing capacity of between 10,250,000 and 12,250,000 bushels of flaxseed was represented by this localized branch of the industry. Over three-fourths of this total capacity is embodied in the five mills at Minneapolis and the six mills at Chicago, the remainder being represented by mills located as follows: Two active mills at Toledo, Ohio, and one each in Superior, Wis.; Milwaukee, Wis.; Redwing, Minn.; South Bend, Ind.; and Cleveland, Ohio.

As a direct consequence of this quasi separation of the industry from the area of principal production, there has grown up that immense internal commercial movement of flaxseed that to-day underlies the linseed oil industry, both East and West, of the United States—the commercial movement of the bulk of the supplies of raw material from the vast areas of agricultural production to the great distributing market, Duluth-Superior, and to the principal Western manufacturing centers, Minneapolis and Chicago. Limited crushing facilities in the principal areas of production are obviously the underlying causes of this traffic. In North Dakota and South Dakota there are no linseed oil mills in operation and but one (at Fargo) in existence. In Iowa the two mills located, respectively, at Des Moines and Sioux City represent the active crushing capacity of that State. In Wisconsin there are but the two mills, at West Superior and Milwaukee. In other words, in the four States which in 1902 produced upward of 20 million bushels of flaxseed there are but four active linseed oil mills, and their combined crushing capacity is equivalent to scarcely 7 per cent of those States' maximum production. Even the great importance in this industry of the fifth Northwestern State, Minnesota, depends almost wholly upon the mills located at the single center, Minneapolis. Moreover, the industrial conditions in the Southwest differ from those of the Northwest only in proportions. In the five States which produce what is commonly known as the Southwestern crop there are but four active linseed oil mills—two at St. Louis, one at Kansas City, and one at Fredonia, Kans. These mills have a combined capacity for manufacturing about a million bushels of seed annually, or, as estimated by the crop of 1902, a little over one-half of the Southwestern crop. The bulk of the surplus finds its way ultimately to the markets of Chicago. It is pertinent to note that flaxseed in its natural state has no domestic uses on the farm except for seeding purposes. Its economic value is dependent entirely upon the products derived from its manufacture. Every bushel of the commercial crop has for its ultimate destination the linseed oil mill, and the internal commerce in this product, therefore, involves the entire crop,

excepting the small proportion reserved for seeding purposes and that consumed by local mills in the producing territory. These quantities excepted, practically the total flaxseed crop of the United States moves directly from the areas of production to the three primary markets, Duluth-Superior, Minneapolis, and Chicago.

The final stage in the internal commerce of flaxseed is the distribution of supplies from these three primary markets to the Eastern mills and to those located along the shores of the Great Lakes. Since the phenomenal development of flaxseed cultivation in North Dakota, Duluth-Superior has become the most important primary and distributive market for flaxseed not only in the United States but in the entire world. For each of the past two years a quantity equal to about one-half of the total flaxseed crop grown in the United States has been received by rail and distributed by lake from that port. The bulk of the flaxseed received at Minneapolis and Chicago, although they also are distributive markets on a smaller scale, is shipped out in the shape of manufactured products. But the functions of the market at Duluth-Superior, where but one small linseed oil mill is located, are almost exclusively distributive. From that center the linseed oil mills at Buffalo, New York City, and Philadelphia, in short, the entire Eastern branch of this industry, derives practically its entire supplies. Under present conditions about 10 million bushels of flaxseed are annually transported across the lakes from Duluth-Superior to Buffalo; of this quantity about 4 million bushels ordinarily would be retained at Buffalo for the consumption of the local mills, 3 million consigned to the other Eastern oil-making centers, and the balance exported through the ports of New York and Boston. Distribution is also made from Duluth-Superior to other American and Canadian ports, according to the varying exigencies of the trade.

PRODUCTS FROM FLAXSEED AND THEIR USES.

