

OUTLETS FOR WOOD WASTE

**A General Statement of Actual and Potential Uses of
Various Kinds of Wood Waste**

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**UNITED STATES DEPARTMENT OF AGRICULTURE
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A General Statement of Actual and Potential Uses of Various Kinds of Wood Waste

The information set forth in this publication is intended to serve chiefly as a guide in the disposal of wood waste. Obviously all of the outlets for such material cannot be covered in a short treatise. Also, the outlets noted cannot take care of all the wood waste produced. While commodities in great variety can be made from suitable waste wood, the production of some of them may be economically unwise. The utilization of wood waste for any purpose, therefore, whether on a large scale or on a small scale should be preceded by a thorough study of all the conditions affecting the manufacture and sale of the finished products. If the volume of the waste involved justifies the expense, the services of a technical engineer or a consulting forester well versed in the utilization of wood waste will be desirable in determining the feasibility of converting the material into marketable products.

Wood refuse may be conveniently grouped into three broad classes:

- (1) Forest wastes, and slabs, edgings, trimmings, etc.
- (2) bark, and
- (3) sawdust and shavings.

1. FOREST WASTE; SLABS, EDGINGS, AND TRIMMINGS

The common forms of forest waste that can in a measure be salvaged are high stumps, tops, and large branches of trees; small, defective, crooked, and short logs, and inferior species. Large size sawmill and factory wastes that can often be utilized more fully consist of slabs, edgings, trimmings, and short-length lumber.

The total logging, milling, and factory wastes noted above comprise approximately one-half of the volume of the timber of merchantable size standing in the forest, divided about equally between woods waste and waste resulting from sawmill and factory operations. The degree to which such wastes can be utilized is largely dependent upon the cost of production of the commodities made from them and the ability of the market to absorb the manufactured articles.

The principal outlets for forest waste, slabs, edgings, and trimmings are:

1. Fuel
 - a. Cordwood
 - b. Baker's wood
 - c. Kindling
 - d. Hugged fuel
2. Physical uses
 - a. Dimension stock and squares
 - b. Short lumber
 - c. Box and crating stock
 - d. Mechanical fiber
 - e. Roofing Chips
 - f. Other products
3. Chemical outlets
 - a. Hardwood distillation
 - b. Softwood distillation and extraction
 - c. Pulp products
 - d. Tanning extract
 - e. Dye extract
 - f. Charcoal (brick or pit kilns)
 - g. Industrial alcohol
 - h. Miscellaneous uses

1. Fuel

a. Cordwood

The greatest single use for wood is for fuel. In normal years fuel wood comprises about 2/5 of the entire volume of timber removed from the forests. The use of so-called bodywood for fuel is extensive in this country. Frequently the value of standing timber is under rated, and trees that are of considerably greater value for other purposes are cut into cordwood. The more extensive use of tops, defective and crooked logs, inferior species, etc., for cordwood is urged as a very practical method of conserving the better grades of timber for higher uses. While it is common practice at sawmills to utilize slabs and edgings for fuel, for both plant and domestic purposes, a wider utilization of such material of no value for higher uses is desirable. A standard cord (128 cubic feet) of air dried wood (20 percent moisture content) of beech, birch, maple, and oak will equal in heat value a ton of good coal.

b. Baker's Wood

Many of the smaller baking establishments still use wood for baking purposes. Supplying the needs of this trade, especially in the larger cities, has become a rather specialized business. The woods required by

the bakers are hardwoods -- maple, birch, oak, hickory, or ash. The form in which the wood is delivered is not so important, except that the pieces must be small enough for ordinary range use. The length of baker's wood averages about 24 inches.

Baker's wood consists mostly of maple and birch edgings, hickory slabs and edgings, and oak flooring waste. Except for flooring waste, which is kiln dried, practically all baker's wood is air dried and bundled before shipment.

c. Kindling

Suitable mill waste of softwood species, largely hemlock and pine, are sold in considerable quantities for kindling use. For this purpose the material is cut chiefly into 4-foot lengths, after which it is air dried and bundled. Considerable quantities of kindling are sold in northern cities, particularly during the fall season.

d. Hogged Fuel

Special forms of fuel wood may offer opportunities for profitable disposal of wood waste. Large sawmills are equipped with "hogs" for reducing wood waste to smaller and more uniform size for convenient handling and use. "Hogged" wood in excess of the needs for plant fuel is used for providing heat and power in localities where conditions are favorable. Three and one-half tons of green "hogged" wood are about equal in fuel value to 1 ton of average coal. The relatively low heat value of hogged fuel and the comparatively high handling and transportation costs restrict the use of that material to points close to the place of origin. "Hogged" wood is the principal fuel used at several power plants in Oregon and Washington, notably at Eugene and Portland, Oreg. The use of "hogged" wood for domestic heating and for heating hotels and other large buildings is common in the Pacific Northwest.

2. Physical Uses

a. Dimension Stock and Squares

Mechanical uses of wood waste cover a very wide field and include all those in which the material is converted by further manufacture into wooden articles. The usual product made is small square-edged material -- "dimension stock," and "squares." Occasionally finished and semifinished commodities are made from wood refuse at the point of waste production.

Dimension stock and squares can be made from logs ordinarily unsuitable for lumber of marketable quality. Slabs, edgings, and trimmings, and to a less extent factory wastes are also made into dimension stock and squares. These sources of dimension stock can be exploited successfully only under the best conditions of manufacture and seasoning.

Because of the great variety of conditions under which dimension stock is produced, information of a detailed nature relative to the industry cannot be set forth in this report. Specific information on the subject may be had, however, by writing the Director, Forest Products Laboratory, Madison 5, Wis.

The production of dimension stock, squares, and other commodities from wood waste is discussed to an appreciable extent in various publications of the Forest Products Laboratory covering manufacturing methods, equipment used, seasoning, marketing, and other essentials in the conversion of such materials in several forest regions. Publications will be supplied free upon request.

b. Short Lumber

In the manufacture of softwood yard lumber considerable material in lengths under 8 feet is normally wasted or is so used as to yield but a fraction of its real value. Most of these "shorts" are 4 and 6 feet long, since odd lengths are not commonly made in softwood lumber manufacture. Short length lumber occurs as rough square-edged stock, chiefly as a result of taper, crook, and defects in logs and as surfaced, worked, or patterned material from planing mill operations.

