A REFERENCE GUIDE FOR THE CONSTRUCTION AND INSPECTION OF WOOD PALLETS

Project No. NT003-020

DEPARTMENT OF THE NAVY
BUREAU OF SUPPLIES AND ACCOUNTS
WASHINGTON 25, D.C.

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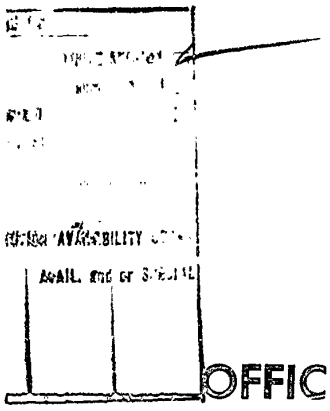

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ABSTRACT

This reference handbook is intended for use by government pallet inspectors and commercial pallet suppliers, in order that suitable pallets will be accepted in the Navy Supply System with minimum cost possibilities. It contains factual pallet data, descriptions of usage, and inspection guides for pallet lumber.

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A REFERENCE GUIDE FOR THE CONSTRUCTION AND INSPECTION OF WOOD PALLETS

INTRODUCTION

The U. S. Armed Services are the largest single users of wood pallets in the entire world. Latest available figures placed some 60 million wood pallets in use by the Armed Services. In addition, military procurement of pallets for the fiscal year 1952 amounted to 2,633,797. Approximately 45% of this total was purchased to satisfy Navy Department demands. It is readily apparent why specifications for wood pallets are of major concern. Current specifications for wood pallets have been prepared after considerable test and development work. Investigations were made into the most minute pallet details relative to the basic operational requirements of the Armed Services. The objective was to secure an effective pallet specification which would permit delivery of commercially manufactured wood pallets, acceptable for the intended use, at the least possible cost. However, a carefully written specification is only as effective as the care exercised by pallet manufacturers and inspectors in complying with and correctly interpreting its provisions.

During the past several years, a general lack of understanding was noticed on the part of pallet manufacturers in their interpretation of certain portions of pallet specifications. In addition, it was found that different standards of inspection prevailed among the regional offices of the Inspector of Naval Material. The result was that certain shipments of pallets being received were of such poor grade that the useful life of the pallet could be only a small fraction of the normal life expectancy.

In view of the large quantity of pallets used by, and procured for the Armed Services, the acceptance of inferior pallets is uneconomical in that large maintenance and repair costs may be anticipated. Inferior pallets also present a considerable safety hazard.

In the past, attempts have been made to apprise pallet manufacturers and inspectors of the seriousness of the situation. As early as 1949, the Supply Engineering Division of the U. S. Naval Supply Research and Development Facility, presented to the mem-

bers of the National Wood Pallet Manufacturers Association, a demonstration of actual operating conditions encountered with pallets in the Navy Supply System in conjunction with a thorough analysis of pallet details. This afforded the pallet suppliers an opportunity to see first hand the reasons why Navy Pallet Specifications must be based upon a realistic appraisal of each characteristic of its use.

Continuing along this line, the Bureau of Supplies and Accounts, by letter dated 5 November 1951, authorized the Supply Engineering Division, U. S. Naval Supply Research and Development Facility to conduct an investigation into inspection procedures for wood pallets. The objective was to develop a system wherein standardization and uniform methods of pallet inspection might be effected.

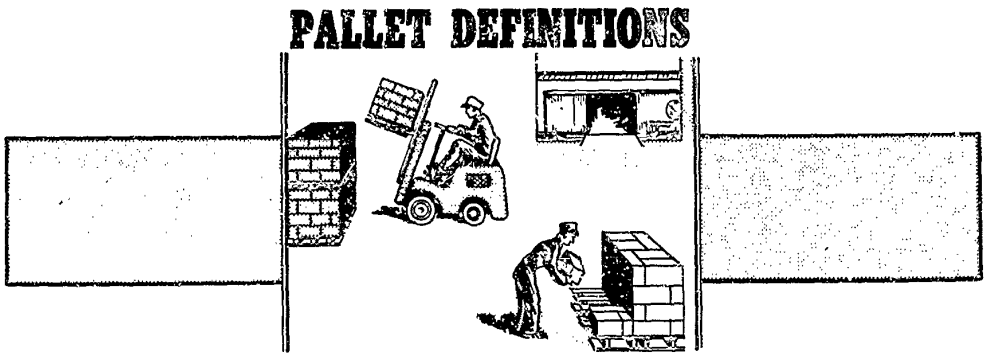
This reference guide for wood pallets is the direct result of the investigations conducted. It is believed that the material contained herein will assist the pallet suppliers and inspectors by providing pertinent background data and fundamental principles necessary for the exercise of proper judgment in making decisions relative to the manufacture and inspection of wood pallets. In addition, such material can well be a basis for the indoctrination of inexperienced industrial and government personnel, both civil and military.

Six distinct sections are presented: sections I and II deal with the operational and practical background of pallet usage and handling equipment; and sections III to VI inclusive, present fundamental information about pallet lumber upon which grading and inspection rules are based. The latter sections were prepared by the Forest Products Laboratory, the leading authority on lumber in this country.

An index is appended to afford a ready and handy system of locating desired information.

Pallet manufacturers and government inspectors should bear in mind that the material presented in this book should in no way be interpreted as superseding any requirement in the contract specifications. However, this book will serve as a handy guide towards the end purpose; a well constructed, serviceable pallet, suitable for military requirements, at the least possible cost.

SECTION I



1.1 GENERAL. A pallet is a portable platform on which merchandise is placed to facilitate transport and materials handling; a two deck structure which permits mechanical handling and tiering of unit loads of materials or products; and a modern version of the old time industrial skid, different in that it conserves cube and permits handling and tiering of unit loads by high lift mechanical equipment.

Among the advantages gained by use of the pallet are:

(a) Speed in handling

(b) Utilization of overhead storage space

(c) Use of inexperienced labor

(d) Reduces re-handling costs

(e) Lessens damage and pilferage

(f) Reduced terminal time

(g) Improved ventilation in storing perishables

(h) Simplification of vermin control

(i) Reduction of industrial accidents

(j) Rapid movement

1.2 TYPES. There are basically three different headings into which pallets may be classified: (a) expendable, (b) general purpose, and (c) permanent pallet. The material used for construction, cost, and the intended usage, usually are the factors which determine the category into which they may be placed.

1.3 NAILED WOOD PALLET. The type predominantly in use by the Armed Services is the general purpose nailed wood pallet. This type is one with which this book is principally concerned. The selection of this material type for general use by the military is due to its versatility, utility, cost, availability of material, simplicity of design, strength characteristics and ease of repair. When properly constructed, this pallet is known to give long time service at a minimum of repair cost.

For purposes of clarification, the two other basic types are briefly described as follows:

1.4 EXPENDABLE PALLET - a low cost, lightweight, special purpose pallet requiring different design considerations for each individual application. Normally used as a shipping medium for unit loads to effect maximum savings in shipping costs.

1.5 PERMANENT PALLET - a heavy duty pallet usually constructed of metal or wood or a combination of both and used primarily for intra- and inter-plant storing and handling of heavy raw materials or bulky merchandise principally used in industrial plants.

1.6 DESIGNS. There are many variations of the general purpose nailed wood pallet. The designs more commonly utilized are described below. Each design contains the features of construction found to provide the most efficient results in the particular application for which it is intended.

1.7 FLUSH-STRINGER TYPE - a pallet in which the deck boards are flush with the outside faces of the between deck supports.

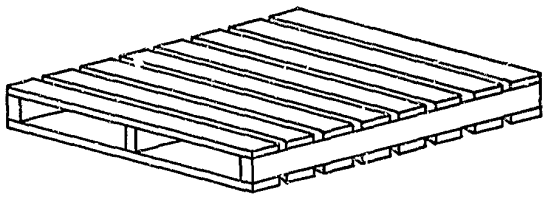


Fig. 1. - Flush type-reversible-2 way entry

This design usually has a two way entry for fork lift equipment and top and bottom deck construction is similar. This reversibility of decks provides more bottom area support for proper distribution of the load under tier.

1.8 DOUBLE WING TWO WAY ENTRY - this design is a standard type used by the Navy during World War II. Bottom deck openings are provided to enable handling by hand operated pallet trucks.

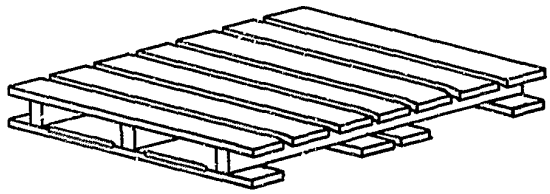


Fig. 2. - Double wing type-non reversible 2 way entry

The stringer supports are set in from the edges of the deck boards to accommodate bar slings when hoisting pallet loads in shiploading operation. The common size is 48" x 48" which is ideally suited for railroad car dimensions and warehouse layouts. This size permits efficient stacking of the majority of commercial package sizes.

1.9 DOUBLE WING-FOUR WAY ENTRY - the between deck supports consist of individual posts which enable entry of all mechanical handling equipment on all four sides of the pallet. This design was adopted by the Navy shortly after World War II. The four way feature of this type, together with an overall

pallet dimension of 40" x 48", meets the requirements imposed by both railroad car and truck dimensions and permits efficient use of available space in either of these two methods of transportation.

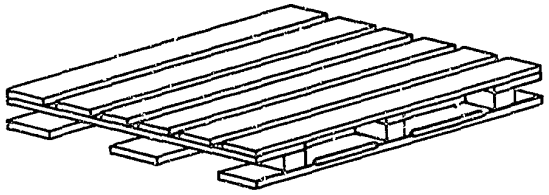


Fig. 3. - Double wing type-non reversible 4 way entry (posts)

Posts are spaced inward from the edges of the top deck to provide wings for hoisting by slings. The bottom deck boards are spaced to allow the wheels of the hand operated pallet trucks to drop through.

