HANDLING BURLEY TOBACCO on PORTABLE CURING FRAMES

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HANDLING BURLEY TOBACCO ON PORTABLE CURING FRAMES

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SUMMARY

Burley tobacco can be handled on portable curing frames with a front-mounted tractor-loader with about half the man-hours per acre required by conventional tobacco production practice. Approximately half the man-hours required by this partly mechanized handling system involves manual labor. The work, performed by a smaller crew, is both easier and safer than that performed with conventional handling methods.

Unit production costs of the experimental system are generally independent of acreage, with the exception of amortization of tractor-loader and wagons.

Labor advantages for handling burley tobacco on portable curing frames with tractor-loaders are:

- Safer and easier work.
- Reduced labor requirement.
- Reduced crew size.
- Improved scheduling of labor.

INTRODUCTION

The Problem

Labor problems are severe when harvested stalk-cut burley tobacco is removed from the field and placed in an air-cured barn. This operation, known as housing, is part of the conventional method of tobacco production. The housing operation must be completed as quickly as possible, since harvested tobacco wilting in the stick row is easily damaged by mud during rain. When a field and a barn crew work simultaneously, the grower must have a labor force from six to eight workers to maintain a reasonably efficient operation (fig. 1).

When tobacco plants are harvested, the plants first are placed on sticks and left to wilt in the field for 2 to 4 days. This practice makes the plants easier to handle in the barn and reduces problems associated with air curing.

Cured tobacco hangs in openly constructed barns until it absorbs sufficient moisture during humid weather to become pliable. This process is called "casing." Since the grower must depend on appropriate weather to remove cured tobacco from the barn, he frequently has problems in scheduling labor assignments.

Bondurant and Hole (1) reported that labor performance varies widely among farms.2 The average farm labor crew requires about 40 man-hours per acre to house tobacco and 15 man-hours per acre to take down and bulk the cured tobacco for stripping.

Problems of housing and takedown are caused as much by the difficulty of scheduling a large crew for disagreeable work as by the required man-hours of labor. Some workers refuse assignment to the tier rails because of the poor working conditions and hazards involved (fig. 1).

Objective

The objective of the work reported in this publication is to improve labor productivity by handling burley tobacco on portable curing frames with tractor-loaders.

1 Paper No. 71-2-88, approved for publication by the director of the Kentucky Agricultural Experiment Station, Lexington.

2 Italic numbers in parentheses refer to Selected References, p. 25.
EQUIPMENT REQUIRED FOR THE PORTABLE FRAME SYSTEM

A tobacco-handling system developed by the USDA and University of Kentucky Agricultural Experiment Station includes portable curing frames, a tractor-loader, transport wagons, curing barns, and an optional casing structure with a water evaporator.

Handling tobacco on portable frames with loaders allows considerable versatility for selection of equipment and work methods. These selections will be influenced by the type and amount of equipment and labor existing at the farm. A typical method for using the equipment is shown in figure 2. Equipment and work procedures are illustrated in figure 3. Material lists and test results are tabulated in the appendix.

Portable Curing Frames

General Requirements

The frames should be capable of supporting freshly harvested tobacco. The assumed loading on each rail is 50 pounds per foot of rail. For harvested plants 6 feet long, the top surface of the rails should be at least 6 feet above the bottom of the frame to permit ventilation of tip tobacco during wilting and curing. Rails higher than 6 feet 3 inches are inconvenient to fill at the field. An overall frame height of 7 feet provides adequate ventilation between tiers of frames during curing. Allow at least 5 inches of vertical clearance for inserting the loader tines between the base of the frame and the ground and between the base of the frame and tobacco stalk butts. Construct the frames so that they can be stacked even when mispositioned as much as 3 inches. The structural members of the filled frames should be visible to the tractor-loader operator.

Brace the frames in three directions. Because about 50 percent of the labor required by the handling system involves the manual handling of tobacco into and out of the frames, place braces where they will not be in the way of workers.

Three types of curing frames are described here.

Wood Frames

Wood frames can be cut with minimum waste from standard length lumber. One frame (fig. 4, top) can be constructed from 88 board feet of
HANDLING BURLEY TOBACCO ON PORTABLE FRAMES

unplaned lumber or 101 board feet of planed lumber. Parts can be cut from salvage lumber having dimensions not less than those of the specifications. The service life of the frames will be increased if a wood preservative is applied to the parts that contact the soil.

One frame can be constructed with assembly jigs (fig. 4, bottom) in approximately 50 man-minutes.

Bolted-Steel Frames

Bolted-steel frames can be constructed of 12- and 14-gage hot-dipped galvanized steel. Equipment for shearing, punching, and roll-forming light-gage steel is suited for factory fabrication of these frames. Economical structural steel shapes can be efficiently packaged for shipping. All parts of the frame can be quickly removed for repair or replacement. (fig. 5).

Welded-Steel Frames

Frames can be constructed of welded metal. Metal cut-off saws or shears are not normally available to a grower except at the metal supplier. The cost of shop cuts should be considered when purchasing metal.

A typical welded frame made from standard steel angles and flats is shown in figure 6. Jigs reduce welding time. Bare metal should be spray painted to prevent rusting.

Air-Cure Barns

Requirements

Locate air-cure barns on well-drained sites where wind movement is not greatly impaired by topography, trees, or buildings. Provide an area adjacent to the barn adequate for maneuvering the tractor-loader and transport wagons. Select a site where roads or farm lanes between the field and barn will not restrict transporting the frames.

The interior vertical height of a barn should exceed by at least 1 foot 6 inches the total height of two stacked frames. Doorways should be at least 1 foot higher than the total height of two stacked frames to allow two tiers of frames to be stacked adjacent to the doorway. For moving and stacking single frames, horizontal clearance across doorways or between poles should be at...
FIGURE 3.—Handling tobacco in portable curing frames: A, Empty frames are transported and distributed around field before harvest; B, frames may be filled within 1 day after harvest; C, loader-operator brings empty frames from edge of field; D, tobacco wilts on frames for about a week; E, frames of wilted tobacco are transported to curing barn; F, more than one wagon can be towed by tractor-loader; G, portable frames eliminate tier rails in air-curing barn; H, frames are stacked two high in barn; I, operator can transport and house frames of tobacco without assistance; J, sidewall doors are opened, as in conventional curing methods; K, frames of cured, out-of-case tobacco can be removed from barn and placed in tight structure for steam casing; L, naturally cased or steam-cased tobacco is transported to stripping shed.
least 1 foot 6 inches wider than the frame length. Interior horizontal clearance across a clear-span barn should be approximately the combined lengths of the frames plus 1 foot for each frame.

Place the equipment doors to allow straight-line movement of the tractor-loader while it is handling and stacking the frames. When equipment doors are installed at end walls, install these doors at both ends of barns longer than 200 to 250 feet.

Doors for sidewall ventilation should provide approximately 50-percent maximum sidewall opening. Supplemental heat can be satisfactorily distributed below and between the frames of tobacco with fans. However, field trials have indicated that supplemental heat is unnecessary, even during difficult curing seasons, if frame-wilted tobacco is housed in a well-ventilated barn. Ridge ventilators are not required.

Make the floor smooth and level. An earth
1. LIST OF MATERIALS SHOW MINIMUM RECOMMENDED NOMINAL DIMENSIONS FOR STRUCTURALLY SOUND UNPLANED LUMBER. IF FRAME IS CONSTRUCTED FROM PLANED LUMBER, CUT PARTS G AND H FROM 2" x 4" MATERIAL.

