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Research Paper NE-666

Graphic Model of the Processes Involved in the Production of Casegood Furniture

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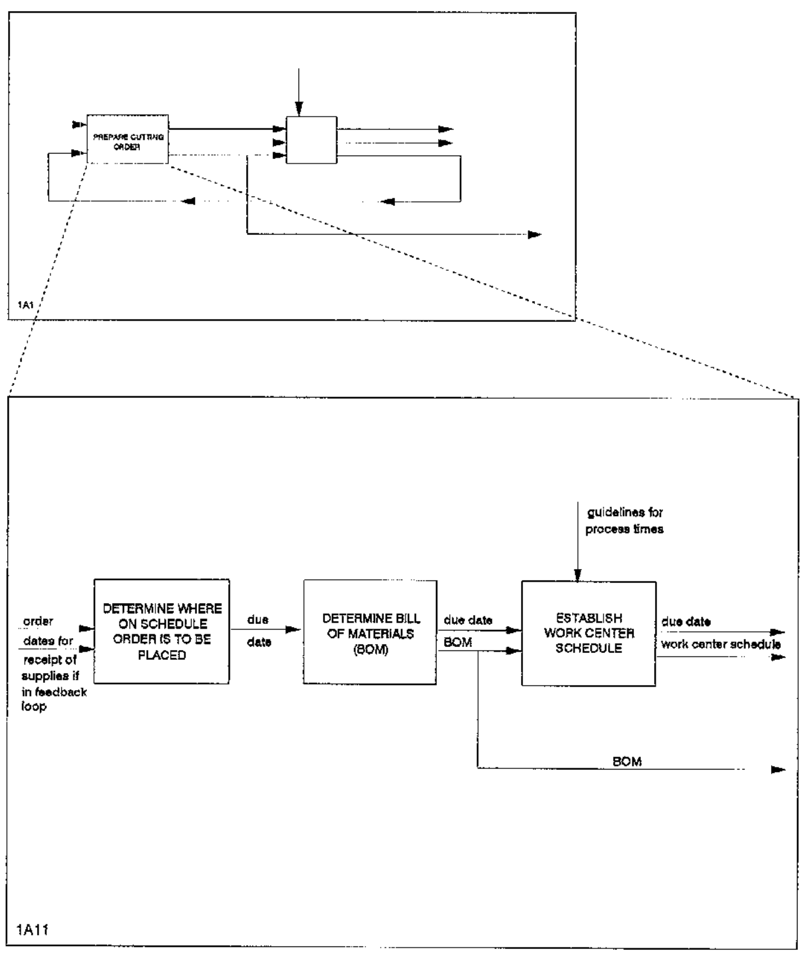

Abstract

Imports from foreign furniture manufacturers are on the rise and American manufacturers must take advantage of recent technological advances to regain their lost market share. To facilitate implementation of technologies for improving productivity and quality, a graphic model of the wood furniture production process has been developed using the IDEF (ICAM—Integrated Computer Aided Manufacturing—DEFinition) modeling process and is presented. IDEF modeling provides a graphic representation of the production process by presenting the information in easy-to-grasp chunks. A description of the modeling process explains how the model represents the data that flows through the plant, the activities in the plant, and their interaction. Analysis of the model may result in improved communication, recognition of specific points for implementing new technologies, evidence of bottlenecks and problem areas, simplified inventory control, or reduction of paperwork.

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The heading, "Appendix A--IDEF Model" on page 9 should appear on page 10 to accompany Figure 7, rather than Figure 6. Figure 6 is a part of the text and is referenced on page 2, third paragraph.

Introduction

As imports from foreign manufacturers increase, American wood furniture producers are searching for reasons for this loss of market share. Foreign competition in the furniture industry has increased significantly since 1972, and the greatest competition has been in the wood furniture category (U.S. Department of Commerce 1985). To regain market share, U.S. wood furniture manufacturers need to use new technologies. To better communicate and analyze manufacturing for applying the new technologies and improving productivity, a graphic model of the wood furniture production process has been developed. The model represents the functions of the wood furniture production system and the information and objects that interrelate with those functions.

Reasons for Loss of Market Share

The Myth of Labor Costs

The most common perception among American manufacturers for the cause of this increased competition is reduced labor costs associated with many foreign countries, especially those in the Pacific Rim. While this may have been true in the past, it is no longer true today. For example, Taiwan, for many years, has enjoyed the advantage of lower wage rates than the U.S. However, today Taiwanese firms faced with labor shortages operate below capacity. The factory workers that are available are demanding higher wages and improved working conditions (Smith and West 1991). Since this trend occurs as countries become more industrialized, it is reasonable to expect wage rates to climb in other Pacific Rim countries, also.

European manufacturers have no advantage in labor costs since wages in European countries are nearly the same as, or higher than, American wages. Aggregate figures for the 16 European countries for which 1988 data is available (Fig. 1) show that in 1986 European countries paid an average hourly rate at 83 percent of the United States average, 101 percent in 1987, and 105 percent in 1988 (U.S. Department of Commerce 1989).

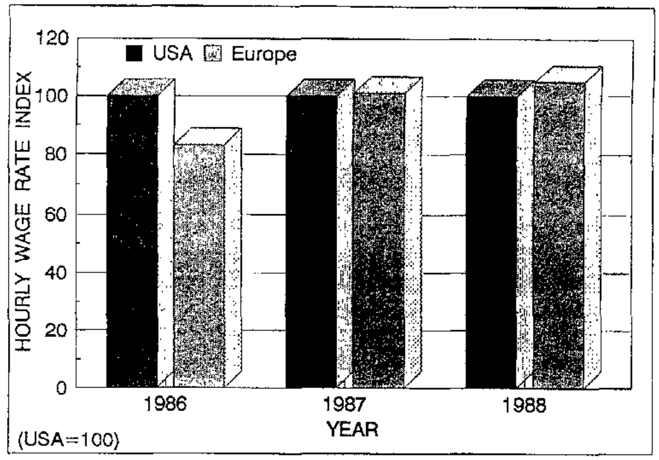

Figure 1.—Index of American and European hourly compensation costs (USA=100).

The Reality of Quality

One reason for the U.S. loss of market share is the resistance of American manufacturers to design products with customer expectations in mind. In a recent international quality study conducted by the American Quality Foundation and Ernst & Young, it was discovered that Japanese companies are three times as likely as American and Canadian businesses to incorporate customer expectations into the design of new products and services. Furthermore, German businesses are twice as likely as North American businesses to translate customer expectations into the design of new products and services (Bemowski 1991).

Clearly, to improve the perceived quality of American products by meeting customer expectations is key to increasing the market share. New technologies must be applied to respond to customer expectations in a timely fashion, and employees need training in the application and implementation of the technologies. Models of manufacturing systems ensure that all employees not only understand the current system, from raw materials to finished product, but can effectively determine potential points for implementing new technologies.

Strategy for Improvement

By educating the workforce on the complete manufacturing process and the tools and techniques used to evaluate productivity and quality, America can regain its competitive status. The 1988 ASQC/Gallup survey reported that employee education is one of the most important ways to improve quality in American business (Ryan 1989). A practice common to recent winners of the Malcolm Baldridge National Quality Award is the implementation of training courses in managing for quality, making improvements, and using the tools and techniques available (Juran 1991). Before improvements in quality can be realized, managers must recognize the points where quality problems are likely to arise, where improvements are needed, and at which new techniques may be applied effectively.

Once expertise on managing for quality is acquired, new tools and techniques must be applied to gain control of the manufacturing process. "Gaining total control of the process requires a system applied uniformly across the operation, from raw materials to finished product, so that communication barriers come down via a common language and common format." (Slater 1991). A graphic model can be used to explain the manufacturing process to individuals not familiar with the furniture industry, as well as to pinpoint areas where quality might be a problem before final assembly.

Description of Model

This paper presents the graphic model of a typical casegood furniture plant. The model (Appendix A) was developed using the IDEF (ICAM—Integrated Computer Aided Manufacturing—DEFinition)[1] modeling process developed by the U.S. Air Force program for Integrated Computer Aided Manufacturing (ICAM) (Softech, Inc. 1981). The basic premise behind the process is that the human mind has the ability to accommodate any amount of complexity if it is presented in easy-to-grasp chunks that fit together to make the whole. To impose the restriction that only related information is shown on any single chart, the IDEF method limits a function to six or fewer subfunctions; thus a consistent level of detail for each function within a chart is maintained and decision points become apparent.

In using the IDEF method, each box in the model represents a function. Figure 2 contains six boxes, each representing a major stage in the production of wood furniture. Each arrow entering a box from the left represents an input and each arrow exiting a box from the right represents an output of the function. As shown in Figure 2, the order preparation stage (prepare order box) produces the supplies (including lumber, hardware, fasteners, adhesives), due date, and work center schedule. However, to see all the intermittent steps, it is necessary to explode the box into several smaller boxes. This decomposition is shown in Figure 3. Each of these boxes, prepare cutting order and procure supplies, in turn, can be decomposed further, hence Figures 4 and 5.

Arrows entering from the top represent constraints. For example, in Figure 2, the moisture content of the lumber is considered a constraint since moisture will affect how long it will take to prepare the lumber for processing. Arrows entering from the bottom represent mechanisms or devices needed to execute the function which that box represents. In Figure 6, the stickers placed in between the lumber to facilitate air flow are considered devices.

In addition, the IDEF method associates a node index with the entire set of charts. The node index, an outline of the process, is generated by assigning a number to each box within a single chart. If a box is exploded into another chart, each box within this chart is numbered and that number is appended to that of the "parent" box. The process continues recursively until entirely catalogued. The node index provides a listing of all the functions and is formatted to show "parent" functions and their "offspring." For example, Figure 2 is the overview of the process and is assigned the number 1A. Prepare order, a decomposition of the first function, is designated 1A1; prepare lumber, 1A2; dimension pieces, 1A3, and so on. Figure 3 generates 1A11, prepare cutting order, and 1A12, procure supplies.

[1]The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture or the Forest Service of any product or service to the exclusion of others that may be suitable.

If no greater level of detail is required for a particular function, then it is not imperative to generate additional boxes even though other functions that follow may require further decomposition. The complete node index for the entire process is presented immediately following the model in Appendix B.

The model describes the manufacturing processes of a dresser, bureau, or nightstand. It may be customized easily to show specific production lines for additional parts such as doors, or different procedures such as a gang-rip-first cutup operation.

Previous Applications

The IDEF modeling process improves problem analysis, requirements definition, and functional specifications through the rigorous expression of complex ideas that had seemed too abstract and obscure to treat technically. The process does not solve problems; it is a tool that allows people to express, understand, manipulate, and check problem areas.

The U.S. Air Force provides the showpiece of this technology in their ICAM program. Thousands of people from hundreds of organizations working on more than one hundred major projects used the methodology not only for the technical work of system definition and design, but for project management and integration as well.

Additional applications of this tool include system design, package design, documentation organization, curriculum design for teaching, and project estimation and management. Some specific examples are separation of function and design in environment control systems; uncovering overlooked tasks in the structure of a software development project; and assessment of the impact of factory modernization on engineering, purchasing, quality assurance, and shipping. Furthermore, one large corporation applied the IDEF product specification and design diagrams to meeting control; participants addressed specific issues and made decisions with less effort and time than before using IDEF (Ross 1985). These examples demonstrate the breadth of problems addressed using the IDEF modeling procedure.

Future Applications

Within the wood furniture industry, the possible benefits of applying the IDEF modeling process are vast. As furniture manufacturers move to respond to customers more quickly and take advantage of new technologies, they must analyze their product and current production system to determine which technologies are applicable and feasible. The analysis must also uncover points where the new technologies may be integrated with the current system. By modeling the production process with IDEF, such an analysis would be greatly facilitated.

Inventory control may be improved by diagram analysis to pinpoint areas where excess inventory is generated.

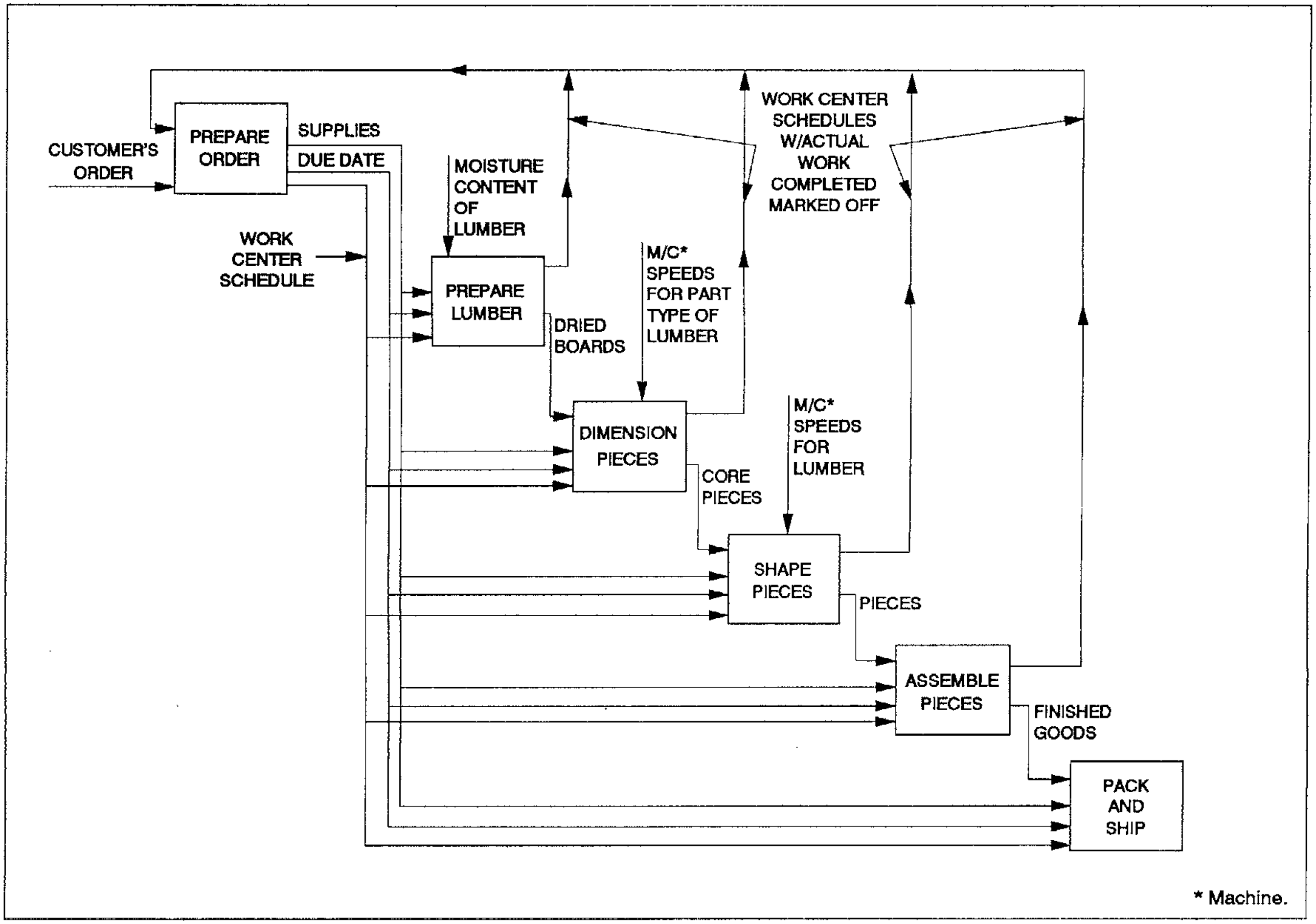

Figure 2.—1A Overview.

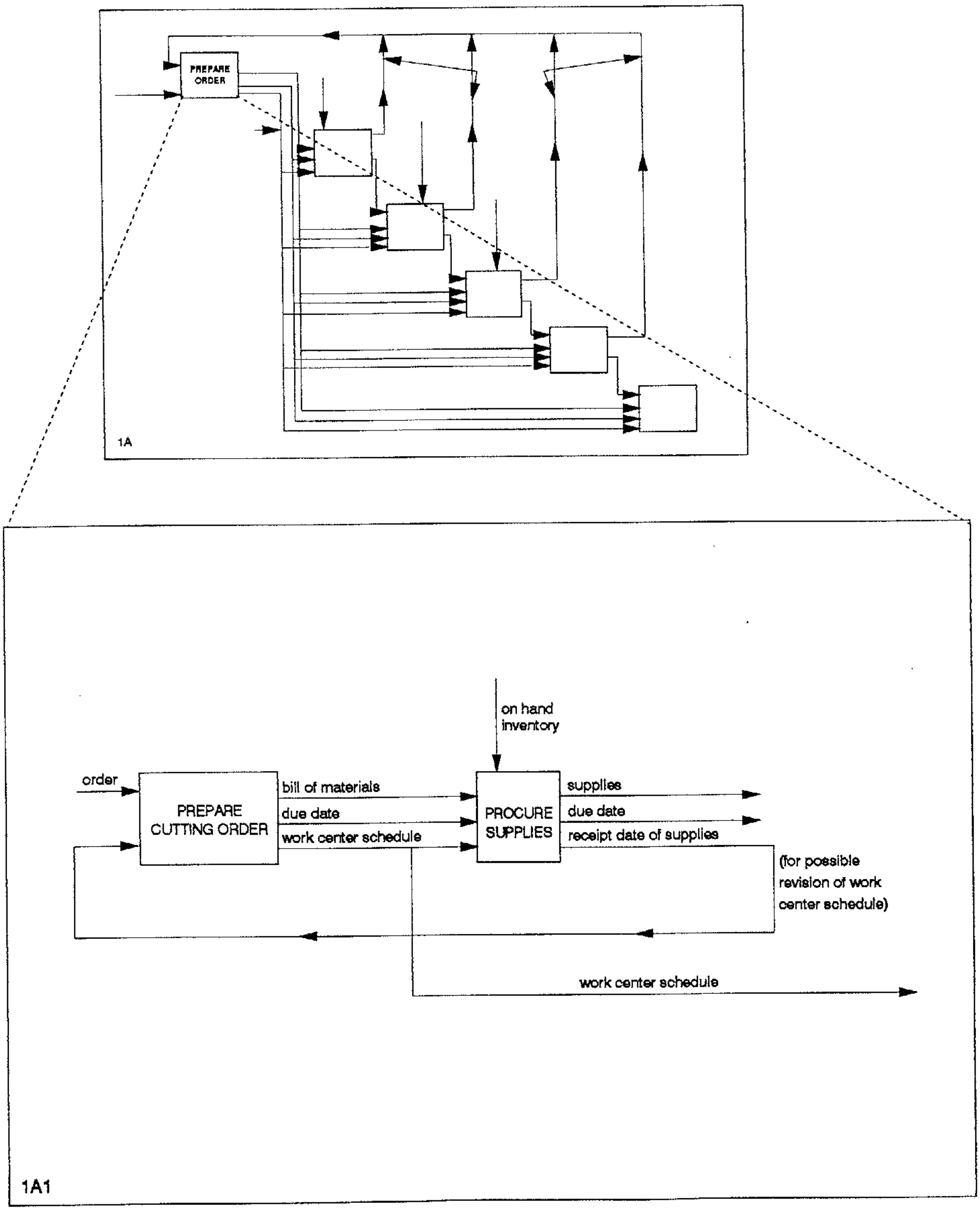

Figure 3.—Decomposition of prepare order.