1.10 DOUBLE WING - NOTCHED - Stringer - this design is similar to the Double Wing Two Way Entry pallet. The difference is that two cutouts are made in each stringer length to allow entry for the forks of the high lift trucks. This design permits a four way entry for fork trucks but only two way entry for hand pallet trucks.

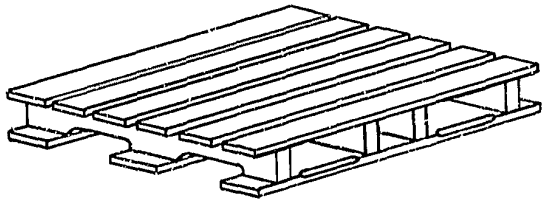


Fig. 4. - Double wing type-non reversible notched stringer -4 way entry (partial)

1.11 SINGLE WING - NOTCHED STRINGER - a pallet in which the stringers are set in from the ends of the top deck boards only. The bottom deck boards are flush with the faces of the stringer.

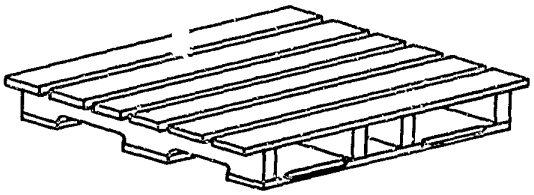


Fig. 5. - Single wing type-non reversible notched stringer 4 way entry (partial)

Each stringer has two cutouts for entry by high lift fork trucks. This design allows four way entry by fork trucks and two way entry by hand operated pallet trucks. The purpose of the single wing is to allow use of straddle type manually or mechanically operated lift equipment where conservation of aisle space is required.

1.12 STEVEDORING (CARGO) PALLET - the inclusion of this size (48" x 72") pallet as a general purpose type is justified because of its extensive use by the Armed Services in terminal, shiploading and warehousing operations.

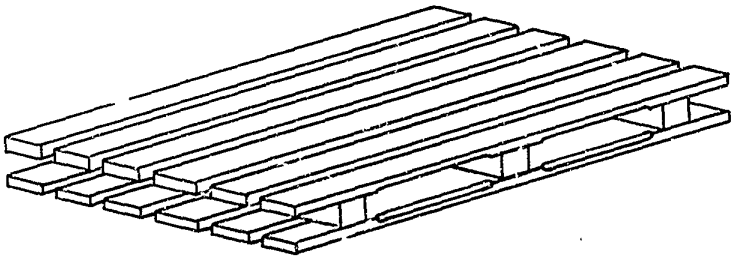


Fig. 6. - Cargo pallet (stevedoring) 48" x 72"

This structure is usually composed of nominal 2" x 8" lumber with top and bottom decks alike.

The stringers are nominal 4" x 4" set in from the ends of the deck boards to allow for insertion of the sling bar under the top deck boards. Two way entry for high lift fork equipment is provided. The principal application of this pallet is in the handling or storing of large, irregular or heavy loads.

1.13 INTENDED USAGE. The general purpose nailed wood pallet has multiple military application. In conjunction with the conventional types of fork trucks it is employed as a means for handling, shipping and storing of a considerable number of different items (See Figures 7 to 10). Its advantages have already been stated in paragraph 1. The operational requirements of a pallet may include service anywhere from a continental military supply establishment to a supply dump located on a remote overseas island.

1.14 HANDLING EQUIPMENT. The equipment used to handle the loaded pallet will include many types. The standard types are the high lift fork truck and the manually operated low lift truck. There are many different designs and sizes of these two basic types, the selection usually is dependent on the characteristics demanded by the particular storing and shipping operation or by local conditions (See Figures 8 to 14). Other equipment used to handle pallets will include types peculiar only to the military. Figures 15 to 22 depict the actual procedures followed in handling loaded pallets in operations wherein conventional methods cannot be utilized. These illustrations will indicate the details that have been carefully incorporated into the pallet design and specification to insure suitability for the intended military functions.

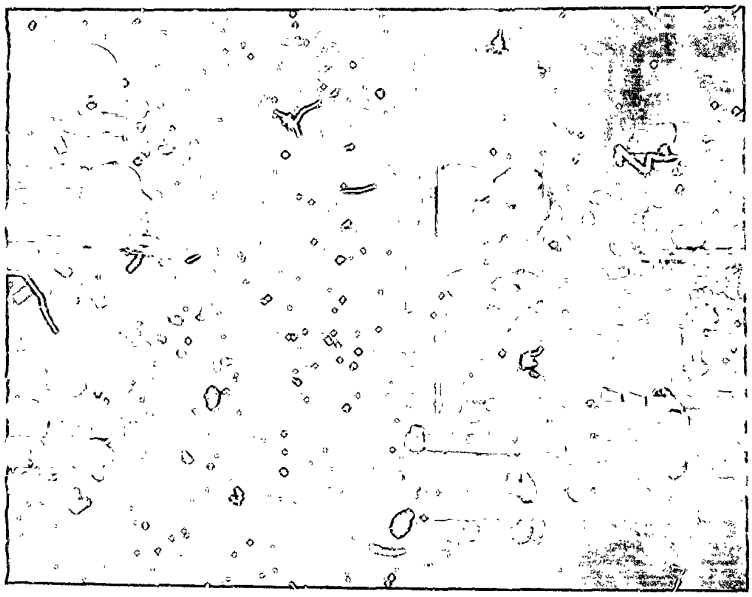


Fig. 7. - Typical Navy warehouse showing variety of different shaped items handled on wood pallets in the military supply system. Neg. No. 294-3.

Fig. 8. - Typical warehouse tiering operation. Note utilization of height space by fork truck pallet system. Sound pallet construction is required to insure safety of operation. Neg. No. RS-41-5.

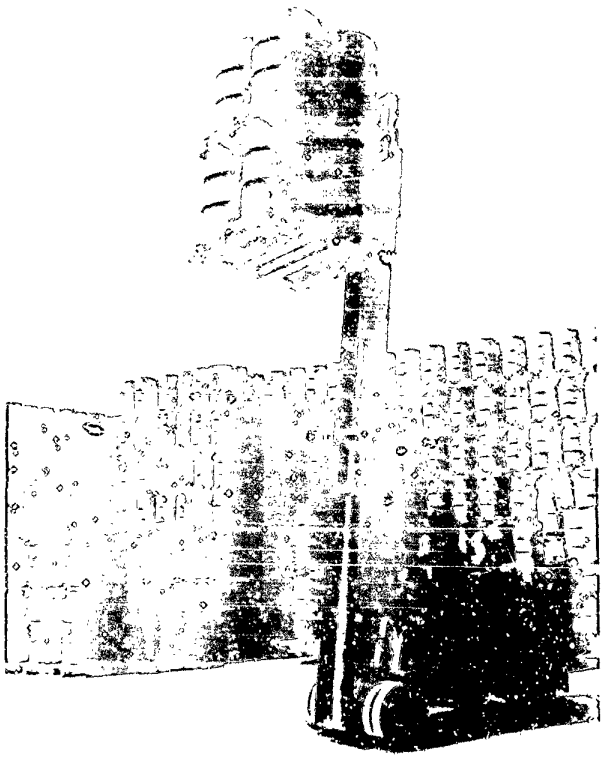


Fig. 9. - Outdoor storage operation. Wood pallet provides speed of handling, efficiency, and safety of operation in high stacking. Neg. No. 316-1.

Fig. 10. - Tractor-trailer combination used to convey palletized unit loads over long distances within a military supply depot. Fork truck is unloading dollies in the warehouse and tiering the loads. Neg. No. 154-1.

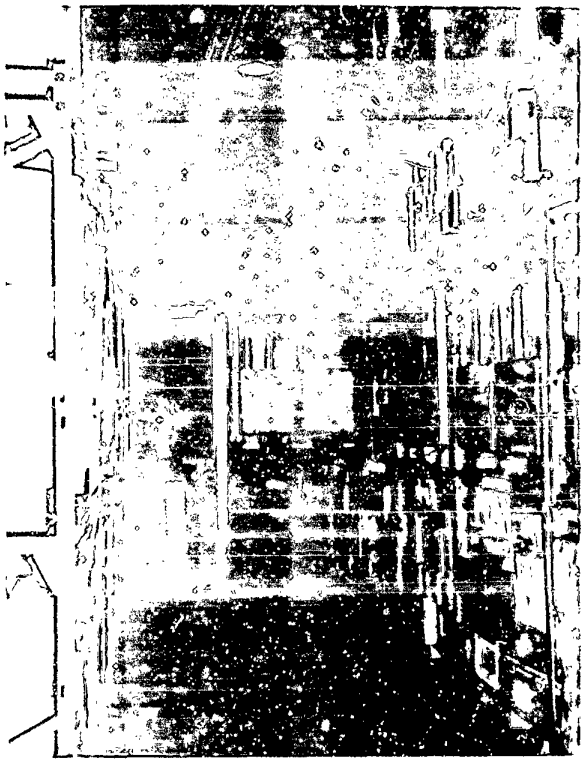


Fig. 11. - Straddle type fork truck and pallet rack operation. Single wing wood pallets are employed so that straddle arms may enter under the pallet on the ground to work close to the rack tier. Neg. No. 139-1.

'ig. 12. - Loading of a reight car with palletized oads. Wood pallets must e able to resist the im- acts encountered in freight umping operations and be ble to protect the lading uring such shipment. leg. No. 249-1.