2. APPLY DIP TREATMENT PENTACHLOROPHENOL WOOD PRESERVATIVE, OR EQUIVALENT, AT MANUFACTURER'S RECOMMENDATIONS TO PARTS D AND E TO BE INSTALLED AT BOTTOM OF FRAME, TO LOWER 12 INCHES OF PARTS C, AND TO THE LOWER 12 INCHES OF PARTS H.

3. SELECT RING OR SCREW-SHANK NAILS OF SUFFICIENT LENGTH TO OBTAIN FULL PENETRATION WITHOUT BREAK-THROUGH. SUGGESTED SIZES ARE 8 AND 12 PENNY FOR PLANED LUMBER, AND 10 AND 16 PENNY FOR UNPLANED LUMBER.

### List of Materials for One Frame:

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>DESCRIPTION</th>
<th>QUANTITY</th>
<th>DIMENSION</th>
<th>CUT FROM</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>RAIL</td>
<td>2</td>
<td>2&quot; x 4&quot; x 14' - 0&quot;</td>
<td>2&quot; x 4&quot; x 14'</td>
</tr>
<tr>
<td>B</td>
<td>BASE</td>
<td>2</td>
<td>2&quot; x 4&quot; x 8' - 0&quot;</td>
<td>2&quot; x 4&quot; x 8'</td>
</tr>
<tr>
<td>C</td>
<td>LEG</td>
<td>4</td>
<td>2&quot; x 4&quot; x 7' - 0&quot;</td>
<td>2&quot; x 4&quot; x 7'</td>
</tr>
<tr>
<td>D</td>
<td>TIE</td>
<td>4</td>
<td>2&quot; x 4&quot; x 6' - 8&quot;</td>
<td>2&quot; x 4&quot; x 14'</td>
</tr>
<tr>
<td>E</td>
<td>SPACER</td>
<td>4</td>
<td>2&quot; x 4&quot; x 4' - 0&quot;</td>
<td>2&quot; x 4&quot; x 14'</td>
</tr>
<tr>
<td>F</td>
<td>BRACE</td>
<td>4</td>
<td>2&quot; x 4&quot; x 4&quot; - 6&quot;</td>
<td>2&quot; x 4&quot; x 12'</td>
</tr>
<tr>
<td>G</td>
<td>BRACE</td>
<td>4</td>
<td>1&quot; x 4&quot; x 4&quot; - 6&quot;</td>
<td>1&quot; x 4&quot; x 12'</td>
</tr>
<tr>
<td>H</td>
<td>BRACE</td>
<td>4</td>
<td>1&quot; x 4&quot; x 2&quot; - 11/2&quot;</td>
<td>1&quot; x 4&quot; x 12'</td>
</tr>
<tr>
<td>I</td>
<td>BRACE</td>
<td>4</td>
<td>1&quot; x 4&quot; x 6&quot; - 0&quot;</td>
<td>1&quot; x 4&quot; x 12'</td>
</tr>
<tr>
<td>NAILS</td>
<td></td>
<td>3 LB.</td>
<td></td>
<td>AS REQUIRED</td>
</tr>
</tbody>
</table>

PENTACHLOROPHENOL AND DILUTANT, OR SUITABLE WOOD PRESERVATIVE.

Dimensions of this frame meet requirements of the curing barn of Figure 8 and of Figure 9. If the frame is to be placed in a modified conventional curing barn, reduce length of rails (parts A) as shown in Figure 7.
Figure 4.—Top, 14-ft. wood portable curing frame; bottom, jig for fabricating and assembling wood frames.
floor is satisfactory. Crushed rock can be spread on the floor if dust occurs during repeated movement of the tractor-loader. Normally, weather conditions during takedown are such that a graveled apron is necessary in front of barns that have end-wall doors.

Modified Conventional Barn

Existing conventional barns in sound structural condition can be modified for housing tobacco on portable frames. A barn considered for modification should be first thoroughly inspected, particularly at the timber joints and at the foundation. Damaged joints, decayed wood at sills and piers, and inadequate masonry foundation must be capable of being repaired or replaced economically to justify the cost of modifications.

Three advantages for moving frames through sidewalls of a modified barn instead of through end walls are:

- Less barn bracing is removed or distributed.
- Clearances for frames are uniform.
- Large sidewall doors assure good ventilation during air curing.

A guide for modifying a conventional barn is shown in figure 7. Major renovations are removing tier rails, moving interior lengthwise diagonal bracing upward to provide approximately 16 feet of vertical clearance, and installing track-mounted sidewall doors.

Normally, dust on the earth floor during housing will not be a problem in modified barns having sidewall entry for the tractor-loader. Well-drained sodded ground outside the barn is required.

Portable curing frames (figs. 4, 5, and 6) 2 feet shorter than the normal center-to-center pole spacings can be conveniently handled and stacked in the barn. Tier rails removed from the barn can be used in building wood frames.

Loads and Lumber Stresses

Drawings for two types of newly constructed barns are shown in figures 8 and 9. For these barns maximum loads caused by wind-velocity pressure and snow on each newly constructed barn are each assumed to be 15 pounds per square foot (p.s.f.). Working unit stresses for lumber are computed for material having planed dimensions one-half inch less than nominal size. Allowable unit stresses for lumber (No. 2 dense southern yellow pine) are 1,300 pounds per square inch (p.s.i.) at extreme fiber in bending, 925 p.s.i. tension parallel to grain, 1,000 p.s.i. compression parallel to grain, and 400 p.s.i. compression perpendicular to grain. These allowable unit stresses are modified by factors 1.15 and 1.33 for short-term loads caused by snow and wind, respectively.

Standards occasionally are revised for planing dimensions and for allowable unit stresses of different lumber grades and wood species. Consult an engineer if materials do not meet these specifications.

Rafter-Roof Barn

A rafter-roof, rigid-pole barn (fig. 8) is applicable where interior poles spaced at approximate 12-by 16-foot centers will not conflict with other

Figure 5.—Left, factory-fabricated steel frames can be conveniently assembled at farm with impact wrench and are easy to maintain; right, frames are long lasting and withstand out-of-doors storage.
anticipated barn uses. Roof and wall framing is suited for locally milled unplaned lumber.

Material to construct one 12-foot bent is listed in appendix table 1.

**Truss-Roof Barn**

Advantages of the clear span of a truss-roof, rigid-pole barn (fig. 9) are unrestricted movement of the tractor-loader while handling the portable

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**Figure 6.**—Welded-steel frame: A, Welded frame constructed from standard angles and bars; B, jigs are helpful for assembling the frame; C, approximately 80 man-minutes are required to weld each frame.
Modifications of a conventional air-cure tobacco barn for side-wall entry of portable curing frames:

1. Side-wall doors: Install single track for full length of each side of barn at minimum vertical clearance of 15'-0". Construct sliding doors for opening at even-numbered bents for one side of barn, and at odd-numbered bents for other side of barn. Nail shut the conventional side-wall ventilators not converted to sliding doors.

2. End-wall doors: No modification is required.

3. Side-wall bracing: Remove girts and side-wall bracing at the bent walls to be opened by sliding doors. Install diagonal bracing at each side-wall bent not opened.