Short length stock constitutes approximately 5 percent of the total volume of softwood yard lumber marketed under the regular specifications. It is thought that if all the suitable material available at sawmill operations under present practice were utilized in the production of short lumber such stock would constitute at least 10 percent of the total softwood yard lumber production.

Hardwood lumber is marketed in the regular grades in lengths as short as 4 feet. Pieces up to 4 feet long and at some mills longer pieces have been quite commonly wasted. Much of this short length lumber is clear material and can be used to advantage in many of the hardwood-using industries. More complete utilization of short lengths in hardwoods is desirable, and if carried out to the limit under present manufacturing practice, would help materially to conserve our stand of hardwood timber.

An investigation was conducted by the Laboratory to find industrial outlets for short-length stock. The results are published in Department of Agriculture Circular 393, "Industrial Outlets for Short-length Softwood Yard Lumber."

The following are among the more important items made from the larger pieces of wood waste and short lengths of lumber often discarded:

Agricultural implement parts

Beehives
Boot and shoe findings
Brooms and carpet sweepers
Brushes
Cable reels
Chairs and chair stock
Construction uses
Dowels
Drying racks
Farm equipment
Furniture
Handles
Hardwood flooring
Ice cream cabinets
Incubators

Industrial uses

Lath
Millwork
Novelties
Picture frames and molding
Planing mill products
Refrigerator parts
Seating
Sewing machines
Shades and map rollers
Signs and supplies
Skewers and butcher blocks
Step ladders
Toys
Woodenware
Wood turning

c. Box and Crating Stock

Slabs, edgings, short stock, and low-grade lumber of both hardwoods and softwoods are sometimes made into box shooks and crating material. This is done at the mills or the material is trucked or shipped to box factories for conversion. The enormous volume of box and crating stock consumed suggests that suitable waste and low-grade material can be used for those items to the limit, so far as such operations may be profitable.

d. Mechanical Fiber

Suitable forest and mill waste is shredded by means of mechanical "defiberators" to yield a rather coarse wood fiber. The principal use of the "defiberized" material is for filler in roll roofing, building felts, and composition shingles. It is also used for mattress stuffing and similar purposes. "Defiberized" wood has been mixed with the ordinary materials for making fiber containers. The species preferred for defiberizing are reported to be maple, birch, and aspen.

e. Roofing Chips

In prewar days roofing felt contained about 12 percent by weight of wood fiber as a partial filler. Currently up to 50 percent of the felt is composed of fiber, made chiefly from chips the principal source of which is wood waste largely in the form of slabs and edgings, with or without bark. The pieces are run through chippers to reduce the material

to sizes that can be readily worked into fibrous material. Many common species of wood can be used for roofing chips.

f. Other Products

Woods waste, generally, should yield material suitable for posts in most forested areas. Other products that can be made from suitable wood waste are mine props and railway ties in the smaller sizes, lath, and snow fence slats.

3. Chemical Outlets

a. Hardwood Distillation

The hardwood distillation industry is notable in that a large part of its raw material is woods and sawmill waste, the bulk of which comes from the woods. Small-sized pieces are not desirable, and sawdust is usually of no value. The species most commonly used are beech, birch, maple, and oak. A few other woods are used to a limited extent, chiefly for the production of special types of charcoal. The principal products of hardwood distillation are wood alcohol, acetate of lime, charcoal, and hardwood tars. However, in small scale operation no attempt is made to recover any products other than charcoal.

b. Softwood Distillation and Extraction

The distillation of resinous woods is confined for the most part to longleaf and slash pines. The yields from destructive distillation of these woods vary greatly, depending on the quality of the wood. The raw material consists almost wholly of stumps from which the sapwood has rotted away. Other materials that can be distilled are pitchy slabs, turpentine faces, and other resinous parts of the tree. The principal products of dry distillation of resinous pine are wood turpentine, tar oils, tar, and charcoal.

Another method for the recovery of byproducts from resinous wood is known as the extraction process. In this process the wood is first hogged into small chips, and the pine oil and turpentine extracted by steam distillation, after which the rosin is recovered by means of some solvent such as gasoline. Only the most resinous wood can be used with profit, and practically all the wood consumed consists of pine stumps. Resinous stumps have ready sale if within shipping distance of distillation plants.

c. Pulp Products

The manufacture of wood pulp from waste offers excellent opportunities for efficient and profitable operations. Waste of various types has been used in paper making for a number of years. At present this consists largely of spruce and hemlock slabs, butt cuts, and other large pieces. Hemlock waste is frequently cut from peeled logs, and hence is free from bark. There are several mills in the South that use yellow pine mill waste. They employ the "kraft" or sulphate process, in which the presence of some bark is not objectionable for most of the products. In the other chemical processes, namely, the sulphite process and the soda process and in the mechanical or ground-wood process, the bark must be removed entirely before the wood can be pulped. This is a serious obstacle to the use of waste because of the fact that the removal of bark from slabs and other irregular forms is more difficult than its removal from roundwood. Another drawback is the fact that the handling of slabs in the wood room of the average pulp mill and their conversion into chips is more expensive than with roundwood. In order to obviate handling costs in wood rooms not especially equipped for handling waste and to save in freight and other items, certain operators are now chipping the waste at the sawmill and shipping the chips to the pulp mill.

Recently wood waste has assumed some importance in the production of fiber boards, particularly insulation boards. New pulping processes have been or are being developed which appear very efficient in the utilization of such materials and offer promise of greatly increasing the consumption of wood waste for pulp products. The same processes are also applicable to the byproducts of the various wood extraction processes -- particularly to spent chestnut chips from the tanning extract industry.