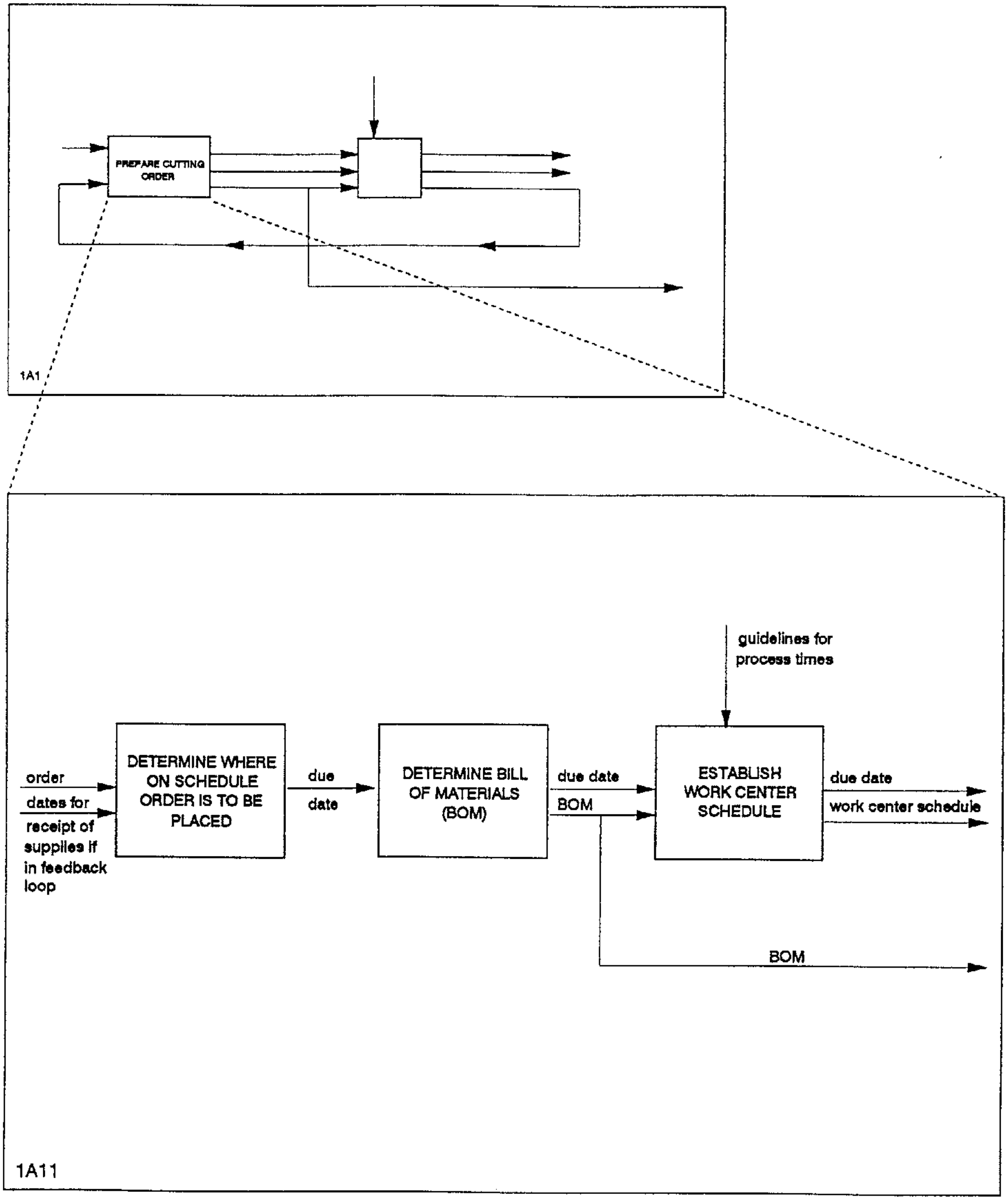

Figure 4.—Decomposition of prepare cutting order.

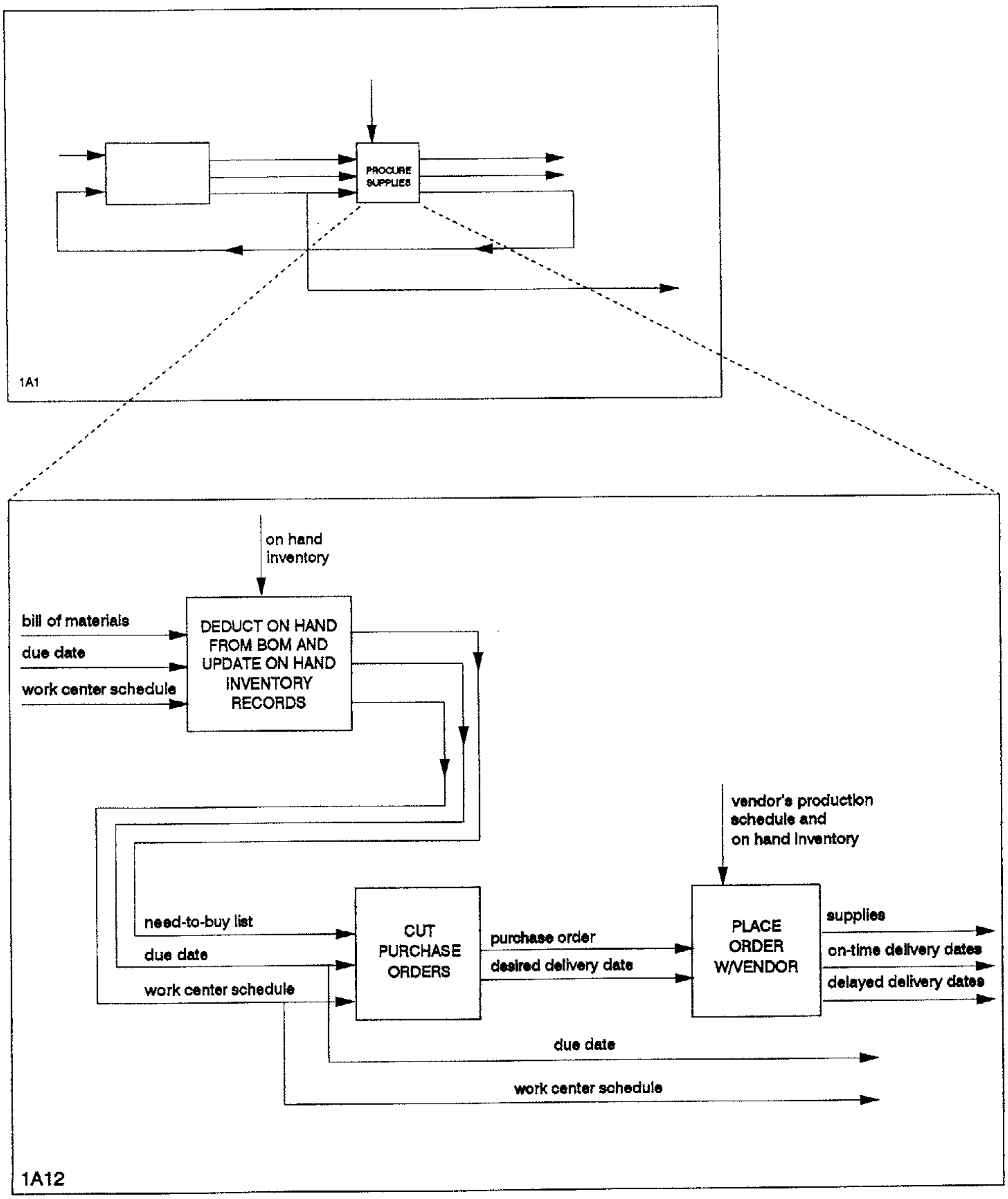

Figure 5.—Decomposition of procure supplies.

Similarly, production flow may be streamlined as bottlenecks become obvious. Diagramming of the entire production system reveals work-in-process accumulation. Once such problems are identified, steps can be taken to resolve the congestion, such as adding another machine or rerouting work to a different machine.

Paperwork may be reduced and information flow improved. When all inputs to a function are identified, they may be checked, one by one, to see if that information is necessary to the function. If it is not necessary, that transaction can be eliminated and the information provided only when it is necessary. Conversely, by analyzing the IDEF model, it may become apparent that information required for a particular function may not be carried through formal communication channels. In this instance, a direct line of communication may be opened, thus eliminating the need for a production employee or expeditor to trace the information.

Decision making should improve. The IDEF model allows managers to analyze a specific subsystem while considering its interrelations with the system as a whole. Previously overlooked factors that influence decision making are revealed. In addition, downstream factors may have more bearing on decisions than previously realized, forcing decisions to be made too soon.

Setup time may be reduced once production employees become familiar with the entire manufacturing system. Also, when design engineers are acquainted with the complete process, design for manufacture can be implemented. An additional operation early in the production process may eliminate two or more operations later on. In addition, the change may be accomplished more easily earlier in the process. The IDEF model shows the most frequent changeover occurrences and which changeovers constrain the system.

The IDEF model of the wood furniture production process may be analyzed to shed light on a wide range of problems, not just those listed here. Only after these problems are defined, can they be addressed.

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Appendix A — IDEF Model

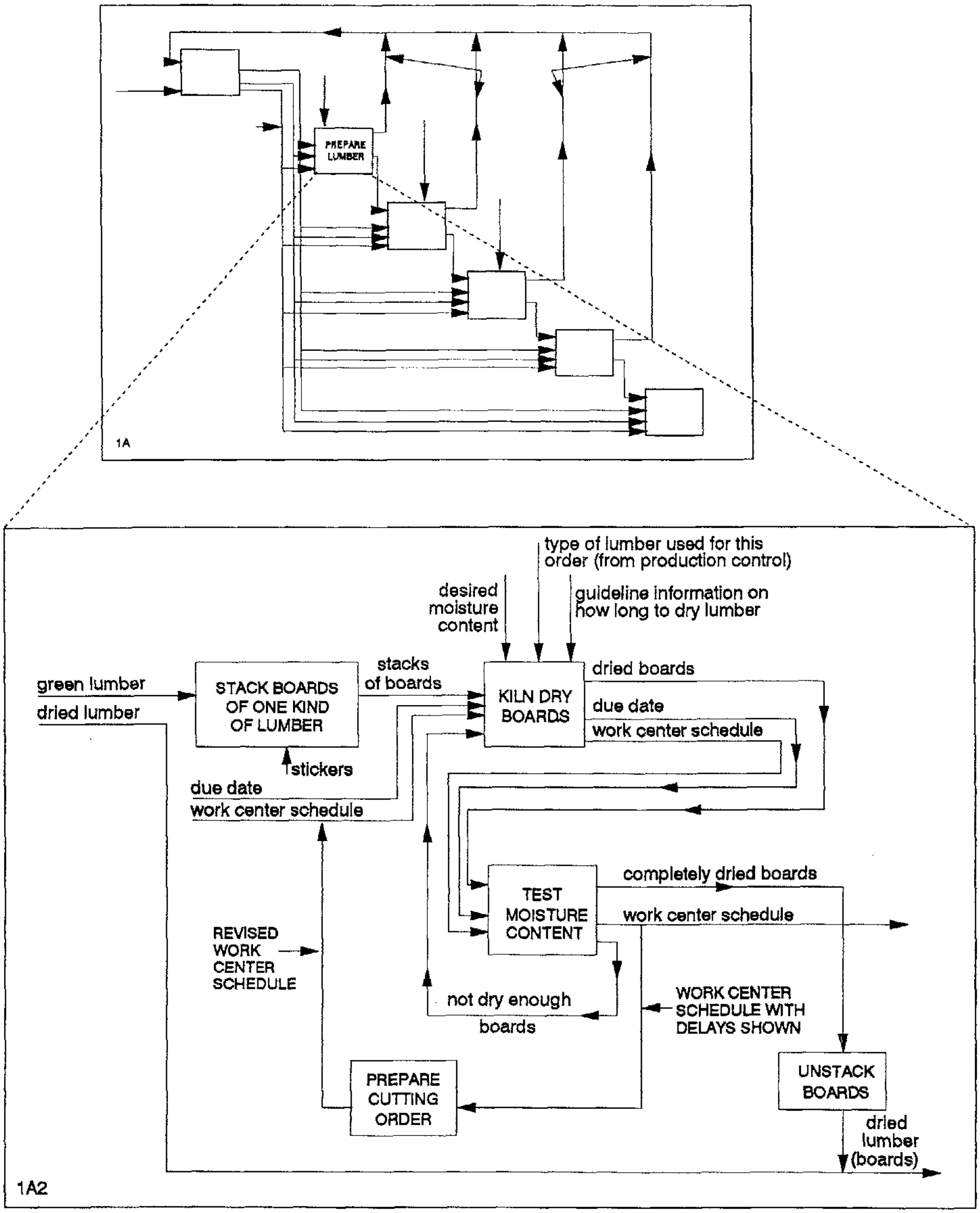

Figure 6.—Decomposition of prepare lumber.

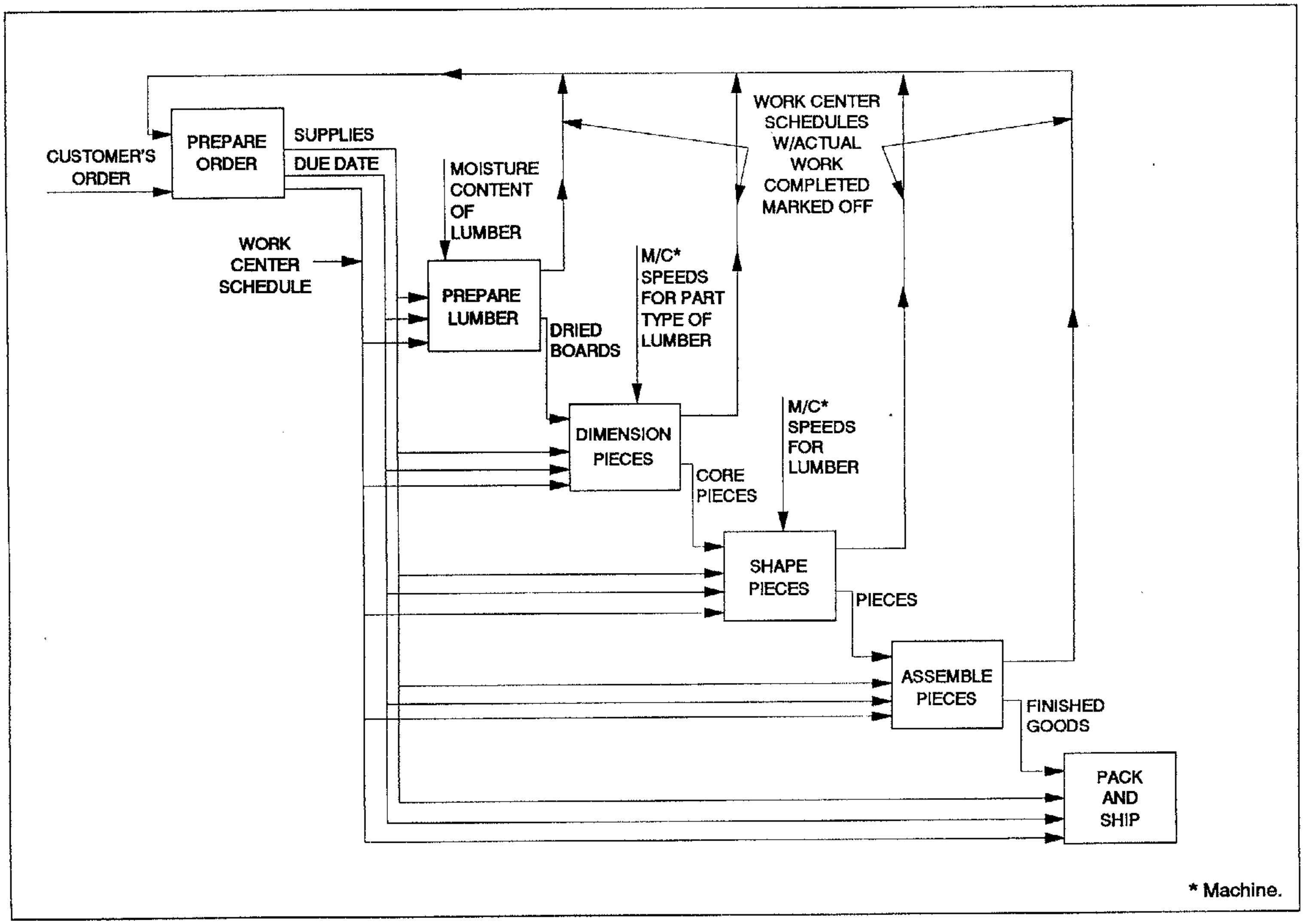

Figure 7.—1A Overview.