4. Tier rails: Remove tier rails to provide minimum interior vertical clearance of 16'-0". Retain sufficient tier rails above 16'-0" to provide adequate longitudinal tying within the barn.

5. Cross-tees and cross bracing: No modification is required.

6. Longitudinal bracing: Modify all longitudinal diagonal bracing between interior poles to provide vertical clearance at the pole of 18'-0".

7. Floor: Earth floor should be smooth and level. Floor sill at side-wall entry doors should be smooth.

8. Portable curing frames: Length of stick rails of portable curing frame described by figures 4, 5, and 6 are to be 2'-0" less than the center-to-center bent spacing of the barn columns.

9. Barn capacity: When tobacco sticks are spaced at 5" inch intervals on portable curing frames stacked two-high in a modified barn of 40-feet width, each 12-foot bent or 14-foot bent will hold 400 or 480 sticks, respectively.

Figure 7.—Modified conventional tobacco-curing barn.
frames, and versatility for other farm activities. Locally milled unplanned lumber is suited for all construction except trusses. Material to construct one 8-foot bent is listed in appendix table 2.

The trusses may be commercially fabricated and installed at intervals recommended by the fabricator, or fabricated on site by nail-glue, plywood-gusset construction (fig. 10) for installation at 4-foot intervals.

Nailed connections are used for planed or unplanned lumber for purlins, beams, pole bracing, and scabs meeting loading conditions specified in figure 9 when trusses are spaced at intervals of either 4 feet, 2 feet 8 inches, or 2 feet.

Trusses should be lifted to the truss support beams with web members held vertical. To do this, a lifting height is required that can be provided by a mobile crane or movable gin poles. Extensions on farm tractor-loaders are usually not sufficiently strong to handle a 46-foot truss.

Four end-wall panels sliding on an exterior-mounted double track (fig. 9) provide access for straight-line movement of the tractor-loader during housing. Sliding panels are moved during housing for access to each of the three respective rows of frames.

**Tractor-Loader**

**Requirements**

Either vertical-mast or conventional farm loaders are suited for handling portable curing frames. An advantage of conventional front-mounted tractor-loaders is their versatility for other farm activities.

Tractors for front-mounted loaders require rear-tire fluid, rear-wheel weights, and, possibly, an auxiliary weight carried on the three-point hitch (figs. 3E and 3G). Front tires should be 6.50 by 16, or larger. An automatic hitch is an inexpensive convenience for the operator (fig. 37).

Minimum manufacturer's ratings for conventional front-mounted tractor-loaders are:

- Rated lifting capacity: 1,500 pounds for full lift.
- Height to bucket or tine pin: 8 feet 6 inches at full lift.
- Number of tine cylinders: One or two.

Required modifications for the tractor-loaders are:

- Tines: Spacing not less than 4 feet.
- Masts: Channel or pipe, capable of supporting frame at accidental rearward tipping, welded to rear of each tine as shown in figure 3. These are essential for operator's safety.
- Self-leveling tines are not required but are a convenience that normally justify the cost to farmers growing more than 2 or 3 acres of tobacco. A self-leveling feature is available as optional equipment from some loader manufacturers. When self-leveling tines are not commercially available for either a new or a used loader, either a mechanical or a hydraulic self-leveling device can be installed at the farm or local shop.

**Mechanical Linkage For Self-Leveling Tines**

An advantage of modifying the tractor-loader with a mechanical self-leveling device is that existing hydraulic controls are unchanged. A disadvantage may be the clutter of added structural members. Construction of two typical mechanical self-leveling devices are described in figure 11. Each involves installations of two linkage members at each side of the loader.

The No. 2 linkage members may be optionally installed to act normally in compression or to act normally in tension, whichever is most suited to clearances at the front wheels of the tractor. The essential requirement for either type of mechanical self-leveling device is to install the pins at locations and dimensions according to construction notes 3 to 7 in figure 11.

**Slave Cylinders For Self-Leveling Tines**

One method of modifying a loader for hydraulic self-leveling is by adding slave cylinders to the existing hydraulic circuit. Slave cylinders act as parallel-connected hydraulic pumps for moving oil into and out of the rod end of the tine cylinders (or single-tine cylinder) while the load is lowered or raised by the boom cylinders. The desired rate of pumping is obtained by selecting slave cylinders that have a combined rate of cylinder displacement at the blind end (the end opposite the rod) equal to the combined rate of displacement at the rod end of the tine cylinders.

The rate of displacement at the blind end of the slave cylinders is determined by selection of bore
RAFTERS SPACED 2'-0" O.C.

1. THIS BARN IS DESIGNED FOR EITHER PLANED OR UNPLANED LUMBER EQUIVALENT TO 2" DENSE SOUTHERN YELLOW PINE TO WITHSTAND SNOW OR WIND LOAD OCCURRING WITHIN A 25-YEAR RECURRENCE INTERVAL FOR STATES OF TENNESSE, KENTUCKY, WEST VIRGINIA, INDIANA, AND OHIO.

2. MINIMUM CIRCUMFERENCE OF 22-25 FOOT CLASS 5 TREATED POLES MEASURED AT THE TOP AND 6 FEET FROM BUTT SHOULD BE 19 AND 26 INCHES, RESPECTIVELY.

3. USE RING SHANK OR SCREW SHANK NAILS.

CONSTRUCTION NOTES:

FOR DETAILED INSTRUCTIONS ON CONSTRUCTION PROCEDURE FOR ERECTING A POLE-TYPE BUILDING OBTAIN THE 16-PAGE BULLETIN "HOW TO ERECT A POLE-TYPE CLEAR SPAN BUILDING," FARM BUILDING SERIES CIRCULAR 735, COOPERATIVE EXTENSION SERVICE, DEPARTMENT OF AGRICULTURAL ENGINEERING, MICHIGAN STATE UNIVERSITY, EAST LANSING, REPRINT MAR, 1963.

1. TOP EDGE OF SIDE WALL RAFTER SUPPORT BEAMS INSTALLED 15'-3" ABOVE GROUND WILL PROVIDE 1'-6" TO 2" INCHES OVERLAP OF 14'-0" SIDE WALL SHEATHING OVER THE TRUSS SUPPORT BEAM AND LOWER GIRT. SIDE WALL VENTILATING DOORS MADE FROM 14-FOOT WOOD SHEATHING ARE OF CONVENTIONAL CONSTRUCTION, EACH DOOR IS TO BE APPROXIMATELY 2 FEET WIDE AND ATTACHED TO THE BARN WITH 3 SUITABLE STRAP HINGES.

2. A DOUBLE TRACK IS TO BE INSTALLED EAVE HEIGHT AT ONE END OF THE BARN ACROSS A SIDE ALLEY AND THE CENTER ALLEY, WITH A SINGLE TRACK CONTINUING ACROSS THE REMAINING SIDE ALLEY. CONSTRUCT 3 SLIDING DOOR PANELS APPROXIMATELY 12'-0" X 15'-0".

3. DOOR CONSTRUCTION AT OTHER END IS OPTIONAL. OPTIONAL END WALL CONSTRUCTION IN SKETCH AT RIGHT SHOWS EQUIPMENT DOORS FRAMED IN CENTER ALLEY AND MOUNTED ON SINGLE TRACK.