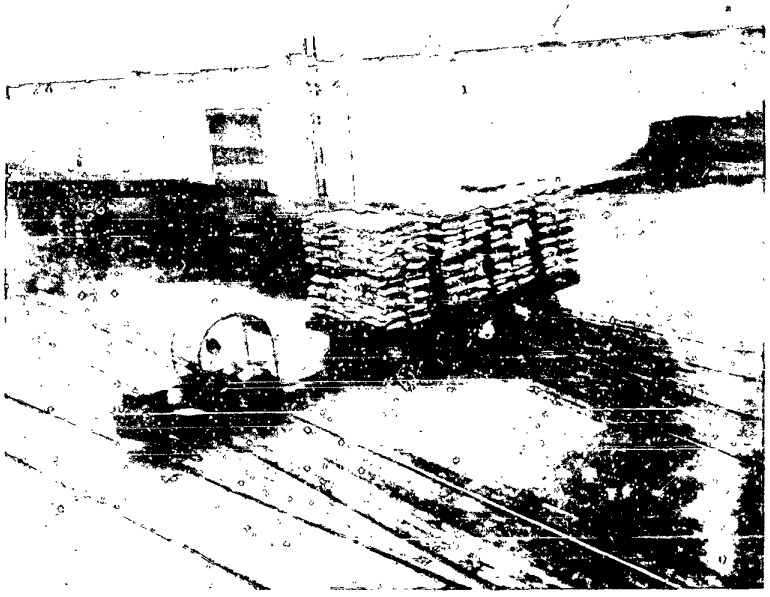


Fig. 13. - A tractor-flat combination moving pallet loads to the transshipment shed at a Navy Supply Depot. Neg. No. 267-3.

Fig. 14. - Method used to position first load in freight car unloading. Fork truck is then placed in car for handling remaining loads. Dragging of pallet requires strong material construction. Neg. No. 297-4.

Fig. 15. - Typical stevedoring operations. Note variety of equipment needed to handle pallet loads. Pallet is subjected to considerable abuse during these operations and requires strong design to resist damaging forces. Neg. No. 287-6.

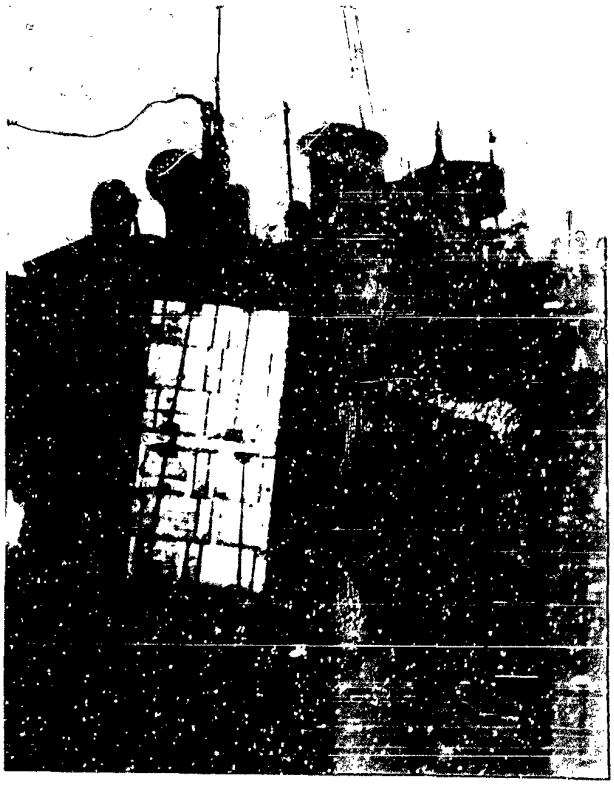


Fig. 16. - Typical slinging operations for shiploading of pallet loads. Rugged pallet construction is required to absorb impacts during hoisting and dropping of loads. Neg. No. 62-19.

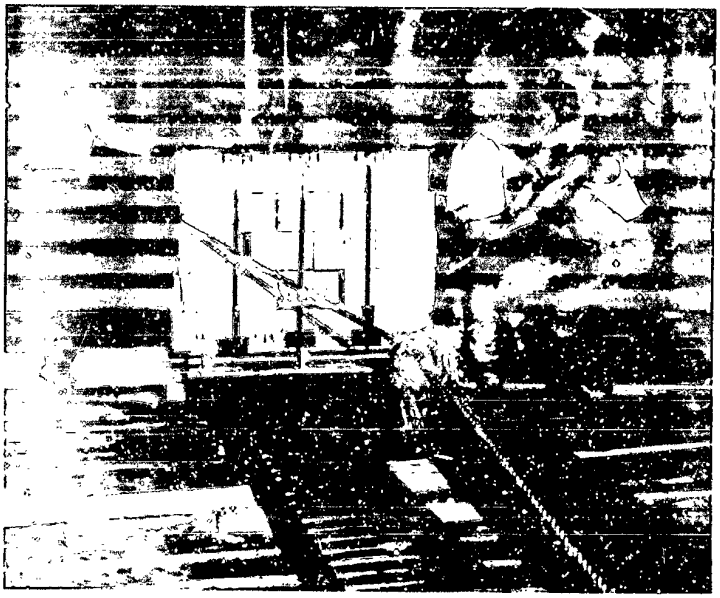
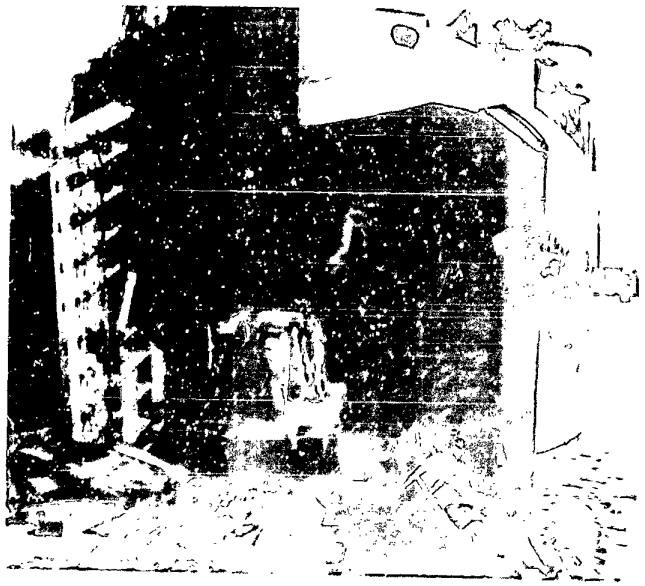


Fig. 17. - Movement of pallet load over sections of roller conveyors during stevedoring operations. Wood pallets must be able to withstand the concentrated forces indicated in photo. Neg. No. 317-4.

Fig. 18. - Fork truck pallet operation in the hold of a ship. The pallet must have general duty capability for overseas requirements. Neg. No. 287-5.

Fig. 19. - Typical handling of palletized loads in amphibious operations. Crawler type fork truck is used to move pallet loads over sandy beaches. Neg. No. 298.

Fig. 20. - Typical military operation showing pallet loading of a landing ship. Pallet handling is severe in such operations and requires a strong pallet design. Neg. No. 317-6.



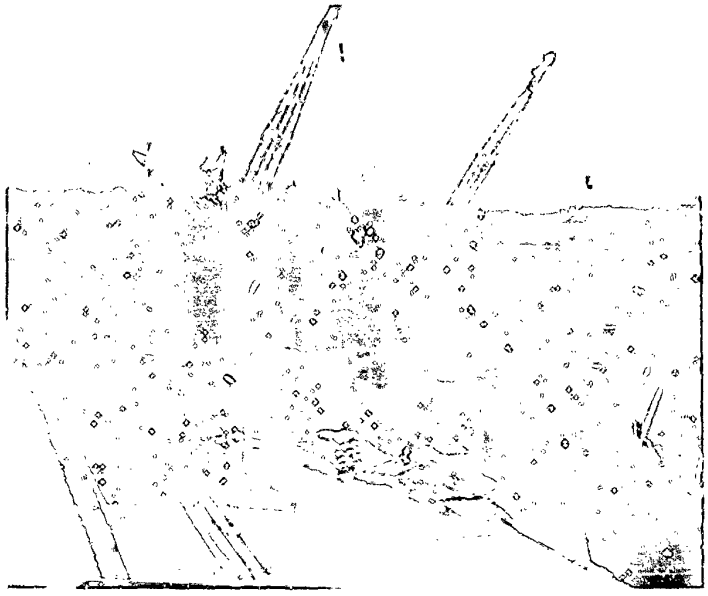
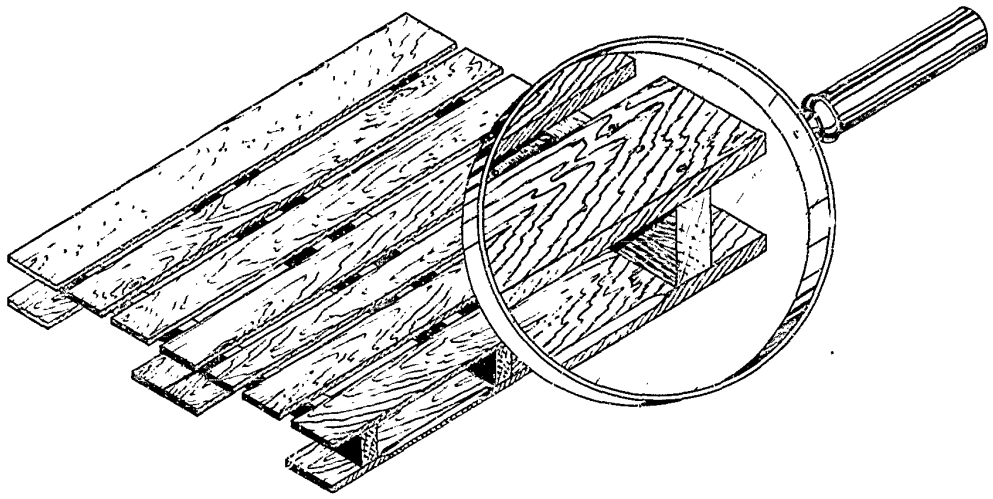


Fig. 21. - Typical overseas port operation. Pallet usage in such operations indicates the wide area of pallet requirements for the military services. Neg. No. 317-3.

