Fiber flax is processed in the United States only in the Willamette Valley of Oregon. Flax plantings there have varied from 18,000 acres in 1942 to about 1,000 acres in 1950. The 1942 crop yielded 2,000 tons of linseed fiber, which is about a third of the quantity imported each year. Nearly 6,000 tons of unmanufactured flax fiber and 35 million dollars' worth of manufactured linen were imported into the United States in 1948.

The future of the Oregon industry depends largely on the ability of American farmers and processors to mechanize their operations so that high-grade fiber can be supplied at a price that will make competition possible with European flax fiber, which is produced with low-cost labor.

The United States Department of Agriculture, the Oregon Agricultural Experiment Station, and the fiber-flax industry have been working cooperatively on processing problems since 1938. New techniques and machines have been developed to reduce costs of production and processing and at the same time preserve the inherent good quality of fiber.

Linen is a textile of great antiquity. Linen that was manufactured 10,000 years ago by the neolithic lake dwellers has been found in Switzerland. Flax was one of the first crops grown in the New World by the Pilgrims at Plymouth and by the early settlers at Jamestown. Nearly every farmhouse had a spinning wheel, and women were skilled in the art of spinning linen and woolen yarns. Homespun cloth was the chief textile of Colonial days. Flax growing and processing increased in the United States until Eli Whitney invented the cotton gin in 1793. The flax processors, unable to compete with the lower-cost cotton production, were forced to close their plants.

Flax is grown commercially for seed and for fiber. The varieties grown for seed are generally short plants with many lateral branches. Fiber from the seed varieties is often coarse and harsh and is not well suited for textiles. The varieties grown for fiber have fewer lateral branches and reach a greater height than seed flax. The fiber is finer, longer, and softer than that in seed flax. The seed from fiber flax is as valuable for oil and meal as that from seed flax.

Production of high-grade fiber flax calls for a cool, moist growing season, a requirement that has somewhat restricted the areas where the crop can be successfully grown.

The commercial processing of fiber flax in the United States has been largely confined to Michigan and Oregon. In Michigan, the industry ended with the beginning of the First World War. The present industry in Oregon began in 1915, when the State legislature appropriated $50,000 to the Oregon Penitentiary to erect a processing plant, which is still in operation.

Three cooperative processing plants were established jointly by the State of Oregon, the Works Progress Administration, and growers' cooperatives in 1936. Ten more were built with Federal, State, and private capital from 1941 to 1943, bringing the total to 14. The number of active processing plants dropped to four in 1950 because of the
decline in prices of domestic fiber, competition from cheaper imported European fiber, failure of the industry to establish grade standards, lack of orderly marketing procedures, and high prices paid for competitive crops.

Flax processing comprises six major steps: Pulling, or harvesting; deseeding, or separation of seed from straw; retting, or partial rotting, to loosen the fiber from the rest of the plant; drying, or removal of the retting water from the straw; scutching, or separation of the long line fiber from the rest of the plant; and hackling, or combing, to make the long fibers parallel and remove the short tangled fibers.

Fiber flax is usually planted from February 15 to April 15. It is pulled and delivered to the processing plants in July and August. A small part of the straw is deseeded as it is delivered; the rest is deseeded by January. Retting and drying are ordinarily done from June to October of the following year. Scutching and hackling are done from October to May. The processing operations cover from 18 months to 2 years from the time the straw is pulled until the fiber is ready for the market.

Flax plants grown for fiber are pulled by hand or by machine. Reapers, sometimes used, cut the flax straw from 3 to 7 inches above the ground. As the line fiber runs the full length of the straw, a good deal of valuable fiber is left in the field to rot when the crop is harvested by cutting.

A skilled workman can hand pull an acre of flax in 68 hours. The tractor-drawn Willamette puller with two men can do it in far less time.

Mechanical pullers thus far developed often scuff, or crush, the straw where it is gripped in the pulling mechanism and cause the fiber to overret and weaken at the damaged points during retting.

Uneven bundles produced in pulling cause seed losses in the deseeding and straw losses in the processing operations. The unevenness results in a lower yield of line fiber; it increases the proportion of tangled fiber, which is called flax tow, and causes the discharge of fiber with uneven ends from the scutching machine.

Many patents have been granted on flax pullers, but only four or five have been developed to the stage where they are used commercially. The slowness in adapting mechanical pullers has been attributed to an abundance of cheap labor in the flax areas and the small plantings of flax on each farm. The shortage of labor after the First World War stimulated the development and use of flax pullers.

