A Study of Wood and Bark Residue Disposal in the Forest Products Industries

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A Preliminary Report
to the
Fifty-fifth Legislative Assembly

February 1969

Oregon State Board of Higher Education
Oregon State University
Forest Research Laboratory
Corvallis, Oregon 97331

SUMMARY

This is a preliminary report of a two-year study that was authorized by the Fifty-fourth Legislative Assembly in 1967. The study was aimed at providing means of lessening air pollution from disposal of wood and bark residues by forest products industries. The final report summarizing conclusions of the study will be published in August 1969. Included in the study are a statewide survey of wood and bark residues; a transportation cost study; an investigation of three methods for disposing of residues, 1, burning in a wigwam burner, 2, burning in other types of incinerators, 3, disposal by landfill; and an investigation of three means of utilization: 1, as fuel, 2, on the soil, and 3, wax extraction from bark.

In Oregon, use of wood residues for paper and composition board manufacture has increased greatly in the last 14 years. Only 6 percent of wood residues from sawmills and plywood plants was used for paper and composition board in 1953, compared to about 60 percent in 1967. Quantity of residues being burned in wigwam burners has been consequently reduced in recent years. Utilization will continue to increase in the future and quantities of wood and bark requiring disposal will decrease.

> Preliminary investigations indicate that modified wigwam burners may operate within existing air-pollution regulations on some fuels. Tests will be made to evaluate effectiveness of certain modifications and operating procedures; results will be included in the final report.

> Wood and bark wastes could be burned with improved combustion in refractory-lined incinerators, but costs would be higher than for a wigwam burner. An analysis of costs for burning wastes in certain other incinerators now being made will be included in the final report.

> The sanitary landfill, a common method of disposal of municipal refuse, might also be satisfactory for wood and bark wastes, but costs would be higher than burning in wigwam burners. Cost factors will be presented in the final report.

> To decrease quantities of wood and bark residues requiring disposal, three means of utilization are being studied. These residues are economical for fuel under certain conditions. Their use as a mulch or ground cover is expanding. An economic re-evaluation indicates that producing wax from Douglas-fir bark can be profitable.

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THE COVER PICTURE shows two burners at Olson-Lawyer Lumber Co., Inc., White City, Oregon. One has been converted to a storage bin for shavings before they are hauled by truck to a particle board plant; the other in the background is operating with only a trace of smoke visible. The photograph is by courtesy of Curtis Nesheim, District Forester, State Forestry Department.

ACKNOWLEDGMENTS

In addition to an appropriation from the State's General Fund and aid from the Forest Products Harvest Tax, this study was supported by a grant from the Public Health Service, U. S. Department of Health, Education, and Welfare.

State and regional air-pollution-control agencies provided valuable information and advice during the planning and conduct of the study.

Many persons and companies in forest products industries extended wholehearted cooperation and assistance. This industry cooperation contributed greatly to many parts of this study.

There also were organizations, companies, and many individuals from other than forest products industries who provided useful information and valuable assistance. This help is gratefully appreciated.

Assistance and published information of Richard W. Boubel, Professor of Mechanical Engineering, Oregon State University, was especially useful.

The following persons at the Forest Research Laboratory, Oregon State University, worked directly on this study:

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Consultants engaged in the study were:

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Engineers and Planners

John W. Anderson, Chemical Engineer

Garretson, Elmendorf, Klein and Reibin
Architects and Engineers

February 1, 1969

The Fifty-fifth Legislative Assembly
State Capitol
Salem, Oregon

Gentlemen:

In accordance with House Bill 1376, now cited as Chapter 377 Oregon Laws 1967, I am pleased to transmit to you the Preliminary Report entitled, "A Study of Wood and Bark Residue Disposal in the Forest Products Industries."

House Bill 1376 referred to a research program on air and water pollution as it relates to the forest products industries of this state, with particular attention to the prevention of such pollution by means that are consistent with the continued growth and development of such industry. This is an extremely broad charge. Hearings were held in the House Committee on Natural Resources, Senate Committee on Air and Water Quality Control, Joint Ways and Means Committee, and its Subcommittee on Natural Resources. Testimony brought out that research to be conducted between July 1, 1967 and June 30, 1969 was to be directed toward development of acceptable disposal methods for wood and bark wastes at the mill site. The budget approved by the Joint Ways and Means Committee was based on such a program.

The Preliminary Report deals with disposal of wood processing plant residues in wigwam burners, other types of incinerators, and landfills; and with utilization as fuel, soil mulches, and some chemical extractives.

A final report is also required. This will be submitted by August 31, 1969 to the Governor, to the members of the Fifty-fifth Legislative Assembly, to the Sanitary Authority of the State of Oregon, and to representative groups and members of the forest products industry.

The study conducted by the Forest Research Laboratory brings out in the Preliminary Report that disposal alternatives for wood and bark wastes show promise in meeting existing air pollution control regulations, if adequate disposal facilities are available and are properly maintained and operated. The final report should further substantiate these findings and will provide recommendations for their implementation.

Sincerely,

R. E. Lieuallen
Chancellor

REL:sk

AN ACT

[HB 1376]

Relating to a study of air and water pollution; creating new provisions; and amending ORS 526.215.

Be It Enacted by the People of the State of Oregon:

Section 1. The State Board of Higher Education, through the Forest Research Laboratory at Oregon State University and in collaboration with advisory committees appointed under ORS 526.225, shall cause to be conducted a research program on air and water pollution as it relates to the forest products industries of this state, with particular attention to the prevention of such pollution by means that are consistent with the continued growth and development of such industry.

Section 2. The State Board of Higher Education may:

(1) Purchase necessary equipment, materials and supplies for the Forest Research Laboratory.

(2) Receive moneys from any source and expend the same in accordance with sections 1 to 3 of this Act.

(3) Enter into agreements with state or local agencies and private groups or institutions to assist in carrying out sections 1 to 3 of this Act, and to make reimbursement therefor.

Section 3. The State Board of Higher Education shall cause a preliminary report of the study conducted under sections 1 to 3 of this Act to be submitted to the Fifty-fifth Legislative Assembly by February 1, 1969, and a final report by August 31, 1969, to the Governor, to the members of the Fifty-fifth Legislative Assembly, to the Sanitary Authority of the State of Oregon and to representative groups and members of the forest products industry, the final report to contain all the findings and recommendations of the board.

Section 4. (1) Notwithstanding any other provision of law, for the fiscal years beginning July 1, 1967, and July 1, 1968, the rate of the tax levied by subsection (1) of ORS 321.015 shall be one-half cent higher than the rate that otherwise would be in effect under subsection (1) of ORS 321.025 and subsection (3) of ORS 321.035. The revenue raised by this additional levy shall be used exclusively for the purposes of sections 1 to 3 of this Act, and shall not be considered in any computations under subsection (3) of ORS 321.035.

(2) Not later than August 31, 1969, the State Board of Higher Education shall certify to the Secretary of State the amount of unexpended and unobligated moneys remaining in the Forest Research and Experiment Account that are attributable to the additional levy under subsection (1) of this section, and thereupon such remaining moneys shall revert to the Forest Research and Experiment Account for expenditure pursuant to law.

Section 5. Sections 1 to 4 of this Act expire and stand repealed on September 1, 1969.

Section 6. ORS 526.215 is amended to read:

526.215. To aid in the economic development of the State of Oregon, the State Board of Higher Education shall institute and carry on research and experimentation to develop the maximum yield from the forest lands of Oregon ~~[and]~~, to obtain the fullest utilization of the forest resource, *and to study air and water pollution as it relates to the forest products industries.*

Approved by the Governor June 12, 1967.
Filed in the office of Secretary of State June 12, 1967.

A STUDY OF WOOD AND BARK RESIDUE DISPOSAL IN THE FOREST PRODUCTS INDUSTRIES.

Oregon's forests supply raw material to forest industries that employ about half of the state's manufacturing employees. Oregon leads the nation in the production of lumber, plywood, and particleboard, and produces much pulp and paper as well.

In the manufacture of forest products such as lumber and plywood, not all of the log entering the mill can be converted to the primary product. At a sawmill, less than half of a log is converted to lumber. The residual parts of the log appear as slabs, edgings, trim, sawdust, shavings, and bark. The inevitable development of these residues presents disposal problems for mills.

Much of the mill residue formerly disposed of by burning is now extensively used as raw material for pulp, paper, particleboard, and hardboard. Efforts toward utilization, however, have not been successful in developing economically practical uses for all residues. Many mills, therefore, still dispose of unmarketable residues by burning in wigwam burners. The wigwam burner is a simple incinerator that often causes air pollution through smoke and particulate emission.

The Fifty-fourth Oregon Legislative Assembly took steps in 1967 to find solutions to the problem of pollution by passing House Bill 1376, which directed the State Board of Higher Education to establish, through the Forest Research Laboratory at Oregon State University, a study of air and water pollution as they relate to the forest products industries. The Bill further stipulated that particular attention be directed to the prevention of such pollution by means that are consistent with the continued growth and development of such industry. Although the enabling legislation was broad, related legislative Committee meetings clearly indicated that first priority should be given to study of air pollution caused by residue disposal in the forest industries.

Objective

The objective of this study is to investigate means by which air pollution from disposal of wood and bark waste at forest industries can be minimized.

Financing

Funds for the study were provided for in House Bill 1376 by increasing by one-half cent a thousand board feet the privilege tax on harvest of Class A timber during fiscal years 1968 and 1969. Funds from the additional tax are expected to provide about $80,000. An appropriation of $70,000 from the General Fund also was made available for the same period.

Additional financing of $50,000 was from a grant made through the Solid Wastes Program of the U.S. Public Health Service. PHS financing was for a one-year period from February 1, 1969, to January 31, 1969.

Approach to the Problem

How bad is the wigwam burner in causing air pollution? Can it be improved? How many burners are there in Oregon? What are the quantities, kinds, and moisture contents of residues going into wigwam burners? If burners are not acceptable, how can residues be disposed of? Can utilization be stepped up to significantly reduce residues requiring disposal?

To get answers to these important questions, an approach was devised to evaluate the most promising possibilities for utilization or disposal of wood and bark residues. These possibilities were determined by project personnel in consultation with industry, other researchers, and public officials.

An early step in the study was to conduct a statewide survey of residues to identify types and quantities of material burned, trends in utilization, and number of burners, and to predict future quantities of residues that would require disposal.

An obvious way to reduce air pollution from wigwam burners is to reduce the amount of material going into the burners. This reduction can be accomplished through increased utilization, which is a desirable solution. However, most utilization solutions require time to prove out, and the problem of air pollution from wigwam burners needs an immediate solution. Moreover, even though increased utilization may significantly reduce air pollution, it is likely that there always will be quantities of waste that must be disposed of by unprofitable means. In this study, therefore, it was concluded that there was merit in investigating the most promising methods of both utilization and disposal. By this double approach, if research yielded positive solutions, the forest products firms faced with problems of air pollution and residue disposal would have a choice of evaluating needs either in terms of utilization alternatives with, hopefully, some economic returns, or in terms of disposal alternatives with no possibility of return on investment. The dual approach seemed most prudent because a single solution is not likely to fit all situations where air pollution exists. On the contrary, it is likely that a combination of utilization and disposal means may provide a solution in many instances.

One might identify the multi-pronged approach to the solution of this problem as "burn it, bury it, or use it." Disposal alternatives under study in this project are:

1. Improved incineration in wigwam burners,
2. Incineration in other types of incinerators, and
3. Disposal in landfills.

Utilization possibilities being evaluated are:

1. Expanded use of residues as fuel for heat and power,
2. Increased use of wood and bark on the soil for amendments, mulch, or for landscaping, and

3. Extraction of wax and certain chemicals from Douglas fir bark.

Progress in study of each of the above alternatives is discussed in detail in six subsequent sections of this report. These reports of progress are supported by a series of ten reports prepared for submission to the Public Health Service in October 1968. The ten reports are indexed in a bibliography of references appended to this report. The reports are not available for general distribution because a limited quantity was printed and information contained therein soon will be presented in a final report to the Governor, the Fifty-fifth Oregon Legislative Assembly, the State Sanitary Authority, and the forest industry in August 1969.

Two final sections of this report summarize future plans and present overall conclusions based on work to date.

WIGWAM BURNERS

The wigwam burner is used extensively in the Oregon forest products industry. Three hundred and seventy-six burners were inventoried. These represented most of the burners within the state. The large inventory of these devices and the large investment led to the conclusion that a candid appraisal should be made of the wigwam burner.

The purpose of this phase of the study is to determine if wigwam burners, in their present or modified forms, can be made to consume wood waste in compliance with air-pollution regulations. If the conclusion is that wigwam burners can be modified to meet regulations, a further objective is to evaluate and recommend modifications and operating procedures.

Approach to Study of Wigwam Burners

Eight different means of approach were included in this phase of the study:

1. Inventory burners in Oregon. Note size and general characteristics, overall condition, and methods of operation; and observe quantity, type, species, and moisture content of wood and bark waste burned.
2. Observe and single out for further observation those burners that functioned best. Try to identify any common characteristics of construction or operation of the best burners.
3. Study grate systems, underfire and overfire air systems, controls, burner shapes, vents, and methods of feeding.
4. Consult with burner manufacturers.
5. Observe tests and trials of existing burners.
6. Consult with air-pollution-control officials and other researchers.

7. Engage consultants to investigate specific questions and make recommendations.

8. Study existing literature pertinent to the problem.

Information compiled was to be weighed and evaluated to determine whether the wigwam burner could be improved. If the conclusion was that they might be modified and operated in conformance with air-pollution regulations, the next step would be to devise a course of research and testing that would result in recommendations for modification and operation.

Accomplishments

A total of 376 operating burners have been inventoried in Oregon. Figure 1 is a graph of the distribution of burners by size. From this graph, one can see that the 50-foot (base diameter) burner with 118 installations occurs most frequently and that 71 percent of the burners are between 40 and 60 feet in diameter.

Most of the burners in use today are of the familiar cone-shape and are not refractory lined. Years ago, cylindrical, refractory-lined burners were used at many sawmills (Figure 2). For lack of recorded tests, there is no present evidence to indicate that these burners were more efficient than the present wigwam burners.

Many companies keep burners in good condition, but, nevertheless, a large number of burners were observed to be in disrepair. Moreover, a wide divergence of operating conditions was observed. Burners were operated under widely varying conditions, which include doors open, doors closed, doors off, vents open, vents closed, underfire air, no underfire air, and many others.