Several pulp mills on the Pacific Coast are using hemlock woods and sawmill waste in the production of newsprint and other grades of paper that will admit some dirt and discolorations in the product.

d. Tanning Extract

The only native wood used to any extent in the manufacture of tanning extract is chestnut. We have no record of the amount of waste used by the extract manufacturers, but the material is assuredly as rich in tannin as the solid wood, and, since the wood must be reduced to small chips, the only objections to the use of waste would seem to lie in a slightly greater handling expense and possibly in a greater percentage of bark present in the stock. The chestnut extract industry has in the past used several hundred thousand cords of wood annually.

e. Dye Extract

Although there are a number of native woods that are used to some extent in the manufacture of dye extract, there is only one of importance at present. This is osage-orange, the wood of which furnishes a yellow extract which is employed in producing a series of yellows and browns upon leather, paper, and textiles. Practically all of the wood now used comes from Oklahoma and Texas, and is in the form of woods waste and wood in the round. The present annual consumption is probably more than 5,000 tons.

f. Charcoal

The production of charcoal in brick and pit kilns for local use consumes considerable wood in some localities, a large portion of which is wood waste. The industry is well developed in the southern states where Southern yellow pine is the principal species used. In northern localities hardwoods comprise the bulk of the raw material. While small round pieces are used in pit burning, wood split from sticks 6 inches and over in diameter is preferred.

Several types of portable charcoal kilns have been developed for use in woodlot and other small scale operations. They are reported to be efficient, but are not extensively used.

g. Industrial Alcohol

The manufacture of industrial alcohol from sawdust and other mill waste was carried out on a commercial scale for a number of years. Sawdust and shredded waste of almost any species are suitable, and it is not necessary to remove the bark, though it is not desirable to have a large percentage of bark present. The wood is placed in rotary digesters, and treated with dilute acid at high temperature, converting the cellulose into fermentable sugars. These sugars are then separated out and fermented into alcohol, which is distilled and rectified in the usual manner, making a product that is the equal of grain alcohol produced by any of the other commercial processes, and superior to some.

Alcohol from wood waste produced on a large scale basis requires large volumes of material daily for profitable operations. A commercial plant in Oregon costing about 2-1/2 million dollars will begin operations late in 1945.

h. Miscellaneous Uses

The production of various wood, bark, and leaf oils is a small industry which has been in existence for many years and which seems to have slight chance for appreciable expansion. Some of the oils distilled are spruce oil, eucalyptus oil, cedar leaf oil, cedar wood oil, and birch bark oil.

Under present conditions the manufacture of potash from wood ashes is not particularly profitable. Hardwood ashes are more desirable than ashes from coniferous woods because of their higher potash content. Pure hardwood ash will probably yield as much as 10 percent of potash.

2. BARK

Except for a few species, waste bark has little commercial value other than for fuel. The following uses include the more important outlets for such material:

a. Tanbark and Tanning Extracts

The principal native barks used in the production of tanning extracts and in the tanning of leather are chestnut oak bark, tan oak bark, and the bark of Eastern and Western hemlock. Other oak barks are used to some extent. The total amount of bark annually produced in this country is probably well over one million cords. Some is used directly in tanning and the balance is extracted and used in liquid form.

Practically all of the bark is peeled in the woods, but especial attention is directed toward the possibility of mechanically peeling the sawlogs at the sawmill or recovering the bark from pulpwood and extracting the tanning material from it or of marketing the dried bark for direct use. The bark is rossed from the sawlogs, shredded to a uniform fineness, dried in specially constructed dryers, and then put up in bales for shipment.

b. Paper Specialties

The newest use for barks is in the manufacture of certain kinds of paper, in which it takes the place of more expensive materials. Notable among such papers is roofing felt, used in making asphalt shingles. The use of bark is being experimented with in the production of boxboard and similar items. The production of insulating felts, hanging papers, car liners, indurated ware, sheathing, etc., composed largely of waste bark of various kinds, is suggested.

c. Miscellaneous

A recent development concerns the bark of redwood. Equipment has been devised for shredding the material and reducing it to a fibrous condition. The longer fiber is used for heat insulation. Some is used for mattress stuffing and similar purposes. The finer fibers are made into yarn that is mixed with wool for cloth making. The dust resulting from shredding is sold as a soil conditioner.

For certain purposes finely ground bark is used as a substitute for wood flour. The corky portion of Douglas-fir bark, when ground, resembles ground cork, and may be substituted for that product for some purposes.

The stringy bark of certain western species is used for making novelties, table mats, table tops, and wallboards. It is also used to some extent for packing.

Bark can be used as an insulating material, and also as a sound deadener.

3. SHAVINGS AND SAWDUST

Shavings and sawdust are marketed in larger quantities and for a greater variety of uses than is generally supposed. Dealers in the Chicago district alone dispose of upwards of 12,000 cars, or approximately 360,000 tons annually. While the volume of sawdust and shavings consumed in the industries is in the aggregate large, it represents but a fraction of the amount of such materials available at sawmilling operations and woodworking plants. The existence of shavings and sawdust in great abundance does not mean that there is always suitable material available for users of such stock. On the contrary shortages of sawdust and shavings are quite common during the periods of greatest use of those commodities.

Character of the Industry

The shavings and sawdust industry is seasonal. During the spring, summer, and early fall months important markets for certain items in the shavings and sawdust field largely disappear. Unfortunately, this seasonal depression comes at the time of greatest activity at sawmills and woodworking plants when shavings and sawdust are produced in greatest abundance.

Dealers in shavings and sawdust usually contract with producers for the output of the factory or milling plant for a stated period or for a stated number of cars, usually 25 or 50. Contracts commonly provide for the movement of cars whenever they are ready for shipment. Sawdust and shavings will not stand heavy transportation charges during normal periods. The rate from northern Michigan and Wisconsin points to Chicago is 15 cents per hundred pounds, which is normally about all the traffic will bear on ordinary grades of stock. For special uses or in times of scarcity sawdust and shavings are shipped on rates as high as 50 cents and more per hundred pounds.