The principal product derived from flaxseed by the process of manufacture is linseed oil. The residue after the extraction of the oil constitutes the only by-product, linseed oil cake, a valuable cattle food, which, when ground for feeding purposes, is known on the market as linseed oil meal. In the oil-making process there is practically no waste, and on an average for the entire country it is generally accepted by the crushers that a bushel of flaxseed (56 pounds) is converted by manufacture into $18\frac{3}{4}$ pounds of oil ($2\frac{1}{2}$ gallons), and $37\frac{1}{2}$ pounds of oil cake. Out of a crop like the exceptional one of 1902 (29 million bushels) there could, therefore, be manufactured, after deducting a couple of million bushels for the next year's seeding, about $67\frac{1}{2}$ million gallons of oil, and upward of 1,000 million pounds of oil cake. The actual manufacture of linseed oil in the United States, however, is subject to a somewhat rigid limitation, arising from the fact that for this product there is little foreign demand. Importing

nations, as a rule, import the raw material in the shape of flaxseed and make their own oil, and the foreign demand upon the United States amounts to only about 100,000 gallons a year. The quantity of flaxseed manufactured in this country is, therefore, in the long run, practically limited to the domestic demand for linseed oil. Exactly what the demand amounts to annually it is of course impossible to determine, but, considering the fact that the principal use of this oil is for paint, there can be no doubt that, as a result of the unprecedented prosperity of recent years, the consumption of linseed oil has greatly increased. During the crop years, 1895-1896 to 1900-1901, both inclusive, it seems that the average quantity of flaxseed annually manufactured in the United States amounted to about 15 million bushels, with a resultant average annual yield of about $37\frac{1}{2}$ million gallons of oil, and 558,750,000 pounds of oil cake. During these five years, it should be noted, there was successively a gradual increase in the quantities manufactured, and the continuation of this tendency in the subsequent year, together with the exceptionally heavy supply of domestic seed available for oil extraction, leads to the somewhat general opinion in the trade that the quantity of flaxseed consumed in 1901-1902 by the linseed oil mills of the United States amounted to about 20 million bushels, and that the domestic demand for linseed oil now absorbs an output of about 50 million gallons. On this basis, assuming that 2 million bushels is at present annually required for seeding purposes, the total annual consumption of the flaxseed in the United States now amounts to about 22 million bushels; hence, out of a 29 million bushel crop, a surplus of about 7 million bushels would remain for export and for reserves. In this connection it is interesting to note that exports of flaxseed from the United States in the twelve months ended December 31, 1901, amounted to 3,563,162 bushels, and for the corresponding period in 1902 to 4,046,178 bushels, the great bulk of the exports from every crop being made in the three or four months following harvest.

Of the two products derived from flaxseed, linseed oil has a sphere of economic usefulness peculiarly its own. It has no uses as an illuminant, none as a lubricant; and, although small quantities fresh from the presses are utilized, curiously enough, as a cooking grease by an element of the foreign population in some of the large cities, commercially it is valueless as an edible oil. In fact, linseed oil is adapted to none of the industrial or edible uses to which other oils are ordinarily put, whether they be vegetable, animal, or mineral. But, possessing in an exceptional degree the property of absorbing oxygen upon exposure to the air, it is essentially a "drying" oil; and, compounded on the one hand with divers pigments and on the other with various gums, it finds a field of usefulness in the composition of paints and of varnish to the almost total exclusion of all other oils. Its monopoly of this field is so complete that it has no adulterants,

except those which detract greatly from its economic value, and no substitutes, excepting possibly the single competitor, corn oil. Linseed oil is also utilized to the practical exclusion of other oils in the manufacture of linoleum, oilcloth, oil silk, patent and enameled leather, and printers' ink. Probably 65 to 75 per cent of all linseed oil manufactured in the United States is compounded with pigments and gums and used as paint and varnish in the preservation and adornment of the wood and other substances that enter into manifold structural uses. The bulk of the remainder is utilized in the manufacture of linoleum and oilcloth. Among the minor uses to which this product is put, it has been stated upon good authority that probably a million gallons are consumed annually in the manufacture of printers' ink. Linseed oil is also used in the manufacture of waterproof fabrics not made of rubber, as an enamel for buttons made of wood pulp, in the manufacture of opaque window shades, for some few medicinal purposes, in the making of a soap especially valuable for washing woodwork, and for other minor purposes.