The most common fuel disposed of in burners is bark (Figure 3), because much bark-free wood now goes into manufacture of paper,

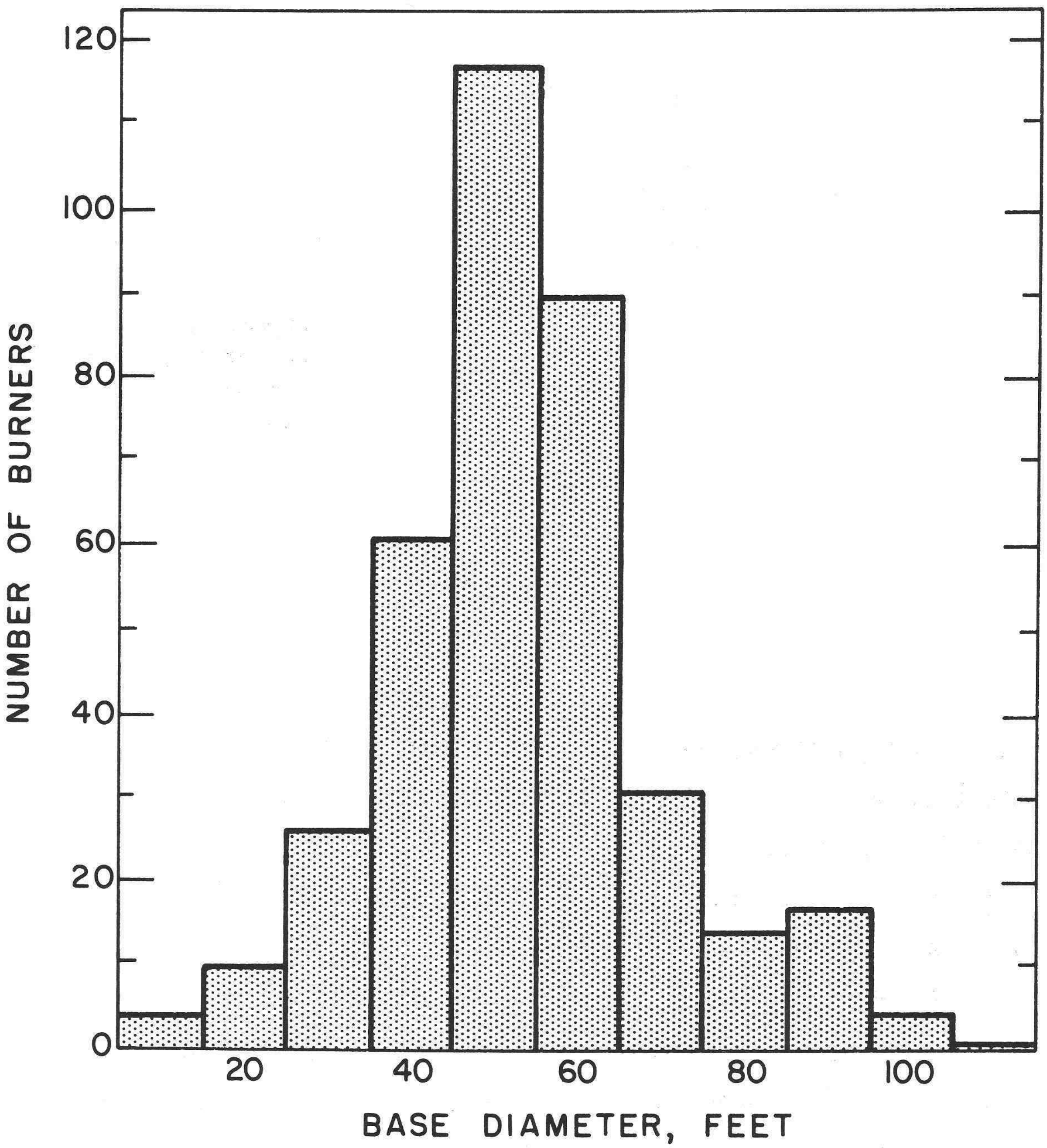


Figure 1. Distribution by size of 376 burners in Oregon in 1968.

hardboard, softboard, or particleboard. Recently, buyers have been purchasing chips in Oregon, Washington, and California for export to Japan. Planer shavings have found wide use in the past few years as a raw material for particleboard. Use of sawdust in pulp is increasing, but an appreciable quantity of sawdust still is disposed of by burning. Miscellaneous other fuels disposed of in wigwam burners include sander

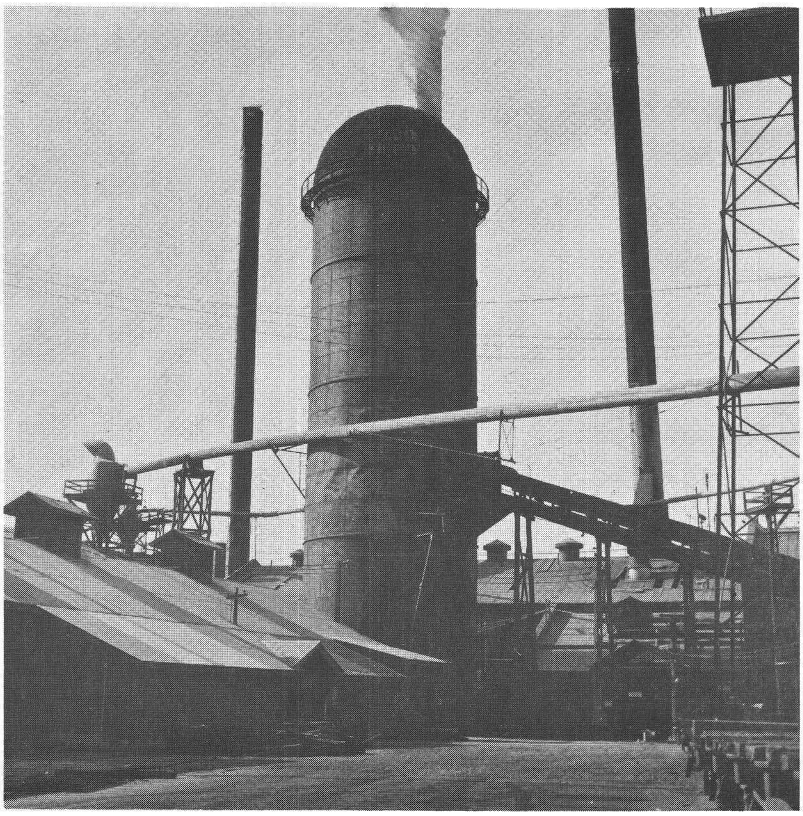


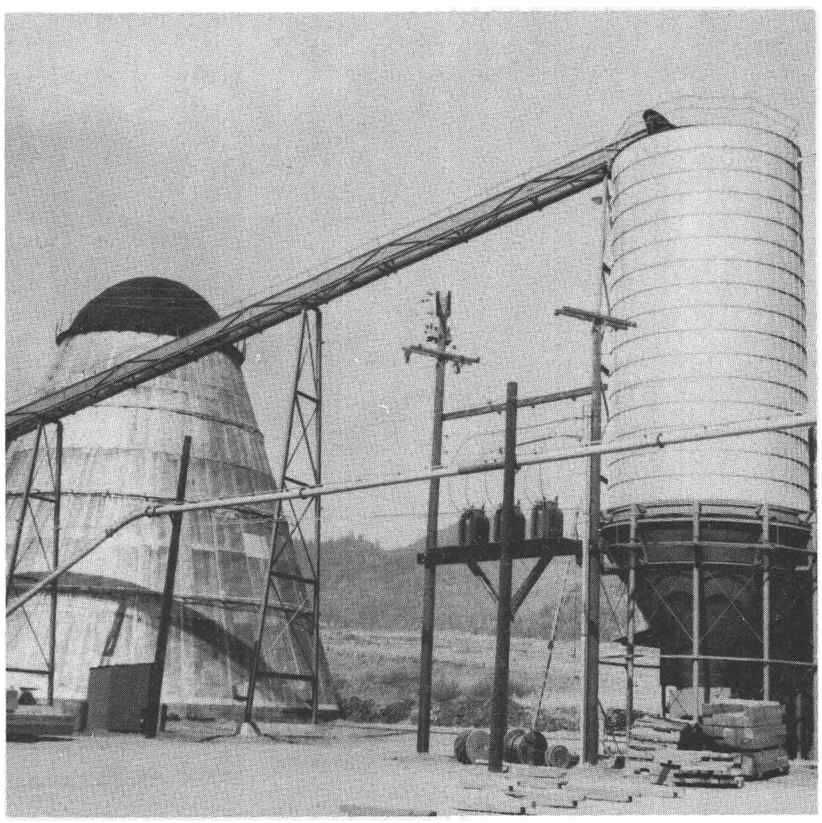
Figure 2. Cylindrical refractory-lined burner for sawmill waste.

dust and dry plywood trim (10 percent moisture or less), veneer trim, and in some instances, slabs and edgings. Species burned may range from the wet species with moisture content of the fuel about 185 percent of the dry weight, such as sugar pine, to relatively dry Douglas fir with moisture content about 80 percent.

A search was made for burners that operated cleanly, because these might provide the basis for most effective modifications. Some "good" burners were found. These burned with little visible smoke and fallout most of the time. Four of these burners are shown in Figures 4 through 7. Notation was made of characteristics common to all that would contribute to good combustion. All "good" burners were well maintained and concerted efforts had been made to adjust air supply for optimum combustion. Beyond this, the burners were not necessarily identical. Moreover, other similar appearing burners were observed that also were in good repair, yet smoked excessively.

Figure 3. The most common fuel in burners is bark.

Figure 4. A burner in operation on Douglas fir bark and sawdust.



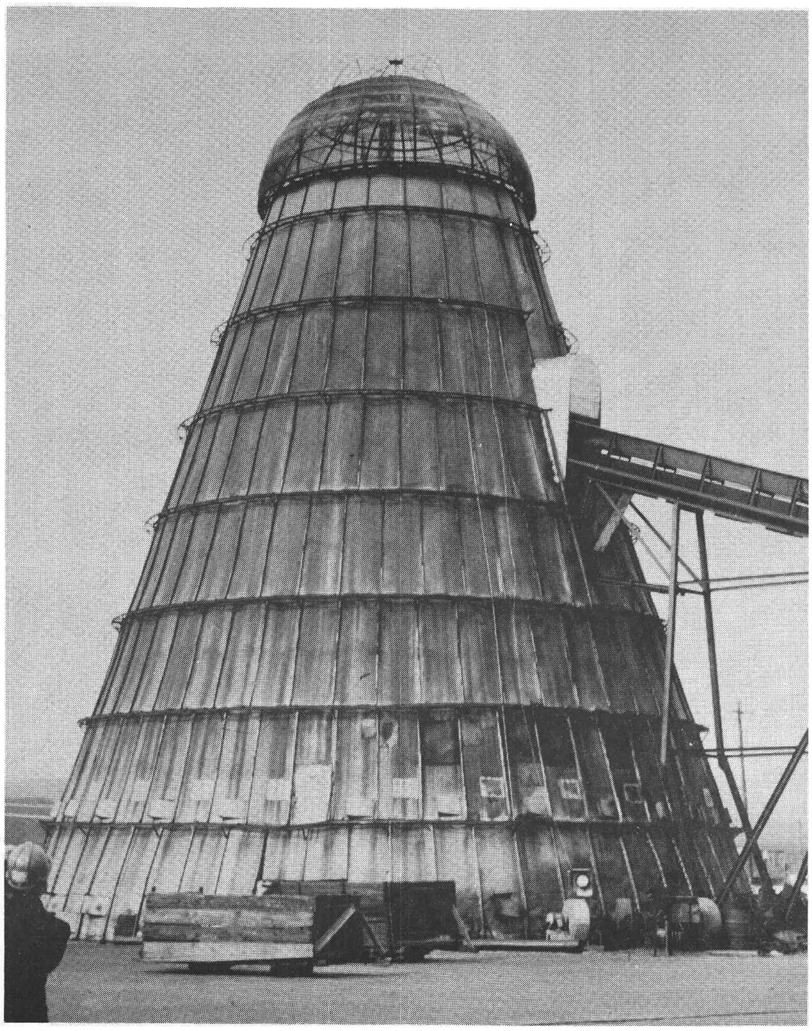


Figure 5. A high-capacity burner that operates on Douglas fir, white fir, and ponderosa pine.

Burner modifications studied

Wigwam burners are variable in construction. The various modifications in use were studied to gain insight that would guide researchers in improvement of burners.

Although most all burners were generally conical, different side-slopes were used. Effect of slope of side on combustion is not known.

Grate systems were studied, some of which were elaborate (Figure 8), and embodied a pit beneath the grates. Others were simple and ash was removed by front-end loader when the fire was out.

Underfire air systems varied from no underfire air to an elaborate ring of piping that supplied a combination of underfire and overfire air (Figure 9).

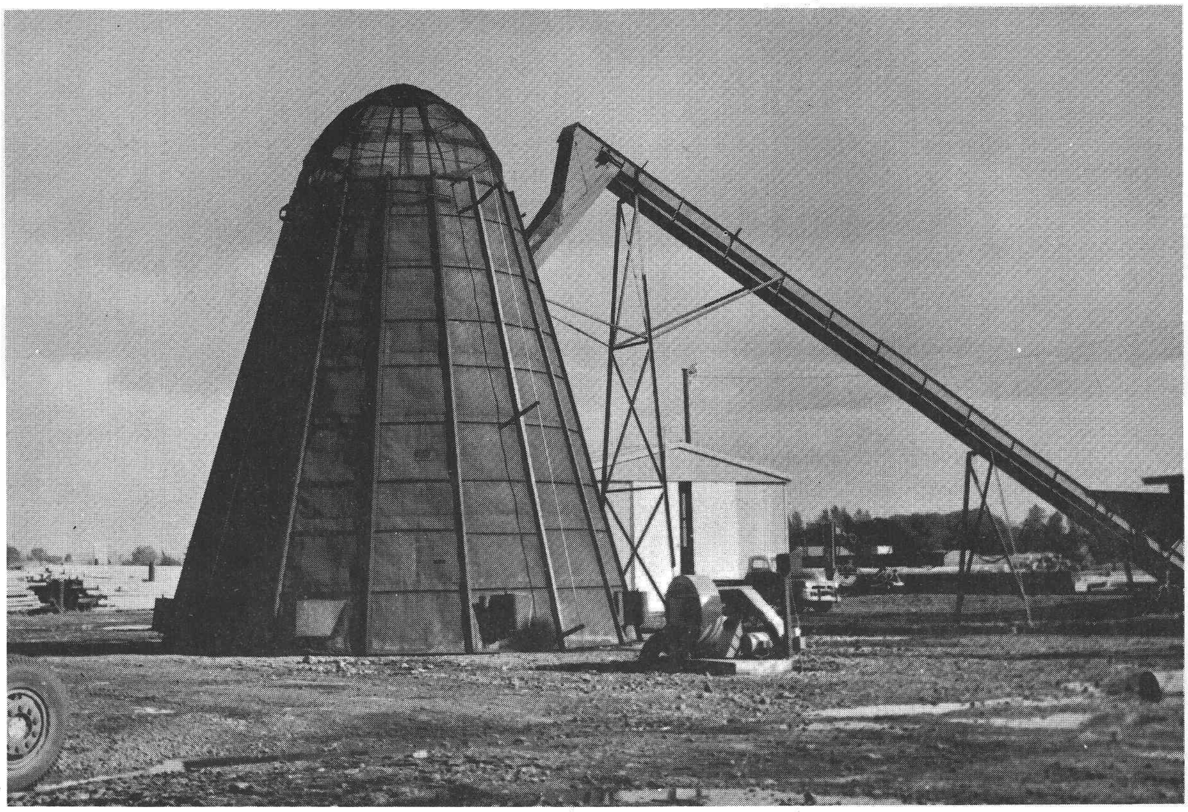


Figure 6. A burner operating on Douglas fir bark.