Fig. 22. - Method used to move pallet loads in emergency operations when lift equipment is not available. Pallet toboggan towing is used in amphibious operations. Neg. No. 245-6.

SECTION II

PALLET REQUIREMENTS



2.1 COMPONENT PARTS. The general purpose wood pallet contains either all or a majority of the following sections: (a) load bearing surface or top deck, (b) vertical support members and, (c) bottom deck or floor bearing surface. Both hardwood and softwood are used in manufacture in accordance with particular specifications. The parts are bonded together by the grooved shank pallet nails which provide an efficient and strong pallet structure at the least cost. The accepted nomenclature used by military specification for the pallet parts is illustrated in Fig. 23. These parts will be covered in detail further in this report.

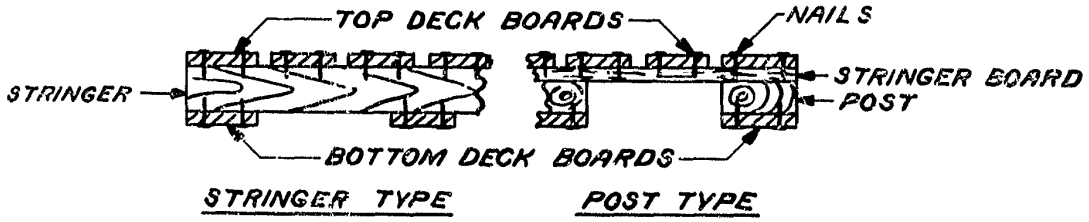


Fig. 23. - Pallet Nomenclature

2.2 WOOD. By far the most widely used material for military pallets is hardwood. Considerable research and development work, together with long time usage data, has firmly established this material as best for overall military requirements at minimum cost. Hardwood pallets, properly constructed, have been known to have a life span of over ten years with low maintenance costs in the military supply systems. (Fig. 24). However, this advantage can be quickly lost when the material and workmanship employed in pallet construction is of low grade. People having an interest in pallet procurement should be aware of the expected hard usage a pallet encounters in the Armed Services. Unlike a commercial plant in which the pallet usually serves a specific function, the military has a considerable amount of different applications, thousands of different items to be handled and overseas and emergency conditions to be considered in the overall pallet usage requirements. The hardwood pallet has been found to provide the most economical results for general purpose duty covering all the above conditions, both in original cost and in maintenance requirements.

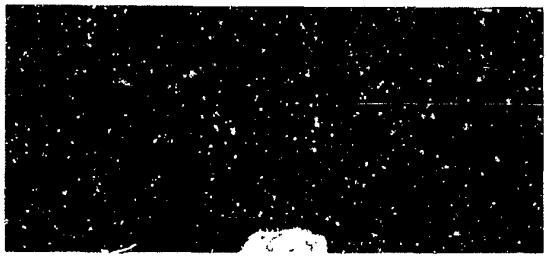


Fig. 24. - A properly constructed hardwood pallet can be expected to have a long and efficient life with minimum maintenance costs. This pallet is estimated to be at least 10 years old and is still useful. Neg. No. 151-13.

For special cases when or where the availability of hardwood for pallets may be limited, specifications for a general purpose pallet having softwood parts have been prepared. However, the inclusion of softwood in the pallet structure has been made at points that do not generally receive hard wear and are not exposed to damaging conditions. It has been determined from performance data that the parts of the pallet that are more susceptible to damages in abnormal operations are the outer end boards of the decks and the vertical support members. Military specifications covering softwood pallets will usually include hardwood at these points. When a more liberal use is made of softwood for pallets, the members are of greater

thickness so as to be comparable to hardwood in strength and wearing qualities. The stevedoring (cargo) pallet composed of nominal 2" softwood deck boards and nominal 4" x 4" softwood stringers is an example of softwood usage that has given satisfactory performance. (Fig. 25).

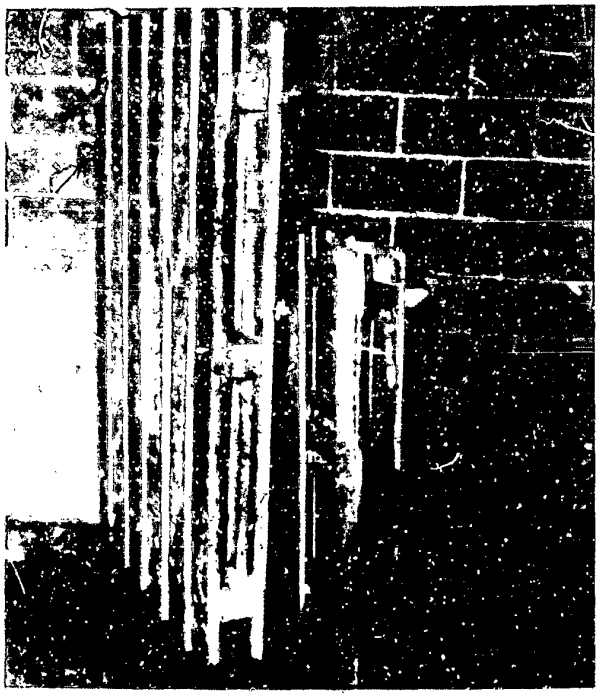


Fig. 25. - Efficient use of softwood for pallets is made in the stevedoring (48" x 72") cargo pallet shown at left. Relative strength qualities comparable to the 40" x 48" hardwood pallet at right is obtained by increased lumber thickness. Neg. No. 151-15.

The hardwood species utilized for pallet construction include those found in GROUP 4 woods. This group contains those woods having the greatest nail holding power and the highest resistance to wear. Another important characteristic found in these woods from a pallet standpoint is their cleavage values which indicate the resistance of the wood to chip and split. This quality is particularly important for the post members of the pallet which are continually exposed to impacts from the forks of lift equipment when they are entered between the pallet decks. (Fig. 26). Tests conducted by the

Forest Products Laboratory have indicated that the cleavage values give a good indication of the expected behavior of a species of wood under impacts from the forks. Thus, when species with high cleavage values (such as those found in hardwoods) are used for post and stringers, the pallets may be expected to afford more resistance to splitting and chipping than constructed from species with low cleavage values, such as those found in softwoods. Specifications covering softwoods for pallets have been carefully prepared to include only those softwoods having the better overall strength characteristics. In collaboration with the U. S. Naval Supply Research and Development Facility, the Forest Products Laboratory has conducted considerable studies and tests with different softwood species and has advised on the selection of those species having the better advantages for pallet use. These species are usually found in the GROUP 1 and 2 woods. It is mentioned again, however, that when softwood is used for pallets it must have strength equivalent to hardwood. This is made possible by increased thickness.

Fig. 26. - Effect of using woods for posts having low cleavage values such as those found in softwoods. Note chipping and splitting of posts due to sharp impacts. Neg. No. 557-4.

2.3 MOISTURE CONTENT. The most important condition that directly affects the serviceability and life of the wood pallet from the date of purchase is the moisture content of the lumber used in manufacture. Pallets constructed with seasoned lumber will contain the following important qualities that are definite factors governing performance and life expectancy of the pallet in service:

(a) Greater strength

(b) Longer life

(c) Better nail holding

(d) Resistance to decay

(e) Minimal shrinkage

(f) Dimensional stability

(g) Overall economy

The results of tests and long time service data have clearly shown that a pallet constructed with wood having low moisture content will give long time service use with minimum repair costs. Military pallet specifications generally list the moisture content requirements in the form of average percent moisture contents for the component wood parts, and place a limit on the maximum amount of any one member. This allows a practical method of obtaining pallets with an acceptable moisture content and yet is considered not too restrictive. In spite of this, the moisture content requirements of military specifications has been the object of much controversy with regard to compliance and inspection. Much of this has been attributed to the fact that most pallet suppliers have treated this requirement lightly at the time of bidding on government pallet contracts. Another factor has been limited availability of seasoned wood for pallets due to lack of time, space and means to season lumber properly in the majority of pallet manufacturing mills. Most of the difficulties have been resolved by specifying different grades of wood pallets based on the moisture content requirement. In this way, when the availability of seasoned wood may be limited for pallets, suppliers would have the opportunity to submit bids on a grade of pallet having high moisture content. While this is considered detrimental (see Fig. 27 and 28), in that inferior grades of pallets will be accepted into the supply system, it has maintained large scale competitive pallet bidding for government procurements which is beneficial from an overall military standpoint in times of emergencies.

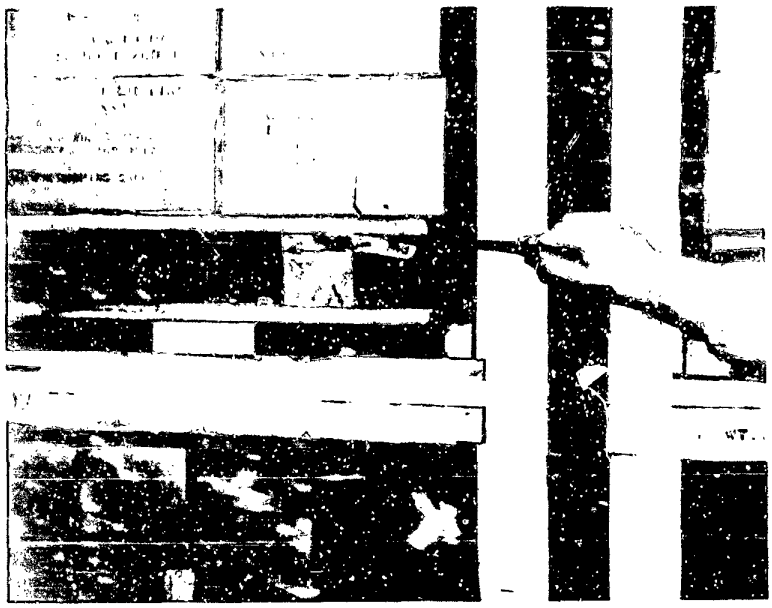


Fig. 27. - Result of use of high moisture lumber in pallet construction. Stringer board has warped and is in a position to be damaged. Neg. No. RS-151-7.