MOVEMENT OF DOORS DURING HOUSING AND TAKING DOWN TOBACCO
Figure 8.—Top, Rafter-roof, rigid-pole barn for curing tobacco; bottom, joint detail for barn.
NAIL-GLUE PLYWOOD-GUSSET TRUSSES SHOWN IN FIGURE 10 AT 4'-0" O.C., OR
PRESSED-ON METAL-GUSSET TRUSSES AT SPACING SPECIFIED BY FABRICATOR.
INSTALL 2" X 6" X 4' BRACES ON INSIDE OF BARN ONLY
INSTALL 2" X 6" X 3' SCABS ON BOTH SIDES OF POLE
MINIMUM OF 4'-0" CONCRETE EMBEDMENT IN ROCK HOLE, OR
8" CONCRETE FOOTER WITH MINIMUM OF 5'-6' WELL-TAMPED EARTH EMBEDMENT

MATERIALS NOTES:
1. THIS BARN IS DESIGNED FOR EITHER PLANED OR UNPLANED LUMBER EQUIVALENT TO #2 DENSE SOUTHERN YELLOW PINE
TO WITHSTAND SNOW OR WIND LOAD OCCURRING WITHIN A 25-YEAR RECURRENCE INTERVAL FOR STATES OF TENNESSEE,
KENTUCKY, WEST VIRGINIA, INDIANA AND OHIO.
2. MINIMUM CIRCUMFERENCE OF 22 - 25 FOOT CLASS 4 TREATED POLES MEASURED AT THE TOP AND 6 FEET FROM BUTT
SHOULD BE 21 AND 28 INCHES, RESPECTIVELY.
3. USE RING SHANK OR SCREW SHANK NAILS.
4. STRENGTHS OF TRUSS SUPPORT BEAMS AND NAILED CONNECTIONS ARE DESIGNED FOR MAXIMUM LOADING
CONDITIONS OCCURRING FOR TRUSS SPACING OF 2'-0", 2'-8", OR 4'-0" O.C.

CONSTRUCTION NOTES:
FOR DETAILED INSTRUCTIONS ON CONSTRUCTION PROCEDURE FOR ERECTING A POLE-TYPE BUILDING OBTAIN THE 16-PAGE
BULLETIN "HOW TO ERECT A POLE-TYPE CLEAR SPAN BUILDING," FARM BUILDING SERIES CIRCULAR 725, COOPERATIVE
EXTENSION SERVICE, DEPARTMENT OF AGRICULTURAL ENGINEERING, MICHIGAN STATE UNIVERSITY, EAST LANSING.
1. TRUSS SUPPORT BEAMS INSTALLED FOR 15'-9" VERTICAL CLEARANCE WILL PROVIDE 1 1/2 TO 4 INCHES OVERLAP OF
14'-0" SIDEWALL SHEATHING OVER THE GIRTS. SIDEWALL VENTILATING DOORS MADE FROM 14-FOOT WOOD SHEATHING
ARE OF CONVENTIONAL CONSTRUCTION. EACH DOOR IS TO BE APPROXIMATELY 2 FEET WIDE AND ATTACHED TO THE
BARN WITH 3 SUITABLE STRAP HINGES.
2. A DOUBLE-TRACK IS TO BE INSTALLED FULL WIDTH OF BARN AT ONE END, SUPPORTED BY TWO TRUSSES, CONSTRUCT 4
SLIDING DOOR PANELS APPROXIMATELY 12'-6" X 15'-6".
3. DOOR CONSTRUCTION AT OTHER END IS OPTIONAL.
OPTIONAL WALL CONSTRUCTION IN SKETCH AT RIGHT SHOWS EQUIPMENT DOORS MOUNTED ON SINGLE TRACK
AND FRAMED BETWEEN INTERMEDIATE END WALL POLES.

MOVEMENT OF DOORS DURING HOUSING AND TAKEDOWN TOBACCO

END VIEW

SIDE VIEW
TRIM TOP OF POLE AFTER NAILING TRUSS

EIGHT 40 D NAILS

2" x 6" x 4" BRACES INSIDE OF POLE,
FOUR 12 D OR 20 D NAILS

2" x 10" x 16" ALL TRUSS SUPPORT BEAMS,
FOUR 40 D NAILS FOR EACH CONNECTION

2" x 6" x 16' ALL GIRTS,
THREE 20 D NAILS EACH SIDE

INSTALL 2" x 6" x 7' - 6" STIFFENER
IF GIRTS ARE PLANED

2" x 4" GABLE TRIM

TREATED POLE

TREATED POLE

2" x 6" x 3' SCABS BOTH SIDES OF POLE,
EIGHT 40 D NAILS

2" X 6" x 16' GIRT

DETAIL AT INSIDE OF POLE

DETAIL FOR GABLE

WOOD OR METAL SHEATHING

2" x 4" TRUSS BLOCKING, EXTEND
TO TOP CHORD OF TRUSS

LOWER CHORD OF INNER TRUSS

LOWER CHORD OF OUTER TRUSS

METAL FLASHING

HANGER

DOUBLE TRACK

DETAIL FOR DOUBLE TRACK

ATTACH SHEET METAL ROOF ACCORDING TO
MANUFACTURER'S RECOMMENDATIONS

2" x 4" x 18' PLANED FOR TRUSSES AT
4' - 0" O.C., 1" x 4" x 18' UNPLANED
FOR TRUSSES AT 2' - 6" O.C.

TWO 10 D OR 12 D NAILS

2" X 10" DOOR HEADER

2" X 6" x 16' FASCIA

PURLINS AT 2' - 6" O.C.

DETAIL FOR SINGLE TRACK

DETAIL FOR PURLINS AND FACIA

Figure 9.—Top, Truss-roof, rigid-pole barn for curing tobacco; bottom, joint detail for barn.
and stroke of the slave cylinders, and by slave-cylinder mounting position. One slave cylinder is adequate for hydraulic considerations; however, two cylinders should be installed to prevent the loader frame from being twisted.

An advantage for this type of modification is that no additional structural members are added. Construction of a slave-cylinder self-leveler is shown in figure 12. Materials are two clevis-mount double-acting cylinders, four cylinder-mounting brackets, two pressure-relief valves, two adjustable flow-control valves, and hydraulic lines and fittings. Pressure ratings of this equipment should be equivalent to hydraulic equipment existing on the loader.

The cylinder brackets usually must be installed on the side of the loader frame and boom to provide clearance when boom cylinders are at their extended position.

Adjustable flow-control valves to the boom and tine cylinders are desired for convenient adjustment of piston speed by the operator. These are usually needle-type valves. Pressure-relief valves are required to prevent excessive pressures during certain operating conditions.

Some loaders require slightly slower piston speed of leveled-tine cylinders while tines are near the ground. These loaders will require a smaller slave-cylinder bracket angle (fig. 12). To obtain this angle without affecting the displacement of the slave cylinders, move the rear bracket forward and upward while moving the front bracket forward and down.

Transport Wagons

Empty and filled frames are transported between the field and the barn on conventional farm wagons. These wagons may be modified by attaching steel- or wood-cross bunks to either the flatbed or the chassis (fig. 13). Each set of bunks carries two frames.

Loader operation is more convenient when all frames can be handled from either side of the wagon. This convenience is assured when bunks are attached to the chassis and may be available when bunks attached to the flatbed. Wagons having wheel tread less than 6½ feet may be unstable during loading and unloading.