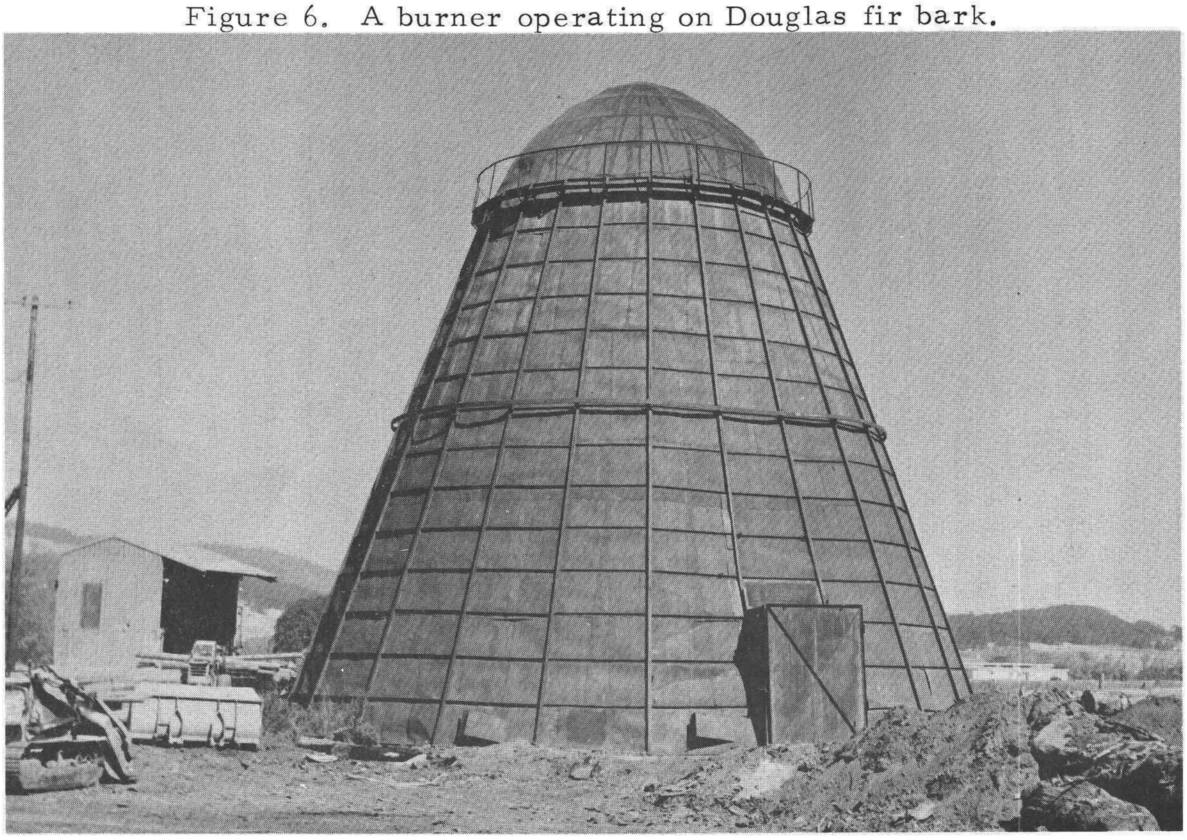


Figure 7. A burner operating on western hemlock and white fir bark.

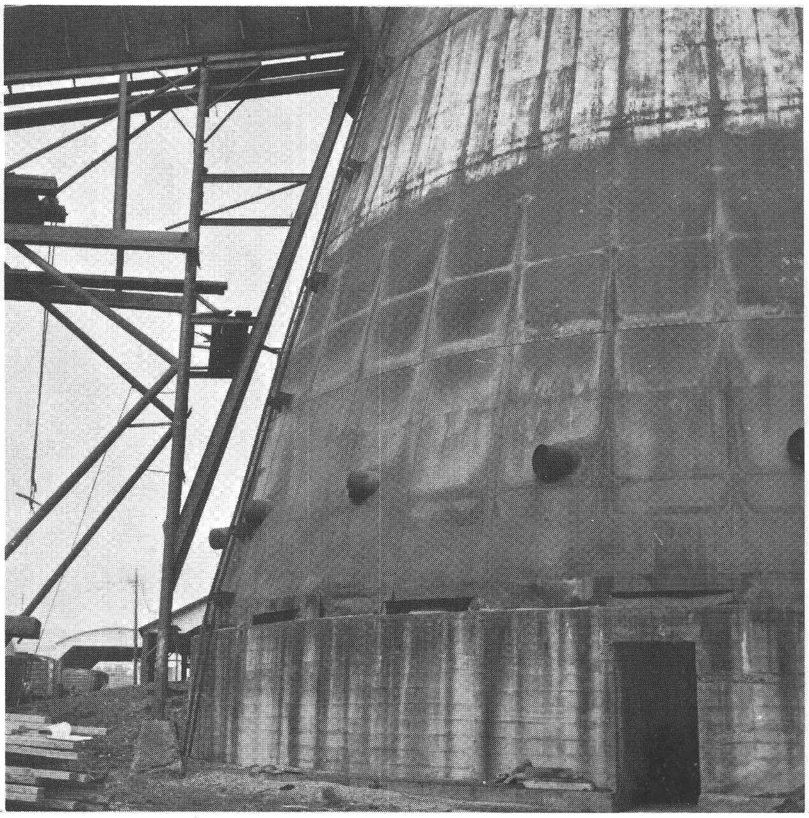
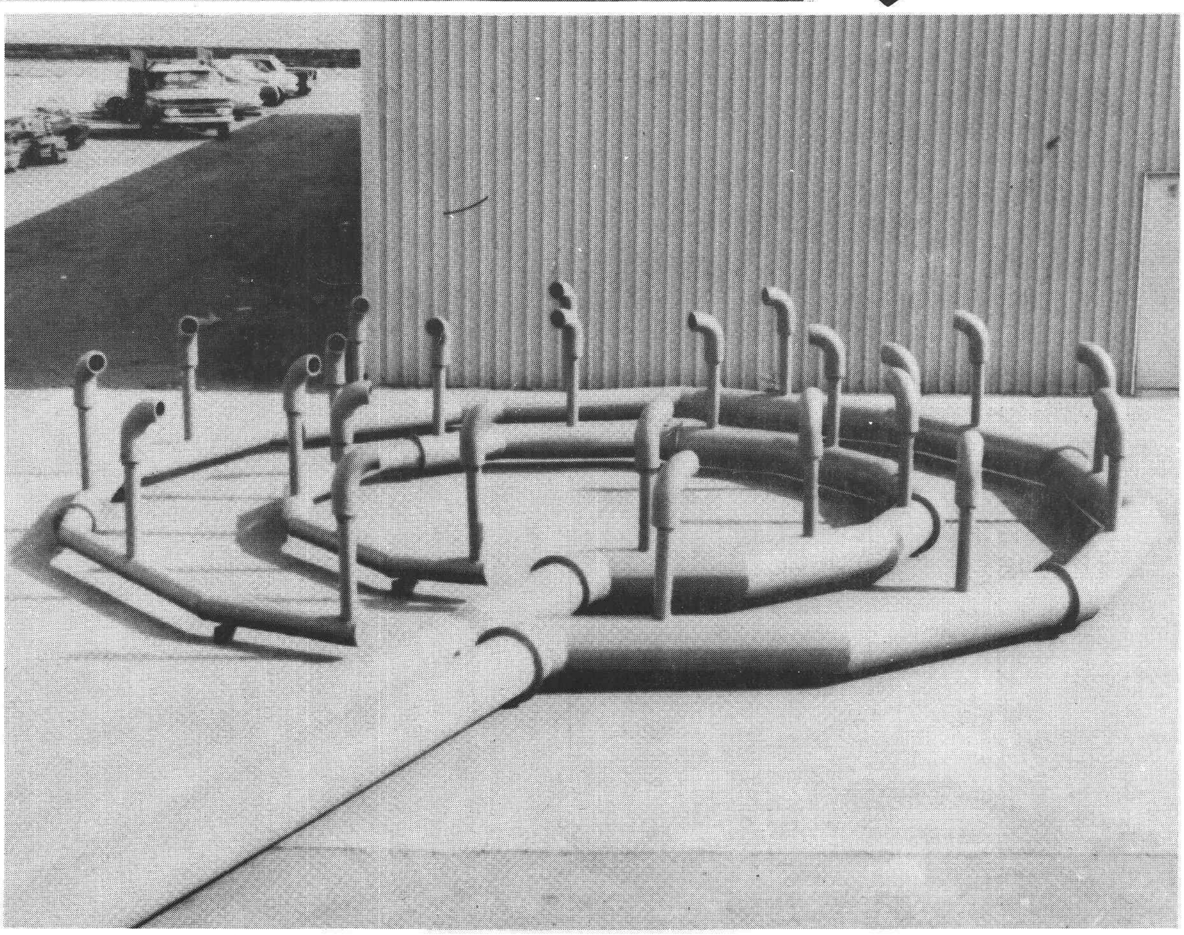


Figure 8. Burner with pit beneath grates.

Figure 9. A piping system for supplying air to burners.



Overfire air systems ranged from natural draft vents (Figure 10) to forced draft overfire fans (Figure 11).

Feed systems also were variable. Figure 12 shows a more or less conventional conveyor method of feeding. Conveyors were high entry and low entry. Some were tightly closed at entry, and other entered through large openings. Fuel also was dropped from cyclones (also shown in Figure 12) and blown in through pipes.

Instruments and controls on burners were not used widely. Many burners had temperature indicators (Figure 13) that can be used as a guide in making manual adjustments to air flow. Only one burner was observed that had automatic controls to regulate air with respect to temperature of the fire (Figures 14 and 15).

A possibility for decreasing air pollution is to install gas-cleaning devices on burners. Several burners with gas cleaners were located. The burner in Figure 16 has a washer with a water spray to remove particles from the gas. Figure 17 is another washer of the same manufacture on a new burner. A different configuration of gas scrubber was used on a wigwam burner in an urban renewal project. This burner is no longer in existence (Figure 18). Finally, a manufacturer has developed the scrubber shown on an experimental burner in Figure 19.

Tests and trials by others

To see what solutions or partial solutions others had found for problems with the wigwam burner, results of other research efforts were studied.

The most research and testing of wigwam burners have been reported by Boubel and co-workers (4, 5, 3, 18) at Oregon State University. They have determined operating characteristics and emissions from many burners in the state. A 15-foot-diameter experimental burner was built and tested by them. From their many tests and studies, they have made recommendations for best operating conditions

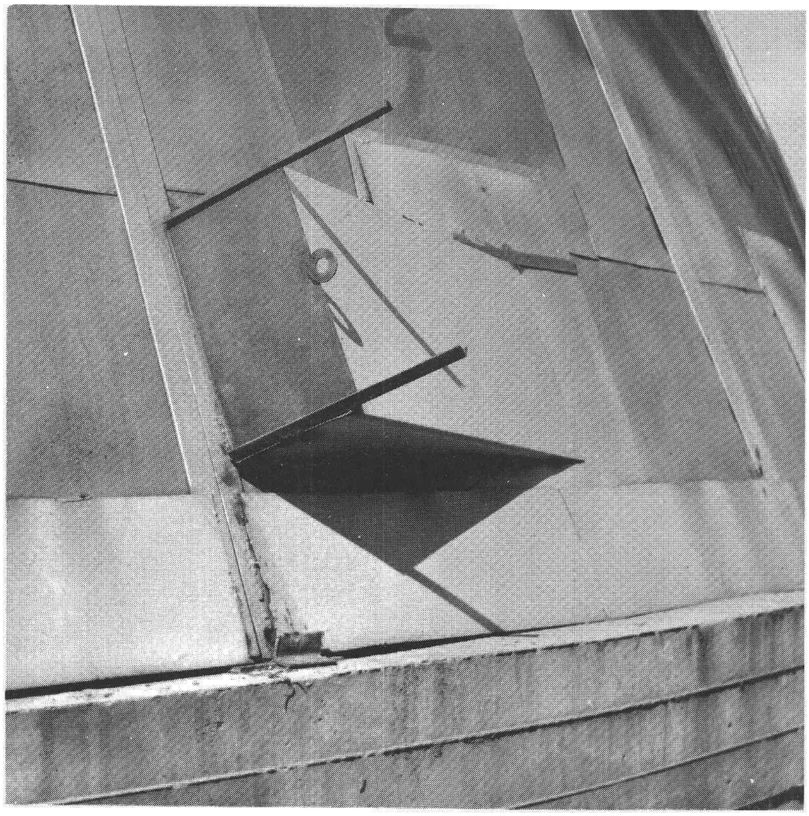


Figure 10. Natural-draft, overfire, air vent (closed) on wigwam burner.

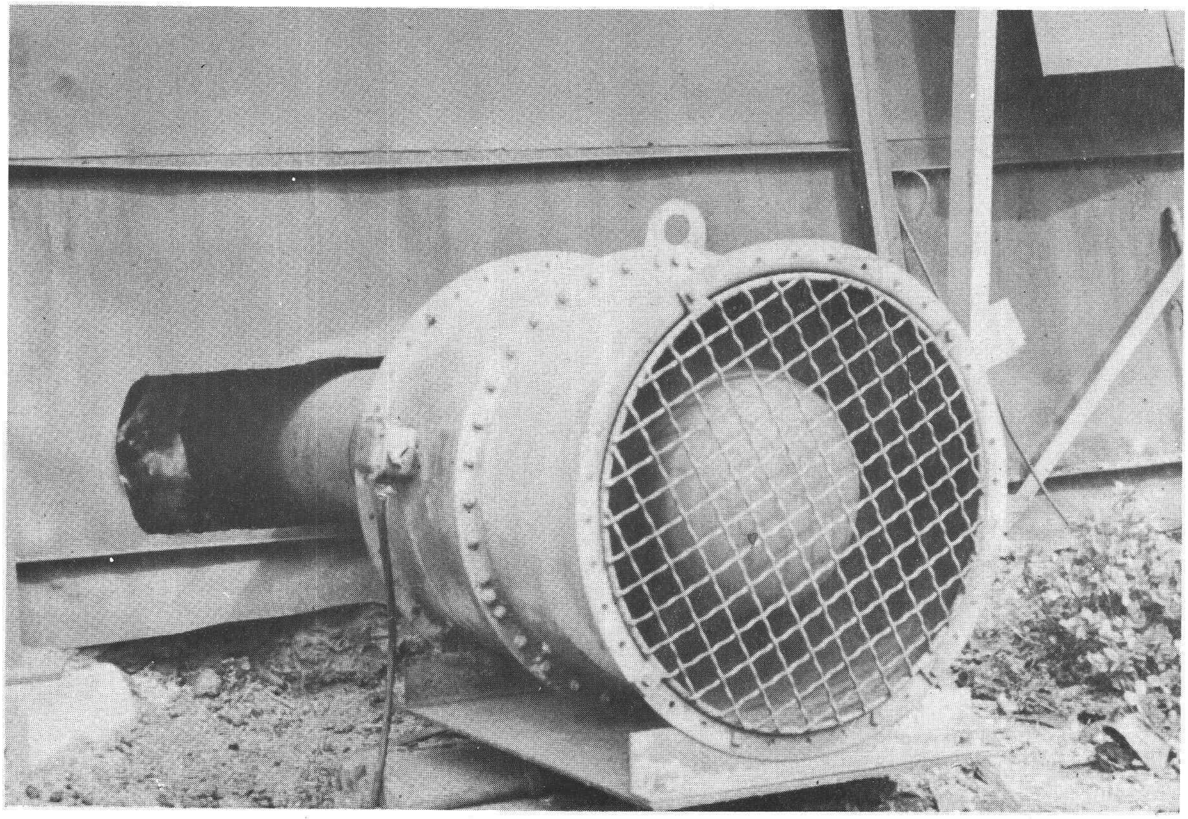


Figure 11. Overfire air fan.

Figure 12. Most burners are fed by chain conveyors.