Fig. 28. - Exposed nail heads in pallet top deck have caused damage to bagged material. The cause may be traced to high moisture content of lumber at time of pallet manufacture and subsequent drying and shrinkage of the board. Neg. No. 151-5.

2.4 QUALITY OF LUMBER. It is obvious that the structural strength and life span of a wood pallet would depend to a very large extent on the quality of lumber used in its construction. The different grades of commercial lumber are distinguished by the amount and size of defects permitted in a piece. The Forest Products Laboratory defines "defects" in lumber as, "any irregularities occurring in or on wood that may lower some of the strength, durability or utility value". The military pallet specification has treated this important requirement only as it directly affects the performance of the pallet for its intended use. Limitations on the size and amount of defects have been incorporated in the specifications to insure a pallet suited for its requirements and yet permit utilization of grades of lumber in which maximum economies are made. The characteristics of lumber defects influencing pallet design are covered in complete detail by the Forest Products Laboratory in Section VI of this report. An attempt is made here to emphasize the results that can be expected when the limitations on imperfections of lumber are disregarded. Figs. 29 and 30 are illustrations of the actual condition of pallets received at a military installation and indicate a complete failure to comply with pallet specifications. A further discussion on the effects such inferior grade lumber may have on pallet performance based on the individual component pallet parts follows.

2.5 BOARDS: The greater percentage of parts built into a wood pallet structure are boards. These members form the surface areas of the top and bottom deck and as such are subjected to severe impact. This is a normal condition in pallet handling operations and results from any of the following actions: dropping of packages on the deck, stevedoring operation in which the loaded pallet is hoisted by bar slings and lowered and then stopped abruptly, dropping and positioning of empty pallets by laborers, and striking of the pallet boards by mechanical lift equipment. It can be seen that any defect in board lumber affecting the strength of the piece would result in repeated repairs and high maintenance costs. The stipulations in pallet specifications with regard to quality of pallet board lumber have been based on a realistic approach, namely, that the wood need not be of high and costly quality, but that the limitations placed on the nature and size of defects would permit economies in procurements without sacrificing economy in pallet operations.

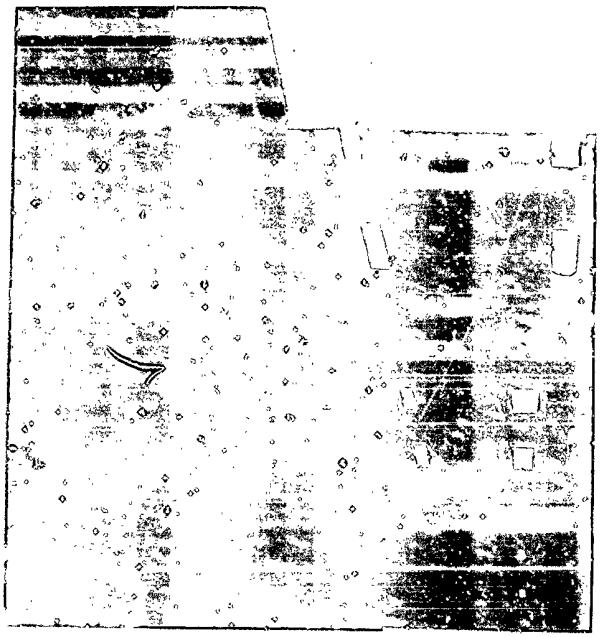


Fig. 29. - Actual condition of new pallets received showing non-conformance to the specifications. Use of boards having excessive wane results in false economies. An early trip to the repair shop is likely, thus increasing maintenance costs. Neg. No. 600-8.

Fig. 30. - Utilization of lumber having only scrap value indicates a total disregard of the specifications by the manufacturer. Large decays will render the post useless for nailing and unsafe for operational work. Excessive costs are involved to replace a post. Neg. No. 600-3.

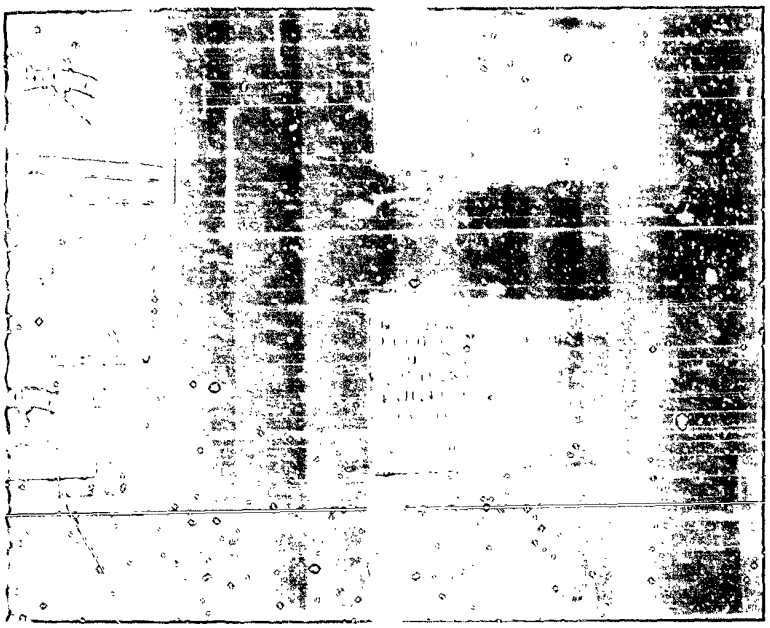


Fig. 31. - Typical of damages to the pallet end boards due to rough handling. Note how the stringer board may have better resisted the impact if it had been properly nailed at the time of manufacture. Neg. No. 151-14.

Fig. 32. - Illustrating defective lumber used in pallets that have actually been received. The excessive knot hole in the stringer board has earmarked this pallet for an early visit to the repair shop or possibly the scrap heap. Neg. No. 151-11.

Fig. 33. - Illustration of an unsound knot and cupped deckboard on a typical pallet rejected by a government inspector. Neg. No. 321-1.

Fig. 34. - View of improperly nailed pallet. Note that top deckboards are not flush with stringers. Gap between board and stringer is due to nails not being fully driven. Upon use, pressure of load would force board down against stringer but nails would project and would tear bagged goods and cause other damage to palletized loads. Sloppy workmanship on pallets such as this should be rejected. Neg. No. 321-2.

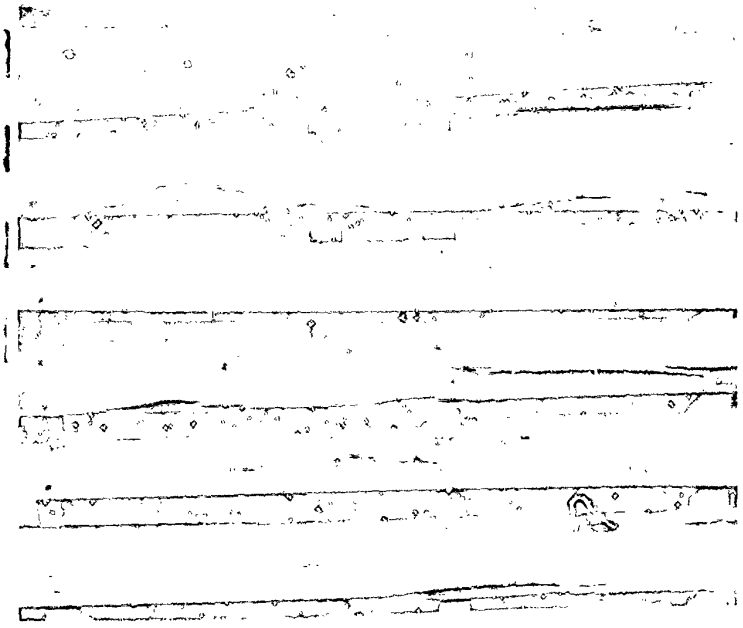


Fig. 35. - Another illustration of poor pallet assembly and material. Pallet is out of square since stringers and deckboards are misaligned. Lower stringer has excessive split. Pallets such as these should be rejected since maintenance costs on such pallets are excessive. Neg. No. 321-3.

Fig. 36. - Illustration of pallet rejected by a military inspector due to multiple reasons:

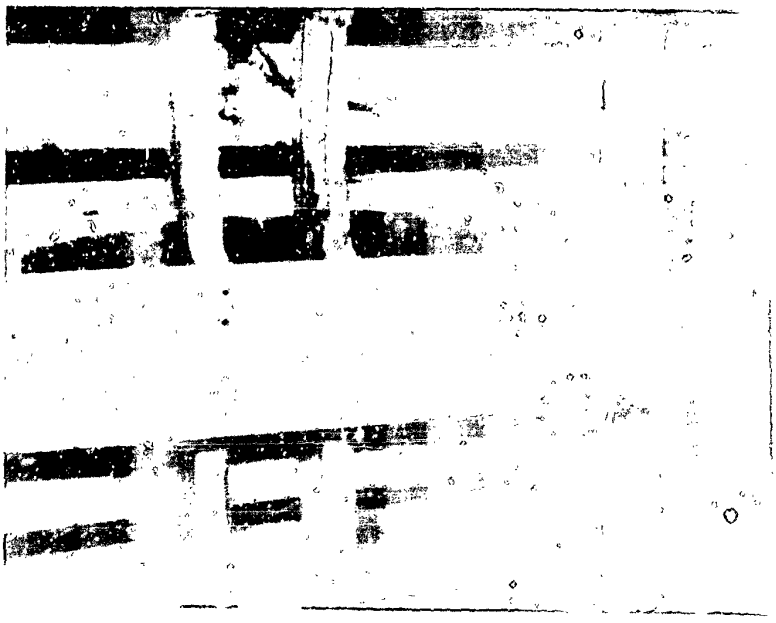
Item 1. - Rotten stringer.