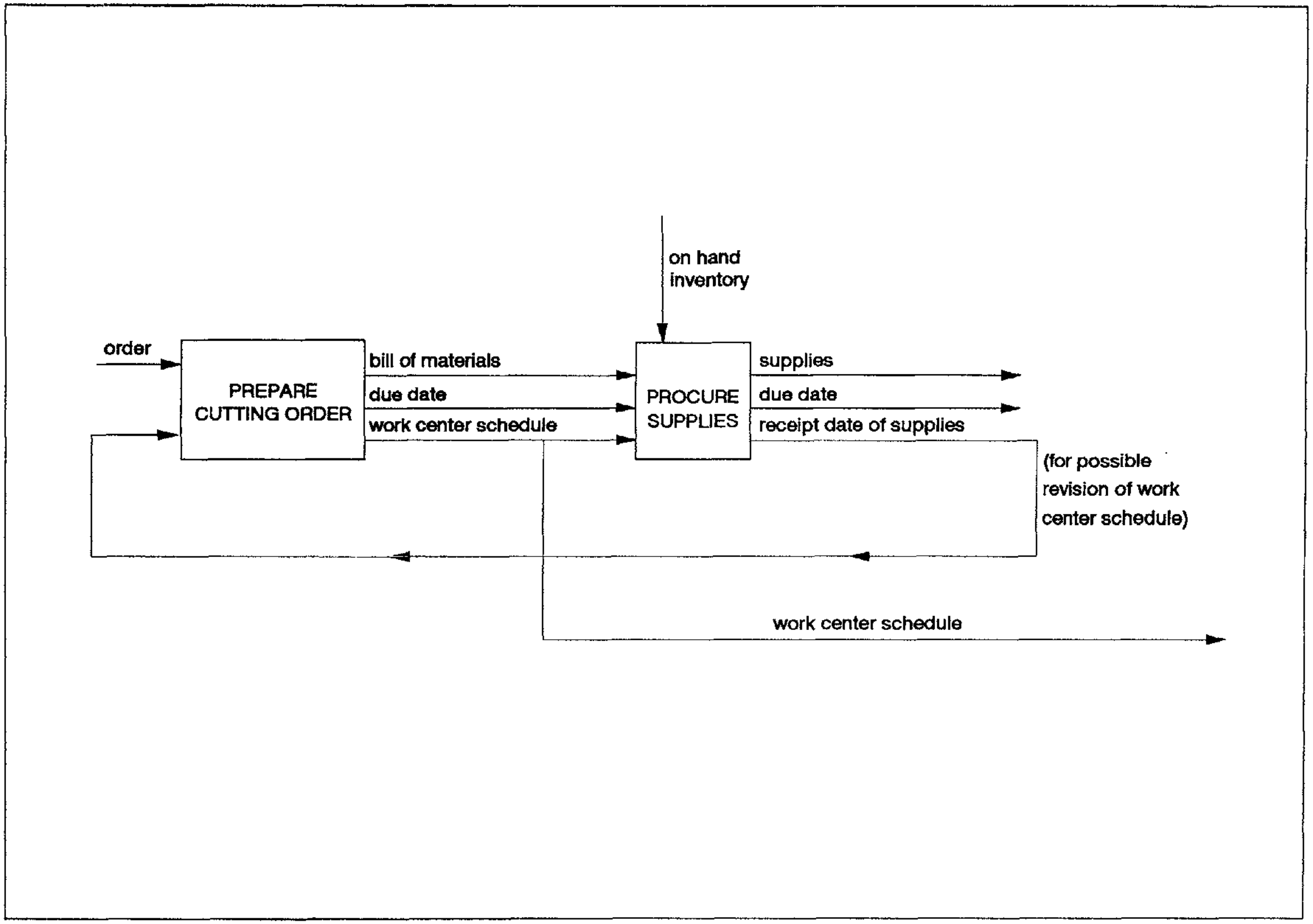

Figure 8.—1A1 Prepare order.

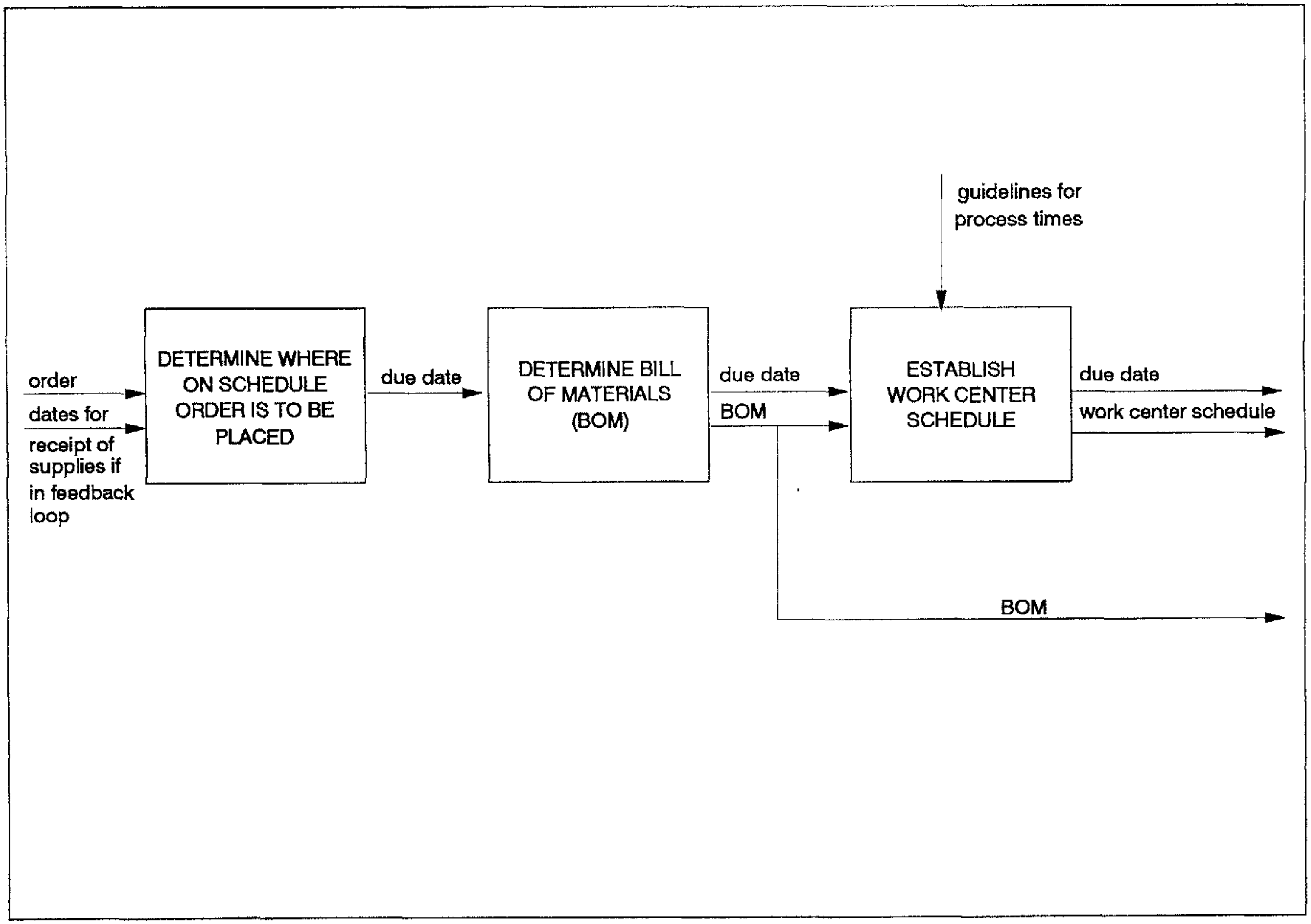

Figure 9.—1A11 Prepare cutting order.

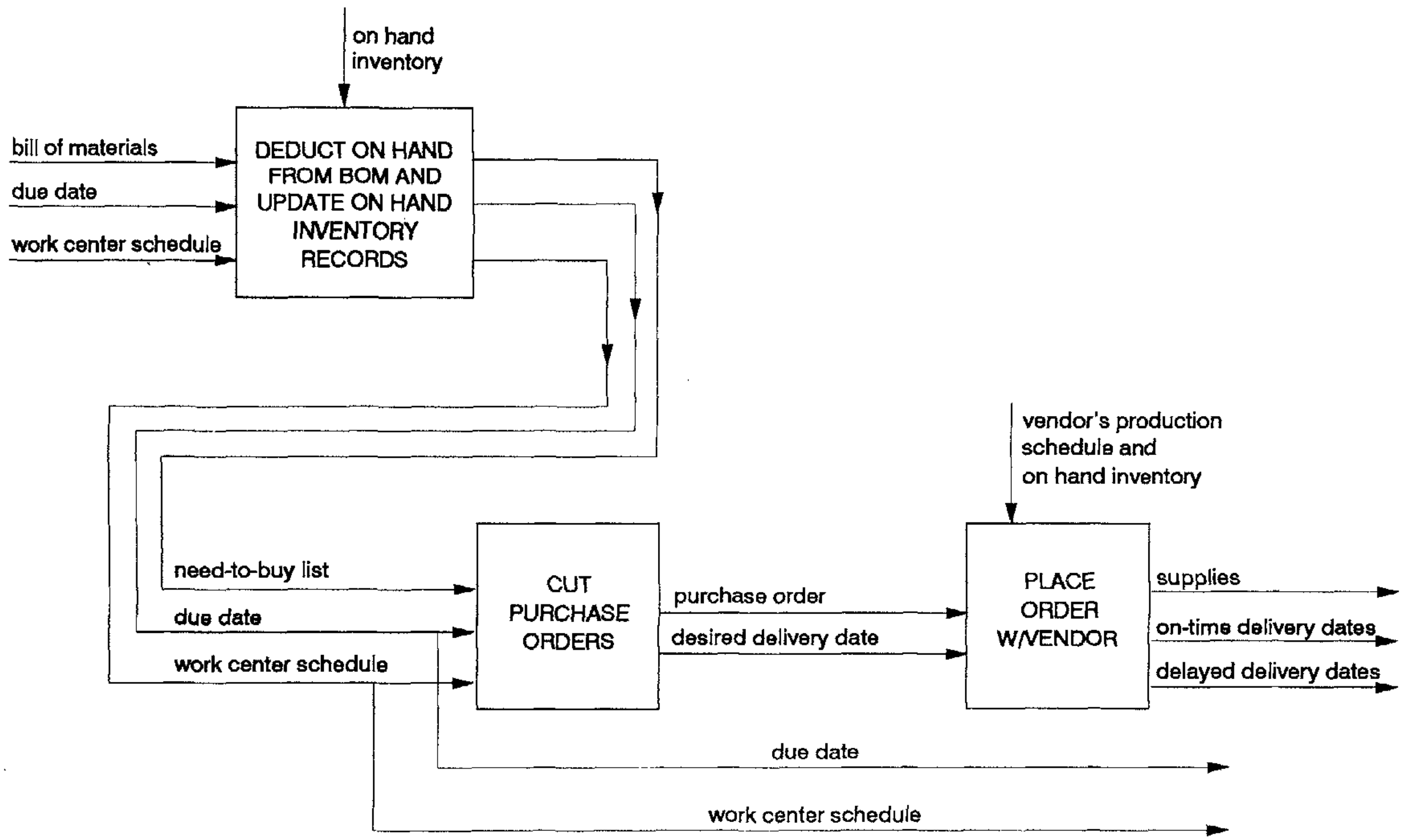

Figure 10.—1A12 Procure supplies.

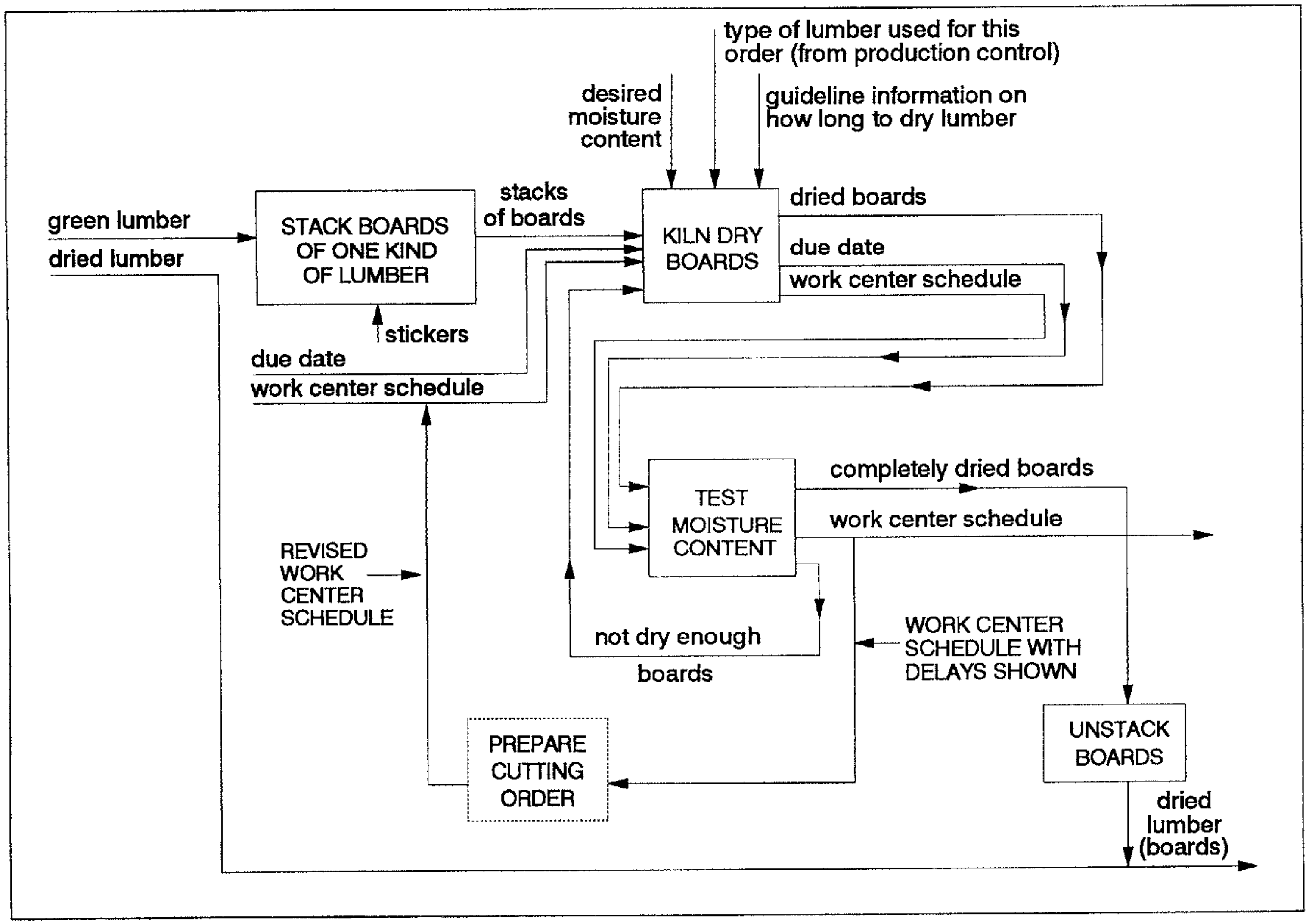

Figure 11.—1A2 Prepare lumber.

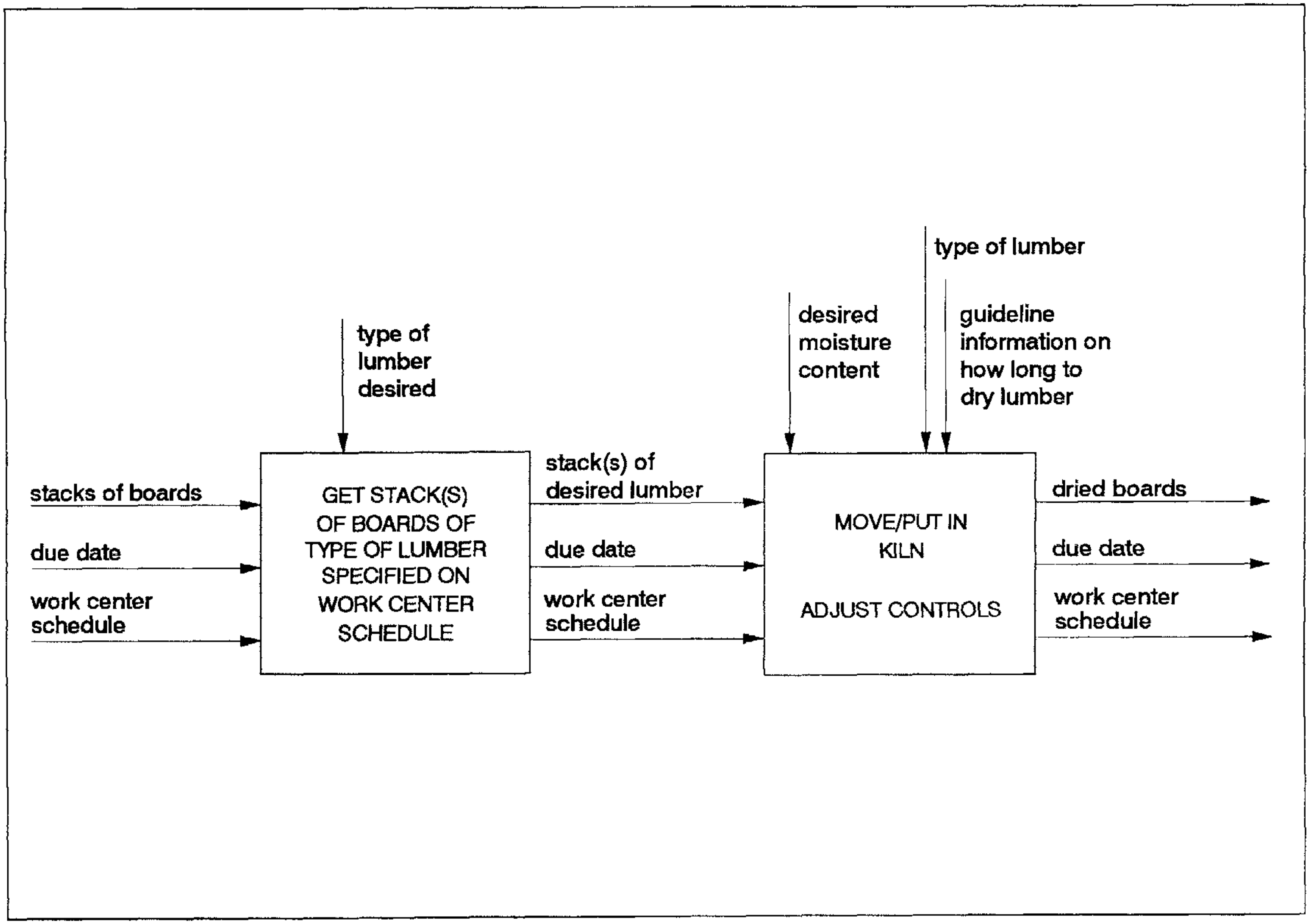

Figure 12.—1A22 Kiln dry boards.