Linseed oil cake, the single by-product from the manufacture of linseed oil, is in very limited demand in the United States, but finds an extensive market abroad. This cake is used only as a cattle food, and forms one of that group of highly concentrated albuminoid or flesh-forming feeding stuffs, including cotton seed oil cake, corn oil cake, rape seed oil cake, compound and other cakes, so highly prized by European stock raisers, but little appreciated on this side of the Atlantic. To determine accurately the proportion of linseed oil cake retained in the United States for domestic consumption as compared to the proportion exported is not possible. But, assuming that 20 million bushels of flaxseed were crushed in this country in the crop year 1901-1902, the total production of linseed oil cake was about 745 million pounds; the exports for the fiscal year 1901-1902 were 582,886,775 pounds, indicating in a general way that about 78 per cent of the total output was sent abroad against only 22 per cent retained for home consumption. From the best available data obtainable for the two preceding years the proportion exported as compared to the total output shows no material difference, so that it is doubtless safe to assume that not much more than 20 per cent of the linseed oil cake manufactured in the United States is utilized as feed for domestic live stock. Almost 80 per cent of the total available supply of this valuable cattle food (exceptionally valuable from an economic point of view, both as a fattening food and because of the high fertilizing properties of the manurial residue) is shipped abroad and converted into milk and beef upon the dairy and stock farms of northern Europe.

The principal customer of the United States for linseed oil cake is Belgium, her takings having increased from 39,021,367 pounds in

1895 to 148,263,752 pounds in 1901. Of almost equal importance is Holland, whose imports of this product from the United States have increased from a quantity less than one-half those of Belgium in 1895 to 136,728,914 pounds in 1901. These two countries combined take annually upward of 60 per cent of the total exports of linseed oil cake from this country. In the United Kingdom, third in importance as a customer for this product, the use of American linseed oil cake seems to have been to a considerable extent supplanted by cotton seed oil cake. In 1895 the English demand upon the United States for linseed oil cake amounted to 168,717,198 pounds, and for the like product from cotton seed to 156,048,267 pounds, but since that date the demand for the linseed product has declined almost without interruption until in 1901 it amounted to only 98,368,610 pounds, while the demand for American cotton seed oil cake had increased in the same period to 312,409,282 pounds. The English people prefer for feeding purposes a cake containing a high percentage of oil; and to the fact that cotton seed oil cake better fulfills this requirement, and is also cheaper than linseed oil cake, is largely due this remarkable change in the character of this trade. The only other European customers for American linseed oil cake are France and Germany, whose combined takings, however, amount to only about 60 million pounds a year. From countries on this side of the Atlantic there is little demand for this product; the West Indies and Canada are practically the only importers, and their combined trade amounts to only about 10 million pounds annually. The average annual exports of linseed oil cake from the United States to all countries for the five years ended June 30, 1902, amounted to 488,891,125 pounds, and the average annual value of the trade was \$5,665,392. The exceptionally heavy exports in the fiscal year 1901-1902 were valued at \$7,508,133.

Practically all, both of the linseed oil cake and of the cotton seed oil cake exported from the United States to Europe, is taken by six countries, the United Kingdom, Denmark, Holland, Belgium, France, and Germany. And it is curious to note the almost inexplicable preferences shown by each for one or the other of these feeds. With the notable exception of Denmark all of these countries feed both cakes. But, divided on the basis of a larger importation from the United States of one or the other feed, Belgium, Holland, and France may be classed as the linseed oil cake importers, and Germany, the United Kingdom, and Denmark as importers of the cotton seed product. Belgium imports about three times as much linseed oil cake as cotton seed oil cake, Holland almost equal quantities of each, and France, though not an important taker of either, shows a preference for the linseed product. Germany, whose imports of linseed oil cake are on a small scale is, on the other hand, the largest consumer of cotton seed cake in Europe, and takes annually from the United

States a quantity almost equal to the total imports of American linseed oil cake by all Europe combined. The trend of the English trade in these products has already been noted. The trade with Denmark is anomalous; that country takes no linseed oil cake at all, but as a consumer of the cotton seed product ranks third among European countries, and imports annually from the United States from 250 million to 275 million pounds. An attempt to find some explanation of this peculiarity of the oil cake trade with Denmark resulted in the following letter from a prominent importer in Amsterdam:

The reason of so little American linseed cake going to Denmark is not, as you suppose, because of a greater importation of Russian linseed cake, but simply because of a smaller consumption of the article. I have on several occasions discussed the merits of linseed cake with large cattle holders of Denmark, but the discussion always ended in their maintaining their opinion that if cows be fed on linseed cake the butter obtained from their milk was invariably of less delicate flavor. For fattening purposes, however, they admitted linseed cake to be the feed par excellence, but here again importation was debarred by reason of its being so high-priced a commodity. This forces them to use large quantities of cheaper cotton seed meal and cotton seed cake instead. When I pointed out to them the unique reputation linseed cake enjoys in our country (Holland) as the feed for milk-giving cows, they nevertheless stuck to their opinion, stating it was the outcome of practical experience. How it is that linseed cake is held to yield an opposite result in Denmark from what it does in Holland is a riddle I can read as little as many others supposed to be solved by the laws of digestive economy as at present set forth. All I know is that there is no getting round such opinions, and they just have to be accepted *nolens volens*.