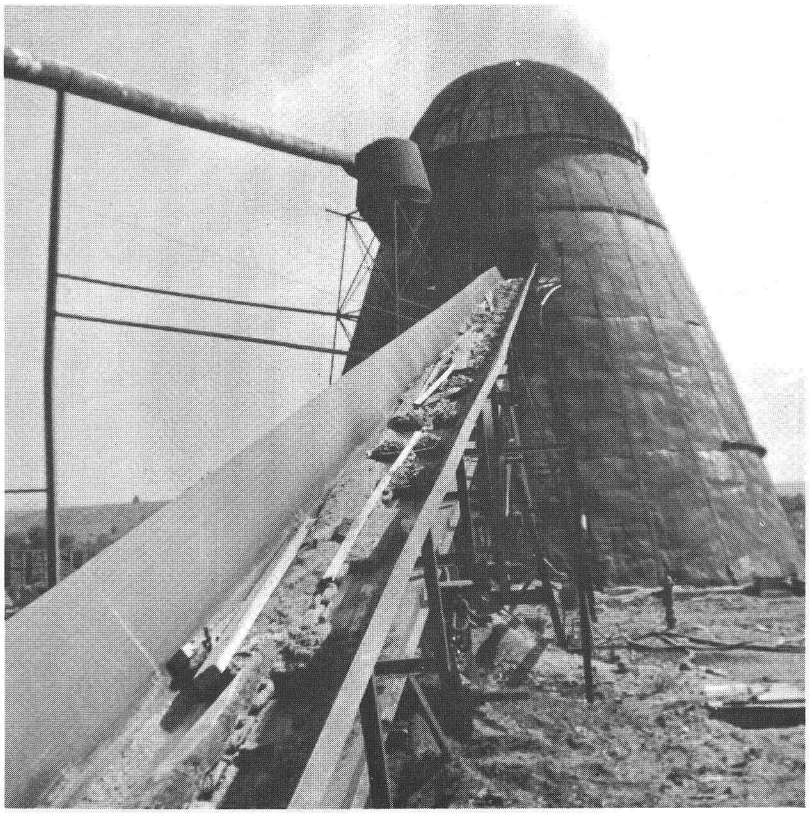


Figure 13. Temperature indicator on a burner.

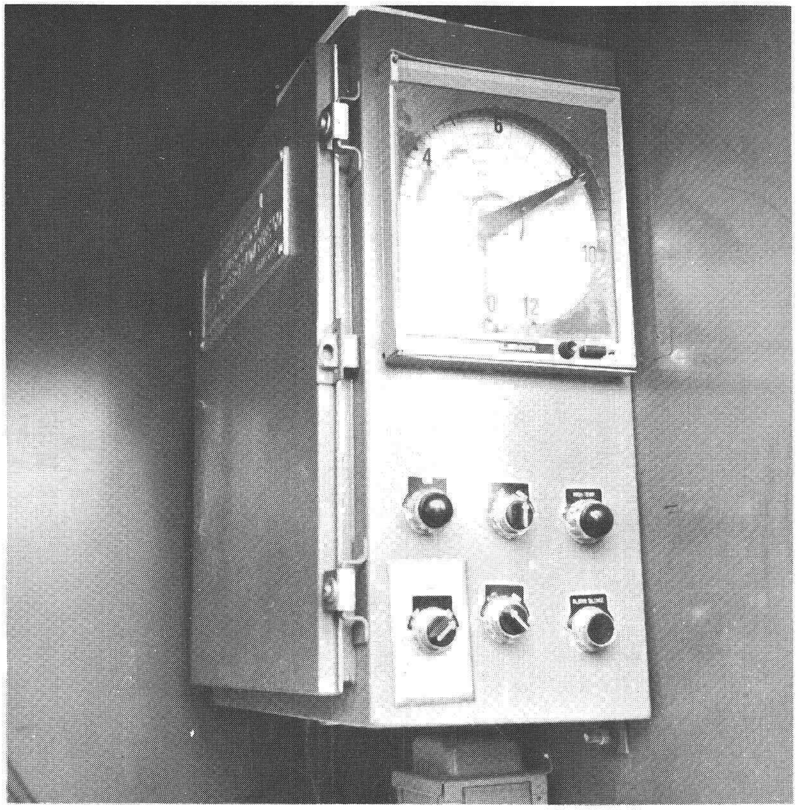


Figure 14. Recorder-controller on a wigwam burner.

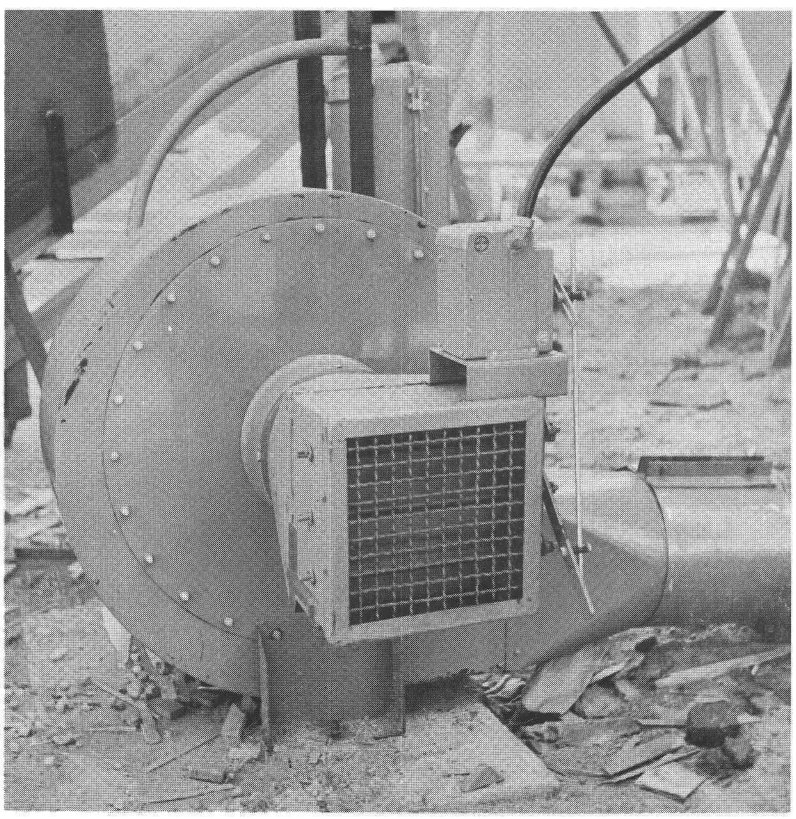
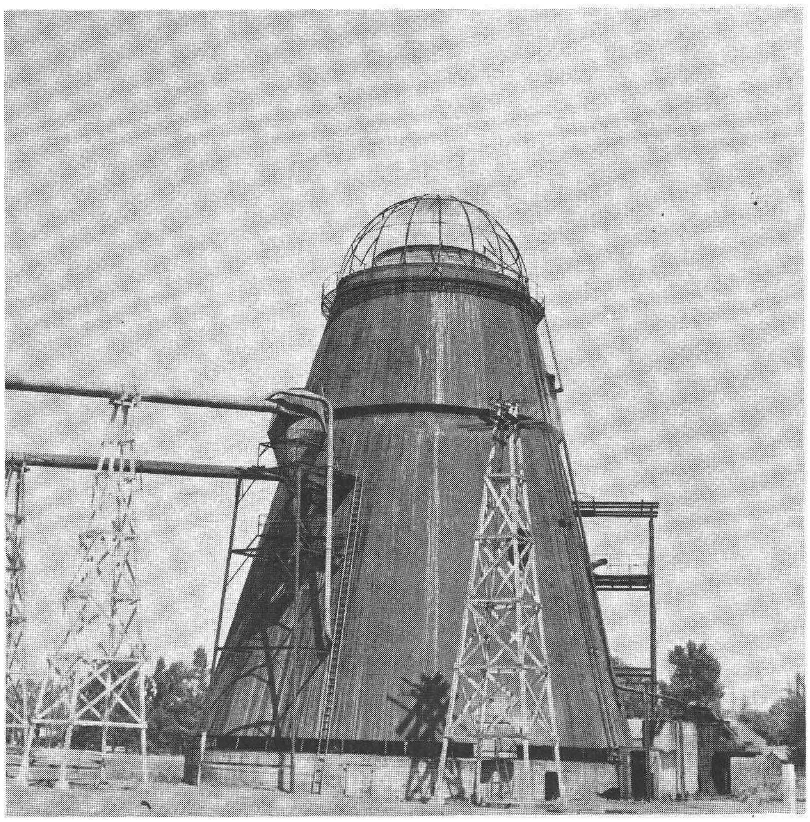


Figure 15. Automatic fan control on a wigwam burner.

Figure 16. Water-wash gas scrubber installed atop a wigwam burner.



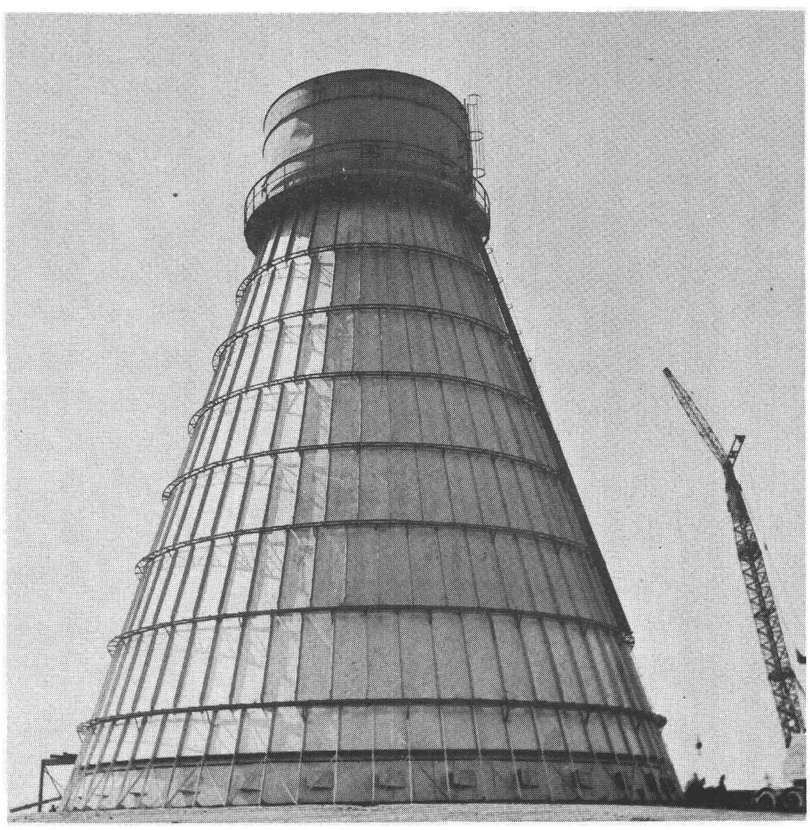


Figure 17. Water-wash scrubber on a new burner.

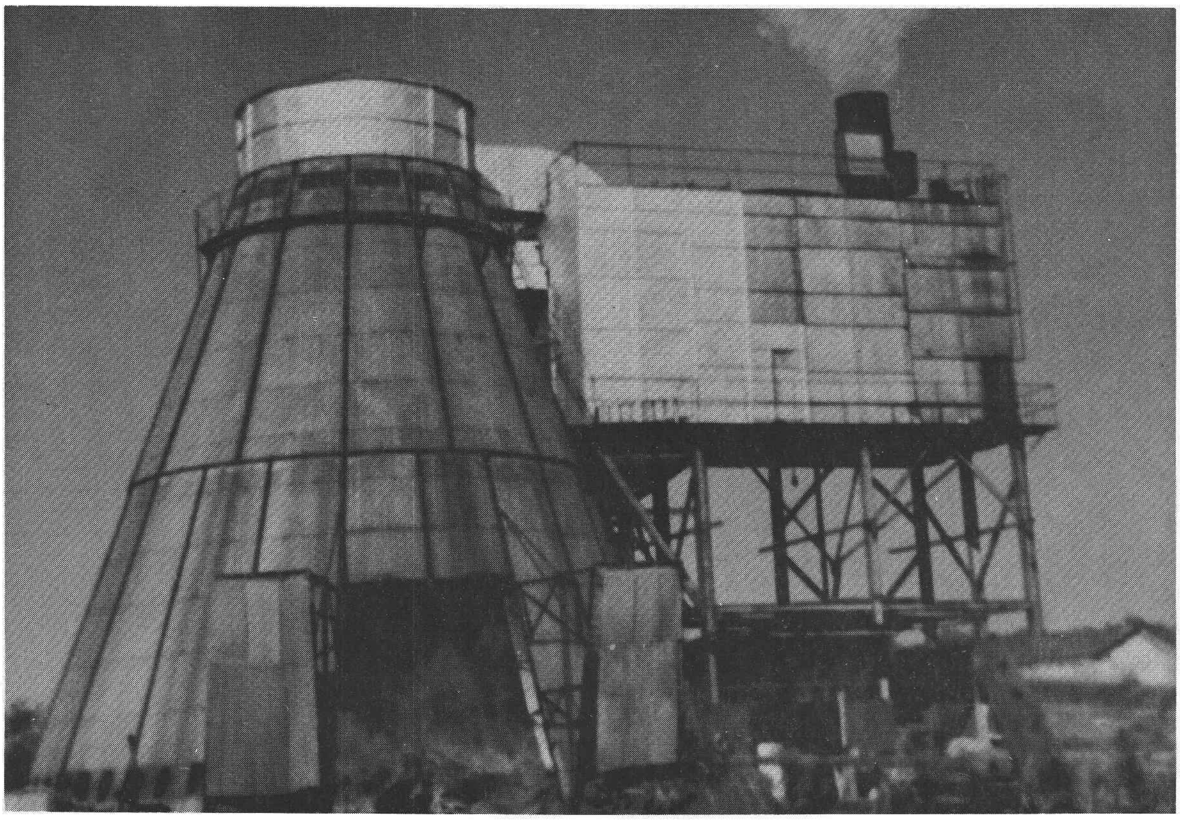


Figure 18. Scrubber on a burner to dispose of urban renewal wastes.

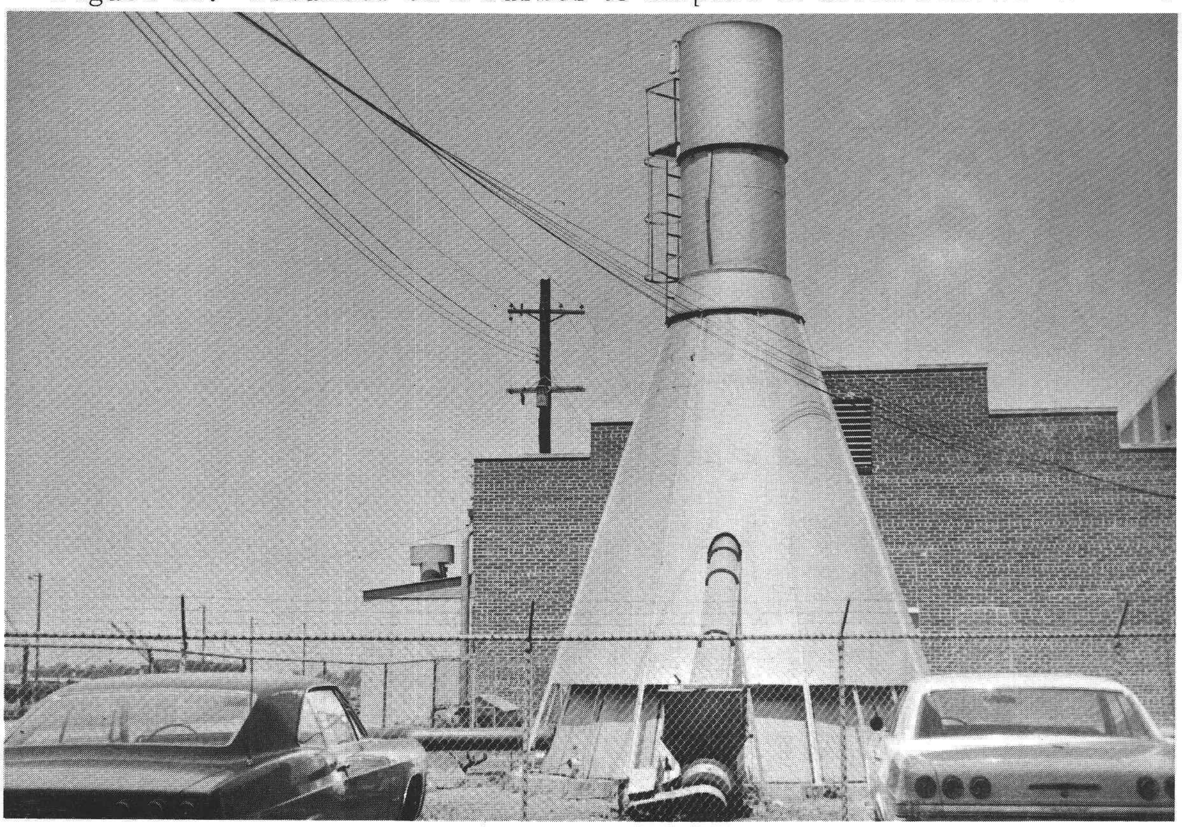


Figure 19. Scrubber unit on an experimental burner.

and operating procedures for a wigwam burner. In a recent study (4), Boubel sampled particulate emissions from 19 burners and reported an average particulate emission of 0.168 grain per cubic foot of gas (corrected to 12 percent carbon dioxide and standard temperature and pressure). Fourteen of the 19 burners tested were reported to have average particulate emissions less than the limitation of 0.2 grain per cubic foot of gas that has been adopted by many air-pollution control agencies.