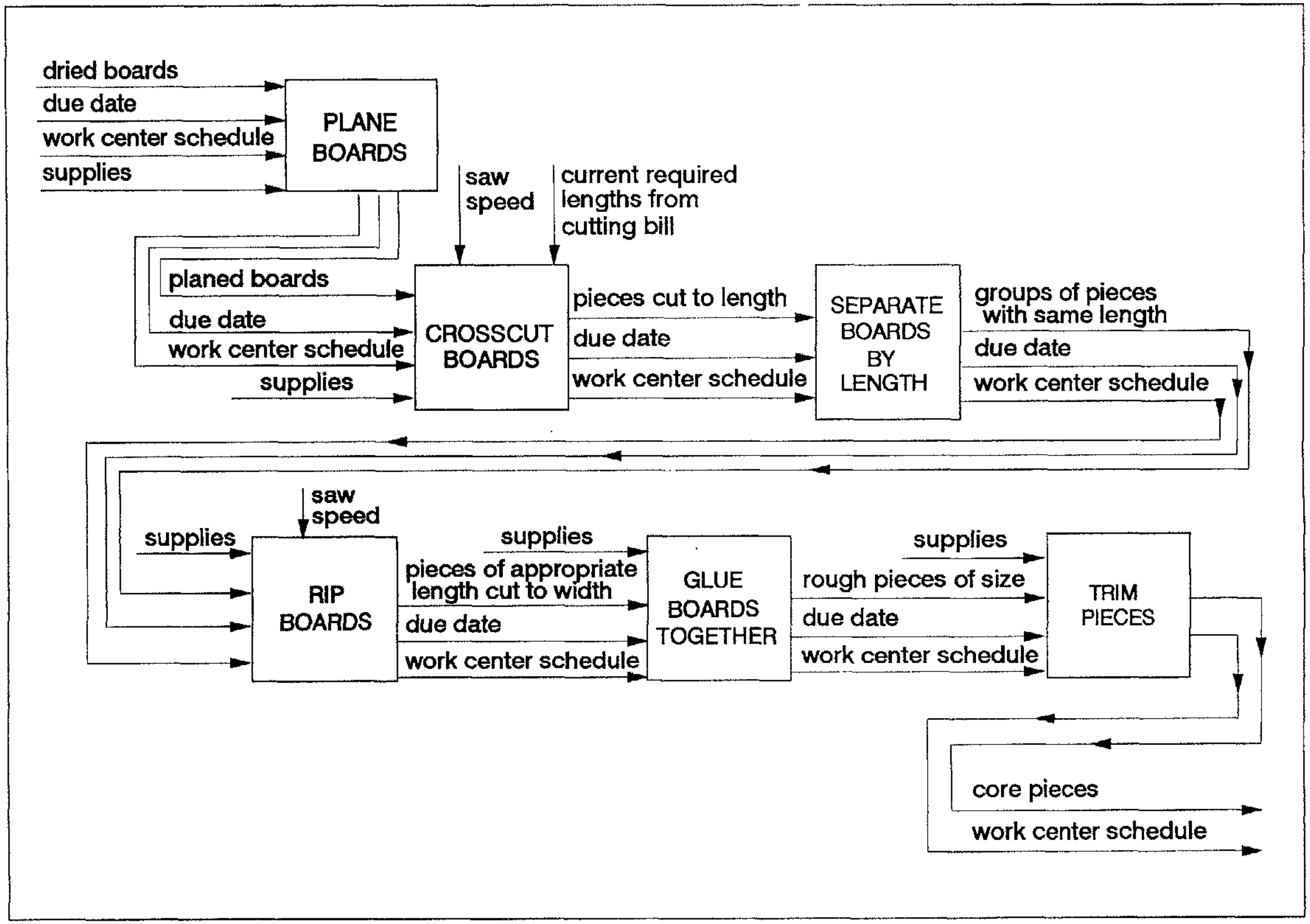

Figure 13.—1A3 Dimension pieces.

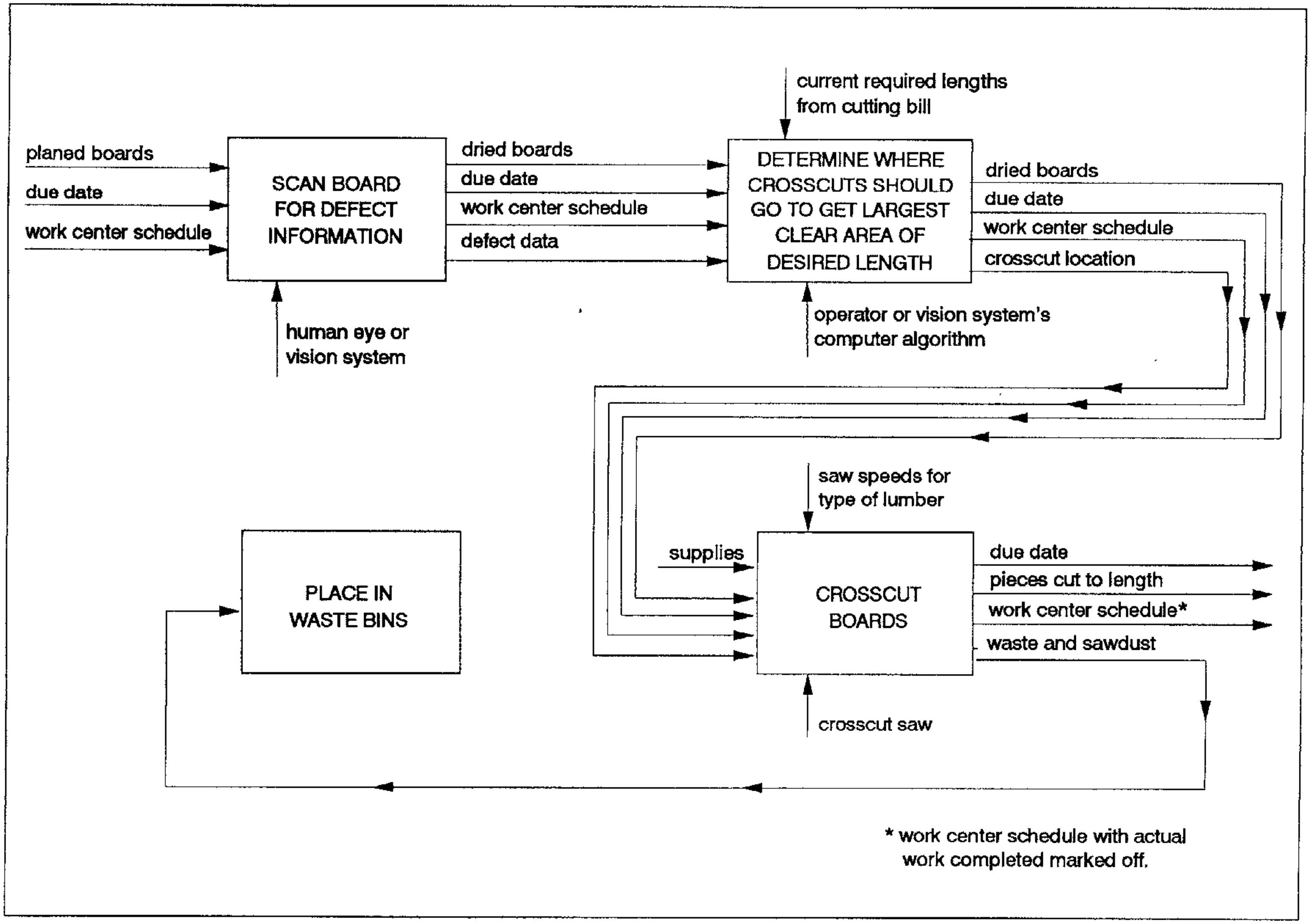

Figure 14.—1A32 Crosscut boards.

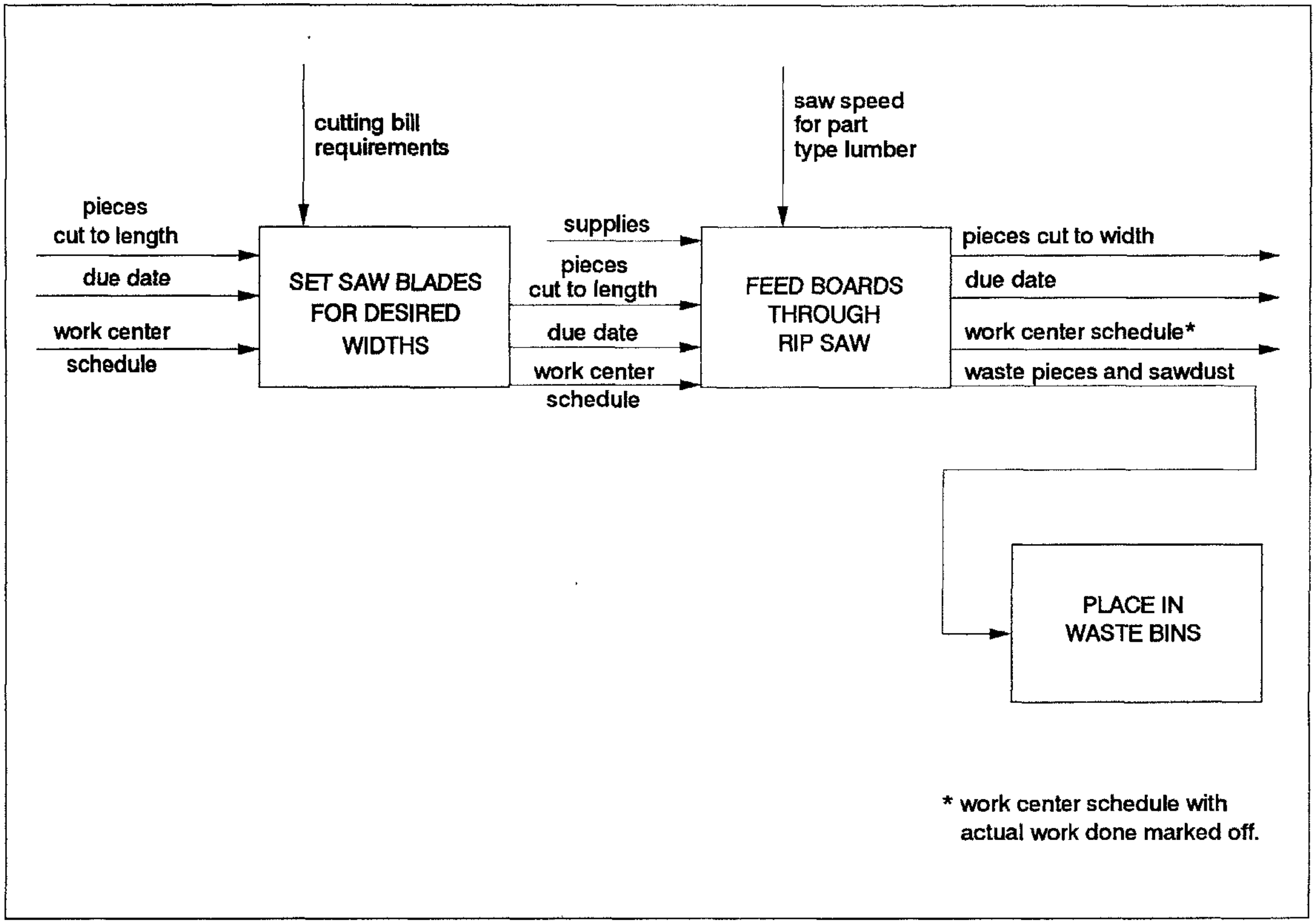

Figure 15.—1A33 Rip boards.

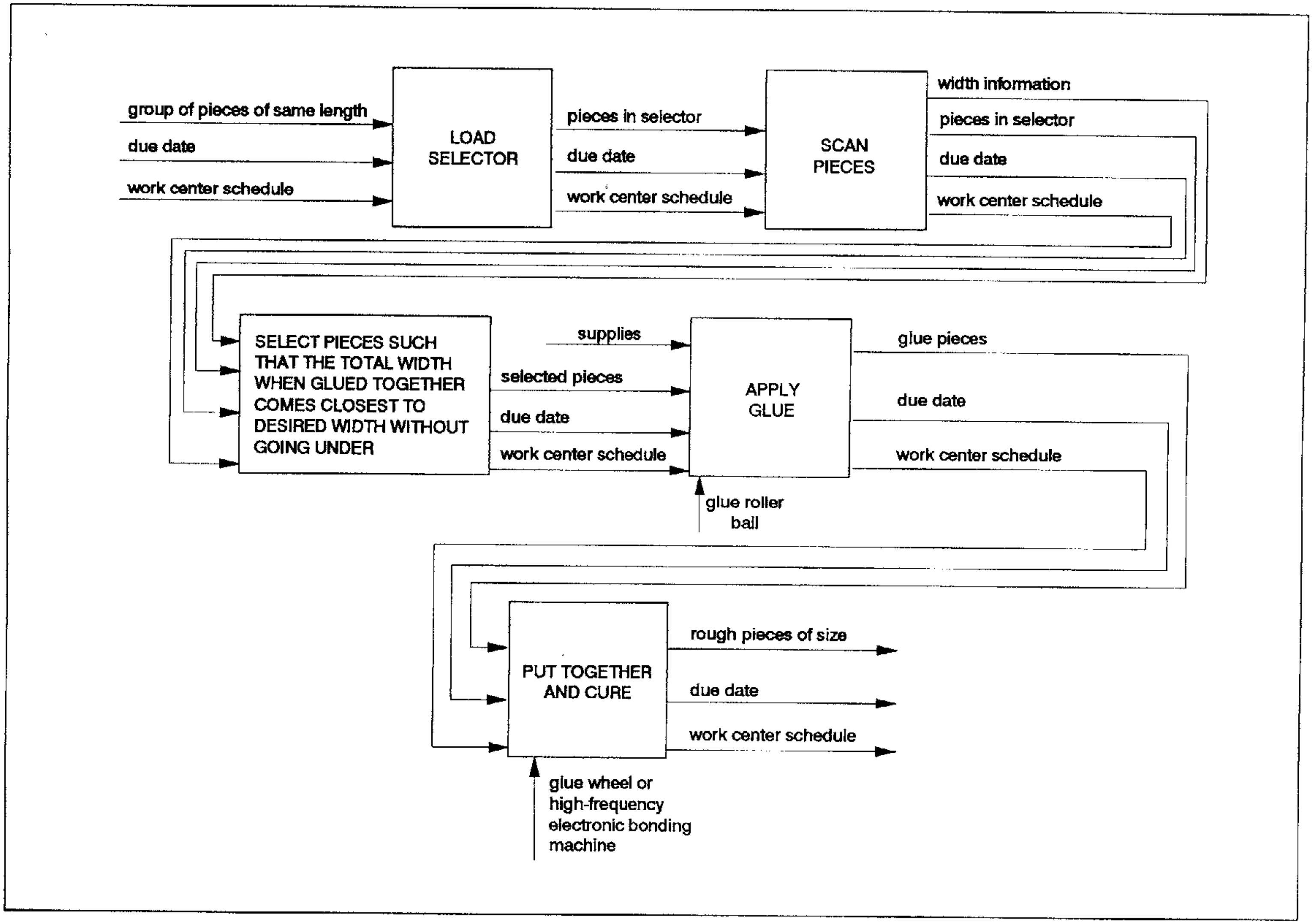

Figure 16.—1A35 Glue boards together.