Item 2. - Excessive splits in stringer.

Item 3. - Excessive small worm holes and decay.

Item 4. - Unsound Knot.

Neg. No. 321-4.



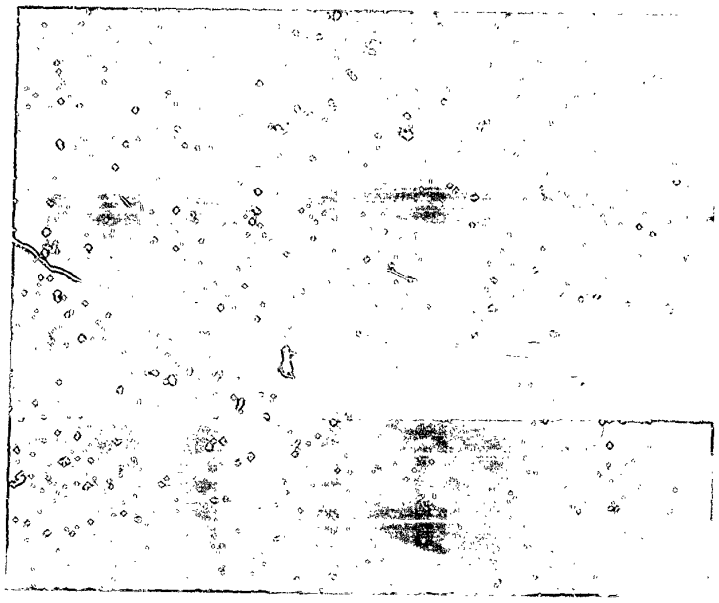


Fig. 37. - Illustration of poor nailing practices as applied to pallets. Bent and protruding nail heads on pallets can easily cause excessive damage to commodities carri thereon, particularly bagged goods. Drive scr nails used on dry lumber pallets seldom loosen a project when once prope driven. Also shown is a twisted stringer resulting from nailing too close edge of stringer. Neg. N 321-5.

Fig. 38. - Illustration of poor lumber for pallets. Hardwood specimens of not acceptable deckboards.

No. 1. - Decay - bleached areas reveal decay in which the disintegration is readily recognized because of the soft and spongy bleached areas - not acceptable.

No. 2. - Decay - pronounced longitudinal strip of decayed area readily recognized because of the soft and spongy bleached area - not acceptable. Neg. No. 321-6.

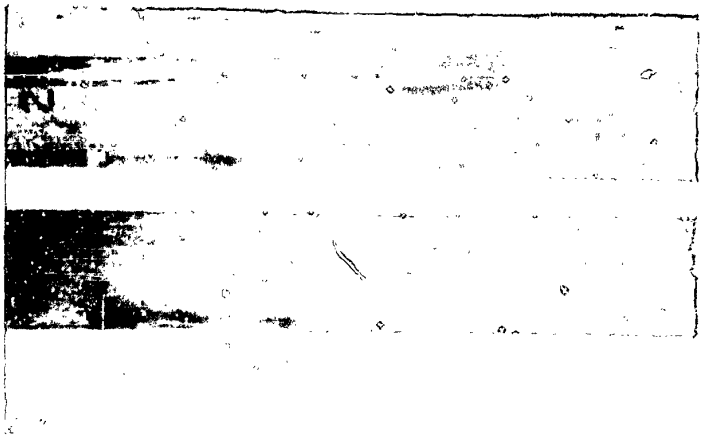


Fig. 39. - Illustration of lumber imperfections. Comparative hardwood specimens of acceptable and not acceptable deckboards.

No. 1. - Hit and miss surfaced area - acceptable manufacturing imperfection, fine season checks (lengthwise separation of the wood) not exceeding in length the width of the deckboard - acceptable.

No. 2. - Fine season checks not exceeding in length the width of the deckboard - acceptable.

No. 3. - Large season checks - exceeding in length the width of the deckboard - not acceptable.

Neg. No. 321-7.

Fig. 40. - Comparative hardwood specimens of acceptable and not acceptable deckboards.

No. 1. - Wane (bark) on edge of deckboard does not exceed the edge thickness of the board - acceptable.

No. 2. - Wane (bark) on edge of board exceeds the edge thickness of the board - not acceptable.

Neg. No. 321-8.

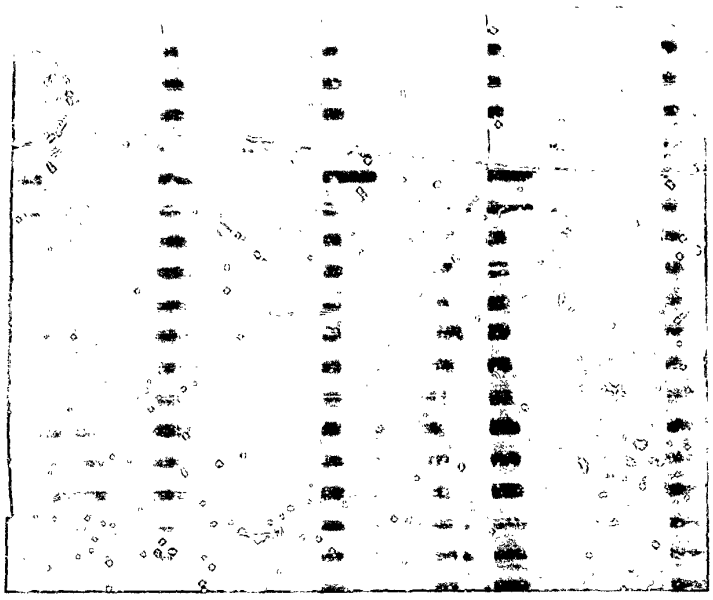


Fig. 41. - Illustration of reasons for pallet rejectio by military inspector. An one of the four defects illu trated is ample cause for jection due to high pallet maintenance costs which would otherwise hav to be borne by using activity. 4-way 40" x 48" pallet (partial entry) - not accep able. Defect No. 1. - exc sive wane (bark) entire l sur.ace length of stringe Defect No. 2. - scar da aged area grown over uri life of tree). Defect No. 3 splits (lengthwise separa of deckboard) exceeding i length the width of the dec board. Defect No. 4. - (n numbered) - spacing of dec boards exceeds 1 1/2 inch Neg. No. 321-9.

Fig. 42. - Comparative hardwood specimens of acceptable deckboards.

No. 1. - Mineral streaks and stains(chemical discoloration of wood) and sound knot - diameter not exceeding one-third the width of the deckboard - acceptable.

No. 2. - Mineral stains - chemical discoloration of wood - acceptable.

No. 3. - Bird pecks - acceptable.

Neg. No. 321-10

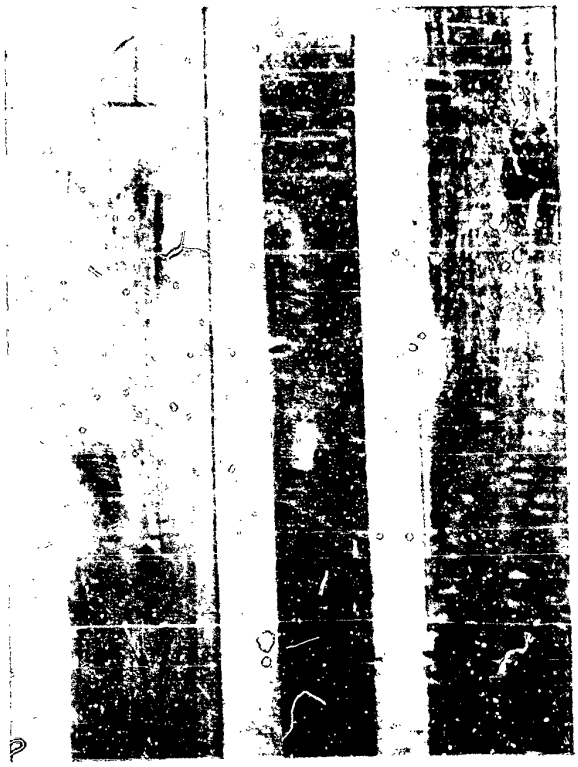


Fig. 43. -
Comparative Hardwood Specimens of Acceptable and Not Acceptable Deckboards for Pallet Use.

No. 1. - Sound Knots - average diameter not exceeding one-third the width of the deckboard, shallow worm hole not exceeding one-half inch in diameter - acceptable.

No. 2. - Cluster of worm holes permeating deckboard and exceeding one-half inch in diameter - not acceptable.

No. 3. - Shallow worm holes not exceeding one-half inch in diameter and small sound knot not exceeding one-third the width of the deckboard and one unsound knot less than one inch in diameter - acceptable.
Neg. No. 321-11.

2.6 **POSTS OR STRINGERS:** The more restrictive parts of military specifications with regard to limitation of defects allowed are those pertaining to the posts or stringers. These are the pallet members to which boards are nailed and are the vertical supports of the pallet. The structural strength of the nailed wood pallet is largely dependent on these members since they not only must be able to withstand the sharp impacts of lift equipment caused by careless entry of the forks under the top deck, but must be able to provide the high nail holding qualities necessary to maintain a tight and strong pallet assembly throughout the life of the pallet. The damaging of these members is more critical than the other pallet parts. The collapse of any one of these members will render the pallet useless. In addition, the labor required to replace a damaged stringer is excessive, since a tedious and costly operation of breaking away the pallet boards at every one of the nailing points along the stringer length must be performed. Invariably, the costs involved may equal or exceed the original price of the pallet.