A major problem confronting the industry at the beginning of the project was how to remove the seed from the flax stems without damaging the straw.

Devices for deseeding fiber flax already patented include a hand-operated ripple, one of the earliest devices. Ripple deseeding is still practiced to some extent in Egypt. The bundle of flax is spread and the seed ends are drawn manually through stationary metal combs. The seed balls are pulled off and collected on a sheet. This ancient method requires 18 to 20 man-hours per ton of pulled flax.

In 1938, when the research project was begun, the Oregon industry used the whipper deseeding machine, which consists of two smooth rollers revolving inward and pressed together by springs. The seed-bearing part of the straw is passed three or four times between the rollers, which crush the seed balls and liberate the seed. A crew of 10 men can deseed a ton of flax in an hour with the whipper machine.

An automatic rotary-comb deseeding device was developed by specialists on the research project. It has been widely adopted in Oregon.

One of the new deseeders, with auxiliary automatic conveying, butting, and tying apparatus, was installed at the Mount Angel flax plant in 1948. Four men can operate it. One unloads
from the wagon to the deseeder table; one cuts the string and places the bundles on the straw conveyor; one receives the bundles from an elevator and stacks them on the wagon; and the fourth operates the threshing machine and sacks the seed.

The capacity of the improved machine has been limited to the ability of the operators to feed it. Four men can deseed 3 tons of pulled straw an hour.

Flax fibers are in the cambium layer of the plant, where they are cemented together and to the other parts of the stem by pectins. To prepare it for fiber separation, the straw is subjected to a retting, or rotting, process. Retting is a bacteriological fermentation; micro-organisms decompose the pectins and loosen the bond between the fiber and other parts of the plant, so that the woody portions can be broken and the fiber removed.

There are two methods of retting—dew retting and water retting. In dew retting, the flax is spread on the ground, where it is exposed repeatedly to heavy dew. The pectins are slowly broken down by the action of mold fungus, so that the fiber is loosened from the remainder of the plant.

Oregon water-retting tanks, of the open-top type, are approximately 40 feet long, 16 feet wide, and 7 feet deep. About 8 tons of deseeded straw is packed, two layers deep, in an upright position in the tanks. The tanks are then filled with warm water and maintained at from 85° to 95° F. for 4 to 6 days, when retting is complete.

Flax straw is held beneath the surface of the water by means of the retting-tank cover, a removable lattice supported by heavy timbers. Nearly 100 separate wooden parts constitute the tank cover. Their installation or removal formerly required the services of 3 men for approximately 45 minutes. The wooden pieces become wet and slimy from contact with the retting water and partly rotted flax. They have an offensive odor, and their removal is laborious and disagreeable.

A mechanical device now makes it possible to fasten the many tank-cover parts together and handle them as a single unit. The operation takes 3 to 5 minutes.

Under the existing methods of flax handling, retted flax straw is dried only in the summer. The wet straw from the large concrete retting tanks is transferred to the field by truck. The strings are cut, and each bundle of retted flax is set up in the form of a wigwam to field-dry. The flax is manually removed from the field after drying and fed to a small mobile binder, which ties the bundle again and leaves it on the drying field. The bundles are loaded on a truck with pitchforks and transported to a storage shed.

A self-propelled machine, developed on the project, mechanically removes the dried wigwams from the field, binds them into bundles with one tie string, and conveys them to a trailing wagon. Three men operate the machine—one, a ground man, sets up wigwams that have been blown over; one operates the machine and guides the bundle; the third receives the bundles from the elevator and stacks them on the wagon.

Scutching, the separation of the fiber from the remainder of the plant, is the next major operation. The condition in which the bundles are received from the field binder directly affects the amount of labor involved in spreading and feeding the flax straw into the scutcher and the percentage of cleaned line fiber discharged by the scutching machine.

The object of scutching is to extract the fiber, loosened during retting, from the remainder of the plant. All methods of scutching are based on two straw treatments. The first is to crush and break the woody central portion of the stem into small pieces, called shives. Next, the straw is held tightly near one end while the free end is subjected to a beating and scraping action to complete the separation of the long fiber from the woody portion.
Research to improve scutching machines has attempted either to increase the amount of long fiber extracted from the straw or to reduce the amount of hand labor involved, without damaging the fiber.

Various types of machines have been developed, but the turbine scutcher, which facilitates straight-line operation, is the most widely used.

An experimental scutching machine of the turbine type has been developed. It extracts 2 percent more line fiber and cleans it more thoroughly than the commercial machines do.