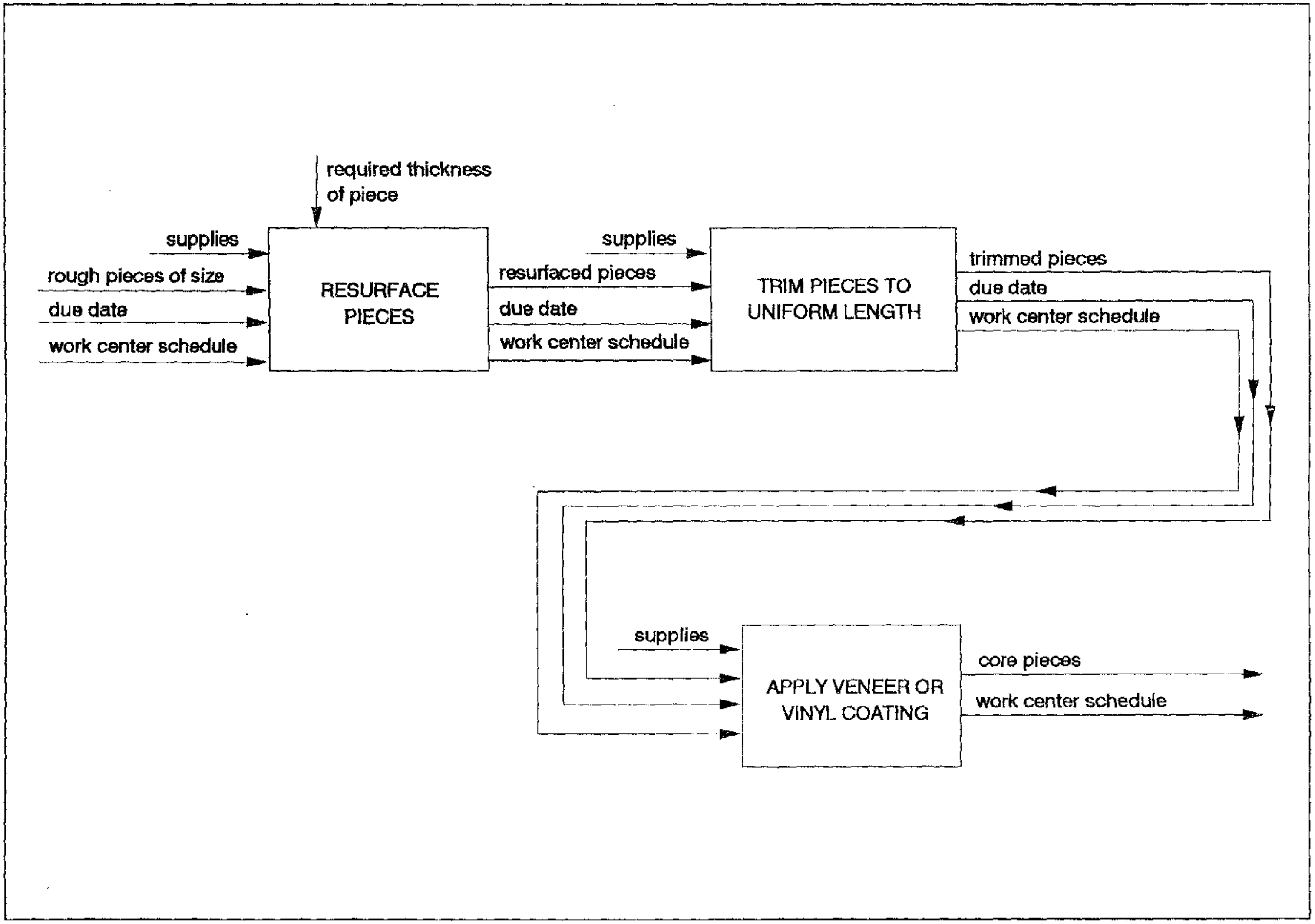

Figure 17.—1A36 Trim pieces.

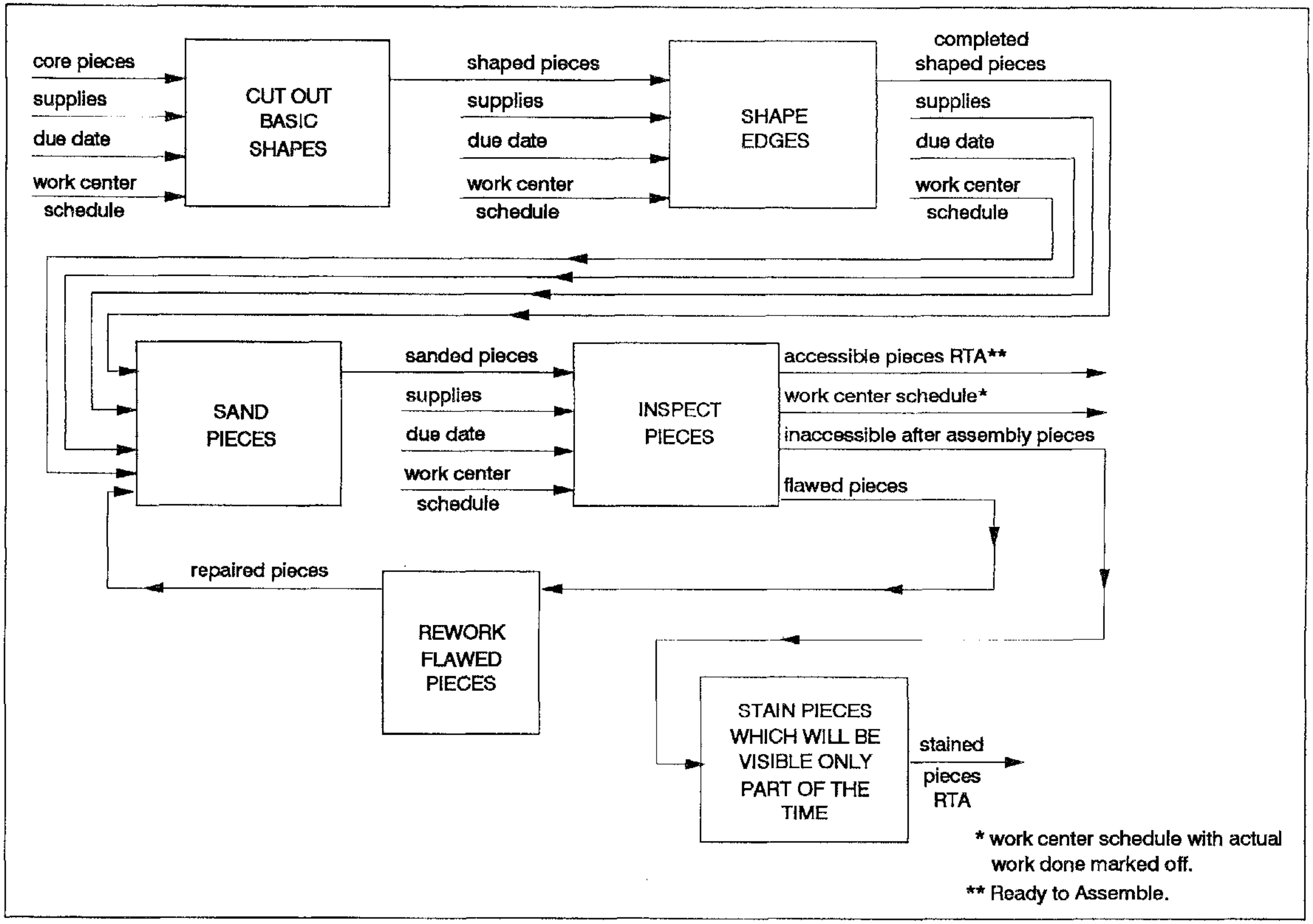

Figure 18.—1A4 Shape pieces.

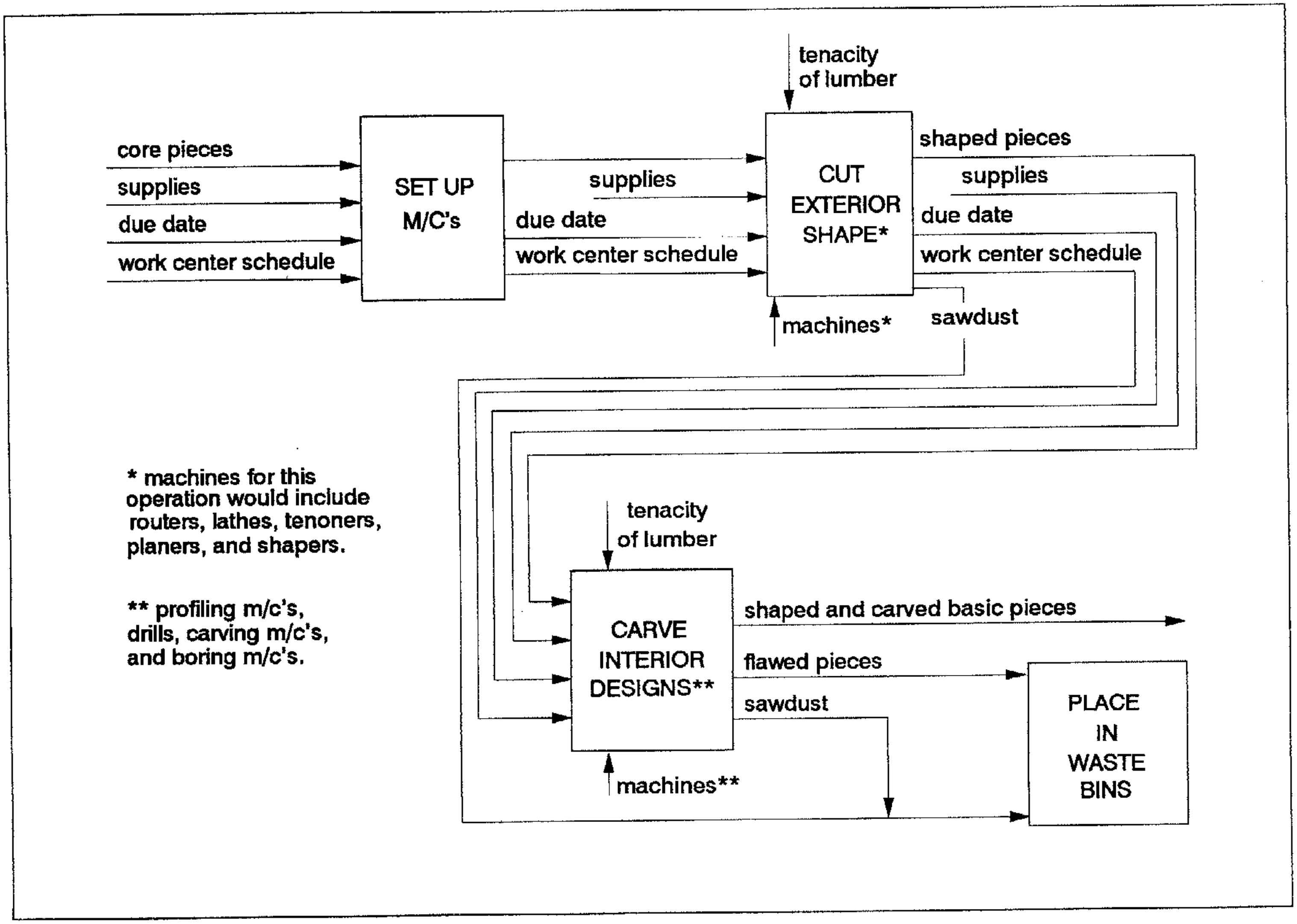

Figure 19.—1A41 Cut out basic shapes

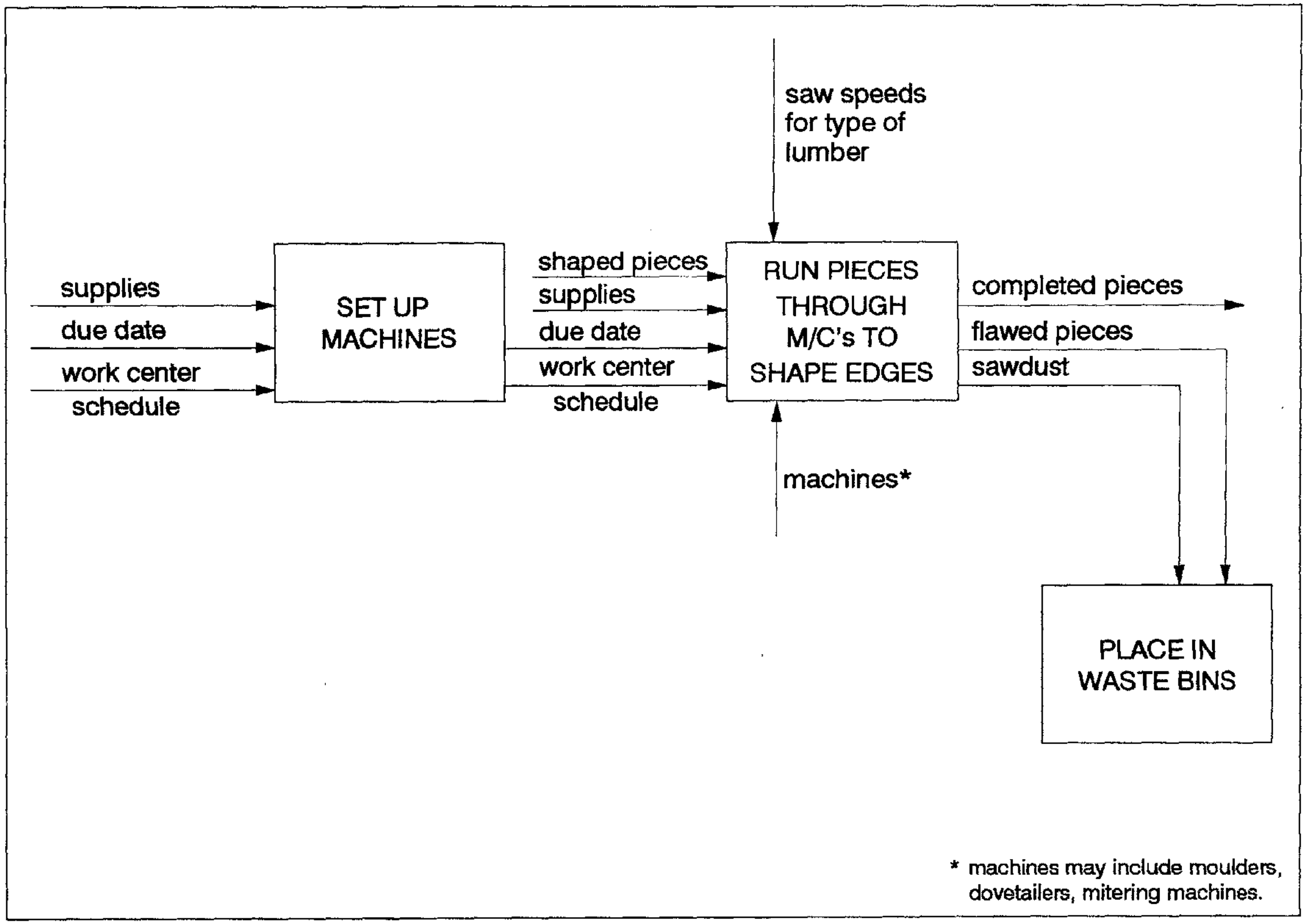

Figure 20.—1A42 Shape edges.

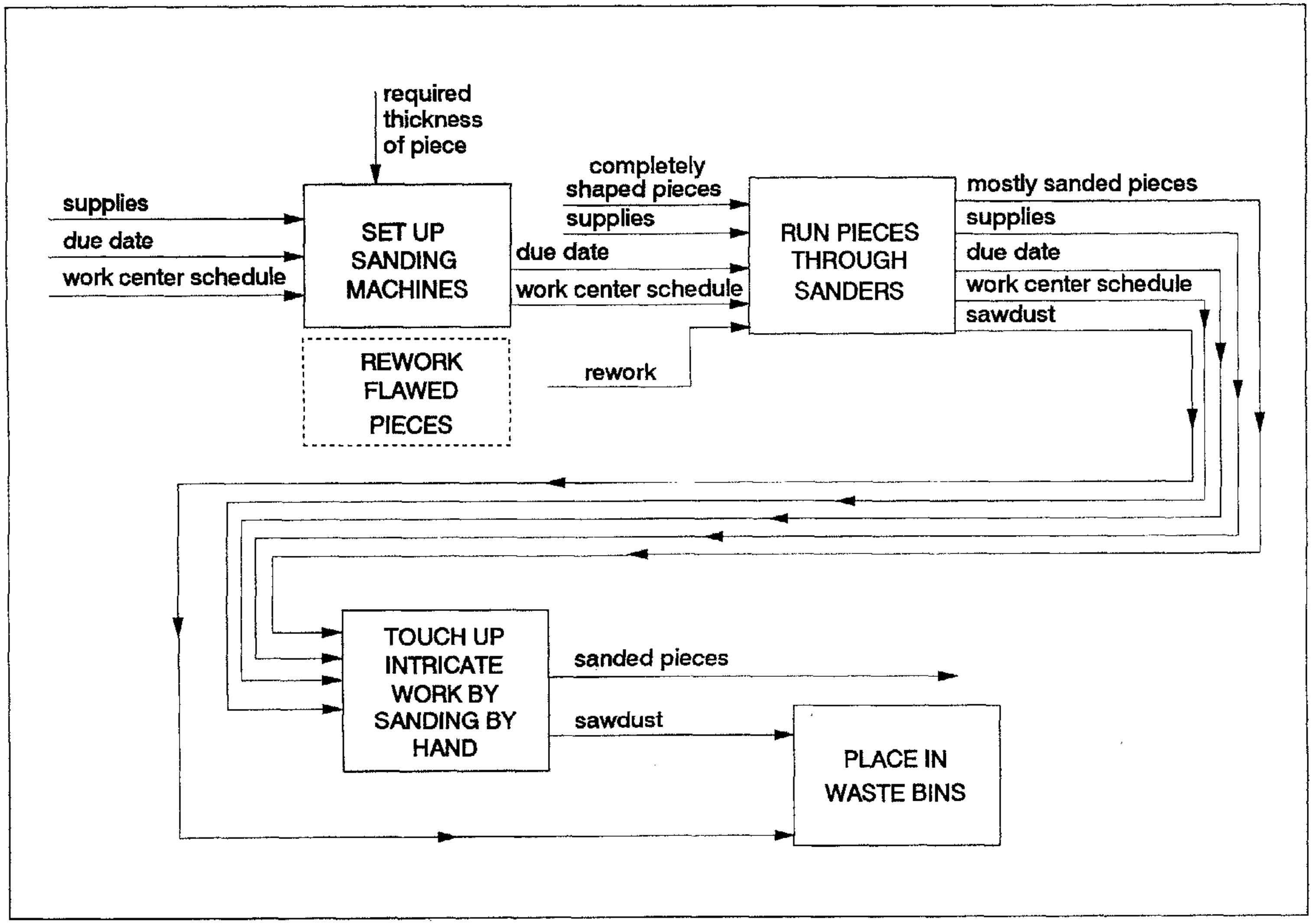

Figure 21.—1A43 Sand pieces.