Types of Shavings and Sawdust

Shavings and sawdust are commonly classified by dealers as softwood, hardwood, mixed softwood, and mixed softwood and hardwood. Stock is marketed green, air dry, and kiln dry. A high proportion of all sales by dealers are of dry stock. Green hardwood sawdust has little commercial value. Hardwood sawdust direct from the mill is used in curing meat, which is the principal outlet for such material. Green softwood sawdust is seldom used except for fuel at point of production. Probably not to exceed 5 percent of the sales of shavings and sawdust dealers is of green material.

Sawdust and shavings users demand much greater refinement of stock than in former years. Specialization in the use of those items is rapidly reaching the point where the average run of sawmill and factory stock has little commercial value. Shavings of one species, such as white pine, soft yellow pine, spruce, and other light-colored softwoods, are in greatest demand. Maple sawdust has ready sale. Pure birch, walnut, or oak is worth more for certain purposes than a mixture of these woods. For some uses sawdust or shavings must have no species in mixture that leach and discolor products with which they come in contact.

Sifted Sawdust

Considerable sawdust is graded for size to meet the requirements of many industries. Much of the dry hardwood sawdust sold is either sifted or marketed in various approximate size grades direct from the factory. Softwood sawdust is seldom sifted. Grading of sawdust at the point of origin is commonly roughly done, and the product is designated chiefly by type of machine at which it is made as resaw dust, sander dust, etc. The latter is considered by some as a type of wood flour. Commercial wood flour is made in an altogether different way and is a more valuable product.

Grades of sifted sawdust are designated by size as 8 mesh, 20 mesh, 40 mesh, etc. Sawdust larger than 8 mesh and finer than 40 mesh has few specialized uses. The most common uses for sifted stock are in fur dyeing and cleaning, plating work, as a filler for composition flooring, plaster, stucco, tile, concrete, and a variety of moulded products. Some packers require sifted sawdust for meat smoking use.

Uses

Outlets for sawdust and shavings are increasing in number, but the volume of material required to supply these new demands as yet scarcely compensates for losses occasioned by changing conditions in industry. For example, the use of sawdust for ice house insulation is falling off sharply because of electric refrigeration. Milk deliveries in cities are increasingly being made by trucks replacing horse drawn vehicles, thereby curtailing the use of shavings for bedding purposes. On the whole the growth of the sawdust and shavings industry is about normal. Some of the principal sawdust and shavings concerns report however, that substitutes for sawdust are making inroads into the business.

The uses to which sawdust and shavings are put are so numerous and varied that any list of them will necessarily be incomplete. The following includes most of the more important uses, and represents the bulk of the volume of sawdust and shavings consumed:

A. Fuel

- At points of production (sawmills, factories, etc.)
- Domestic purposes
- Gas producers
- Briquettes

B. Physical uses

- Stable bedding
- Absorbents
- Composition products
 - a. Floors
 - b. Concrete products
 - c. Cast products
 - d. Stuccos and plasters
 - e. Gypsum compositions
 - f. Clay products
 - g. Moulded articles

Wood flour

Fur cleaning, dressing, and dyeing

Cleaning, drying, and polishing metalware

Packing

Shipment of grapes and other fruits
Leather working
Wallboard
Heat insulation
Floor sweeping compounds
Soaps
Soil conditioners
Grasshopper "bait"
Nursery practice
Lime burning
Protection of fresh concrete
Gas purification
Hardening and annealing of metals
Poultry picking
Wallpaper
Stuffing pincushions and dolls
Moth repellent
Kennel bedding
Fire extinguisher
Filtering oil
Waterproofing mixtures

- C. Chemical uses
Meat smoking
Distillation
Extraction
Carborundum and calcium carbide
Dye production
Tanning extracts

A. Fuel

At points of production.--Most of the sawdust and shavings produced is used for fuel, and practically all of it is consumed at points of production. This use will continue to be the chief outlet for such stock until it commands a price for industrial and other purposes sufficiently high to enable factories and mills to use other forms of fuel or electric power for plant operation.

Dry sawdust and shavings can be burned quite readily with no radical changes in the fuel chamber or in the form of material. Green sawdust and shavings, however, require for best results considerable modification of the combustion chamber and proper mixture of the material with larger forms of wood waste. About 50 percent of hogged fuel mixed with green sawdust or shavings prevents fuel from packing and provides proper draft for good combustion.

The actual heat value of a given weight of bone-dry wood or bark is nearly constant regardless of the nature of the material or species of wood, and is usually assumed to be about 8,600 British thermal units per pound. Woods containing resin have slightly higher fuel values, since resin yields more heat units than wood substance. Good coal has a heat value of about 13,000 B.t.u.'s per pound. Bone-dry wood, therefore yields approximately $\frac{2}{3}$ as many heat units as coal. Most of the sawdust consumed as fuel, however, is green, and its fuel value is therefore greatly reduced. At northern mills green hardwood sawdust has only about 40 percent the heat value of coal.

Fine, dry sawdust is reported to be an ideal fuel when fed to the furnace under pressure, and perfect combustion is reported to be attained. It is said that one cord of sawdust, fired in this manner, equals in efficiency two cords of wood as a steam producer.

Domestic purposes.--In some localities loose sawdust and shavings are used extensively for domestic fuel purposes. The material is bulky, and cannot be burned satisfactorily in ordinary furnaces. Where sawdust and shavings are plentiful and cheap, and of satisfactory species, sawdust furnaces for residence use have been developed. There are several types of such furnaces in use on the Pacific Coast. Approximately 50,000 sawdust-burning furnaces have been installed in homes in the larger cities of Oregon, Washington, and Idaho, notably Portland, Seattle, and Tacoma.

Sawdust heating stoves for room use have proved satisfactory from mechanical and heating standpoints, and can be used to advantage where sawdust is readily available and low priced.

Gas producers.--Sawdust has been used to a small extent as a fuel in gas producers. It is necessary to mix with the sawdust about 50 percent of hogged fuel for best results. Sawdust for producer-gas use should be air seasoned. A type of producer-gas equipment for use with trucks has recently been developed that operates on green sawdust.