Casing Equipment

Casing Structure

A method of casing with steam involves transferring batches of cured out-of-case tobacco from the openly constructed curing barn to a tight structure. A structure capable of holding 6 to 10 frames is adequate for continuously supplying cased tobacco to a 6-member stripping crew. Tobacco can be satisfactorily cased with a simple water evaporator of low capacity when the structure is tightly constructed to retard infiltration of outside air.

A tight structure can be constructed by installing 6-mil polyethylene film as a covering to a simple temporary wooden framework, as drop curtains partitioning part of a curing barn, or as a lining within an existing utility building. To prevent tearing the plastic while handling the frames, make the building about 4 feet wider than the length of the frames.

Roof slope should be at least 3:12 for a covered temporary framework. The film should entirely cover the ceiling and all walls. A rolled drop curtain sealed by temporary battens forms a convenient and tight doorway.

Gravel or crushed rock on an earth floor will prevent muddy conditions during casing.

Water Evaporator

A desirable characteristic for a steam generator is the capability for safe and unattended operation with minimum adjustment and maintenance. At most installations the equipment will be exposed to freezing temperatures during shutdown. A steam generator requiring pressured water supply and an electrical supply other than single phase 110-volt service will have only limited application.

A simple steam generator capable of casing tobacco under these conditions is shown in figure 14. This equipment consists of a portable heater discharging into an insulated cabinet containing overflowing evaporating pans.

Water is metered through a fixed orifice from a gravity reservoir. A fractional-horsepower fan circulates air within the casing structure. The 110-volt heater and fan are plugged into a duplex outlet energized by a normally open pressure switch.
LIST OF MATERIALS:

<table>
<thead>
<tr>
<th>MEMBER</th>
<th>QUANTITY</th>
<th>OVERALL DIMENSION</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2</td>
<td>2&quot; x 8&quot; x 18&quot; - 0&quot;</td>
</tr>
<tr>
<td>B</td>
<td>2</td>
<td>2&quot; x 8&quot; x 8&quot; - 0&quot;</td>
</tr>
<tr>
<td>C</td>
<td>1</td>
<td>2&quot; x 5&quot; x 10&quot; - 11 3/4&quot;</td>
</tr>
<tr>
<td>D</td>
<td>2</td>
<td>2&quot; x 6&quot; x 17&quot; - 7 5/8&quot;</td>
</tr>
<tr>
<td>E</td>
<td>2</td>
<td>2&quot; x 4&quot; x 2&quot; - 5 1/2&quot;</td>
</tr>
<tr>
<td>F</td>
<td>2</td>
<td>2&quot; x 4&quot; x 8&quot; - 0&quot;</td>
</tr>
<tr>
<td>G</td>
<td>2</td>
<td>2&quot; x 4&quot; x 5&quot; - 0 7/8&quot;</td>
</tr>
<tr>
<td>H</td>
<td>2</td>
<td>2&quot; x 4&quot; x 9&quot; - 0 1/2&quot;</td>
</tr>
<tr>
<td>PLYWOOD</td>
<td></td>
<td>5/8&quot; x 4&quot; x 0&quot; x 8&quot; - 0&quot;, AND</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5/8&quot; x 1&quot; - 0&quot; x 4&quot; - 4&quot;</td>
</tr>
</tbody>
</table>

CUTTING DIAGRAM FOR
PLYWOOD GUSSET PLATES

1. THIS TRUSS SPACED AT 4-FOOT INTERVALS MEETS LOADING CONDITIONS DESCRIBED IN FIGURE 9 MATERIAL NOTE 1.
2. USE 5/8" EXTERIOR PLYWOOD C-C PLUGGED OR EQUIVALENT, FOR GUSSET PLATES.
3. USE PLANED SOUTHERN YELLOW PINE GRADE NO. 1 KD, OR EQUIVALENT, FOR ALL MEMBERS.
4. ALL CONNECTIONS ARE BUTT-JOINED WITH A GUSSET PLATE ON EACH SIDE OF CONNECTION.
5. TRUSS MEMBERS HAVING PLANED WIDTHS OF 3 1/2", 5 1/2" AND 7 1/2", CUT TO PRESCRIBED OVERALL LENGTHS, WILL PROVIDE 3/4" CAMBER TO LOWER CHORD WHEN CONNECTIONS FOR MEMBERS A, B, C, D, G, AND H ARE ALIGNED AS SHOWN.
6. ASSEMBLE THE TRUSS IN A HORIZONTAL JIG. MIX AND APPLY WATERPROOF RESORCINOL RESIN GLUE TO BOTH SURFACES TO BE JOINED ACCORDING TO MANUFACTURER'S SPECIFICATIONS. BE SURE TO COMPLY WITH TEMPERATURE REQUIREMENTS. GLUE AND NAIL THE GUSSETS TO TOP SIDE OF TRUSS WITH 6 D RING SHANK NAILS. THEN REMOVE TRUSS FROM JIG, TURN TRUSS OVER AND INSTALL GUSSETS ON OTHER SIDE.

Figure 10.—Nail-glue, plywood-gusset wood truss.
CONSTRUCTING THE MECHANICAL LINKAGE:

1. SELECT 4" x 1 5/8" STANDARD CHANNEL, OR EQUIVALENT, TO CONSTRUCT LINKAGE MEMBERS NO. 1 AND NO. 2, AND THE CROSS-TIE BETWEEN LINKAGE MEMBERS NO. 1.

2. REMOVE PINS FROM BLIND END OF EXISTING TINE CYLINDER (S).

3. CONSTRUCT LINKAGE MEMBERS NO. 1 TO PROVIDE THE PIN SPACING AT A EQUAL TO THE PIN SPACING AT B, AND THE PIN SPACING AT C EQUAL TO THE PIN SPACING AT D.

4. INSTALL THE PIVOT FOR LINKAGE MEMBERS NO. 1 AT SIDES OF LOADER BOOM SO THAT TINE CYLINDERS WILL BE ABOUT HALF EXTENDED WHEN THE SAFETY MASTS AND LINKAGE MEMBERS NO. 1 ARE VERTICAL.

5. INSTALL AN EXTENSION TO THE TOP OF LOADER FRAME ONLY IF LINKAGE MEMBERS NO. 2 ARE TO BE NORMALLY IN TENSION (DRAWING AT RIGHT ABOVE).

6. INSTALL THE PIVOT FOR LINKAGE MEMBERS NO. 2 AT SIDES OF LOADER FRAME EITHER VERTICALLY BELOW OR VERTICALLY ABOVE THE BOOM PIN. REFER TO NOTE 3 FOR PIN SPACING AT A.

7. CONSTRUCT LINKAGE MEMBERS NO. 2 HAVING PIN SPACING AT E EQUAL TO PIN SPACING EXISTING ON THE LOADER AT E.

8. INSTALL LINKAGE MEMBERS NO. 1 AND 2.


10. INSTALL TINE CYLINDER (S) BRACKETS ON CROSS-TIE, AND INSTALL CYLINDER (S).

Figure 11.—Mechanical linkage for self-leveling tines.
SELECTING AND INSTALLING THE SLAVE CYLINDERS:

1. Determine cylinder and rod diameter of tine cylinders. Measure length of tine cylinder movement from position of tines level on the ground to position of tines level at full extension of boom cylinders.