The Oregon State Sanitary Authority has advised industry on modifications to improve combustion in wigwam burners (17), and has conducted workshops to inform burner operators of proper operating procedures. Observations of researchers indicate that substantial improvement in burners has been made by the Authority in this program.

Darley (11) employed the apparatus of Figure 20 to evaluate emissions from open burning of agricultural wastes. His work serves to emphasize the complex nature of the gas evolved in combustion of wood waste.

An open-pit incinerator has received some publicity in the forest industry. A small experimental open-pit incinerator was tested by the U.S. Public Health Service (15). Another pit incinerator was constructed and operated for a short time at a particleboard plant in Oregon, but this equipment is no longer in use.

A cylindrical refractory fire-pit was installed in the burner shown in Figure 21. Observations of this burner in operation indicated that the modification did not result in elimination of visible smoke.

The Bureau of Air Sanitation, California Department of Public Health, conducted tests on the modified wigwam burner of Figure 22. The main modifications to this burner were a cylindrical refractory wall as a fire pit and tangential air entry into the fire pit. Apparently, no report of these tests has yet been published.

Figure 20. Experimental apparatus to evaluate combustion of agricultural waste.

The State of Kentucky has conducted acceptance tests on wigwam burners. The burner tested had automatic controls and an overhead damper to help regulate airflow. As a result of the tests, the burner was accepted for use in Kentucky. Kentucky has particulate and smoke emission standards for burners.

The U.S. Public Health Service has made a study of wigwam burners as a means of disposing of municipal waste (15).

Consultations with burner manufacturers

Burner manufacturers were consulted by researchers. Purpose of these consultations was to gain ideas for improvement of burners and gain benefit of advice from those who have practical experience with burners. Manufacturers consulted were:

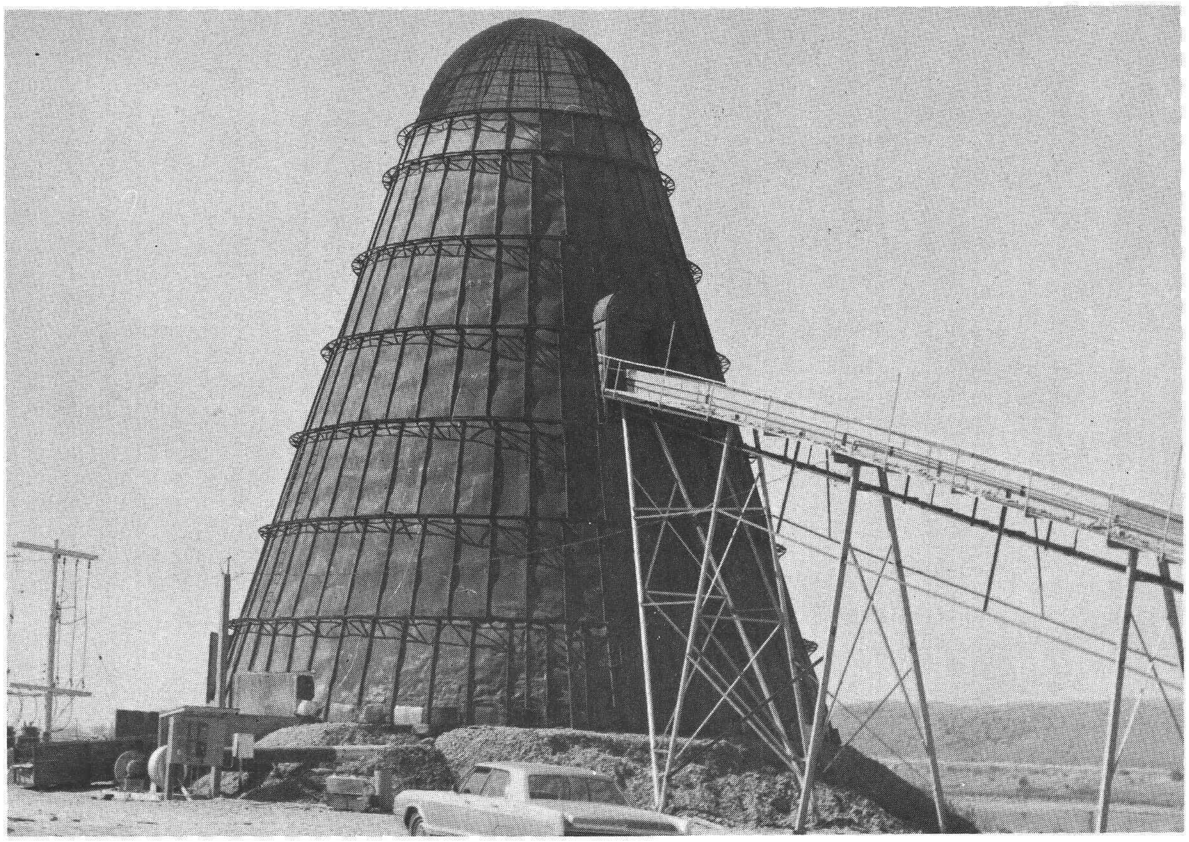
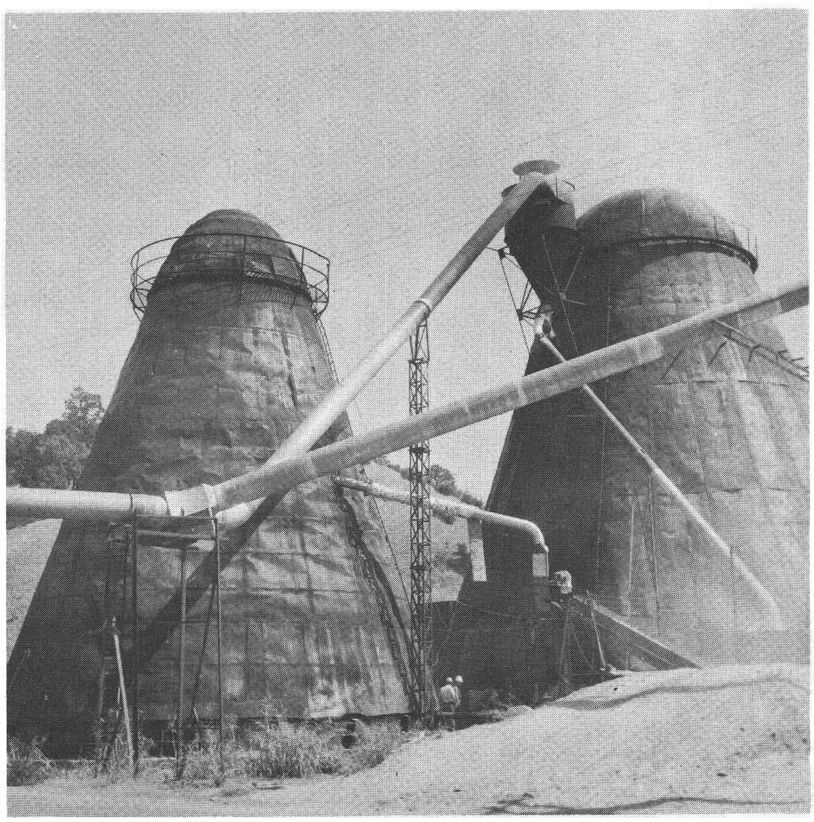


Figure 21. Burner with a cylindrical refractory fire pit.

Figure 22. Burner with refractory wall and tangential air entry (on left).



Rees Burner Co., Berkeley, California

Rees Burner Co., Memphis, Tennessee

Medford Steel and Blowpipe Co., Medford, Oregon

Koch and Sons, Evansville, Indiana

John Stutz, Eugene, Oregon

Clark Sheet Metal, Eugene, Oregon

Steelcraft Corporation, Memphis, Tennessee

Discussions with air-pollution-control officials

Meetings were held to obtain advice and comments on research plans from air-pollution-control officials. Officials in other states where wigwam burners are used were consulted to see how their problem was being met. It was thought that solutions found elsewhere might be applicable in Oregon. Agencies represented in meetings were:

Mid-Willamette Valley Air Pollution Control Authority (Oregon)

Lane Regional Air Pollution Authority (Oregon)

Columbia-Willamette Air Pollution Authority (Oregon)

Oregon State Sanitary Authority

Bureau of Air Sanitation, State of California

Los Angeles County Air Pollution Control District

Georgia Department of Health

Arkansas Pollution Control Commission

Kentucky Air Pollution Control Commission

The major efforts noted outside Oregon in control of wood-fired wigwam burners are in California and Kentucky. California does not have state-wide emission standards, but Kentucky does have such standards.

Burners in Kentucky, Arkansas, and Georgia were selected for study because these states are major producers of hardwood and southern pine lumber and therefore contain many wigwam burners.

Work of consultants

Consultants were hired to estimate the cost of various modifications designed to improve combustion in wigwam burners. This information will serve as a guide in selecting modifications for further evaluation. A report of this work has been prepared (9). In brief, installed costs for certain modifications on a 40-foot burner were:

1. a. Automatic control of overfire air vents by means of a thermocouple sensing element, recorder-controller, and damper motors	\$5,000
b. If the added feature of a smoke-density meter with provision for continuous recording and alarm were desired, add	\$3,500
2. Fuel sizing and fuel-flow regulating equipment, including a blow-hog, conveyors, cyclone, and ductwork	\$32,100
3. Fuel sizing and drying system to enable combustion of excessively wet fuels, including hog, conveyors, storage bin, and rotary drier	\$63,800
4. Equipment for preheating combustion air by recirculating hot gas from top of the burner, including fans, dampers, and ductwork	\$9,600

Cost of certain other modifications also were evaluated by the above consultants. These will be discussed more fully in a final report.

Extent of the benefit to be gained in wigwam burner combustion from fuel sizing and flow regulating (2, above), fuel-drying system (3, above), and preheating air (4, above), is largely unknown. The consulting engineers recommend in their report that such modifications be evaluated by test if they are to be applied. Controls (1, above) will improve combustion, but extent of improvement has been only observed and not evaluated. The smoke meter and alarm system (1b, above) merely makes a record of smoke density and warns when it is excessive.

Consultants were further employed to estimate the installed cost of "off the shelf" equipment for removal of particulate matter from gases emitted from wigwam burners. A summary of the installed costs per burner of various types of equipment as reported (10) by the consultants is below.

	Diameter of burner	
System	40 feet	60 feet
Low-drop collector	$17,300	$ 59,700
Single cyclone collector	21,400	81,500
Multiple cyclone collector	23,500	62,000
Wet gas scrubber	30,000	99,000
Electrostatic precipitator	47,000	200,000

In general, the cost of cinder collectors increases as collection efficiency increases.

Instrumentation, particulate measurement, gas analysis

Air-pollution-control regulations usually are concerned with particles emitted, smoke density, and certain gaseous emissions. Permissible particulate level is usually specified in grains of particles per cubic foot of gas, with gas volume based on certain standard conditions. Measurement of particulate emissions from wigwam burners is a problem because of difficulty in measuring low velocities of gas. A detailed discussion of this problem and recommendations for a new sampling method are contained in a report (13) prepared in this study. The importance of accurate sampling is underscored by realization that effectiveness of any modifications to wigwam burners can be evaluated only by sampling burner emissions. Instruments for sampling particles are being fabricated.

The major components of gases coming from a wigwam burner are nitrogen, oxygen, carbon dioxide, and water vapor. All of these gases are considered non-pollutants. Small concentrations of other gases such as carbon monoxide, hydrocarbons, partially oxidized hydrocarbons, pyrolignic acids, and oxides of nitrogen are also present.

Gases that will be measured on the test burner are carbon dioxide, carbon monoxide, and total hydrocarbons. Limited analysis may be made for wood tars and oxides of nitrogen.

Conclusions

Observations show that many burners are in disrepair. Air pollution from wigwam burners could be significantly reduced if burners were properly maintained; that is, if air leaks were eliminated, doors replaced, and conveyor openings sealed insofar as possible. In short, all inadvertent air leakage into the burner should be eliminated. Once this is done, further improvement in combustion might logically be attained by adjustment of the underfire and overfire air.

Gaseous emissions from wigwam burners should not be a problem in complying with existing air-pollution regulations.

A further conclusion is that the wigwam burner probably is an interim solution to disposal of forest products residue, because waste is decreasing, and utilization is increasing and will continue to increase in the future. Some mills already have solved their problem of residue disposal by utilization and do not need wigwam burners for disposal (Figure 23). It seems likely, however, that the wigwam burner or some other disposal method may be needed by some mills for a number of years.

At the outset of this study, researchers were skeptical that the wigwam burner could be made an acceptable device for disposal of wood and bark waste. Now, however, indications are that a properly

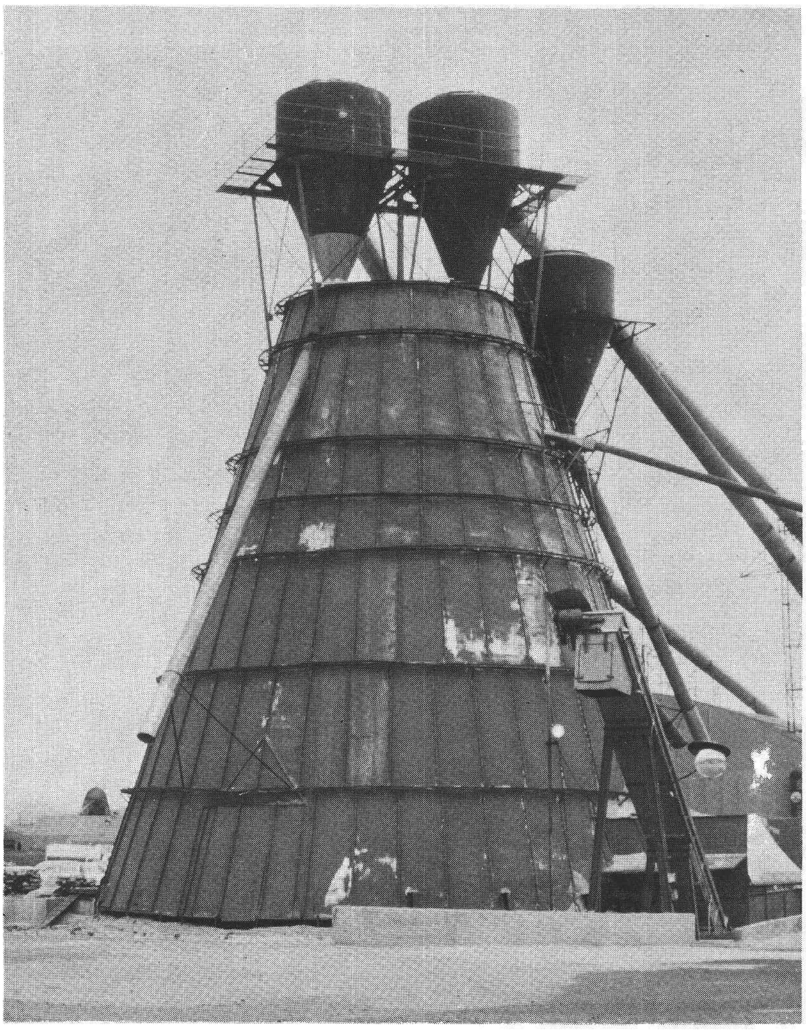


Figure 23. Wigwam burner used as shavings storage.

designed and operated wigwam burner can be made to incinerate wood waste in a manner that would be acceptable by present air-pollution-control standards. This change was brought about by three factors:

1. Some of the burners studied operate consistently with little or no visible smoke and little apparent particulate emission.
2. A well-constructed and properly operated burner consuming sawmill waste has been tested for smoke and particulate emission by control agency personnel in the State of Kentucky. On the basis of these tests, they concluded that burner operation met pollution regulations and approval was given to continue operation of the burner.