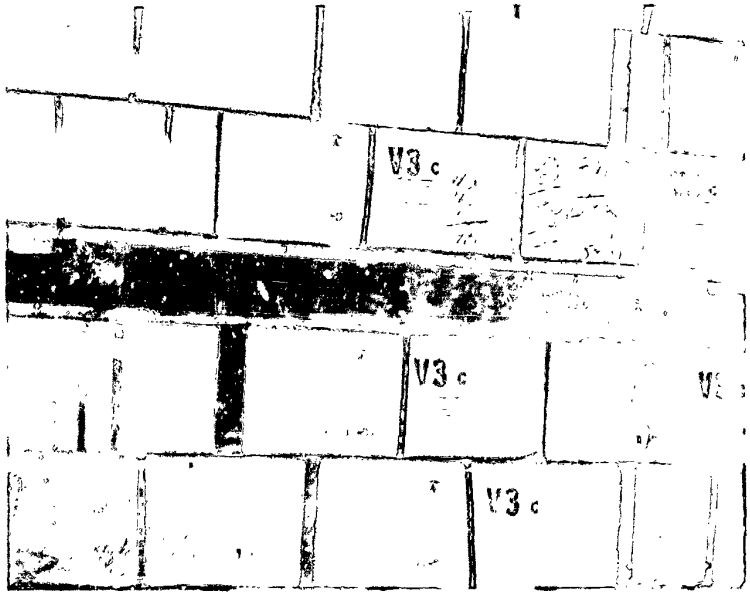


Fig. 44. - Example of damages inflicted to the post members of the pallet by the forks of the lift truck. Note how the hardwood post has been able to resist complete collapse. Neg. No. 41-4.

2.7 NAILS AND NAILING. One of the principal advantages of wood as a construction material for pallets is the ease with which it can be fastened. Nails are the simplest and most economical fastenings for wood, since they require no special tools and little, if any, mechanical skill on the part of the user. The great economic advantages secured by the use of nails in pallets, without serious sacrifice of pallet strength, have been made possible by the development of the grooved shank nail. Two distinct types of grooved shank nails are utilized for pallet specifications. The spiral groove, or what is commonly called the drive screw nail, has been established as the more effective design for pallet usage. Another groove shank nail, the annular ring type, is included for use in softwood pallet specifications. Tests conducted by the Forest Products Laboratory have shown that, under certain conditions, the grooved shank nail design will provide more than six times the resistance to direct withdrawal from wood than the common plain shank nail. More important, the resistance to withdrawal under impacts and lateral forces is almost double that of the smooth nails. These strength characteristics are essential for good pallet performance. Even with these features, the pallet so constructed is no exception to the rule that the strength of a built up wooden structure usually depends on how securely the joints are fastened.

When the special thread of the grooved shank nail is properly designed, the nail turns like a screw during driving. The grooved shank works itself into the wood by forming a thread, thus allowing the nail surfaces to turn and slide along the wood fibers. Once driven, the helically threaded nail develops considerable resistance to withdrawal because of the friction between the nail shank and the compressed wood fibers which have penetrated in and around the grooves of the nail.

From the above details, it can be seen that the thread design is of extreme importance in nail efficiency. The threads should be of sufficient depth in order to secure increased friction between the wood fibers and the nail shank. In addition, the helical angle of the thread should be such as to firmly engage the wood fibers and pull two pieces more tightly together. Certain pallet manufacturers, submitting low bids on military pallet contracts, have disregarded the specification for nail shank design and have substituted nails having a long lead angle or shallow thread in an endeavor to gain driving ease, and lower production costs. This practice can only lead to a poorly constructed pallet that will

penalize the user with high maintenance and repair costs which, in some cases, may double the original purchase cost. (See Figs. 46 to 48). It becomes mandatory, therefore, to treat the nails and nailing specifications of the pallet as one of the most important characteristics of manufacture and as an item for close scrutiny on the part of the inspector passing on the acceptability of pallet lots. Damages to pallets due to the failure of the nailed joints are a common source of trouble. Caution must be exercised to be sure that the right type, number, and size of nails are used and that the best possible nailing practices are employed in construction.

Most pallet specifications will list the required nailing pattern to be used in the fastening of the component pallet parts. Such arrangements as have been specified are those that will provide the most efficient spacing and location of nails to insure a strong joint assembly. Using the proper technique in nailing will alleviate most of the difficulties encountered when driving nails through hardwood. The Forest Products Laboratory has prepared several excellent pamphlets on this subject. They are recommended for reference and use by pallet manufacturers. These are listed as - "Technical Note No. 247", entitled, "Nailing Dense Hardwoods", and "Technical Note No. 243", entitled, "General Observations on the Nailing of Wood".

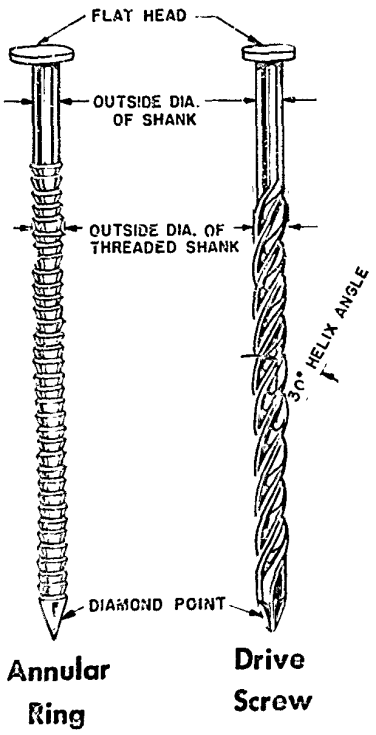


Fig. 45. - Two types of deformed shank nails utilized for wood pallet specifications. The drive screw type is used for hardwood pallets and must have the proper helix angle and depth of thread for maximum effectiveness. The annular groove nail is included in softwood pallet specifications.

ig. 46. - Example of on-compliance to nailg specifications by the allet manufacturer. nproper size and mount of nails used has esulted in separation bottom deck assembly pallet at first handng. Early repair costs re evident. Neg. No. 00-1.

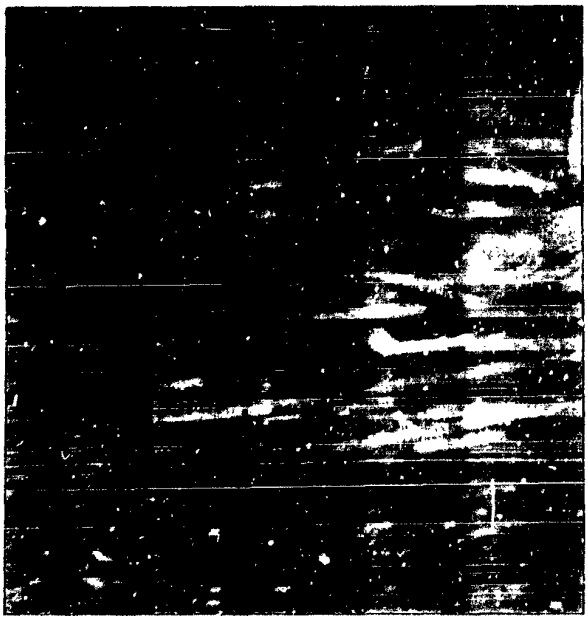


Fig. 47. - Example of splitting due to improper nailing with a serious loss of nail holding power as the result. Neg. No. 41-10.

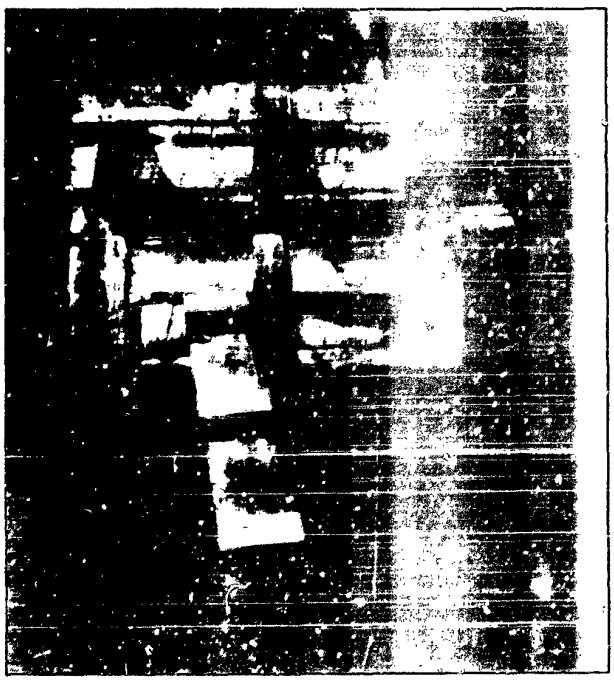


Fig. 48. - Complete disregard of the nailing specification by a pallet manufacturer. Note that one nail has been used at each of the bearing locations requiring four. Also see splitting of the stringer board due to poor nailing methods used in construction. Neg. No. 151-4.

2.8 CONSTRUCTION AND WORKMANSHIP. Military pallet specifications include construction drawings and stipulate requirements in careful detail to provide sufficient guidance to the manufacturer in the assembly of component parts. In this one requirement, more so than in any other, the integrity and managerial ability of the supplier is clearly reflected in the finished product.