2. Compute total volume of oil displaced from the rod end of the tine cylinders using measurements of item 1.

3. Choose a standard cylinder diameter for the slave cylinders. A 2-inch diameter is a size suited for most loaders.

4. Compute a working stroke for the 2 slave cylinders selected in item 3 so that displacement at the blind end of the 2 slave cylinders is equal to the displacement computed in item 2.

5. Select 2 standard double-acting cylinders having a cylinder diameter of item 3 and a stroke about 2 to 3 inches longer than the working stroke computed in item 4.

6. Make 4 brackets for mounting the 2 slave cylinders to the sides of the boom and loader frame.

7. By trial and error, position the brackets with C-clamps so that the measured stroke of slave cylinders is equal to working stroke computed in item 4, and so that the slave cylinders are not fully retracted or fully extended when boom cylinders are either fully retracted or fully extended, respectively.

8. Tack-weld the mounting brackets.

9. Install the 2 slave cylinders, 2 relief valves, 2 flow control valves, hose, tubing and fittings.

10. Slowly operate the loader, continually checking for alignment of slave cylinder pins and brackets, and for clearances during hose flexing. Check for self-leveling of tines and slave cylinder "bottoming" described in item 7.

11. Relocate slave cylinder brackets if necessary, and repeat items 8, 9 and 10.

12. Complete welding the brackets.

Figure 12.—Slave cylinders for self-leveling tines.
Figure 13.—Typical modification of farm wagons to transport portable frames.
An open-pan water evaporator for casing tobacco.
HOW TO OPERATE THE PORTABLE FRAME SYSTEM

Labor requirements observed during 1964–69 are reported in table 3 and summarized in table 4.

Transporting the Frames

Install an automatic hitch on the tractor-loader so that you can work unassisted. Unless restricted by farm lanes or other obstructions, as many as three wagons, each carrying four empty or filled frames, can be towed by the tractor-loader.

Transport empty frames before harvest for uniform distribution along the sides of the field to improve scheduling labor and equipment. Distribute empty frames at both sides of the field when field width exceeds 200 to 300 feet.

An alternate work procedure for hauling either empty or full frames at the field is to use an additional tractor and driver. The tractor driver slowly tows the train of wagons to new work areas convenient to the loader-operator. This procedure reduces travel distance in the field for the loader.

Filling The Frames

Discard sticks shorter than 52 inches. Fill the frames within 1 or 2 days after harvest to reduce probability of rain damage caused by mud spatter. A tractor-loader operator obtaining empty frames from the edge of the field can conveniently supply frames to each of four or five workers.

Filling the frames is the most difficult and labor-consuming part of this handling system. Hand-carrying sticks of tobacco for distances greater than 10 to 15 feet is unsatisfactory. Each frame is most efficiently filled from three or four stick rows when the frame is placed in the center of a work area formed by moving aside four to six sticks. Depending on the size of the tobacco plants, 28 to 36 sticks containing six plants each can be placed in each 14-foot frame (approximately 6- to 5-inch stick spacing, respectively). Spread the plants uniformly along the stick to prevent dislodgment of the sticks while frames are being handled and transported.

Wilting

Tobacco wilting in frames at the field is not damaged during rain by mud spatter. However, stick spacing closer than 5 inches may prevent adequate drying of tobacco that has been exposed to rain. Although the overall drying rate of tobacco wilting in the frames may be less than that of tobacco in the stick row, the tobacco dries more uniformly in the frames. Darkening of leaves caused by rain during the first week after harvest is negligible. However, tobacco is darkened with progressing severity during later exposure to rain.

Some growers haul the frames during wilting to an area adjacent to the barn so that they can be housed quickly if threatening weather is forecast. However, when curing barns are well ventilated (figs. 7, 8, and 9), the additional value of wilting in the frames for longer than a week after harvest is unlikely to be worth the risk of rain or the extra labor involved in handling the frames.

Housing

The wood and steel frames shown in figures 4, 5, and 6 can be stacked even when mispositioned as much as 3 inches. Tractor-loader operators soon develop convenient work patterns for handling the frames.

Barn space required to house tobacco in portable frames is given in table 5.

Curing

The open channels existing above and below tobacco curing in 7-foot high frames form continuous air passages across the barn. These passages contribute to increased air exchange through the barn. The typical curing problem in conventional barns—inadequate ventilation caused by overlapped tobacco—is eliminated. During field trials, tobacco housed in frames air cured 1 to 2 weeks faster than conventionally housed tobacco. Values of tobacco cured on portable frames at a cooperating farm during the 1967–70 period are reported in table 6.

Casing and Takedown

Frames of naturally cased cured tobacco can be removed from the barn to conveniently bulk the tobacco (fig. 3L). When weather conditions are unsuited for natural casing, labor scheduling can
be improved by placing frames of tobacco in a tight structure for steam casing.

The simple water evaporator (fig. 14) is capable of unattended operation and automatic shutdown. Neither repeated freezeups nor poor quality of water normally cause adjustment or maintenance problems. Freezing water does not damage the shallow evaporating pans. Freezing temperatures following automatic shutdown of equipment are not a problem because the reservoir, pressure switch, and tubing are then self-drained.

Heater, evaporator, and water supply may be installed either outside or inside the casing structure. Installing the heater and water supply inside the structure will prevent water inside the reservoir and tubing from freezing when casing in cold water (fig. 15). If heater, cabinet, and water supply are installed outside the structure, the water reservoir and tubing will require insulation to permit operation during cold weather. The intake to the portable heater is placed adjacent to, or ducted to, a wall opening to provide fresh air for fuel combustion.

The rate of water evaporation varies with the size of heater, as indicated in figure 16. Select an operating head (vertical distance between the metering orifice and the average water level in the reservoir) with a rate of discharge equivalent to the rate of water evaporation. For example, a 75,000 Btu per hour heater will evaporate water at a rate of approximately 4½ gallons per hour. Either a No. 54 or a No. 55 drill-size orifice operating at about 2½ or 3½ feet of head, respectively, will meter water at the rate suited to the heater. A small adjustment to the initially selected operating head may be required to match correctly the water metering rate to the heater.

Performance of casing equipment is reported in table 7.

Because a direct-fired heater is unvented, reenter the structure during casing only after temporarily switching off the heater and after opening an entrance door and keeping it open for continual ventilation. While operating the unattended equipment, lock or fasten all doors to prevent anyone from entering.

If tobacco remains in the tight structure for a few hours after the evaporator automatically shuts off, the cooled tobacco retains casing moisture while being removed from the frames for bulk piling.

Low temperature in the tight-casing structure is required when a water evaporator with a capacity as small as 3 or 5 gallons per hour is used. Problems caused by infiltration of air through walls and ceilings may become critical when casing takes place during higher temperatures.

The changes in the air illustrated in figure 17 are typical of those recorded during the casing tests reported in table 7. Relative humidity of air
discharging from the insulated evaporator cabinet at temperatures of 130° to 140° F. was 30 to 40 percent. This air was cooled to approximate dewpoint temperature when mixed with air in the uninsulated structure. Although air in the structure during casing contained only 0.02 to 0.03 pound of water per pound of air, relative humidity was nearly 100 percent.

Within a 10- by 18- by 50-foot structure, served by a 4-gallon per hour water evaporator to maintain 90 percent relative humidity, the allowable air infiltration rate is reduced from 10 to 3 changes of air per hour, when casing temperature is increased from 50° F to 85° F. (2).