3. Dr. R. W. Boubel recently reported (4) that 14 out of 19 wigwam burners tested in the Pacific Northwest had an average particulate emission less than the limitation of 0.2 grain per cubic foot (corrected) currently adopted by many air-pollution-control agencies.

There was evidence to indicate that wigwam burners fueled with wood and bark may be acceptable incinerators under certain conditions. It was also apparent that the effectiveness of potential modifications and operating conditions was not known. It was, therefore, a strong conclusion of this study that certain modifications and operating procedures should be evaluated by testing a wigwam burner. The test program would be designed to evaluate the modifications and procedures deemed mostlikely to reduce smoke and particulate emissions consistent with reasonable cost.

A final conclusion is that a wigwam burner that may be satisfactory as regards air pollution when burning certain kinds of fuel, may not be satisfactory with other fuel. For example, fuels with excessively high moisture, such as sugar pine, may require special treatment compared to a more easily burned fuel such as Douglas fir.

Future Plans

Plans are to locate a suitable burner at an operating sawmill and obtain the approval and cooperation of the owner in conducting modifications and tests with the burner. Initial modifications would be based on experience and information gained by researchers in the course of this project. The modified burner would be instrumented to evaluate effectiveness of modifications.

It is of interest to enumerate the logical modifications that probably would improve combustion characteristics of wigwam burners:

1. Provide means to regulate air supply
2. Provide means for increasing turbulence over fire
3. Modify grates
4. Provide means for making fuel more uniform in size
5. Provide means for regulating fuel rate
6. Change point of fuel entry or method of entry
7. Install automatic controls
8. Provide means for drying the fuel
9. Provide means for pre-heating the air
10. Add refractory
11. Provide means for introducing auxiliary fuel

However, time and funds are not available to evaluate all of these modifications. Therefore, the most promising and least costly of these modifications will be selected for initial evaluation. Modifications and operating conditions judged most likely to give improved burning at least cost are:

1. Optimize distribution of underfire and overfire air
2. Increase turbulence over fire
3. Install automatic controls to regulate combustion

In evaluating the combustion characteristics of, and modifications to, the burner, the following variables, among others, will be measured:

1. Fuel (rate, moisture content)
2. Underfire air rate
3. Overfire air rate
4. Particulate emission
5. Gas composition
6. Smoke density

From these tests, researchers will obtain information to prepare graphs, tables, or charts that will show variation in smoke and particulate emission for the modified burner for different operating conditions. From these test results, the operating conditions that result in least emission will be recommended.

If the test results show ways to improve combustion in wigwam burners, information also will be presented in the form of drawings, sketches, and photographs to show how other burners can be modified so their features will be similar to those of the test burner. Recommendations for fan sizes, air pressure, gas temperature, air-fuel ratios, air rates, and proportions of underfire to overfire air will be presented. These recommendations will necessarily be restricted to those fuels and modifications used in the test burner, with perhaps some tentative observations on operation with other fuels.

If further study of wigwam burners is necessary, recommendations will be presented in the final report of this study.

One might ask, how are the above test plans different from work of others? These tests are for the purpose of evaluating the effectiveness of specific modifications to a wigwam burner and for determining the optimum operating conditions.

A word of caution should be inserted about these future plans. Tests that are planned are not comprehensive enough to answer all questions that should be answered. Further tests probably will be desirable to extend the information developed within the scope of this project as presently conceived. What answers will be lacking? Time and finances probably will limit tests to two species of fuel, Douglas fir and western hemlock. It is known that cedar waste is difficult to burn without air pollution. Time probably will not permit experiments with excessively wet fuels, such as sugar pine. Experiments with dry fuels probably will not be made. Effect of addition of refractory and pre-heating air will not be studied. These are some of the questions that will remain unanswered in the presently planned test program. What is expected is that recommendations can be made for combustion of such species as Douglas fir and western hemlock.

DISPOSAL OF WOOD AND BARK WASTE BY LANDFILL

A common and acceptable method of disposing of municipal solid waste is by sanitary landfill. Such fills, when properly located, do not result in pollution either of air or of water. This method of disposal of municipal waste is expected to increase in the future.

The objective in studying landfills is to determine the cost of disposing of wood and bark in fills and to determine if technical factors such as fire hazard, gas evolution, and ground-water pollution are problems that need further evaluation.

In constructing a sanitary landfill, practice is to dump refuse at the base of the fill. The refuse is then spread in thin layers about two feet thick and compacted with bulldozers. At the end of the day, earth-moving equipment deposits dirt over the compacted refuse to a depth of about six inches, effectively encapsulating the waste between layers of earth. When the fill is completed, it is covered with a final layer of two or more feet of earth. Completed landfills are frequently used for parks and playgrounds. The purpose of covering municipal refuse is to restrict odors and to exclude vermin and birds from garbage in the fill. Wood and bark do not offer an attractive habitat for vermin and, therefore, would not need to be covered with earth at the end of each working day. Consequently, the cost of operating a wood waste fill would be less than that of a municipal fill.

At first glance, landfilling appears to offer an almost immediate solution to problems of disposal of wood and bark waste without objectionable pollution. In fact, if incineration of wood waste were to be prohibited in certain populated areas, landfilling is the only immediate solution unless means of utilization could be developed.

Municipal refuse contains a high proportion of organic waste that in some ways is similar to wood waste. Because of this similarity, it was reasoned that many of the problems in municipal fills may be similar to those that would be experienced in disposing of wood waste in fills. For example, transportation cost, fire hazard, and gas evolution may be similar. Therefore, a study of several municipal fills was planned.

Much literature that deals with municipal landfills has been published. Plans were to prepare an economic analysis of the feasibility of disposing of wood waste in fills from published information. Based on the background of preliminary study outlined above, an area (Medford, Oregon, for example) was to be selected for a case study and economic analysis of the cost of disposal of wood waste by landfill. The analysis was to include all costs; for example, land, transportation, storage bins, equipment, and manpower. In conjunction with the cost estimates for disposal by landfill, costs of disposal of wood waste by incineration in wigwam burners will be prepared. Comparison of these two estimates will make readily apparent the excess costs of one method over the other.

The entrance to one of the large landfills operated by the Los Angeles County Sanitation District is shown in Figure 24. Note that costs for disposal of refuse are printed on the sign. Each truck that enters the disposal area is weighed to determine the net weight of refuse. Figure 25 shows the type of material that is disposed of in the fill. The area in the foreground of the photograph previously has been filled and covered with earth. Figure 26 is a landfill operated by Lane County, Oregon. This fill is in an old gravel pit. The fill is on a considerably smaller scale than the one shown in the previous photograph, and equipment consequently is smaller. No charge is made for disposal, but on the other hand, no forest products wastes are accepted. Several old fills for wood waste were found in Oregon and were observed to see what problems had developed. For example, limited

Figure 24. Landfill entrance in Los Angeles.

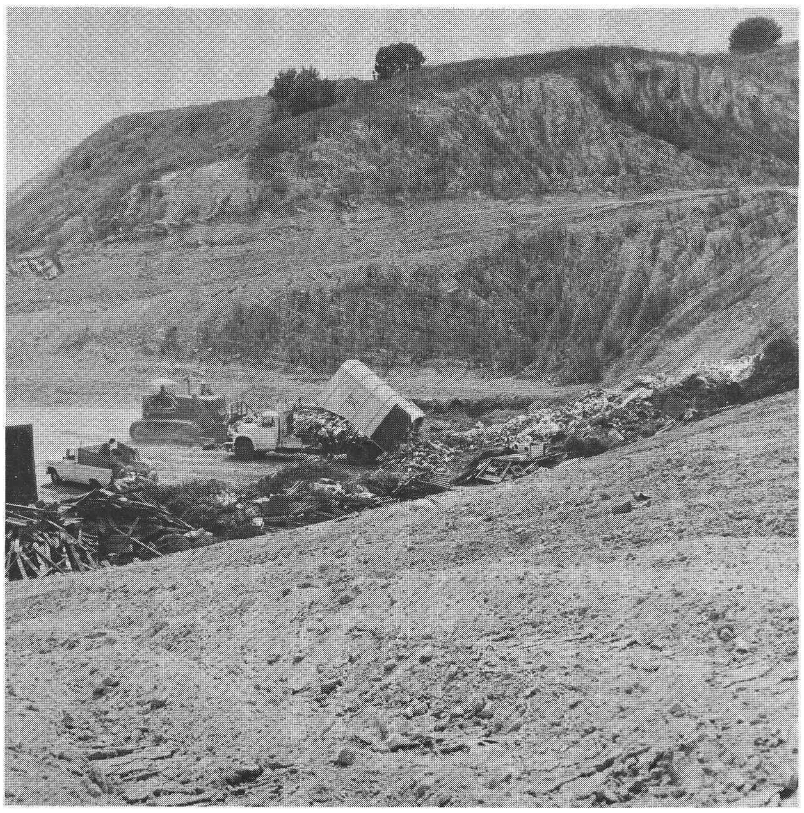


Figure 25. In this large landfill in Los Angeles, bulldozers push refuse up the face of a fill and earthmovers cover refuse with dirt.

Figure 26. A landfill at Eugene, Oregon.

observations were made of settling, gas evolution, vermin or insect infestation, or past fires. In one of the fills observed, fire had occurred, and in another instance, nearby residents mentioned a problem of odor from the fill.

A preliminary report has been prepared on the cost and technical feasibility of disposing of wood waste by landfill (14). This report was prepared mainly from published information relating to municipal fills, which information was adapted to wood waste fills. Estimated cost of disposal of wood waste by landfill was approximately $1.25 per ton of material if all burial procedures were followed as in municipal fills. To this cost must be added the cost of transportation, which can be estimated from another report in this study (12). For a ten-mile haul, costs for transportation by truck are estimated to be about $0.75 per ton. Total estimated cost of disposal by landfill then is about $2.00 per ton of material, if the fill is located ten miles from the mill. Additional costs would be incurred if bins or other storage facilities were necessary for wood waste at the mill. Cost for wood waste at the disposal site would be less than that for municipal waste, however, because municipal waste must be covered with earth every day. Wood and bark wastes may require only a final cover of earth upon completion of the fill to insure against fires and make the completed site more usable.

At present, a case study of the cost of disposing of wood and bark waste in landfill is being made. A subject area has been selected, and all costs are being determined. Because this study is not complete, conclusions cannot be drawn at this time.

The difference between the above study and the preliminary study previously reported (14) is that the earlier study was based on adaptation of data reported for municipal refuse fills. The present cost estimate is being based on volumes, weights, and transportation costs of wood waste, and on actual conditions in a specific area.

Tentative opinion is that cost of disposal of wood waste in landfills would be about \$2.00 per ton, or about \$4.00 per unit of 200 cubic feet, if the material is hauled ten miles and if covering procedures similar to those at sanitary landfills are followed. These costs do not include the cost of a conveyor and storage bin at the millsite. Landfill procedures for wood waste probably could be developed whereby costs at the fill site could be reduced. Transportation costs could be reduced by a short haul. If wood and bark fills can be later used for parks and recreational areas, as has been done in California (a golf course is to be built on land reclaimed by a compacted refuse fill), fills may be permitted close to municipal areas.

There are several technical factors that require investigation if wood and bark wastes are to be disposed of in landfill. These factors are:

1. Fire hazard

2. Pollution of ground or surface water

3. Gas evolution

4. Settling of the finished fill.

The above factors have been investigated by others for sanitary landfills of municipal refuse.

Plans are to complete the case study of disposal of wood and bark waste by landfill. Costs of disposal by this method will be compared with costs of disposal by incineration in wigwam burners. Technical aspects of landfilling wood and bark wastes will not be evaluated in this study because of other priorities. Recommendations may be made for further research to evaluate fire, settling, and ground water pollution.

WOOD AND BARK RESIDUES ON THE SOIL

The purpose of considering use of woody residues on the soil is to encourage utilization of waste wood and bark by determining the extent of the present national market for soil applications of wood and bark residue and by estimating the future potential market. A further objective is to make and present an economic analysis of manufacturing and marketing bark for use on the soil.

Sawdust and bark have been used extensively in Oregon as mulches and soil amendments. Nurseries and garden stores have used these wood residues around shrubs and flowers to retain moisture and beautify displays. The flower and garden show at the Oregon State Fair of 1968 contained numerous utilitarian and aesthetic uses of bark and bark chunks. In a memorial park, bark was used as a walking surface. Newly planted home lawns in Oregon have traditionally been protected from dehydration by a topdressing of sawdust. Sawdust has been used on highway cutbanks for soil stabilization, and both bark and sawdust have been used on highway interchanges as a mulch for retaining soil moisture, deterring weed growth, and beautifying the landscape. Figure 27 shows a workman applying bark mulch to an Oregon freeway interchange.

In various experiments, bark and wood residues have been used to attempt to lighten heavy soils, mulch orchards, provide drainage of wet lands, and stabilize drifting sand dunes.

The above applications indicate a possible widespread use for wood and bark residues. The prospective use seems attractive because it appears that little capital investment is needed to enter the field, little development work is necessary, and the market may be large. These observations led to the conclusion that a study of wood and bark on the soil should be made.

Our approach was to make a preliminary study of wood and bark processing plants and initial observations of the extent of the national market for soil applications of wood and bark. Information was obtained on the extent of markets for wood and bark on the soil and also on economic factors in a manufacturing and marketing operation.

About a dozen producers and several retailers of wood residues for soil application were contacted. Figure 28 is a photograph of a commercial bagging operation in a bark processing plant. This preliminary survey indicated that the number of producers of these products is increasing and processing is increasing in diversity. In the past, sale of sawdust, shavings, and bark traditionally has been handled by fuel dealers as a sideline operation. In recent years, however, specific operations have been based on sales of wood and bark residues for soil application. One producer reported sales averaging 140 tons per day and another estimated sales of about 150 tons per day. Two plants recently built for processing bark residues for this market reported capacities of 120 and 200 tons per day, respectively. Most operations offer to the consumer a variety of products that range from bark chunks, used primarily for landscape architectural effects, to bark dust and sawdust. Material is sold bagged or in bulk, and with or without fertilizers added. One operator maintains a large inventory to permit immediate delivery upon receipt of phone orders.

Most production and sale of bark for use on the soil is in the West, but some western companies are marketing in the eastern United States.

A consultant is making a national survey of markets for wood residues for soil application. He also is preparing a technical and economic analysis of an enterprise to process wood and bark residues for soil application. In this study, large and small producers tentatively have been identified in 30 states. The study is not concluded,

Figure 27. Blowing bark mulch on an Oregon freeway interchange.