Wood and charcoal gas producers are commonly employed for generating gas for operating automobiles, trucks, tractors, buses and stationary engines in many European countries. Wood gas is also used to some extent for industrial and domestic purposes in those countries. It is a satisfactory fuel when gasoline is not available. The comparatively low price of gasoline in this country, however, makes the use of wood gas impractical in most localities under present economic conditions.

Briquettes.--The use of sawdust and shavings in the manufacture of fuel briquettes has only recently attained prominence in this country. During the past few years equipment has been perfected for compressing sawdust and shavings into briquettes that hold together without artificial binders. These machines, first used in northern Idaho, have in recent years been installed in several other localities in the Pacific Northwest.

The principal factors necessary for success in wood briquette production are: A large and constant supply of cheap raw material, low production costs, and a good market for the briquettes at a fair price. Such conditions are found only in especially favored localities. Where fuel is relatively high priced and climatic conditions are such that only a small amount of heat is required during the greater part of the year, the manufacture and sale of sawdust briquettes may be found profitable. The most promising fields for wood briquetting operations are the Pacific Coast Region, the Southwestern States, and Florida.

A common type of wood waste briquette is about 4 inches in diameter and 12 inches long. Under sufficient pressure such briquettes hold together without added binders. Other briquettes of similar type with a core of wire or of rope, which helps prevent them from falling apart, have been made. A Laboratory report "Briquetting of Wood Waste" which describes in some detail the wood briquetting industry, may be had upon application.

A special type of wood briquette is made in small quantities for automobile tourist use. Such briquettes are heavily impregnated with inflammable substances to facilitate combustion.

A briquette consisting of one part dry sawdust and two parts coal dust has been made.

Fire lighters comprise another form of sawdust briquette. So far as we are aware, no firelighters of sawdust are produced in this country, but reports from Europe indicate that their manufacture is quite an industry. The sawdust is mixed with rosin or pitch, and pressed into cakes which are scored so that small pieces may be easily broken off.

B. Physical Uses

Stable bedding.--Sawdust and shavings find extensive use for bedding horses and cattle, particularly in cities and at large dairy farms. Probably three-fourths of all shavings marketed by dealers are for bedding use. Shavings of the softer woods are preferred. The soft pines and spruce are the most commonly used bedding species. The demand for shavings for stable bedding in cities is falling off. Increase in the demand for shavings by dairymen and poultry raisers should, however, be sufficient to offset any loss in city sales.

Absorbents.--The most widespread use of dry sawdust is for absorbent purposes. Shavings are also employed to some extent as an absorbent. Decorative effects are sometimes considered which affect the species used. Probably the greatest consumers of sawdust for absorbent use are machine shops. The sawdust is sprinkled about the machines to absorb oils and grease on the floor. Among other places where sawdust is used as an absorbent are meat, fish, and vegetable markets, abattoirs, hotels, garages, factories, and warehouses.

Almost any kind of dry sawdust can be used as floor absorbents. Some shops, however, demand a clean, light-colored product, such as white pine and spruce.

Composition products.

(a) Floors.--Sawdust is an important ingredient in a number of flooring compounds. The mineral base of most of these substances is magnesium oxychloride. Probably the most common filler is wood, chiefly in the form of sawdust. There is considerable variation in the type, kind, grade, and proportion of sawdust used in making composite flooring. Chiefly, however, hardwood of rather fine mesh (20 to 40) is used. The proportions of sawdust in the mixture may vary from 4 percent to 70 percent and more. One type of flooring, in which 70 percent sawdust is reported to be used, employs kiln-dried hard maple or hickory sawdust of 20 mesh for the top layers and coarse softwood sawdust for the base.

Sawdust is often used in composition floors that are to be covered and to which it is desired to nail the covering. The sawdust makes the floor light and porous so that the nails can be readily driven into it.

Detailed information on composition flooring in which sawdust is an ingredient, including formulae, can be had from Circular 135 "Caustic Magnesia Cement" by the Bureau of Standards, Department of Commerce, Washington, D. C.

(b) Concrete products.--Sawdust and shavings are used to some extent as fillers in various types of concrete-like products. Concrete of such types is light and porous, holds nails and screws well, and has fair insulating qualities. One concern uses mineralized sawdust (sawdust treated with zinc chloride) in making a light-weight concrete. About one-third to one-half of the weight of the material is sawdust. The product is said to be highly wear resistant, fire resistant, a nonconductor of sound, and more comfortable to walk on than concrete. It can be sawed, nailed, screwed, and polished. Sawdust-concrete floors are sometimes laid where it is desired to attach wooden construction by means of screws and nails.

The use of sawdust in place of sand in the making of concrete barn floors has been found, in at least one instance, to produce a floor which is warmer and less wearing on the hoofs of the cattle than ordinary concrete, and the report states that after several years the floor was still in as good shape as when first laid. Reports of other similar concrete work, however, are not so satisfactory. Detailed information on cement-sawdust concrete can be had from Extension Circular 217 "Cement-Sawdust Concrete for Poultry House and Dairy Barn Floors" of the Extension Service, University of New Hampshire, Durham, N. H. The price is ten cents.

(c) Cast products.--The number of products made by casting mixtures containing sawdust is increasing. Burial vaults have been made of sawdust concrete. Tile, fire brick, shingles, and plumbing ware have also been cast. One firm making the items noted uses a high proportion of sawdust in the mixture. The cast products are reported to hold nails well, can be sawn, are waterproof, and fireproof up to 2,600° F. A very beautifully mottled wall and floor tile has a high percentage of shavings in its composition. It is successfully used for bathroom and other interior purposes.

(d) Stuccos and plasters.--Several composition stuccos and plasters on the market use sawdust as fillers. The wood particles help to bind the mass together. The resulting mixtures are lighter and more porous than ordinary stuccos and plasters. They can be nailed without damage, and are said to have better insulating qualities than the ordinary product. One of these compounds, said to contain a high proportion of sawdust, is used for stuccoing, interior plastering, and by modifying the mixture, for floors. Another is sold as wood plaster. The filler of this compound is ground sawdust. The use of sawdust plasters and stuccos is not increasing, and the chances of any considerable development along these lines are not very promising.