The flax line fiber from the scutching machine is usually hackled, or combed, by hand to grade it and prepare it for the spinner. Hackling is done by manually drawing the scutched fiber over a series of coarse and fine pins to straighten or parallel it and to remove short, tangled fiber. The addition of combs to the scutcher blades cuts in half the time required to hackle and dress the fiber.

Fiber removed during the scutching operation falls into the refuse-removal system, where it is mixed with weeds and shives. It is called flax tow.

A large proportion of the foreign material can be separated from the tow by a shaker. Further processing is required to remove shives before the material is suited for use as upholstery tow or for yarn spinning.

Before a combination tow drier and cleaner was developed in 1941, so much dirty tow had accumulated that it filled the available storage space and was being burned for fuel in some plants. With the new tow drier and cleaner, processing plants can clean the tow fiber and render it suitable for making upholstery padding and coarse yarns. The development has transformed a waste material into a valuable byproduct, which now brings 160 to 240 dollars a ton.

The abundant supply of cleaned flax-tow attracted the attention of the California Cotton Mills Co. Members of this organization formed Oregon Flax Textiles, which put up a large flax-tow spinning and weaving plant in Salem, Oreg. It manufactures woven flax rugs and braided linen rugs. The company plans to double its capacity. Coarse yarns and wool-and-flax rugs are among its new items. The rug has a woven flax base and a tufted wool surface. It is an attractive, long-wearing floor covering.

The establishment of the State flax industry in 1915 provided a ready supply of raw flax fiber. This stimulated interest in flax manufacturing and led to the erection of two line-fiber spinning mills in 1925 at Salem, Oreg. Together, the physical plants are valued at 1.5 million dollars.

One of the mills, the Miles Linen Co., manufactures shoe thread, fish netting, sack and mattress twine, and weaving yarns.

The other, the Salem Linen Mills, produces chiefly sack twine, twine used in furniture construction, and colored linen twine for military use and fire hose.

Both mills operated at near full capacity in 1950. Salem Linen Mills operates principally on fast-color yarns to meet the demand of hand-loom weavers. With the increased availability of required yarns, the number of private looms has grown to about 15,000 in Oregon and California. Besides affording an interesting hobby, this growing trend toward hand weaving is providing individuals with an economical method of obtaining a particular type of linen product desired.

Oregon fiber flax possesses qualities which enable it to surpass imported fiber. However, any advantages gained from superior quality are lost through a lack of segregation of qualities. This is a direct result of the conspicuous lack of standards or grades in the flax industry. Thus, a high-quality fiber may be produced which will sell only with difficulty, as it is baled with fiber of high, medium, or low quality.

Since there are no established and enforced quality specifications, the compliance with which would assure a
satisfactory fiber, spinning mills use the Oregon fiber only to blend with the graded and more uniform imported fiber to give added strength. The flax industry stands ready to capitalize on its superior product once the fiber is graded in accordance with its spinning qualities.

The progress made in the mechanical processing of flax since 1940 has been more rapid than in any other period in history. The several machines mentioned here have improved the flax preparation and reduced the processing costs.

While the progress in mechanization has been significant, there is need for the development of new equipment and techniques in bulk handling of flax straw, in artificial drying of retted straw, and in quality control during the production and processing.

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In the early days of the cottonseed-crushing industry, most mills operated only during the 4-month harvesting season and remained idle the rest of the year. The mills thrived, nevertheless, because labor was cheap and poor roads kept the mills isolated, so that there was little competition.

When the industry expanded and new highways made long-distance transportation easier, keen competition for cottonseed sprang up. Mills became larger and more efficient, so they could operate over a longer crushing season. Competition and large-scale operation forced many mills out of business.

But the operation continues to be a seasonal one and competition in buying remains keen, particularly in short-crop years, since each miller strives to obtain his maximum requirements for the season. Thus, the market for cottonseed is largely a seller’s market.

Why do many of the mills operate only a few months of the year? For one thing, the cotton crop must be picked before wet weather sets in. Otherwise the lint will be damaged, and few mills can store cottonseed over a long season. Another reason is the great demand for cottonseed meal as stock feed in winter. How can mills operate profitably while remaining idle the greater part of the year? Mainly because their hydraulic-pressing equipment is relatively inexpensive to install, so that overhead or fixed expenses are lower. Also, the labor costs for hydraulic pressing, though rather high, are eliminated when the mill shuts down.—E. L. D'Aquin, E. A. Gastrock, and O. L. Brekke, Bureau of Agricultural and Industrial Chemistry.