THE MANUFACTURE OF LINSEED OIL.

In extracting oil from flaxseed two processes are used, one known as the "old" or hydraulic-press process, and the other as the "new" or naphtha process. The old process is the one in general use in the United States, the new process being actively represented in 1902 by a single mill in South Chicago.

THE OLD PROCESS.

The distinctive feature of the old process, the process by which over nine-tenths of the oil manufactured in the United States is expressed from the seed, is the hydraulic press. In this system the press is the productive unit, and the capacity of a mill is universally estimated among the crushers by the number of presses it contains. Preparatory to the extraction of the oil by mechanical pressure, the flaxseed is crushed between high-speed steel rollers into a fine meal known as flaxseed meal. In some foreign countries this meal is used to some extent as a feed for calves. It is a frequent practice among dairymen who raise their own calves to add crushed flaxseed to skim or separated milk, regarding it as one of the safest and most economical substitutes for the abstracted milk fat. In this country flaxseed meal is known

popularly in a small way only for its medicinal use as a poultice, and has no other use outside the linseed oil mill. In the oil-making process this meal is heated in "heaters," reservoirs especially constructed for this purpose, either by injecting the steam directly into the meal as it flows in a steady stream from the rollers into the heaters, or by the use of steam-jacketed heaters where no free steam is admitted to the meal. The meal is then drawn from the heaters into cake formers, machines which compress it into a shape of just sufficient consistency to allow, by careful handling, of its being folded in a woolen cloth and placed in the press. Although the press is universally taken as a uniform productive unit, the presses in different mills may really vary in productive capacity according to the number of "plates" they contain, each plate, located one above the other in the press, simply representing a separate compartment for the reception and compression of the meal that has been put into proper shape by the cake former. These plates may range in number from 16 to 26 to the press, but since the usual and average number is about 20 plates to the press, it is obvious that the common custom of estimating capacity by presses answers all comprehensive purposes. The presses, massive pieces of machinery, are arranged in rows in "batteries" of either 5 or 6 presses each, and a force of 3 men is required for each battery. Beginning at one end of a battery the separate compartments of the first press are filled with the slightly compressed meal, powerful hydraulic pressure applied at once, and so on with each press of the battery in succession. The operation of emptying and filling each press requires about ten minutes, and hence it is apparent that in a battery of 6 presses each press is under pressure for an hour, the oil meanwhile flowing from the presses into tanks. At the expiration of that time the hydraulic pressure is taken off from the press first filled, the now hardened oil cakes removed from between the plates, the press refilled with meal and the other presses emptied and refilled in the same way in succession, and so on indefinitely. The oil is then forced through filter presses for the purpose of removing mucilaginous substances known as "foots," after which it is placed upon the markets as raw oil; or, after filtration, its drying properties may be increased by boiling and the simultaneous addition of litharge or other dryers, in which case it is known to commerce as boiled oil. Numerous brands of refined oil also result from various processes of refining. During the crushing season the mills as a rule never stop, the moderately high temperature at which it is desirable to keep the machinery and the atmosphere of the mills requiring their constant operation night and day, stoppages from various causes of course excepted.

THE NEW PROCESS.

The "new" process is a chemical one, the oil being extracted from the seed by the action of the volatile solvent, naphtha. As in the old process the productive unit is the hydraulic press, in this process the distinctive feature is the percolator, a huge iron tank with a capacity for holding about 1,000 bushels of seed. The only active mill using this process in the United States has 16 of these percolators in its equipment. The flaxseed, after having been crushed into meal exactly as in the old process, is dumped into the percolators and flooded with naphtha. The naphtha, having an affinity for the oil, extracts it from the meal, and after the requisite length of time there is drawn off through a valve in the bottom of the percolator a compound product of linseed oil and naphtha. The naphtha is then evaporated and condensed for further use, and there is left the commercial product, linseed oil. The by-product of the new process is obviously not oil cake, but oil meal, which is removed from the percolators after the compound product, oil and naphtha, has been drawn off. It is then dried, deodorized, and placed upon the domestic market as a cattle feed.