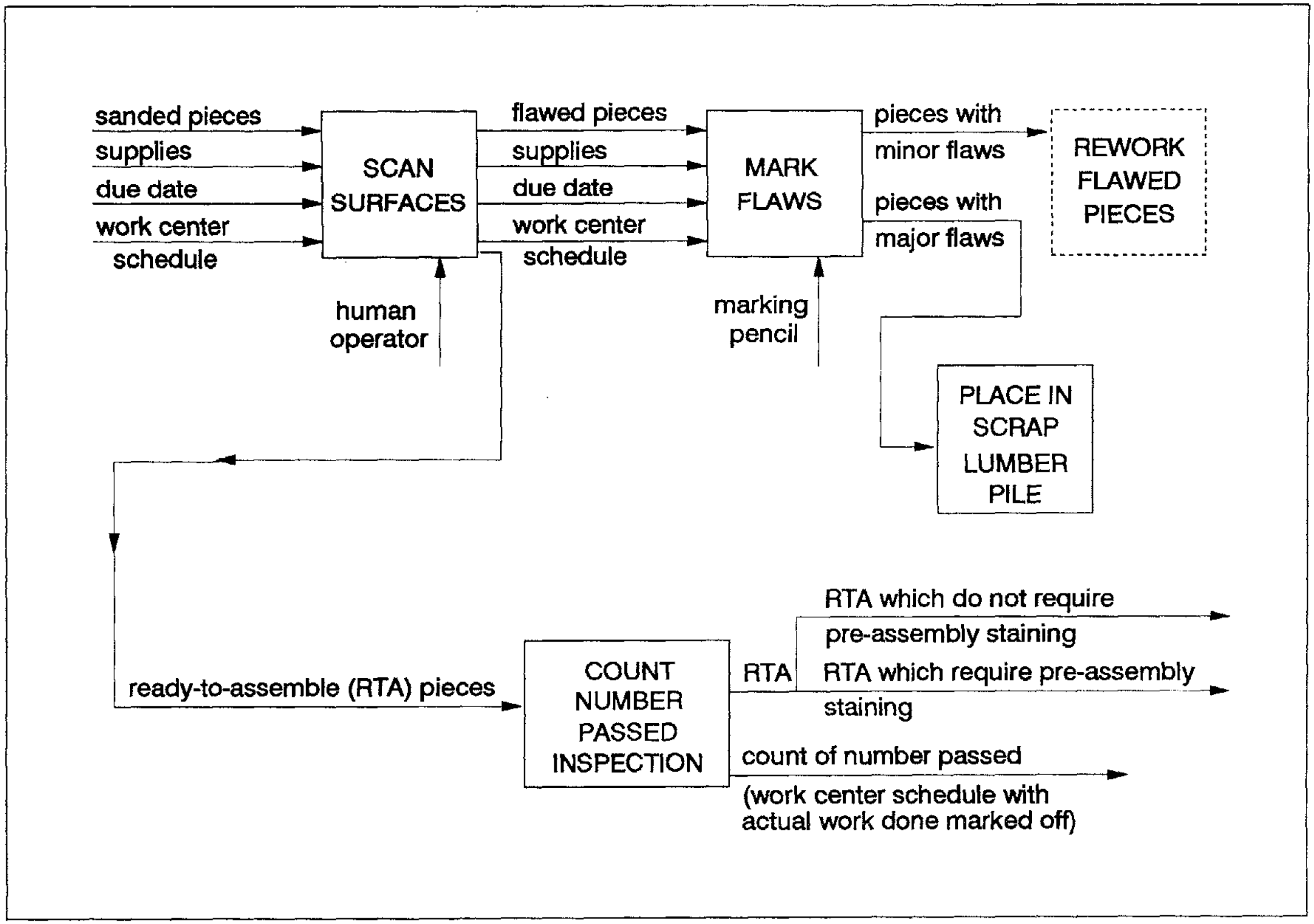

Figure 22.—1A44 Inspect pieces.

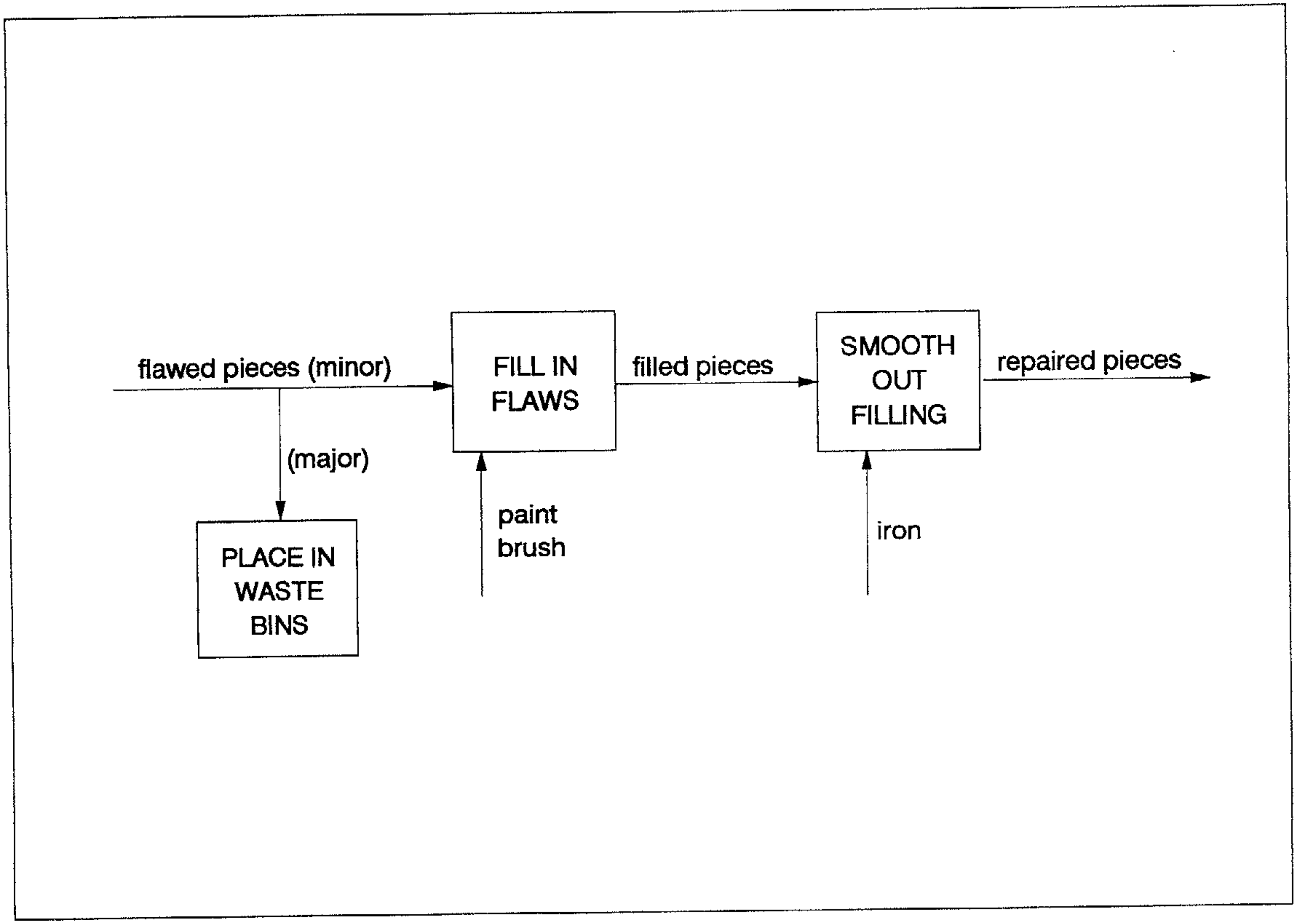

Figure 23.—1A45 Rework flawed pieces.

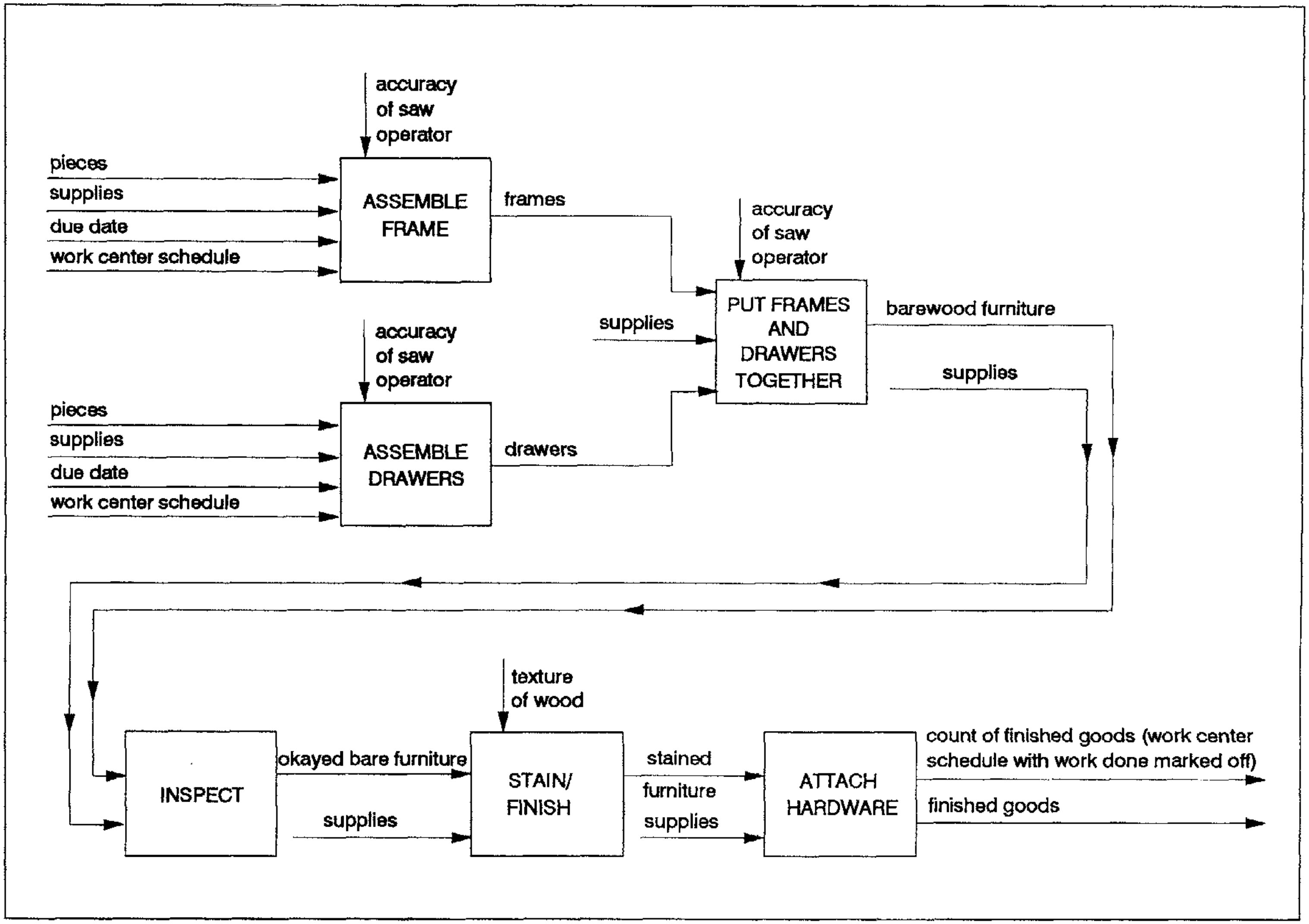

Figure 24.—1A5 Assemble parts.

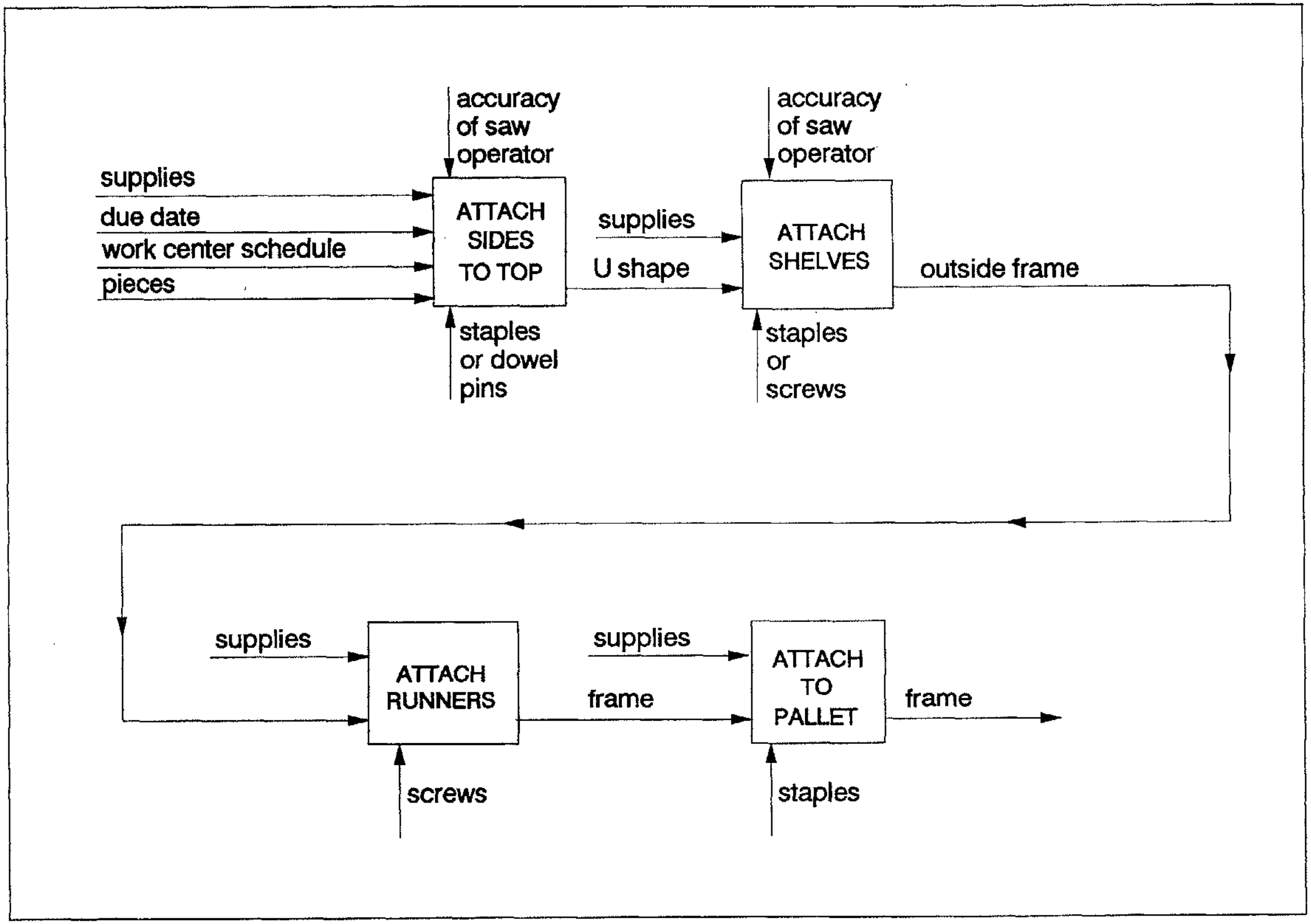

Figure 25.—1A51 Assemble frame.

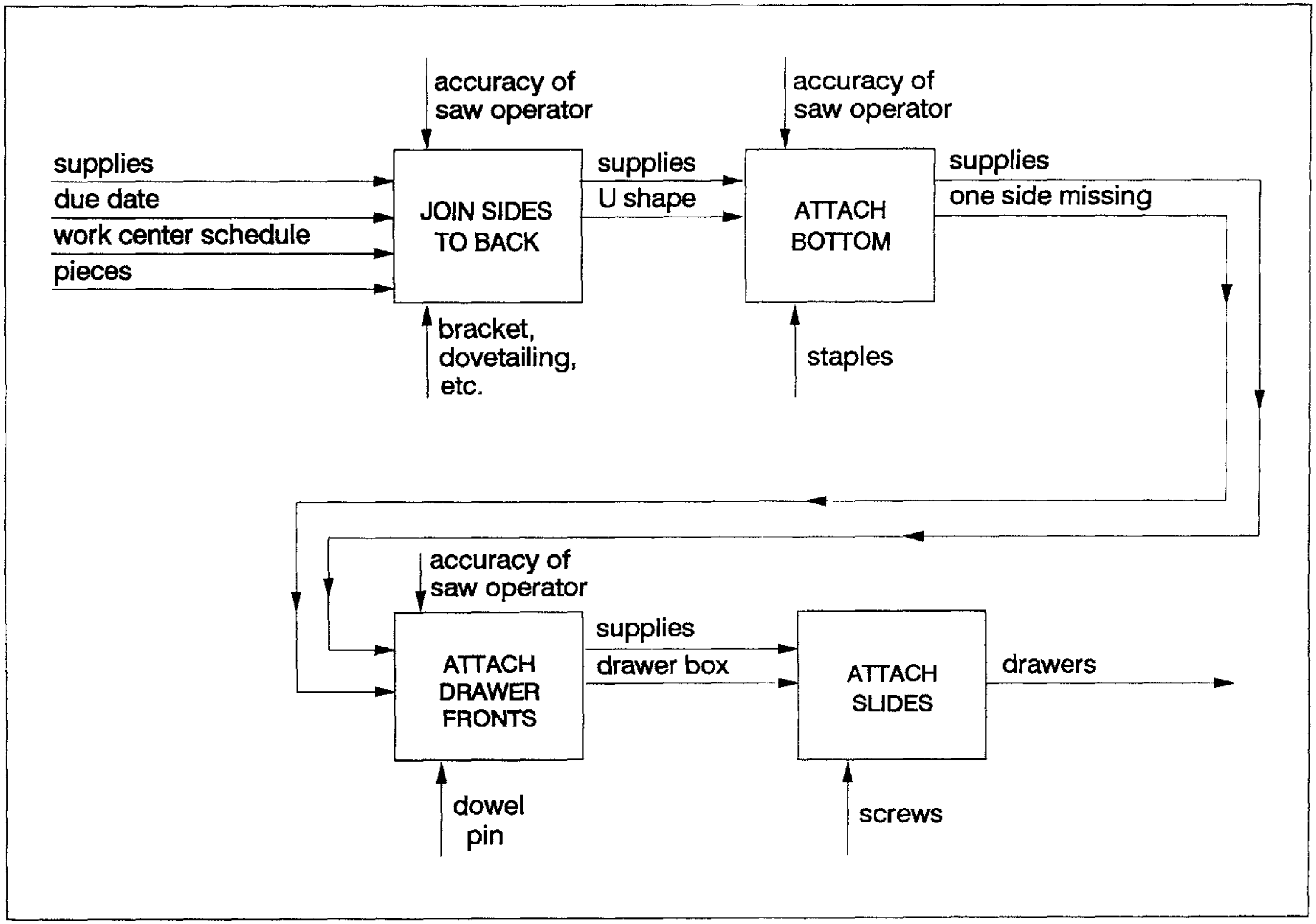

Figure 26.—1A52 Assemble drawers.