(e) Gypsum compositions.--Sawdust is used in the manufacture of a number of gypsum commodities. Sawdust decreases the weight of the products, makes them more porous, increases their insulating qualities, softens the material so that it can be nailed and sawed, and lessens the cost of the finished articles. The following are typical gypsum products in the manufacture of which some sawdust may be used: Interior partitions, floor insulation, wall insulation, wall boards, cast products of a variety of kinds, and roofing material. The last named product is a recent addition to the family of gypsum-sawdust products. Sawdust and shavings used in mixtures with gypsum are usually light colored, light weight, and of nonstaining species.

(f) Clay products.--In the manufacture of porous clay bricks and tile, it is necessary to mix with the clay a substance that will be consumed during the burning and leave the finished product filled with fine cavities or pores. For this purpose either sawdust or finely chopped straw is used. To produce uniform results the sawdust should be dry and sifted. One fire brick of clay and sawdust is reduced in weight from 7 pounds to 2-3/4 pounds in burning. The character of the product can be controlled by varying amount and size of sawdust.

Hollow clay tile for partitions is made light and porous by adding 25 to 35 percent sawdust. In the burning process the sawdust burns out, and the resulting product is soft and porous. When certain clays are used the product can be nailed and cut with ease. A semi-porous tile is made by adding 20 percent sawdust. The use of sawdust in the manufacture of clay and gypsum products is probably decreasing, because of the rather general use of "bubbling" compounds for the purpose of expanding the mass to lighten its weight and increase porosity.

(g) Moulded articles.--Sawdust and shavings ground to the proper fineness are used in making doll heads, display novelties, insulators, jewelry cases, thermometer backs, tiles, furniture ornaments, etc. The wood particles are mixed with a suitable binder, placed in moulds of the desired forms and subjected to heavy pressure. The binders commonly used are ox blood, starch, glue, flour, and aluminum sulphate.

A new type of plastic, in which a high percentage by weight of the materials used is sawdust, has been developed by this Laboratory. Ordinary dry sawdust is hydrolyzed after which it is dried and ground to the fineness of wood flour. To this dried mass certain chemicals are added and the whole thoroughly mixed. The resulting stock is placed in heated moulds, and under pressure produces a satisfactory plastic. Sawdust plastics have great possibilities because they possess many desirable properties and can be produced at a relatively low cost.

Wood flour.--The name "wood flour" is applied to a number of different kinds of finely divided wood. Very fine grades of sawdust, such as those produced on sanding machines are often known as wood flour. Commercial wood flour, however, is produced chiefly by special equipment of which there are several types.

Wood flour is made chiefly from white pine shavings and sawdust. About 75 percent of the domestic product is of that species, and over 60 percent of the total volume is made from the wastes mentioned. The present requirements of industries using the bulk of wood flour production are for light colored, light weight, nonresinous, fluffy, highly absorptive stock. There are no mechanical difficulties involved in the production of wood flour from hardwoods, but the demand for such stock is limited.

The greatest annual domestic consumption of wood flour was about 65,000 tons in 1929, about 9,200 tons of which was imported, chiefly from northern Europe. Present consumption is probably less than 40,000 tons. The principal uses for wood flour are in the production of linoleum, dynamite, and plastics. Details of wood flour production and use can be had from a Laboratory publication entitled "Wood Flour" which is mailed, upon request, without cost.

Fur cleaning, dressing, and dyeing.--The dry raw furs are uniformly moistened before working by covering them with damp sawdust. They are afterwards cleaned by being tumbled in drums with dry sawdust which absorbs the grease and dirt. Often the sawdust is treated with a solvent that cuts the grease and assists in the cleaning process.

After the pelts have been tanned, they are again tumbled with sawdust, primarily to give the hair a light, fluffy appearance and to bring out the luster. The pelts are tumbled a third time with sawdust after dyeing to restore luster temporarily lessened in the dyeing process.

The chief requirements of a sawdust for furriers' use are that it be fine, clean, granular, and absorptive. The most commonly used sawdust for this purpose is kiln-dried hard maple stock of the finer counts. This use furnishes an outlet for large quantities of hard maple sawdust, chiefly the product of flooring plants. Box factory hard maple sawdust is highly desirable, since a larger proportion of the material is of a granular nature. Other hardwoods also furnish some sawdust for fur cleaning and dressing use.

Softwood sawdust is not well adapted for fur cleaning and dressing. It is more fibrous than hardwood and has objectionable pitch, resins, oils, etc., which interfere with the cleaning processes.

Cleaning, drying, and polishing metalware.--The plating industry uses considerable sawdust for drying and polishing its products after removal from the plating solution. For this purpose a coarse sifted sawdust (platers' stock) of about 8 mesh is used. Metals which have been cleaned in a pickling bath are also dried and polished by tumbling in sawdust; greasy pieces made on automatic machines, washed jewelry, etc., can be cleaned, dried, and polished by agitation in a tumbling barrel or otherwise. Heavy machinery is often cleaned of greases and oil by the use of sawdust. For these uses dry sawdust is, of course, essential. The kinds or types of sawdust are not so important, except that the material shall be highly absorptive.

For drying and polishing the more exacting items, especially parts for military equipment, only kiln-dried, acid-free sawdust of the finer grades (18 to 24 mesh) is employed. Wood having appreciable amounts of acid, such as oak, is reported to stain the polished surfaces. The chief species used for these exacting purposes is hard maple (kiln dried). Other non-acid hardwood sawdust, comparable in physical properties, would probably be satisfactory.

Aluminum ware is cleaned and polished by contact with sawdust after passing through a solvent solution. Much of this work is done by hand.

Packing.--This is one of the most common uses for sawdust and shavings. Practically any clean dry stock is suitable for packing use. Not only fragile articles, but many kinds of canned goods are packed and shipped in sawdust and shavings. The insulating properties of the material are of value in cold climates, preventing the freezing of liquids during transit, and the absorbing properties are of value when shipping liquids like ink, which might do a good deal of damage if the containers were to break. In the packing of miscellaneous lots of canned goods, sawdust is convenient, since all the irregular interstices are filled up and the cans prevented from bumping each other. Also sawdust absorbs moisture and prevents cans from rusting in transit or storage.