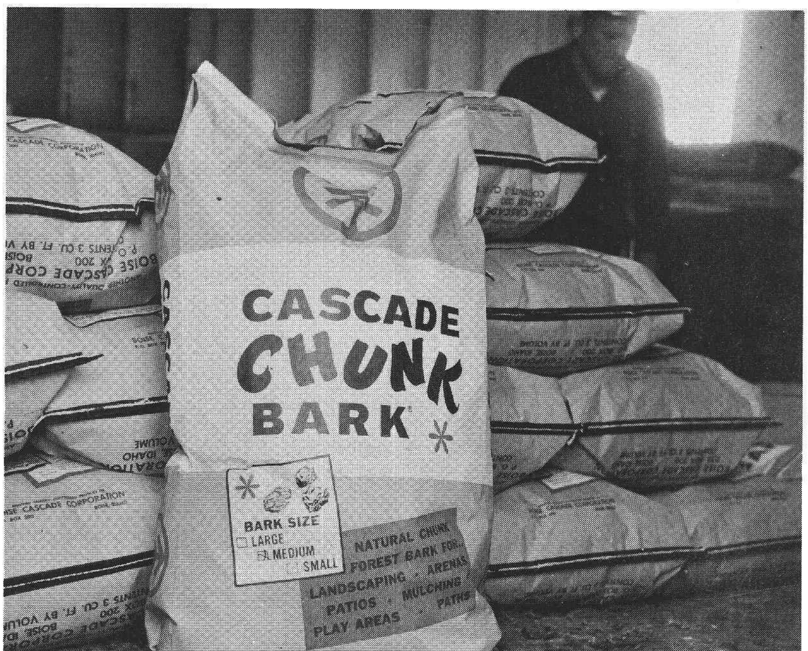


Figure 28. Bagging bark in a processing plant.

but the consultant has ventured the tentative observation that the next 5 to 10 years will see dramatic growth in sales of wood and bark for soil applications in areas outside the West.

The consultant's analysis will be completed by May 1969. More detailed discussion of the findings in this phase of the study will be included in the final report.

Based on preliminary study, the following tentative conclusions are made:

1. Wood and bark residues are finding increased markets for use on the soil.
2. Bark is generally preferred over sawdust, largely because of its more pleasing appearance on the soil.
3. Most present producers of bark-on-the-soil products are in the western United States.
4. A market survey and economic feasibility study presently underway should show market potentials and advisability of future expansion.

CHEMICAL EXTRACTIVES FROM DOUGLAS FIR BARK

Work at the Forest Research Laboratory nearly 20 years ago established the existence of wax and certain pharmaceuticals in Douglas fir bark (16). These components include two different wax fractions, quercetin, dihydroquercetin, and tannin as well as physical fractions of the bark.

Present objectives are to evaluate and update the Kellogg analysis in light of today's economy and to make recommendations for further work to encourage the establishment of a bark-extraction enterprise in Oregon.

The early work on bark extraction laid the groundwork for an economic feasibility study of extraction of Douglas fir bark by the M. W. Kellogg Company of New Jersey, under an agreement with the State of Oregon. In the Kellogg analysis, the entire economic structure of the feasibility investigation was based on the potential sale of the highest quality wax, which comprises an estimated 1.65 percent of the dry weight of the bark. No economic consideration was given to lower quality waxes, tannins, dihydroquercetin, or products that might be manufactured from the extracted bark residue. Even so, by Kellogg's analysis based solely on the high-quality wax, wax extraction appeared to be a profitable enterprise with calculated returns on investment that range up to about 44 percent and payout times as low as 2.3 years. Even so, Kellogg decided not to build a wax plant.

Kellogg's decision appears to be based mainly on three conclusions:

1. Sales of a small fraction of the total extractives (the refined, or high-quality, wax only) must economically justify the entire enterprise.
2. Further development work was necessary.
3. Economics were borderline based on low yield of refined wax,

the unsettled economic structure of the wax market, the apparent non-emulsifiability of the refined wax by conventional means, and the estimate of a market for refined wax of 2,150,000 pounds per year when the preferred plant capacity was about 3,000,000 pounds per year.

Researchers in this study (1) believe that the basis of Kellogg's analysis was too restrictive and that the entire enterprise should be re-evaluated on the basis of today's technology and economy--about 15 years later. Today, there are more products that can be manufactured from "spent bark" residues after wax extraction than existed in 1952. Sales of bark in home garden and horticultural uses is a rapidly growing market. Technology of manufacture of particleboard from bark is developing. The national market for charcoal is expanding. In view of these changes, realistic basis of evaluation of the economic feasibility of an industry based on extractives from Douglas fir bark might be based on consideration of:

1. Market potential of all extractives,
2. Market potential and cost of manufacture of bark board, charcoal, or mulch,
3. Use of part of spent bark as plant fuel, and
4. The most economical balance (for a profit) of the product mix of all items that might be made in the enterprise.

As a beginning on the recommended analysis, plans were made to update--and to expand with the inclusion of other wax fractions--the Kellogg analysis of 1952-1956.

A chemical consultant was retained to study the Kellogg reports and update the analysis of today's economic picture. The analysis was to be based mainly on updating the Kellogg work with spot checks of the data by limited sampling of current markets. The consultant also was to make recommendations of such further research as he might feel necessary to encourage the establishment of a bark extractives enterprise.

The consultant has completed an economic analysis based on the Kellogg reports (1). He considered seven different situations, which included, for example, effect on profit of various plant sizes, capital investments, and wax prices. In these situations, only two possibilities for disposing of spent bark (material remaining after extraction, which may be about 90 percent of input raw bark) were considered: Bark is sold as soil mulch, and fuel needs of a steam plant are supplied from spent bark and the remainder is sold as mulch. Figure 29 is an

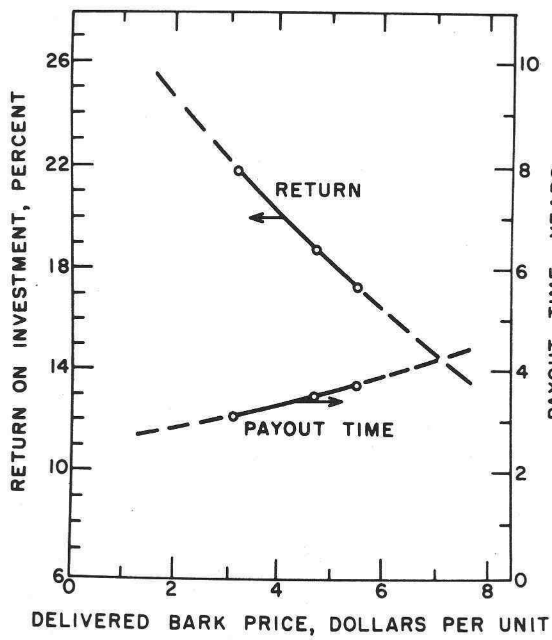


Figure 29. Profitability of bark waxes after taxes as a function of bark price.

example of the kind of information presented in the consultant's report. This figure summarizes the effect of raw bark price on profitability.

The consultant (1) concludes that production of wax from Douglas fir bark would be profitable. Increasing the bark price by 75 percent did not affect the profitability seriously, nor did an increase of 25 percent in capital investment or a decrease of 50 percent in the price of balsam wax. Operation of the plant at 60 percent capacity, or a reduction of plant size by 50 percent, still showed profitable return, but low levels of return emphasized the need for optimum plant size and operation at full capacity.

A further conclusion was that additional research and development would be necessary before the maximum projected plant size could be fully utilized.

No additional work on this phase is expected during this study. However, recommendations for future work presented in the wax report (1) will be proposed for study under another project.

INCINERATORS OTHER THAN WIGWAM BURNERS

Modern refractory-lined incinerators are widely used for disposal of municipal waste. Technology of these furnaces is sufficiently developed that they could be used to dispose of wood waste within air-pollution regulations. Moreover, other industries may have developed low-cost incinerators that could be adapted to the forest products industry. Finally, there are incinerators other than wigwam burners presently in use in the forest products industry that may warrant more general use.

Based on the reasoning behind the discussion above and because incineration offers an immediately applicable solution to the problem of waste disposal, it was decided that a study of incinerators should be made.

The objective of this phase is to survey incinerator types in and out of the forest products industry and estimate the costs of installation and operation of several of those types that appear most adaptable to the combustion of wood waste.

Project personnel have made a preliminary survey of some incinerators in the wood industry. The remainder of the work will be completed by a consultant who has been retained to make a study consistent with the objective outlined above.

Incinerators other than wigwam burners have been observed in the forest products industry. One of these is shown in Figure 30. This is a refractory-lined, high-temperature furnace operating on dry fuel. Another refractory-lined incinerator is the cylindrical one shown in Figure 31, which is used for disposal of dry hardwood waste. A third incinerator, a so-called "open-pit" incinerator, was in use at a plant in Oregon, but has recently been abandoned. Figure 32 shows a small experimental open-pit incinerator that has been tested by the Public

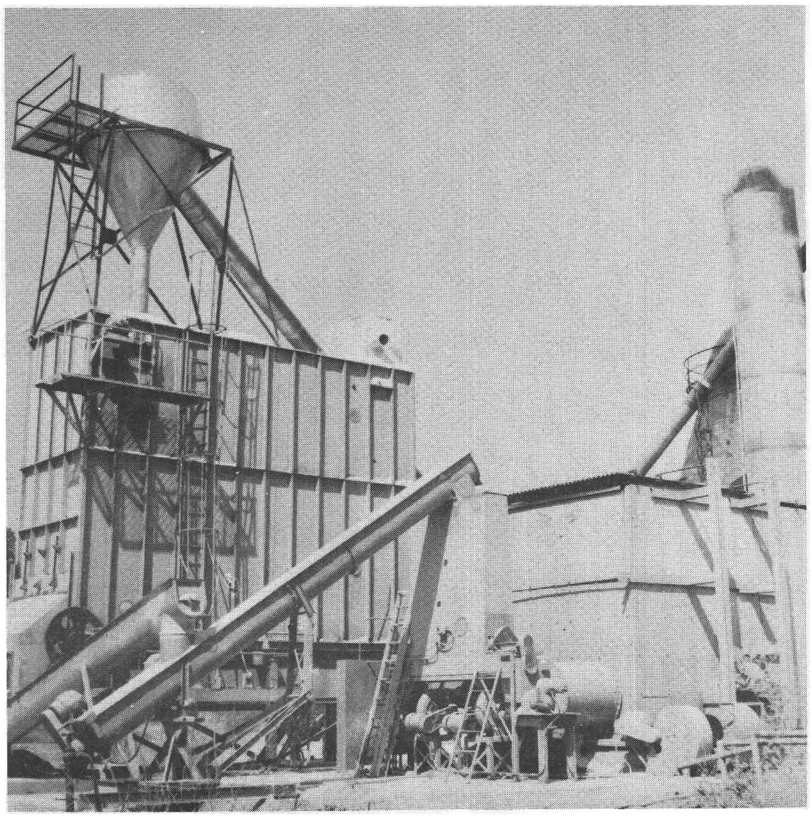


Figure 30. An incinerator burning dry wood waste.

Figure 31. An incinerator for dry hardwood waste.

Health Service (6). These incinerators will be discussed in the consultant's final report.

The consultant's study of incinerators is partially completed. Conclusions and future work will depend upon the results of the consultant's analysis.

WOOD AND BARK RESIDUES AS FUEL

Use of wood and bark residues for domestic fuel has been, in general, declining. Briquetted residues have been increasingly in demand for fireplaces, however. As sawdust and shavings increase in use for pulp and board products, briquets may offer an outlet for bark.

Large forest products firms commonly utilize mill residues as fuel to produce steam and power. Small plants sometimes produce steam from oil or gas while incinerating wood and bark wastes in wigwam burners. Unless wood-fired steam plants were large, economics of steam generation from residues often have been unfavorable because of excessive manpower requirements. Recently, some small, almost automatic, wood-fired steam plants have been installed in the forest products industry with reduced requirements for manpower. Because these furnaces are refractory lined and automatically controlled, favorable conditions for combustion tend to reduce air pollution. These considerations encourage further use of wood and bark residues as boiler fuel.

Plans are to analyze costs of installing and operating several small boiler plants presently in use in the forest products industry. Operating experience will be detailed.

Several boiler plants have been observed. One of these is shown in Figure 33. This particular plant furnishes steam for heating dry kilns to dry lumber. The plant incorporates a storage silo and sawdust dryer and operates without a full-time attendant.

Research engineers are assembling cost and technical information on plants such as the one illustrated. When analyses are completed, findings will be included in the final report.

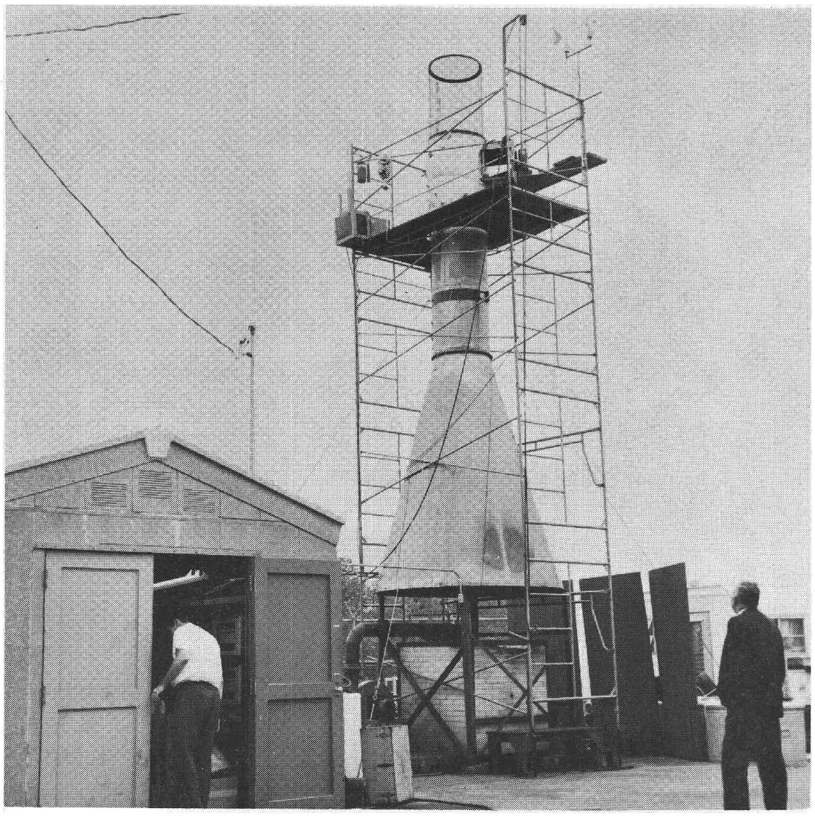


Figure 32. An experimental open-pit incinerator.