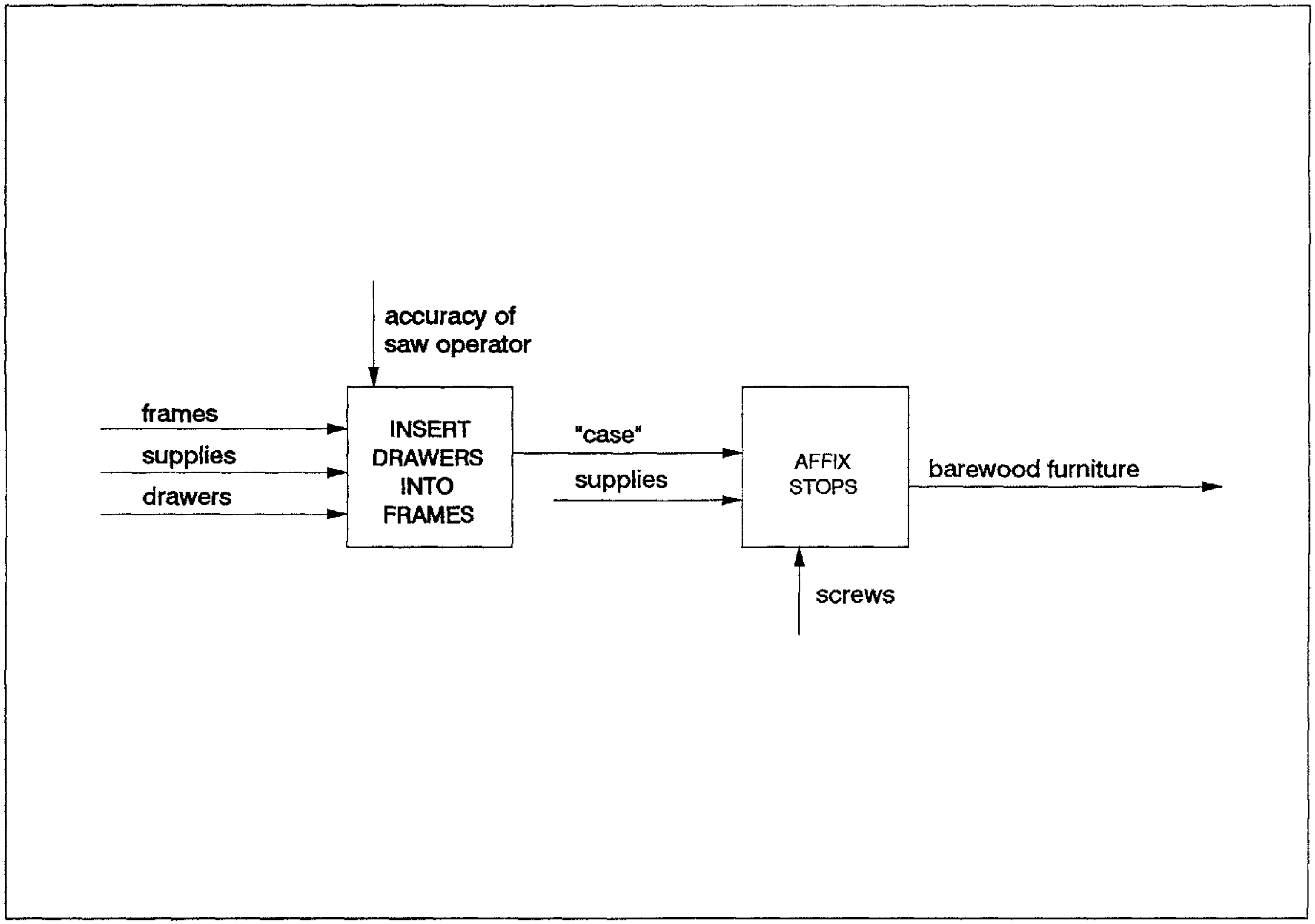

Figure 27.—1A53 Put frames and drawers together.

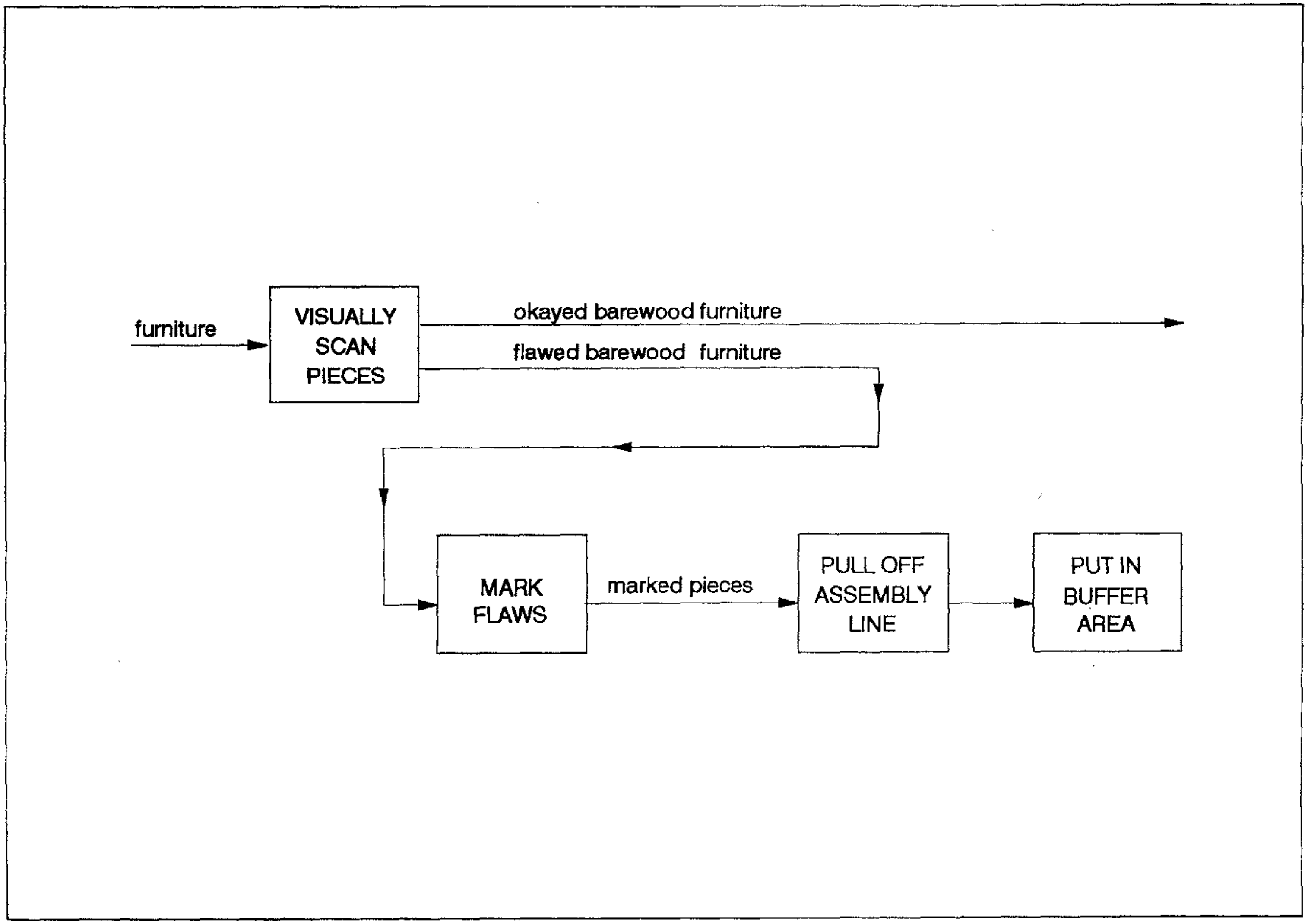

Figure 28.—1A54 Inspect.

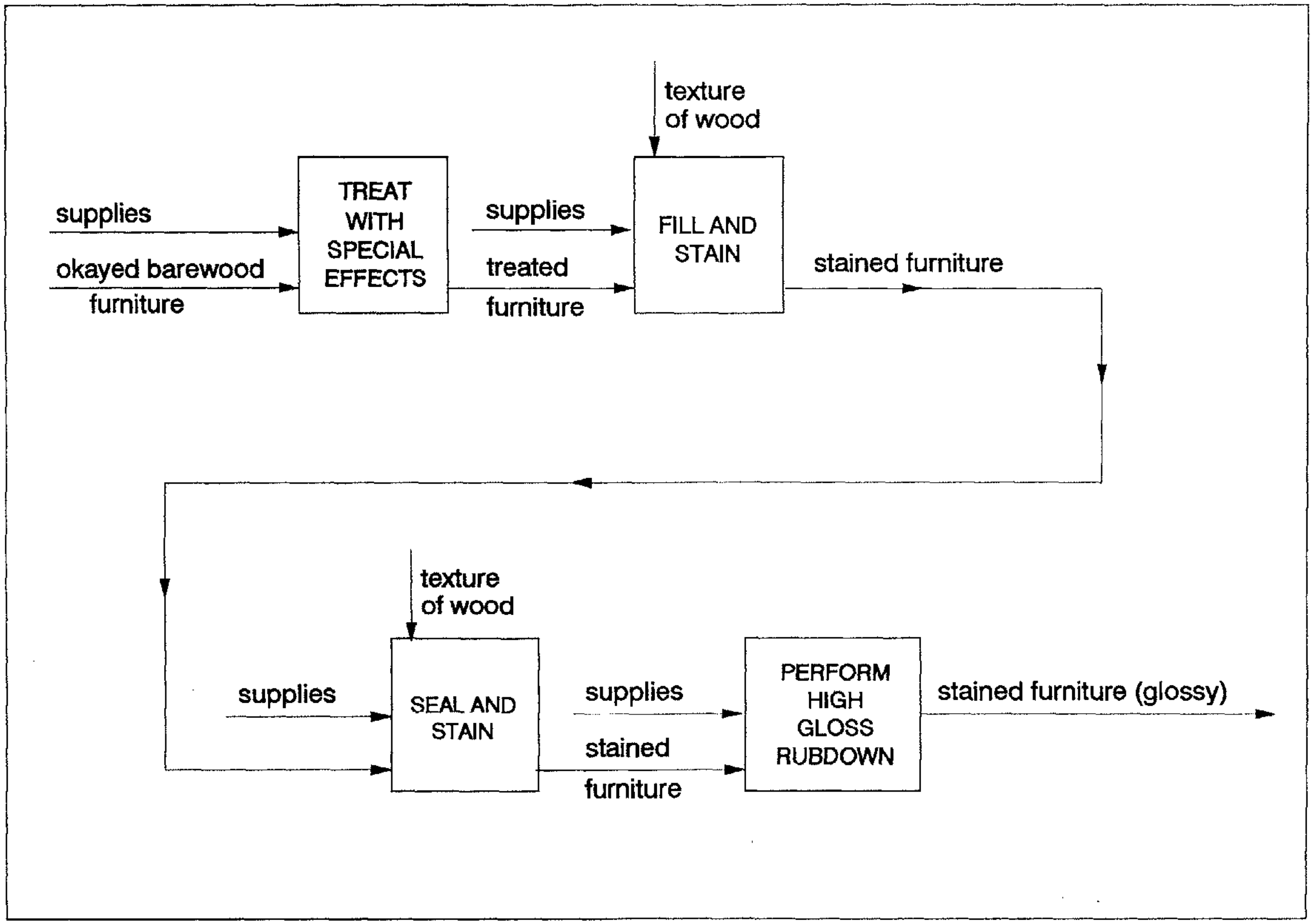

Figure 29.—1A55 Stain and finish.

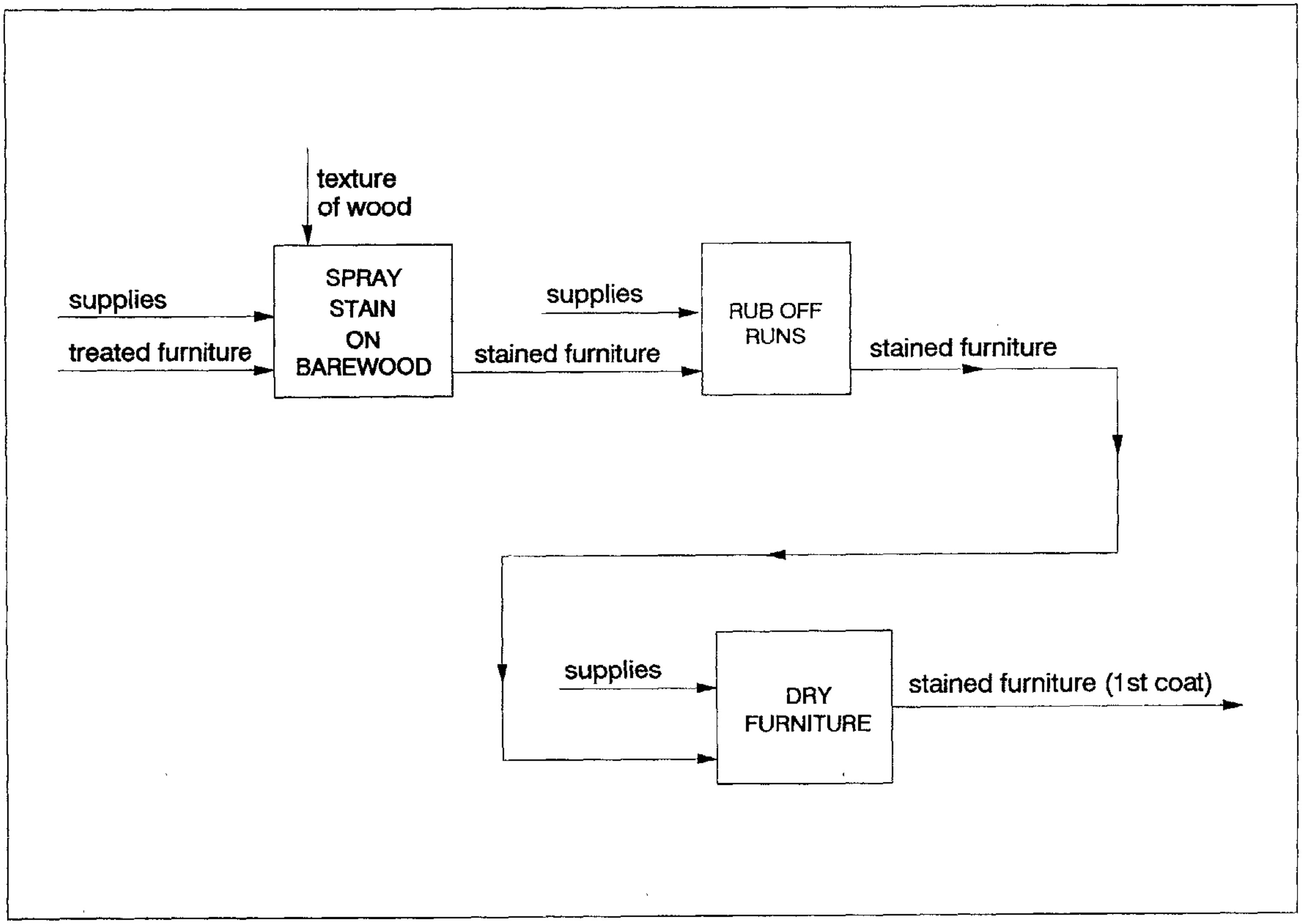

Figure 30.—1A552 Fill and stain.

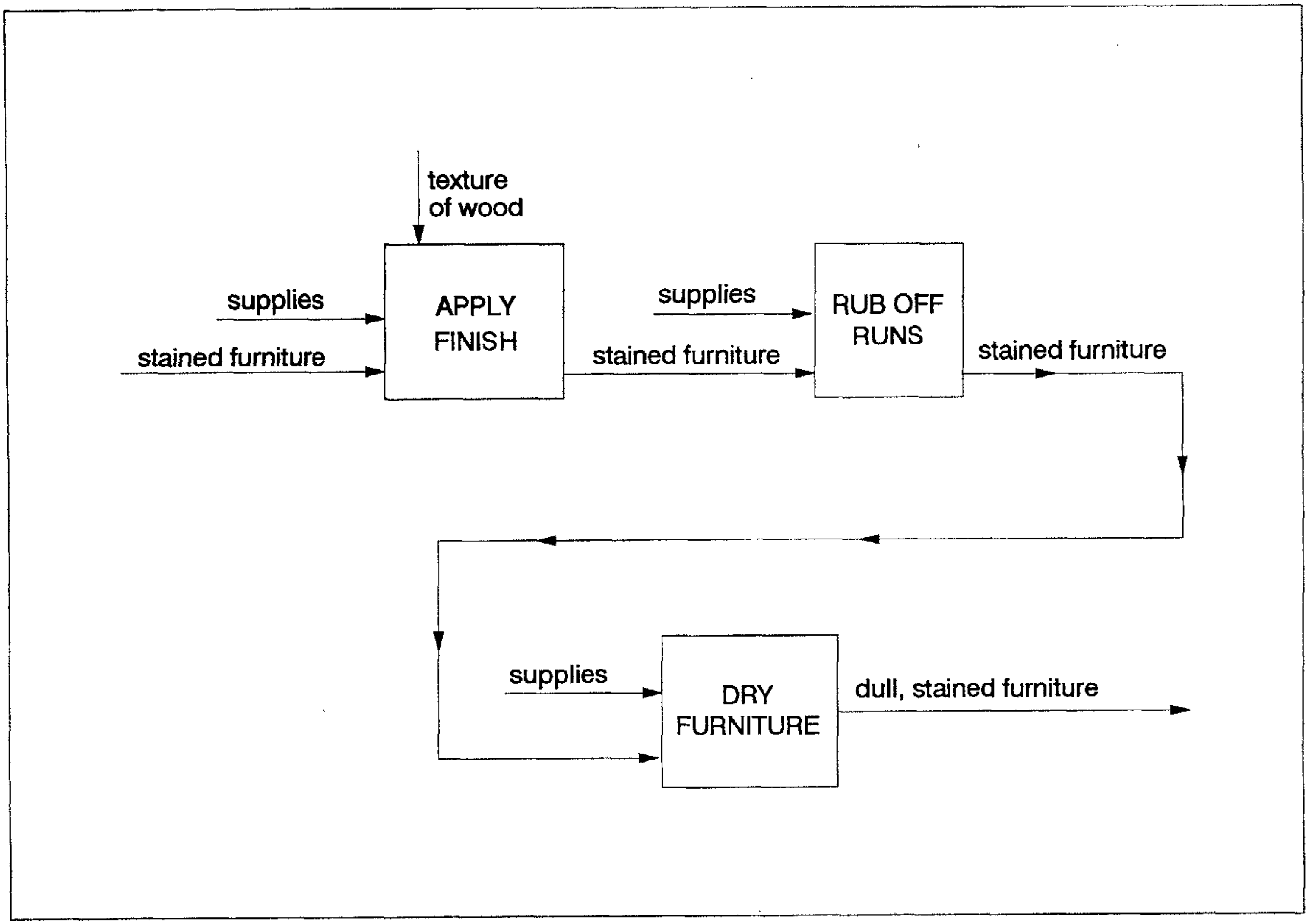

Figure 31.—1A553 Seal and stain.