Shavings are extensively used for packing in between and around blocks of building stone in transit. Since this product is shipped mostly on open flat cars and is exposed to the weather, shavings that stain when wet should not be used.

Shipment of grapes and other fruits.--The shipment of grapes from California is now regularly made in sifted sawdust, and experiments with the shipment of other fruits have been successful. For this use, however, only coarse dust is employed, since the finer grades tend to pack and make the removal and cleaning of the fruit too difficult. Sawdust for fruit packing should be granular, and of kinds imparting no odor or taste to the product. A light colored sawdust is also highly desirable from the packer's standpoint. The principal sawdust now used for grape packing is spruce. Other species used to some extent are redwood, white fir, and Douglas-fir. About 4,000 tons of sawdust are consumed annually by the grape packers.

Leather working.--A considerable quantity of sawdust is used at tanneries in operations where it is necessary to moisten the hides for stretching. Moistening by means of wet sawdust is satisfactory, since the moisture is evenly distributed over the surface and the stretching is done with a minimum of loss from tearing.

The requirements of a sawdust for tanning use are exacting. The species of wood and the degree of fineness demanded by tanners are quite variable, but there is quite general agreement that the sawdust must be free from splinters, foreign matter, grease, and of kinds that will not impart color to the leather. Considerable quantities of sawdust are also used as absorbents in and about tanneries, and in smaller amounts for other purposes.

Wallboard.--A wallboard made entirely of pressed sawdust held together by a suitable binder and lined on both sides with paper is reported. A number of patented wallboards contain sawdust. Over 5,000 tons of sawdust and shavings are reported as used for wallboard and plasterboard annually in southern California. Screened sawdust of 6 mesh is commonly used for that purpose.

Heat insulation.--Dry sawdust and shavings are good insulating materials, approaching in efficiency that of the common commercial fill type of insulating products. When used as bulk insulation in frame construction, dry sawdust and shavings are at least as efficient as commercial board and blanket types. They are extensively used in ice house construction, for insulating refrigerator cars, storage houses, etc. Sawdust and shavings were commonly employed for insulating low cost dwellings in former years in localities where sawdust was plentiful.

When properly packed between studs and joists, sawdust and shavings do not add to the fire risk. In well-constructed buildings vermin cannot readily gain entrance to the insulating materials. If desired, however, sawdust and shavings can be readily protected against fire and insects by the use of low-priced chemicals. A Laboratory report on the treatment of sawdust against decay, insects, animals, and fire can be had upon request.

Condensation may develop in insulated walls during cold weather and the more efficient the insulation the greater is the possibility of condensation. Some form of moisture barrier should be used to prevent vapor from gaining entrance into the wall from the interior. A simple moisture barrier is attained by lining the inside of the studs of outside walls and the ceiling joists below the attic with a vaporproof liner. The walls are then lathed and plastered in the usual manner. A glossy-surfaced, asphalt-impregnated, and surface-coated sheathing paper also affords a satisfactory vaporproof liner.

Sawdust and shavings are used for many other heat insulating purposes. They must be dry and packed with care into the spaces provided. The tendency of sawdust and shavings to bridge over gaps and pack unevenly must be guarded against. The use of these materials for insulating hot and cold water pipes is common. They are also used for insulating steam pipes, but the feasibility of such use is questioned because of the fire risk involved.

Floor sweeping compounds.--The manufacture of floor sweeping compounds is a well established industry, and there are a number of companies regularly engaged in it. In most of these compounds, sawdust, sand, and oil are used in varying proportions, depending upon the particular use to which the compound is to be put. If it is to be used upon highly polished floors, the sand may be left out entirely, since it may scratch the surface. It is probable that the most common sweeping compound is the home-made variety, which consists of ordinary damp sawdust. The Laboratory has prepared an article on sweeping compounds which will be mailed free, upon request.

Soaps.--There are on the market today, hand soaps especially recommended for mechanics' use, in which sawdust is an important ingredient. The sawdust is usually hardwood of a very fine grade, probably about 36 mesh. It serves as a gentle abrasive, carrying the soap into the folds and creases of the skin. Similar use is frequently made of sawdust by employees in factories where it is available, the dust being mixed with oil or soap to remove grease from the hands.

Soil conditioner.--Natural sawdust and shavings have little fertilizing value. However, when mixed with heavy soils, they open up the ground and put it in better physical condition, resulting in increased crop production. Sawdust in a partly charred state is sometimes used alone, or mixed with wood ashes, as a fertilizer. Carbonized sawdust is mixed with liquid manure and the mass left a few weeks to improve its fertilizing value. The importance of sawdust in fertilizing operations lies chiefly in the properties of the wood to absorb fertilizing materials and in opening up the soil, and not in anything possessed by the wood itself.

Sawdust is sometimes used in making an artificial fertilizer. Dry sifted sawdust is moistened with hydrochloric or sulphuric acid and heated to 130°. The material is applied as is, or mixed with blood and heated to 140° and used in this form.

Compost heaps and hot beds are occasionally made with sawdust taking the place of tanbark, leaves, or other vegetable material. Sawdust is also used in small quantities in plant propagation.

Grasshopper "bait".--Sawdust has been employed successfully as a carrier for arsenic and other poisons used in combating grasshopper plagues. The sawdust used so far has been softwood species which has been left in the pile for two years or more to leach out the resinous material. Cottonwood sawdust has also been used.

Nursery practice.--Sawdust and shavings are used in many operations in the production of nursery stock and live plants. The most common uses are for packing around balled trees and shrubs, and about the roots of balled trees, for "heeling in" use, and in packing small stock and live plants. The most common form of sawdust for packing around nursery stock is long stringy shingle tow.

Lime burning.--Lime produced by mixing shavings with the limestone in burning is said to be of high quality. Horse manure added to the shavings retards the burning and improves the quality of the product. Lime burned in this way is said to be entirely free from glazed or shiny surfaces.