MAGNITUDE OF THE INDUSTRY.

The operations of the linseed-oil industry of the United States can probably best be understood by considering the industry with reference to its productive unit, the hydraulic press. Not only the different capacities of the individual mills and the relative importance of the great oil producing centers, but also the magnitude of the industry as a whole can best be expressed, after the custom of crushers, in terms of presses. Presses in different mills, it should be remembered, vary somewhat in seed-consuming capacity according to differences in methods of operation, in the number of plates, etc. In a few mills the quantity of seed consumed per press per day ranges as high as 175 bushels. In some others it amounts to no more than 125 bushels. In most of the well-equipped mills, however, crushers generally claim to press 150 bushels per press per day of twenty-four hours. The most definite estimate probably that can be made as to the capacity of the press, viewing the industry as a whole, is that it is from 125 to 150 bushels per day. And since the average number of days that a mill can be economically operated in a year is generally regarded as about 250, the annual capacity of a press may therefore be put at from 32,250 to 37,500 bushels.

As measured by the number of presses, individual mills differ widely in capacity. The largest mill in the United States in 1902 was located in Buffalo and contained 90 presses. The arrangements which have been made for adding 48 presses to this plant will make it the largest mill, running on flaxseed alone, in the world. The second largest mill in the country operated 84 presses and was located

on Staten Island, New York. One 50-press mill was in operation in Buffalo and a 48-press mill in Chicago. Two mills of 40 presses each constituted the largest establishments of this class in the important Western oil-producing center, Minneapolis. As an illustration of the concentrative tendency of this industry, the above six mills, comprising in number only about one-seventh of the active mills in the United States, had a combined crushing capacity equivalent to almost one-half the active capacity of the entire country. The other mills ranged, as to the number of presses, from 24 presses down to 5, mills of 12 presses being the most common.

In linseed oil making, as in any other industry, the manufacturing capacity of the great producing centers can not be taken as synonymous with the actual industrial operations at those points. Crop failures, changes in transportation rates, the interests of individual manufacturers, and many other causes may incite temporary or even permanent activity at one point while tending to check business in the same lines at others. Probably not far from 70 per cent of the flaxseed crushed in the United States is ordinarily crushed at the four great linseed oil producing centers, Buffalo, Minneapolis, New York, and Chicago.

Estimated on the basis of the number of presses, Buffalo with a total of 157 presses is the leading crushing center of the United States, a supremacy which is to be further increased by 48 additional presses. In the city of Chicago the five mills operating the old process have a total of 95 presses; the new-process mill, being estimated as equivalent to 50 presses, raises the aggregate to 145. As, however, Chicago has declined as a primary market for flaxseed, so it has as a producer of linseed oil; and, ranked by its actual output of that product rather than by its productive capacity, it would stand nearer fourth than second among the great crushing centers. The great linseed oil producing center of the West is Minneapolis; and, although the five mills operating there in 1902 had a combined total of only 118 presses, or 39 less than the total in Buffalo, it is likely that in the long run the quantity of seed actually consumed at that point equals, if it does not surpass, the crush at Buffalo. Moreover, a new mill of 21 presses, which was in process of construction in Minneapolis at the close of the same year, will increase the crushing capacity of that point to 139 presses. The number of presses in the two mills in New York City in 1902 was 108, making the total for the four principal crushing centers of the United States 528 presses. These mills represented an annual crushing capacity of from 17 million to 19 million bushels of seed.

In the forty-odd linseed oil mills in operation in the United States in the fall of 1902, not including a few small, inactive mills, there were approximately 750 presses. Their combined crushing capacity, if operated 250 days in the year, would be from 24 million to 28 million

bushels, with a possible output of from 60 million to 70 million gallons of oil. Since the domestic demand for oil does not exceed 50 million gallons a year and the foreign demand is unimportant, it is evident that the crushing capacity of the country is at the least 4 million bushels in excess of the country's requirements. This surplus capacity is naturally reflected in the operations of the industry. All the mills are not run steadily throughout the crushing season, and gluts in the oil market are obviated to a degree by shutting down some of the sources of supply.