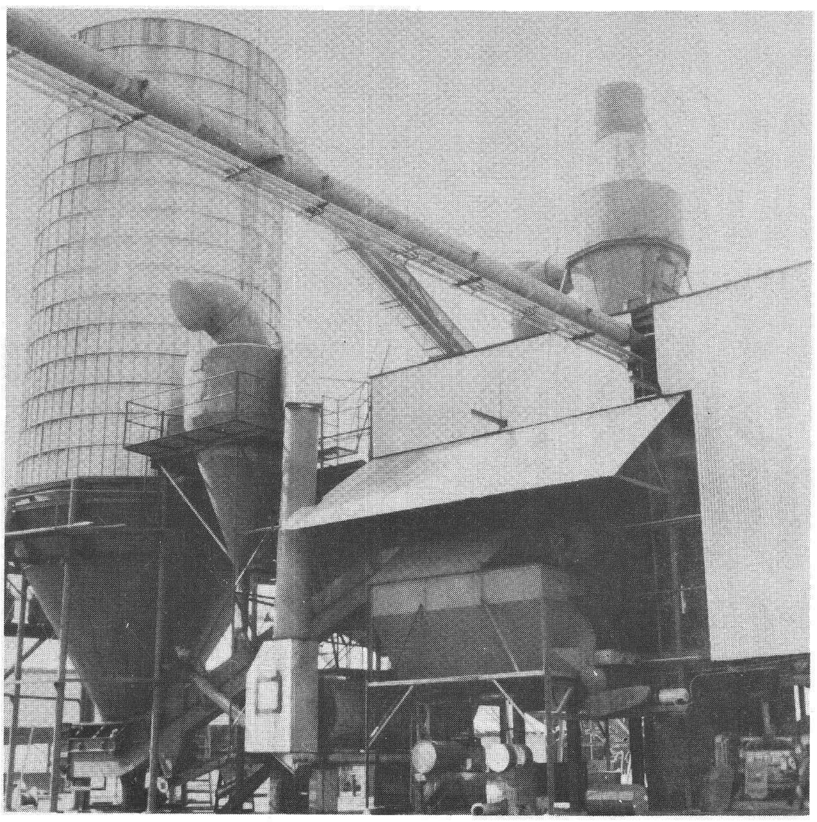


Figure 33. A small wood-fired steam plant.

SUPPORTING REPORTS

At the outset of this project, we found that certain important information necessary to the work in all phases of the study was out of date or nonexistent. The latest survey that listed the amounts and disposition of the various types of wood residue in Oregon industry was made in 1953. Up-to-date information on residues was needed to guide decisions in utilization studies and to show what kinds of waste were currently disposed of by burning. For example, if trends in utilization showed that use of sawdust in pulp was rapidly increasing, it would be better to encourage this use than to try to find better ways of burning sawdust. In the study of improvement of wigwam burners, burning characteristics of bark would be different than those of sawdust or slabs and edgings. Therefore, it is important to know for what fuel to design improvements.

In every utilization or disposal aspect of this study, transportation is an important factor in economic feasibility. Therefore, a separate study was planned to determine transportation costs.

A residue survey of all sawmills and plywood plants in Oregon has been conducted. There are about 600 such plants. Quantities of residue used and unused have been inventoried. Results indicate a large increase in the use of wood residues for paper and composition board manufacture in the last 14 years. In 1953, only about 6 percent of wood residues from sawmills and plywood plants was used for paper and composition board, compared to about 60 percent in 1967. Use of wood residues, including exports, for paper and composition board amounted to more than 6 million dry tons in 1967. The quantity of wood residues being burned in wigwam burners consequently has been reduced. About half of the bark produced in 1967 was used and the other half went to burners. A report of the residue survey is presently being prepared.

A related study of pulp, paper, and board plants was made to determine quantities of chips, shavings, and sawdust that were consumed by paper mills and manufactured board plants in Oregon (19). Quantities of chips exported to Japan also were determined. Figure 34 is a

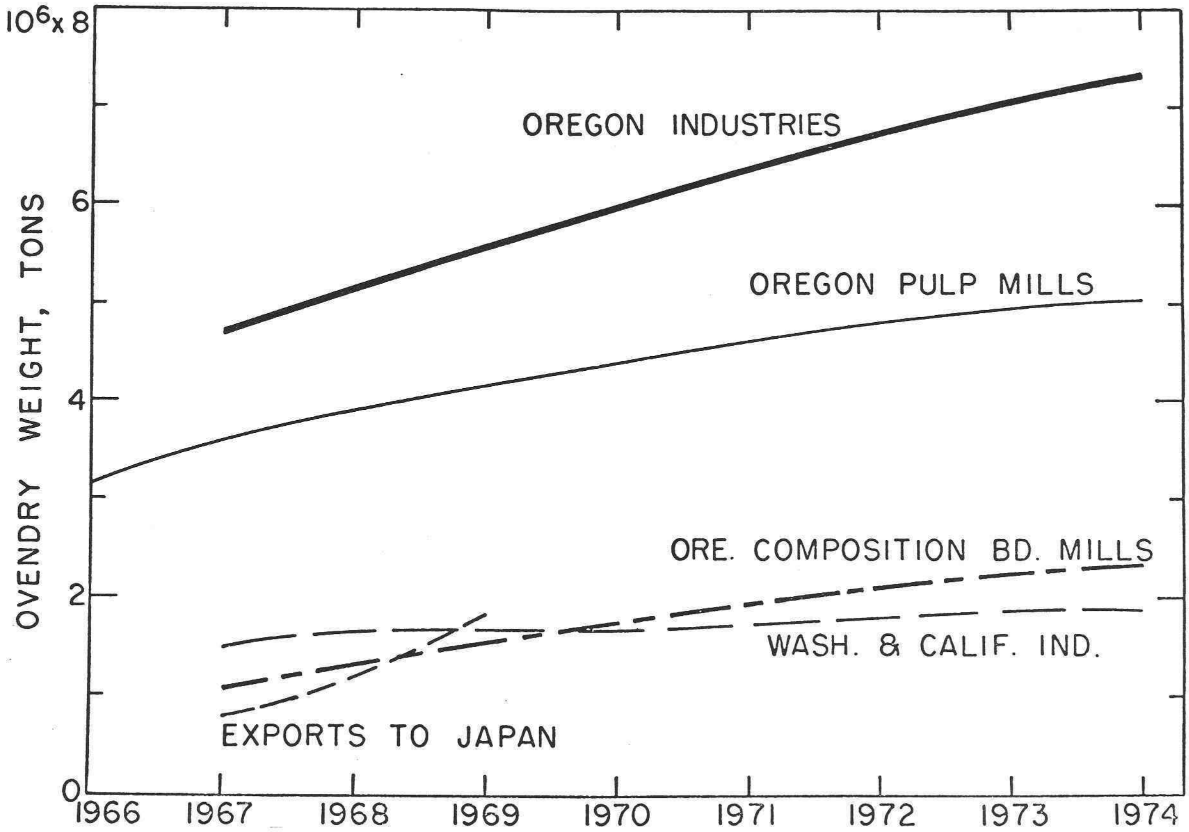


Figure 34. Estimated demand for wood residues from 1968-1974.

summary graph from the above report. The graph shows that in 1969 Oregon industries are expected to require nearly 6 million dry tons of wood residue for paper, particleboard, and fiberboard. Most of this material will be from chips, shavings, and sawdust. In the same year, about 1.5 million tons will be exported to Washington and California, and about 1.7 million tons will be exported to Japan, according to projections. Average price paid for chips exported to Japan in 1967 was $23.70 per unit (equivalent to 2,400 pounds of dry wood).

A report of the costs of transporting wood residues has been prepared (12). Figure 35, taken from that report, summarizes some

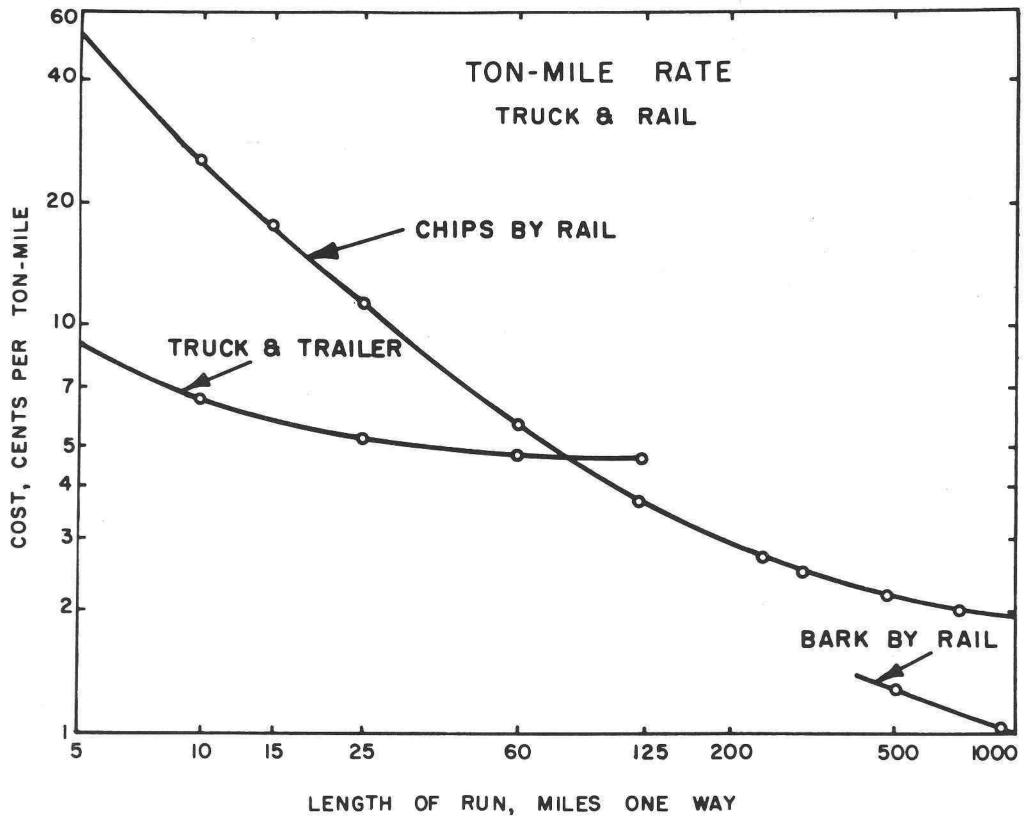


Figure 35. Costs of transporting wood residues.

of the results. Rail transportation costs for chips and bark were taken from quotations. Costs of truck and trailer transportation for wood residues such as chips, sawust, and hogged fuel, were calculated for large-capacity equipment and spot-checked against reported costs by truckers.

The reports show that, while utilization efforts have significantly decreased wood and bark waste, large quantities still are disposed of in wigwam burners. Greatest increase in use of wood residues has been in utilization of planer shavings, chips, and sawdust for pulp and composition board. This trend has reduced wood waste to the extent that present total waste is about half wood and half bark. Utilization will continue to increase and quantities of wood and bark waste requiring disposal will decrease.

Transportation costs may be the deciding factor in economic feasibility of many alternatives for utilization or disposal of wood and bark residue.

Preliminary reports for three of the four supporting studies just discussed have been prepared. Final reports of all studies will be prepared by August 1969.

PRELIMINARY GENERAL CONCLUSIONS

A large part of the residues from forest products industries is now being used. Some mills find profitable uses for all their residues. There still remain, however, significant quantities of residues that are disposed of in wigwam burners. Operation of wigwam burners frequently results in air pollution. The problem of air pollution from wigwam burners is urgent, and public pressure bears on industry and control agencies to do something about it. Therefore, work toward an immediate solution to the problem is of top priority. Immediate solutions appear to be the "burn it or bury it" solutions. With this in mind, these alternatives are receiving top priority.

Another important tentative conclusion of this study is that, for certain fuels, wigwam burners can be made to operate within existing air-pollution regulations, but tests are necessary to define optimum conditions.

The preliminary conclusion is that cost of disposal by landfill will be greater than by wigwam burner.

The largest and most important use of wood residues is in manufacture of paper and composition board, and expansion of this use will continue. The second largest use of wood and bark residues is as fuel. Use for fuel is not likely to expand greatly, but increase in wood utilization will result in greater use of bark as fuel.

Use of wood and bark residues as soil additives is increasing, and this market is expected to significantly increase.

Finally, chemical extractives could be the basis for a new forest products industry.

PLANS FOR CONCLUDING THIS STUDY

The main emphasis will be placed on modification and testing of a wigwam burner at a sawmill. Purpose of the tests is to evaluate modifications and gain results that will lead to recommendations for modification and improved operation of wigwam burners.

Other work presently in progress (landfill, wood and bark on the soil, chemical extractives from bark, incineration, and use as fuel) soon will be completed.

BIBLIOGRAPHY

1. Anderson, John W. and George H. Atherton. Economics of Producing Wax from Douglas Fir Bark. Unpublished report, For. Res. Lab., School of Forestry, Ore. State Univ. 25 pp. Oct. 1968.

2. Atherton, George H. and Stanley E. Corder. A Progress Report. Unpublished report, For. Res. Lab., School of Forestry, Ore. State Univ. 32 pp. Oct. 1968.

3. Boubel, R. W. 1965. Wood Residue Incineration in Teepee Burners. Circ. 34, Eng. Expt. Sta., Ore. State Univ. 30 pp. 1965.

4. Boubel, R. W. "Particulate Emissions from Sawmill Waste Burners." Sixty-first Annual Meeting of the Air Pollution Control Assoc., Paper No. 68-164, St. Paul, Minnesota. 34 pp. 1968.

5. Boubel, R. W., M. Northcraft, A. Van Vliet, and M. Popovich. Wood Waste Disposal and Utilization. Bulletin 39, Eng. Exp. Sta., Ore. State Univ. 93 pp. Aug. 1958.

6. Burckle, J. O., J. A. Dorsey, and B. T. Riley. "The Effects of the Operating Variables and Refuse Types on the Emissions from a Pilot-Scale Trench Incinerator." Proceedings of 1968 National Incinerator Conference, New York. pp. 34-41. 1968.

7. Corder, S. E., G. H. Atherton, and Paul E. Hyde. Site Visits and Consultations (A Photographic Record). Unpublished report, For. Res. Lab., School of Forestry, Ore. State Univ. 1968.

8. Corder, S. E., G. H. Atherton and M. L. Murray. Unpublished report, A Bibliography of Selected References. For. Res. Lab., School of Forestry, Ore. State Univ. 48 pp. Oct. 1968.

9. Cornell, Howland, Hayes, and Merryfield, Consulting Engineers.

Control of Wigwam Burner Combustion. An engineering report, CH_2M, Corvallis, Ore. 8 pp. Aug. 1968.

10. Cornell, Howland, Hayes, and Merryfield, Consulting Engineers. Removal of Particulate Matter from Wigwam Waste Burner Emissions. An engineering report, CH_2M, Corvallis, Ore. 8 pp. Aug. 1968.

11. Darley, E. F., F. R. Burleson, E. H. Mateer, J. T. Middleton, and V. P. Osterli. "Contribution of Burning of Agricultural Wastes to Photochemical Air Pollution." J. Air Poll. Control Assoc., 16(12):685-90. 1966.

12. Hyde, Paul E. Costs of Transporting Wood Mill Residues. Unpublished report, For. Res. Lab., School of Forestry, Ore. State Univ. 9 pp. Oct. 1968.

13. Hyde, Paul E. Particulate Sampling of Wigwam Burners. Unpublished report, For. Res. Lab., School of Forestry, Ore. State Univ. 12 pp. Oct. 1968.

14. Hyde, Paul E. and Stanley E. Corder. Disposal of Wood and Bark Wastes by Landfill. Unpublished report, For. Res. Lab., School of Forestry, Ore. State Univ. 10 pp. Oct. 1968.

15. Kreichelt, Thomas E. Air Pollution Aspects of Teepee Burners Used for Disposal of Municipal Refuse, U.S. Public Health Service, Cincinnati, Ohio. Pub. No. 999-AP-28. 35 pp. 1966.

16. Kurth, E. F., and H. J. Kiefer. "Wax from Douglas Fir Bark." Tappi 33(4):183-6. April 1950.

17. McKenzie, H. W. Wigwam Waste Burner Guide and Data Book. Oregon State Sanitary Authority, Portland, Oregon. 14 pp. March 1968.

18. Popovich, M. "How to Burn Wood Waste without Smoke." Air Engineering, 4(10):16. 1962.

19. Scroggins, Thomas L. Use of Wood Residues in Oregon for Pulp and Composition Board. Unpublished report, For. Res. Lab., School of Forestry, Ore. State Univ. 16 pp. Oct. 1968.