A plastic-lined or plastic-covered structure holding six or more frames of tobacco is sufficiently tight and has enough heat transfer capacity through the uninsulated walls and ceiling to case tobacco with a low-capacity water evaporator during the cool fall and winter weather.

**Safety Precautions**

The strict observance of three previously discussed work methods or equipment specifications is so essential to human safety that their importance is reemphasized. *Do not under any circumstances operate the equipment described in this report in violation of the following procedures.*

**Safety Masts on Loader Tines**

Weld a steel safety mast at the rear of each tine. Make sure that these masts are capable of supporting either an empty or filled frame against accidental rearward tipping. This safety precaution applies to loaders equipped with either manually controlled or self-leveled tines.

**Ground Electrical Equipment**

The tobacco-casing equipment will operate in a wet environment. This equipment must be properly grounded as drawn in figure 14. Use a continuous grounding wire between the cabinet lid, the duplex outlet, and an approved ground at the fuse service panel. Make certain that the service cords to the circulating fan and portable heater each have a grounded plug.

**Operate the Portable Heater Safely**

A low-oxygen level may exist while casing tobacco because all combustion gases from the direct-fired unvented portable heater discharge into the tight structure. Therefore, never enter the structure while the heater is operating. To check partially cased tobacco, enter the structure only after the electrical circuit to the heater is opened and when the entrance door is held open. When the casing equipment is operating unattended, lock all doors to the structure to prevent unauthorized persons from entering.

If the heater is installed inside the casing structure, securely fasten a simple duct between the heater intake and a wall opening to assure ample fresh air for fuel combustion (fig. 15).
SELECTED REFERENCES


APPENDIX

Table 1.—Material required for 1 12-ft bent of rafter-roof tobacco curing barn

<table>
<thead>
<tr>
<th>Material</th>
<th>Where used</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lumber:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 in by 10 in by 12 ft</td>
<td>Beam</td>
<td>8</td>
</tr>
<tr>
<td>2 in by 8 in by 18 ft</td>
<td>Rafter</td>
<td>12</td>
</tr>
<tr>
<td>2 in by 8 in by 10 ft</td>
<td>Rafter</td>
<td>12</td>
</tr>
<tr>
<td>2 in by 6 in by 12 ft</td>
<td>Girt, girt stiffener, scab brace, fascia, blocking</td>
<td>20</td>
</tr>
<tr>
<td>2 in by 6 in by 12 ft (treated)</td>
<td>Girt</td>
<td>2</td>
</tr>
<tr>
<td>2 in by 6 in by 10 ft</td>
<td>Rafter tie</td>
<td>6</td>
</tr>
<tr>
<td>2 in by 4 in by 16 ft</td>
<td>Purlin</td>
<td>20</td>
</tr>
<tr>
<td>1 in by 8 in by 14 ft</td>
<td>Sheathing and rafter bracing</td>
<td>44</td>
</tr>
<tr>
<td>22 ft pole (treated)</td>
<td>Sidewall</td>
<td>2</td>
</tr>
<tr>
<td>25 in pole (treated)</td>
<td>Interior support</td>
<td>2</td>
</tr>
<tr>
<td>Hinges, strap</td>
<td>Sidewall door</td>
<td>18</td>
</tr>
<tr>
<td>Metal roof</td>
<td>Roof</td>
<td>630 sq ft</td>
</tr>
<tr>
<td>Concrete</td>
<td>Footer</td>
<td>0.2 cu yd</td>
</tr>
<tr>
<td>Nails:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40d ring shank</td>
<td>See fig. 7, bottom</td>
<td>10 lb</td>
</tr>
<tr>
<td>20d ring shank</td>
<td>do</td>
<td>10 lb</td>
</tr>
<tr>
<td>10d and 12d ring</td>
<td>do</td>
<td>5 lb</td>
</tr>
<tr>
<td>Lead seal</td>
<td>do</td>
<td>7 lb</td>
</tr>
</tbody>
</table>

1 See fig. 7.
2 Lumber may be either planed or unplaned. Material for end-wall sheathing is not listed. All lumber except where indicated, is untreated.
3 Delete 4 2 in by 6 in by 11 ft 6 in girt stiffeners if unplaned girts are installed.
4 1 in by 4 by 16 ft for unplaned purlins.
Table 2.—Material for 1 8-ft bent of truss-roof tobacco curing barn

<table>
<thead>
<tr>
<th>Material</th>
<th>Where used</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lumber for truss</td>
<td>46 ft nominal span</td>
<td>2, or as required.</td>
</tr>
<tr>
<td>2 in by 10 in by 16 ft</td>
<td>Beam</td>
<td>2.</td>
</tr>
<tr>
<td>2 in by 6 in by 16 ft</td>
<td>Girt, girt stiffener, scab, brace, fascia, truss block.</td>
<td>10.</td>
</tr>
<tr>
<td>2 in by 6 in by 16 ft (treated)</td>
<td>Girt</td>
<td>1.</td>
</tr>
<tr>
<td>2 in by 4 in by 18 ft</td>
<td>Purlin</td>
<td>11.</td>
</tr>
<tr>
<td>1 in by 8 in by 14 ft</td>
<td>Sheathing and truss bracing</td>
<td>30.</td>
</tr>
<tr>
<td>22 ft pole (treated)</td>
<td>Sidewall</td>
<td>2.</td>
</tr>
<tr>
<td>Hinges, strap</td>
<td>Sidewall door</td>
<td>12.</td>
</tr>
<tr>
<td>Metal roof</td>
<td>Roof</td>
<td>410 sq ft.</td>
</tr>
<tr>
<td>Concrete</td>
<td>Footer</td>
<td>0.1 cu yd</td>
</tr>
</tbody>
</table>

Nails:
- 40d ring shank | See fig. 8, bottom | 5 lb. |
- 20d ring shank | do | 4 lb. |
- 12d ring shank | do | 4 lb. |
- Lead seal | do | 5 lb. |

1 See fig. 8. All lumber except that used for truss may be either planed or unplaned. All lumber except where indicated is untreated. Material for end-wall sheathing is not listed.
2 Commercially fabricated trusses at fabricator's recommended spacing, or 2 on-site fabricated trusses as shown in fig. 10.
3 Delete 4 2 in by 6 in by 7 ft 6 in girt stiffeners if unplaned girts are installed.
4 1 in by 4 in by 18 ft unplaned purlins may be installed when truss spacing is 2 ft or 2 ft 8 in.
TABLE 3.—Average observed labor required for handling tobacco on portable curing frames with a tractor-loader

<table>
<thead>
<tr>
<th>Operation</th>
<th>Labor required per operation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Man-minutes</td>
</tr>
<tr>
<td>Hitch tractor-loader to wagon</td>
<td>0.25</td>
</tr>
<tr>
<td>Unhitch tractor-loader from wagon</td>
<td>0.09</td>
</tr>
<tr>
<td>Travel 100 ft, barn to field, or return</td>
<td>0.21</td>
</tr>
<tr>
<td>Place empty frame on wagon at barn</td>
<td>2.25</td>
</tr>
<tr>
<td>Remove empty frame from wagon at field</td>
<td>1.68</td>
</tr>
<tr>
<td>Fill frame with tobacco:</td>
<td></td>
</tr>
<tr>
<td>Carry stick to frame, and return</td>
<td>0.20</td>
</tr>
<tr>
<td>Place stick and spread stalks</td>
<td>0.13</td>
</tr>
<tr>
<td>Position empty frame, and idle time</td>
<td>0.90</td>
</tr>
<tr>
<td>Place frame on wagon at field</td>
<td>1.93</td>
</tr>
<tr>
<td>Remove frame from wagon, place into barn</td>
<td></td>
</tr>
<tr>
<td>First tier</td>
<td>3.50</td>
</tr>
<tr>
<td>Second tier</td>
<td>3.90</td>
</tr>
<tr>
<td>Air-curing</td>
<td></td>
</tr>
<tr>
<td>Transfer frame for casing</td>
<td>4.48</td>
</tr>
<tr>
<td>Take down stick and bulk pile</td>
<td>0.32</td>
</tr>
</tbody>
</table>