Protection of fresh concrete.--Reports from dealers in sawdust indicate that the use of sawdust for this purpose is becoming popular. The sawdust is spread in a layer three or four inches deep over the fresh concrete, and thoroughly wet down. It thus forms a protection and at the same time provides some of the moisture which is needed for the proper setting of the cement.

Gas purification.--Purification boxes filled with a mixture of iron oxide and shavings are used in coal gas plants and producer-gas plants for removing the sulphur from the gas. The volume of shavings used for this purpose is probably decreasing due to the development of other materials for absorbing impurities, in which sawdust is not used.

Hardening and annealing of metals.--This use is limited, since other materials have been found that have certain advantages over sawdust. Charred sawdust can, however, be used in the common casehardening process, and steel can be annealed by heating to a red heat and then burying in sawdust in an iron box. The sawdust acts as an insulator, and prevents too rapid cooling of the steel. The use of sawdust to determine the proper temperature of material in welding is reported.

Poultry picking.--After the main wing and tail feathers are removed and the carcass semi-scalded cover poultry with fine, dry sawdust. Three or four minutes in the sawdust absorbs most of the water, and picking is easier. Makes removal of pin feathers easier and more complete. Does not interfere with wax picking and does not injure skin.

Wallpaper.--Sawdust is added to the furnish in the production of oatmeal wall papers, and produces the distinctive surface of this kind of paper. In velvet or raised wallpapers, sifted and colored sawdust is sprinkled over the properly sized surface of the paper to produce the desired effect.

Stuffing pin cushions and dolls.--Fine, dry sawdust is used in considerable amounts for doll and toy animal stuffing.

Fireworks.--Sawdust and wood flour are used in various kinds of fireworks intended to burn for a time rather than to explode. The sawdust is mixed with the color-producing and inflammable matter in a manner similar to that employed in making signal rockets.

Moth repellent.--Eastern redcedar sawdust is used to some extent for this purpose.

Kennel bedding.--Eastern redcedar sawdust and shavings are used for bedding in dog kennels. It is said to be an excellent flea and other insect repellent.

Fire extinguisher.--Sawdust is effective as an extinguisher of oil, gas, and lacquer fires. The sawdust remains on the surface of the liquid and smothers the fire. It is probably more effective if mixed with soda. For this purpose sawdust will probably always be of minor importance only.

Filtering oil.--Lubricating oil with sludge is passed through a sawdust filter to remove impurities.

Waterproofing mixtures.--Sawdust mixed with asphalt is said to be used in Europe for the damp-proofing of basement walls.

C. Chemical Uses.

Meat smoking.--Meats that have been pickled or cured, such as ham and bacon, fish, and sausage are smoked to give flavor and to increase the keeping qualities. Usually a smouldering fire of hardwood blocks and sawdust is built, and the meat hung in the smoke for a certain length of time. In the slow method, the time is 4 or 5 days, and the temperature about 75° F., whereas in the quick method the time is cut to about a day by increasing the temperature. Several authorities claim that green hickory sawdust is the best for smoking meats, but reports from sawdust dealers indicate that maple, oak, and walnut sawdust are in demand. Mahogany sawdust is also used for this purpose. Large quantities of sawdust are used at packing plants for smoking meats, and at numerous small establishments to which it is delivered by dealers in relatively small amounts.

Distillation.--Many experiments have been conducted in an effort to find a feasible method for the destructive distillation of hardwood sawdust, but up to the present time, there are no plants operating commercially.

Plants have been erected in at least two places in the state of Washington for the destructive distillation of sawdust and other softwood mill waste. The principal product of these plants is charcoal. It is reported that charcoal briquettes made with a binder of other products of distillation can be sold on the West Coast in competition with coal. As a general proposition, however, the distillation of softwood mill waste is not feasible, because of the relatively low yields of the more valuable products.

It is possible to obtain illuminating gas of high calorific value from the distillation of wood waste and sawdust under high temperatures. Plants have been erected in the Pacific Northwest to produce gas in this way. At least one plant has suspended operations, but it is reported that this was due to no fault in the process. A plant for producing gas from wood waste is similar to the ordinary coal gas plant, and wood is distilled in ordinary gas retorts. The resulting charcoal can be used directly under the ovens, or can be burned in a water gas plant, the gas from which can be turned directly into the mains.

Extraction.--The extraction of turpentine from sawdust of resinous woods by means of steam has been carried out experimentally, and at least one plant is operating profitably on a commercial basis. The cost of the process, however, is generally considered too great for financial success. Several of the cedars and junipers contain oils of sufficient value to warrant the extraction of the sawdust, and this is now carried out in several plants throughout the country.

Carborundum and calcium carbide.--It is possible to make both of these products from charred sawdust in an electric furnace, and this method is mentioned as having commercial possibilities. It is understood that present practice calls for a mixture of coal dust and sawdust, the latter serving to lighten the former.

Large quantities of wet sawdust are used in the manufacture of abrasives. Any species of sawdust can be used for the purpose. Sawdust is mixed with the coke, salt, and sand, to provide outlets for escaping gases during the fusing process. The sawdust does not enter into the make-up of the finished product, being simply an accessory in manufacturing.

Dye production.--Sawdust of certain species contains dyes that can be extracted. Of the North American woods, osage-orange and sumac probably yield the highest percentage of coloring matter.

Tanning extracts.--The sawdust from such woods as chestnut yields an extract that is used in the tanning of leather.

The following publications dealing with various phases of wood waste utilization were prepared by and are available without cost upon request from the Forest Products Laboratory, Madison 5, Wisconsin:

Report No. R466, Production of Charcoal in the Ordinary Pit Kiln;
June 1932.

Report No. R565, Wood Flour. Revised June 1945.

Report No. R842, Briquetting of Wood Waste. Revised May 1945.

Report No. R944, The Use of Sawdust and Shavings. April 1942.

Report No. R945, Chemical Utilization of Wood Waste. 1931.

Report No. R1440, Wartime Model Hopper Unit for Burning Various
Forms of Wood in Standard Domestic Furnaces.
December 1943.

Report No. R1450, Wartime Status of Sawdust, Shavings, and Other
Wood Waste as Commercial Raw Materials. July 1944.