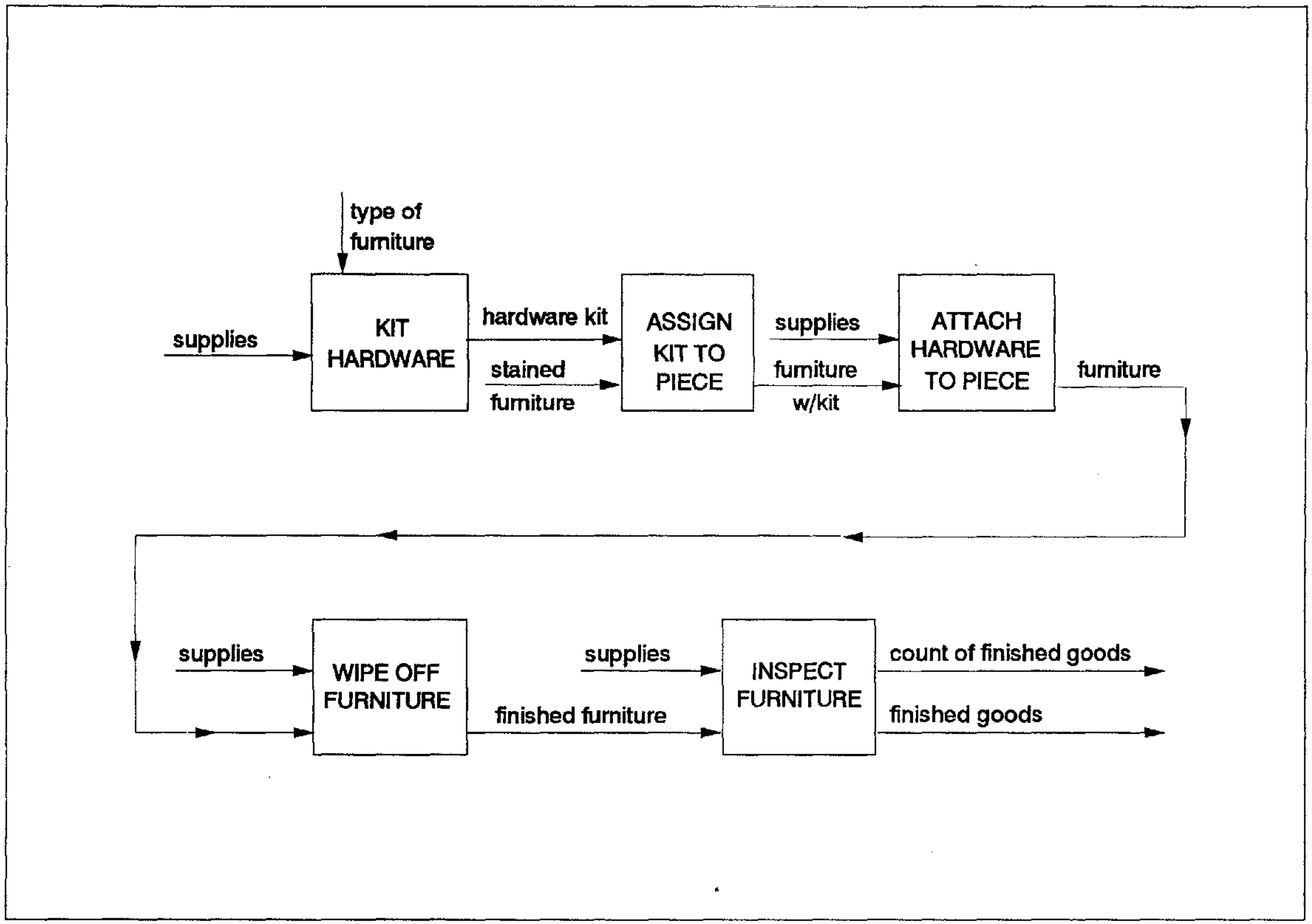

Figure 32.—1A56 Attach hardware.

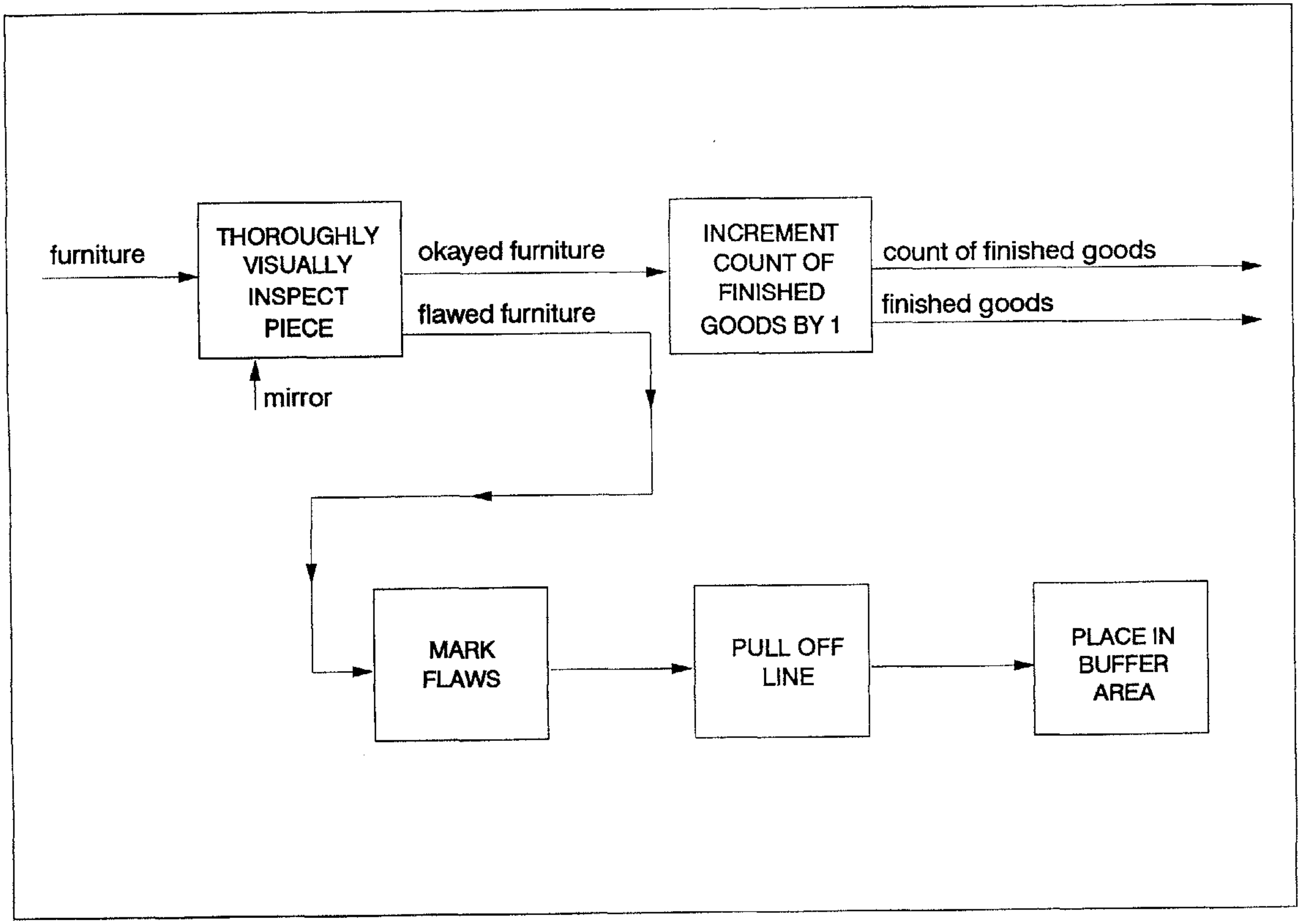

Figure 33.—1A565 Inspect furniture.

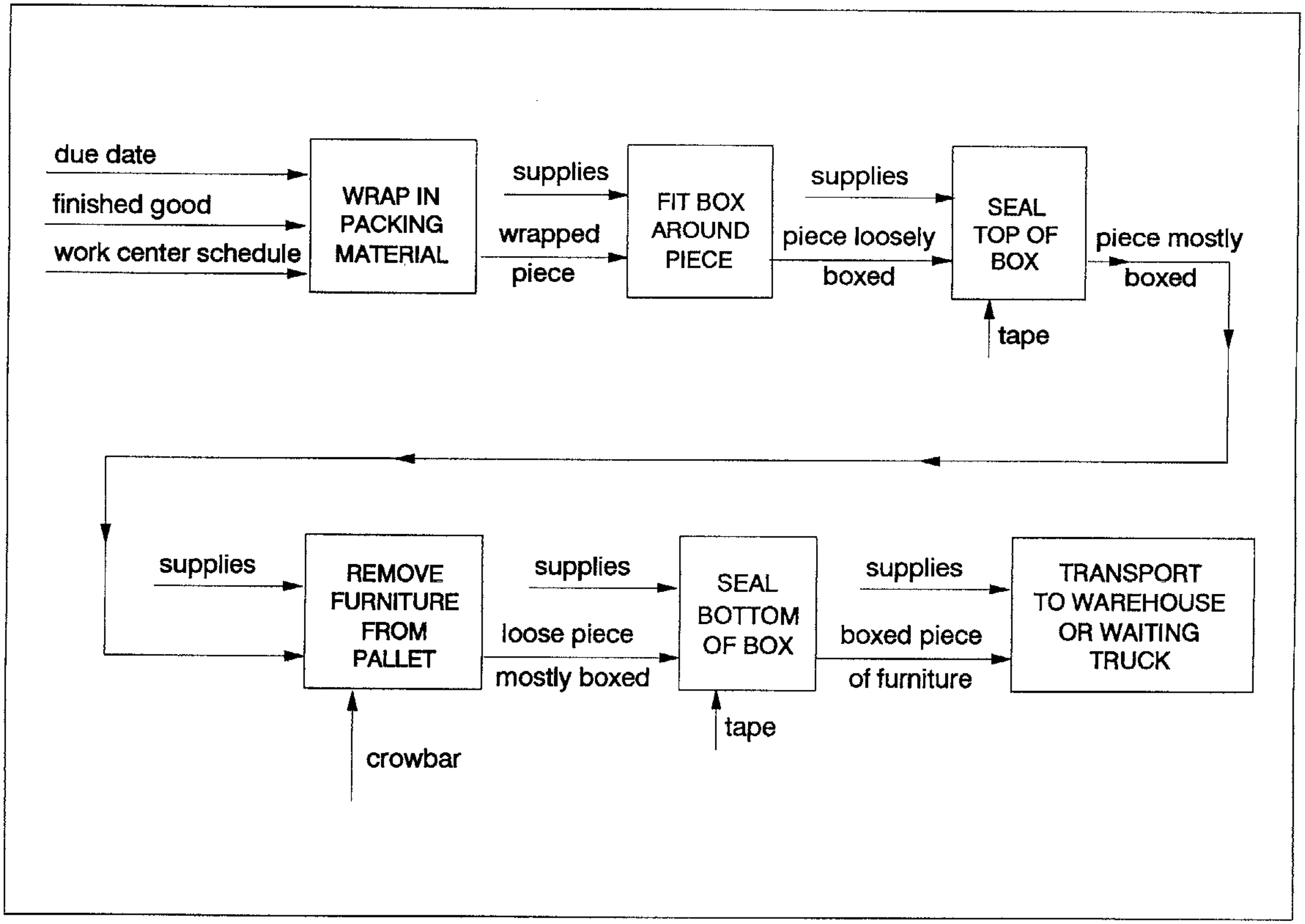

Figure 34.—1A6 Pack and ship.

Appendix B — Node Index

1A. Overview
- 1A1. Prepare order
  - 1A11. Prepare cutting order
    - 1A111. Determine where on master schedule order is to be placed
    - 1A112. Determine bill of materials
    - 1A113. Establish workcenter schedules
  - 1A12. Procure supplies
    - 1A121. Deduct on hand inventory from bill of . materials <u>and</u> update on hand inventory records
    - 1A122. Cut purchase orders
    - 1A123. Place order with vendor
- 1A2. Prepare lumber
  - 1A21. Stack boards of one kind of lumber
  - 1A22. Kiln dry boards
    - 1A221. Get stack(s) of boards of type of lumber specified on work center schedule
    - 1A222. Move and put in kiln and adjust controls
  - 1A23. Test moisture content
  - 1A24. Unstack boards
- 1A3. Dimension pieces
  - 1A31. Plane boards
  - 1A32. Crosscut boards
    - 1A321. Scan board for defect information
    - 1A322. Determine where crosscuts should go to get largest clear area of desired length
    - 1A323. Crosscut boards
    - 1A324. Place in waste bins
  - 1A33. Separate boards by length
  - 1A34. Rip boards
    - 1A341. Set saw blades for desired widths
    - 1A342. Feed boards through rip saw
    - 1A343. Place in waste bins
  - 1A35. Glue boards together
    - 1A351. Load selector
    - 1A352. Scan pieces
    - 1A353. Select pieces such that the total width when glued together comes closest to desired width without being under desired width
    - 1A354. Apply glue
    - 1A355. Put boards together and cure
  - 1A36. Trim pieces
    - 1A361. Resurface pieces
    - 1A362. Trim pieces to uniform length
    - 1A363. Apply veneer or vinyl coating
- 1A4. Shape pieces
  - 1A41. Cut out basic shapes
    - 1A411. Set up machines
    - 1A412. Cut exterior shape
    - 1A413. Carve interior designs
    - 1A414. Place (flawed pieces and sawdust) in waste bins
  - 1A42. Shape edges
    - 1A421. Set up machines
    - 1A422. Run pieces through machines to shape edges
    - 1A423. Place flawed pieces and sawdust in waste bins
  - 1A43. Sand pieces
    - 1A431. Set up sanding machines
    - 1A432. Run pieces through sanders
    - 1A433. Touch up intricate work by sanding by hand
    - 1A434. Place sawdust in waste bins
  - 1A44. Inspect pieces
    - 1A441. Scan surfaces
    - 1A442. Mark flaws
    - 1A443. Place in scrap lumber pile
    - 1A444. Count number passed inspection
  - 1A45. Rework flawed pieces
    - 1A451. Fill in flaws
    - 1A452. Smooth out filling
  - 1A46. Stain pieces which will be visible only part of the time
- 1A5. Assemble parts
  - 1A51. Assemble frame
    - 1A511. Attach sides to top
    - 1A512. Attach shelves
    - 1A513. Attach runners
    - 1A514. Attach to pallet
  - 1A52. Assemble drawers
    - 1A521. Join sides to back
    - 1A522. Attach bottom
    - 1A523. Attach drawer fronts
    - 1A524. Attach slides (and blocks)
  - 1A53. Put frames and drawers together
    - 1A531. Insert drawers into frames
    - 1A532. Affix stops
  - 1A54. Inspect
    - 1A541. Visually scan pieces
    - 1A542. Mark flaws
    - 1A543. Pull off assembly line
    - 1A544. Put in buffer area
  - 1A55. Stain and finish
    - 1A551. Treat with special effects (highlight, fly speck)
    - 1A552. Fill and stain
      - 1A5521. Spray stain on bare wood
      - 1A5522. Rub off runs
      - 1A5523. Dry furniture
    - 1A553. Seal and stain (top coat)
      - 1A5531. Apply finish (glaze)
      - 1A5532. Rub off runs
      - 1A5533. Dry furniture
    - 1A554. High gloss rubdown
  - 1A56. Attach hardware
    - 1A561. Kit hardware
    - 1A562. Assign kit to piece
    - 1A563. Attach hardware to piece
    - 1A564. Wipe off furniture
    - 1A565. Inspect furniture
      - 1A5651. Thoroughly inspect piece visually
      - 1A5652. Increment count of finished goods by one
      - 1A5653. Mark flaws
      - 1A5654. Pull off line
      - 1A5655. Place in buffer area
- 1A6. Pack and ship
  - 1A61. Wrap in packing material

1A62. Fit box around piece
1A63. Seal top of box
1A64. Remove furniture from pallet
1A65. Seal bottom of box
1A66. Transport to warehouse or waiting truck

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Imports from foreign furniture manufacturers are on the rise, and American manufacturers must take advantage of recent technological advances to regain their lost market share. To facilitate the implementation of these technologies for improving productivity and quality, a graphic model of the wood furniture production process is presented using the IDEF modeling process. Description explains the data that flows and the activities that occur in the plant, and their interaction. By analyzing the model, communication may be improved, specific points for implementing new technologies may occur, bottlenecks and problem areas may become evident, inventory control may be simplified, and paperwork may be reduced.

Keywords: Wood furniture production; quality improvement; productivity improvement; IDEF

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