1 Tractor-loader with self-leveling tines and automatic hitch.
2 Standard deviations are computed from samples having 18 or more observations.
3 Travel time for 100 ft computed from mean velocities observed during 3,000 to 5,000 ft travel.
Table 4.—Summary of labor required per acre for handling tobacco on portable curing frames (4 ft by 14 ft) with a tractor-loader

<table>
<thead>
<tr>
<th>Operation</th>
<th>4 frames per trip</th>
<th>8 frames per trip</th>
<th>12 frames per trip</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Transport and distribute empty frames</td>
<td>4.4 ± 0.5 Man-hour</td>
<td>3.5 ± 0.4 Man-hour</td>
<td>3.2 ± 0.4 Man-hour</td>
</tr>
<tr>
<td>2. Fill frames with tobacco</td>
<td>12.5 ± 2.6</td>
<td>12.5 ± 2.6</td>
<td>12.5 ± 2.6</td>
</tr>
<tr>
<td>3. Transport filled frames</td>
<td>3.1 ± 0.5</td>
<td>2.2 ± 0.4</td>
<td>1.9 ± 0.4</td>
</tr>
<tr>
<td>4. Place frames in barn</td>
<td>2.4 ± 0.4</td>
<td>2.4 ± 0.4</td>
<td>2.4 ± 0.4</td>
</tr>
<tr>
<td>5. Curing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Transfer frames to casing structure</td>
<td>3.0 ± 0.3</td>
<td>3.0 ± 0.3</td>
<td>3.0 ± 0.3</td>
</tr>
<tr>
<td>7. Takedown and bulk pile</td>
<td>9.8 ± 1.2</td>
<td>9.8 ± 1.2</td>
<td>9.8 ± 1.2</td>
</tr>
<tr>
<td>Total</td>
<td>35.2 ± 3.0</td>
<td>33.4 ± 2.9</td>
<td>32.8 ± 2.9</td>
</tr>
</tbody>
</table>

1 Based on table 3. The computations are also based on: 8,300 plants per acre, 6 stalks per stick, 5-in stick spacing on 4 ft by 14 ft frames, 39.4 frames per acre, 2,500 ft between field and barn, tractor-loader with self-leveling tines and automatic hitch, loader operator and 3 workers for operations 2 and 7.
2 Delete operation for handling naturally cased tobacco.

Table 5.—Barn length required for curing tobacco in portable frames

<table>
<thead>
<tr>
<th>Type of barn</th>
<th>8,300 plants per acre, 5 in</th>
<th>8,500 plants per acre, 5 in</th>
<th>8,700 plants per acre, 5 in</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6 in</td>
<td>6 in</td>
<td>6 in</td>
</tr>
</tbody>
</table>

Modified barn:

- 32-ft wide:
  - 14-ft bent: 54, 64
  - 12-ft bent: 55, 66
- 40-ft wide:
  - 14-ft bent: 40, 49, 41, 50, 42, 51
  - 12-ft bent: 42, 50, 43, 51, 44, 52
- Rafter-roof barn: 32, 38, 33, 39, 34, 40
- Truss-roof barn: 32, 38, 33, 39, 34, 40

1 6 plants per stick (fig. 4).
2 See figs. 7, 8, and 9.
3 12-ft frames for 14-ft bent length; 10-ft frames for 12-ft bent length.
Table 6.—Weight and value of tobacco cured on portable frames vs. conventionally housed tobacco 1967-70

<table>
<thead>
<tr>
<th>Year</th>
<th>Experimental plots</th>
<th>Check plots</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Production per acre</td>
<td>Value</td>
</tr>
<tr>
<td></td>
<td>Pounds</td>
<td>Dollars</td>
</tr>
<tr>
<td>1967</td>
<td>3,439</td>
<td>2,530</td>
</tr>
<tr>
<td>1968</td>
<td>2,733</td>
<td>2,042</td>
</tr>
<tr>
<td>1969</td>
<td>2,933</td>
<td>2,174</td>
</tr>
<tr>
<td>1970</td>
<td>2,765</td>
<td>2,080</td>
</tr>
<tr>
<td>Average</td>
<td>2,969</td>
<td>2,206</td>
</tr>
</tbody>
</table>

1 Weights and values determined by auction price for experimental and check plots on 2 acres. Sticks of tobacco placed in frames at approximate 5½ in stick intervals within 2 days after harvest. One-half to 3 in of rainfall occurred during the 7 to 10 days of wilting in the frames, but caused little or no visible damage. Barn provided maximum of 50 percent sidewall opening for ventilation during the curing. Supplemental heat was applied during the 1967 and 1968 seasons from overhead ducts that directed heated air down between rows of frames. Application of supplemental heat was, therefore, regarded as unnecessary and was discontinued during the 1969 and 1970 seasons. Check tobacco was cured and handled conventionally. Cured tobacco was naturally cased.

Table 7.—Values per pound of cured tobacco cased with and without steam, 1966 and 1967

<table>
<thead>
<tr>
<th>Treatment</th>
<th>1966</th>
<th>1967</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without steam</td>
<td>$0.648</td>
<td>$0.686</td>
</tr>
<tr>
<td>With steam</td>
<td>.649</td>
<td>.697</td>
</tr>
<tr>
<td>Check, without steam</td>
<td>.646</td>
<td>.682</td>
</tr>
<tr>
<td>Least significant difference at 5-percent significance level</td>
<td>.008</td>
<td>.025</td>
</tr>
</tbody>
</table>

1 Values determined by USDA support price for Government grade. Check tobacco was handled and cured conventionally. During 1966 and 1967, experimental tobacco at 5-in stick spacing wilted on frames for 6 days with 2.3-in rain and for 10 days with 0.3-in rain, respectively. Casing structure was 10 ft by 10 ft by 50 ft temporary wooden framework covered with a single thickness of 5-mil polyethylene film. Batches of frames containing 0.15 to 0.25 acre of tobacco were cased during weather temperatures of 25° to 55° F. Approximately 100 gallons water per acre of tobacco were placed in reservoir. Water was metered at rate of 3.5 gal./hr. to the evaporating cabinet fired by a heater having fuel consumption of 0.5 gal./hr. Average temperature rise within structure was 15° F. Relative humidity was 90 percent or more. Differences of temperature and relative humidity at extreme locations within the structure having a ¼ hp. circulating fan were less than 2° F. and 5 percent, respectively. Upon depletion of water in reservoir, a normally open pressure switch opened the electric circuit to heater. After tobacco cooled to the outside temperature, it was removed from the structure. Fuel cost was approximately $0.001 per pound of cured tobacco.