Careful workmanship should start at the cutting operations where the component wood parts are cut and selected for use. Boards, stringers and other parts should be cut square and to proper length to assure the desired rectangular dimensions specified in the construction drawing. Board thicknesses and the wood parts forming the vertical supports between the pallet decks must be of uniform dimension to insure safety of operation in the high tiering of pallet loads.

It is also in the assembly operation that opportunities exist to screen out lumber that does not meet the requirements of the specifications. Board widths should be segregated and stacked so that they may be readily selected for use in the proper location of the pallet assembly. Pallet specifications requiring certain board widths are based on advantageous and important design considerations which are necessary for operational or strength functions. For example; the end boards of the top deck may be specified for 5-5/8" widths or greater, to insure adequate strength at locations that are more susceptible to damages due to rough handling than the other board members. Other dimensional requirements of boards may be made to satisfy operational requirements, such as entry spaces for handling equipment, grooves for the insertion of steel bands for strapping of loads to the pallet, chamfering of certain bottom deck boards and space openings in the bottom deck for the wheels of the hand pallet truck. (See Fig. 52 and 53).

At this point also, attention to the run of the grain and nailing patterns will eliminate splitting, and provide a strong, operationally stable unit. Nothing could be simpler than employing a staggered pattern in driving nails, yet the failure to observe this one construction detail is responsible for more damage, pallet failure expensive repairs than any other single requirement.

Nails should be driven below the board surface and bent nails pulled or broken off below the surface so that bags and other merchandise are not damaged when placed on the pallet.

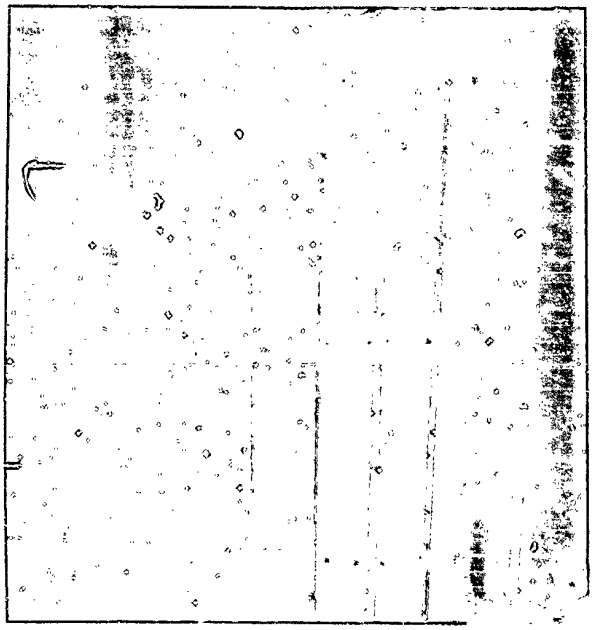


Fig. 49. - Example of poor workmanship of pallet construction. Note non-parallel sides of pallet, improper board spacing and irregular board width and lengths. Neg. No. 600-7.

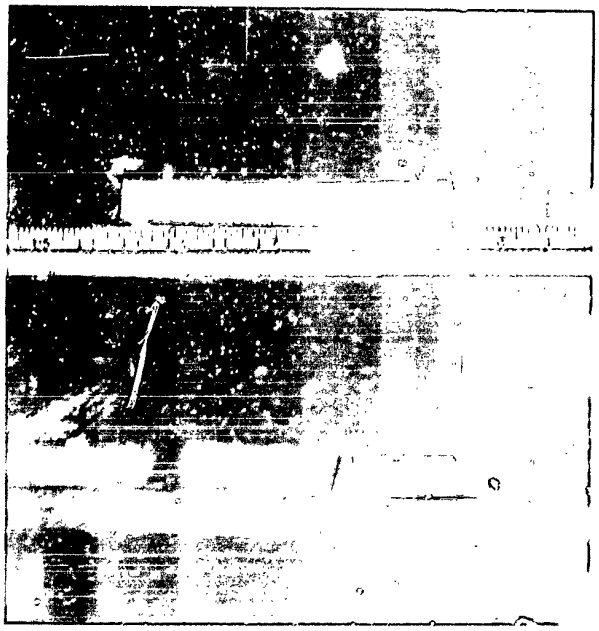


Fig. 50. - Pallet specification lists 1" minimum to 1-1/2" maximum board spacing. Note complete disregard in spacing deck-boards by this pallet manufacturer and poor workmanship in construction. Neg. No. 600-12.

Fig. 51. - Another example of poorly constructed pallets. In addition to excessive defects in lumber, note non-alignment of stringer boards with posts. Neg. No. 106-6.

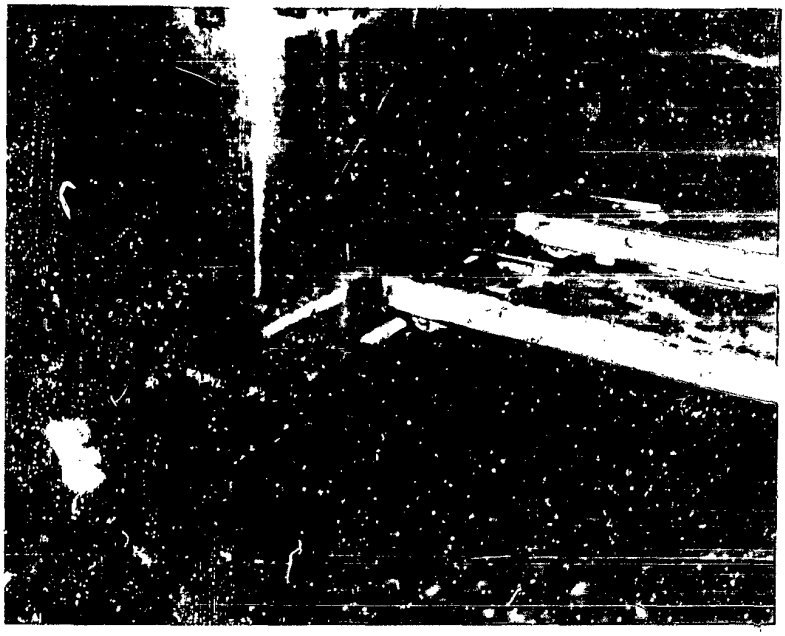


Fig. 52. - Chamfering of the bottom deck boards is required to permit the small wheels of the hand pallet truck to easily ride over when entering for the pickup. Neg. No. 151-3.

The spacing of top deck boards is another critical design element. The following are the controlling considerations:

1. Structural strength - Requires as many board feet of lumber as possible.

2. Economy - Requires as little lumber as practicable.

3. Ventilation and Cleanliness - Requires wide, frequent spaces between boards.

4. Maximum bearing surface - Requires as much covered area as possible.

The spacings selected and specified are those disclosed by investigations to be the most compatible with the above requirements.

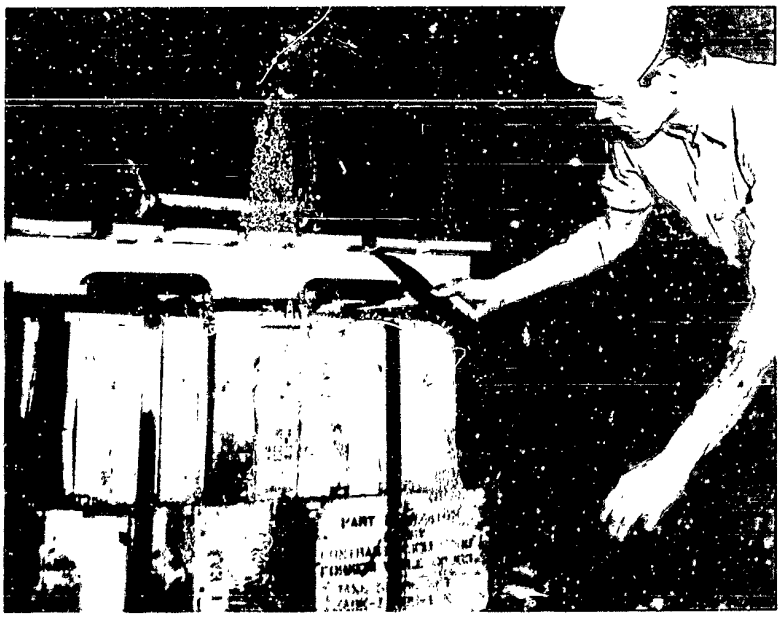


Fig. 53. - Slots are required in the pallet for the insertion and passing through of steel bands for strapping unit loads to the pallet. Note strapped pallet load at bottom. Neg. No. 151-2.

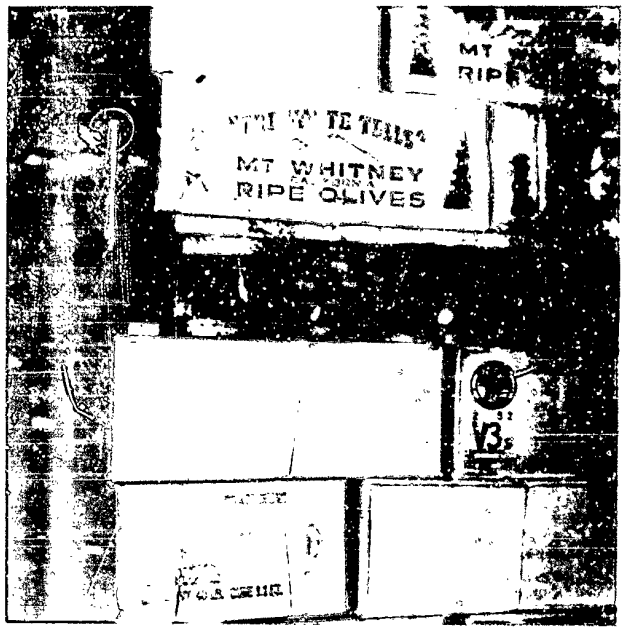


Fig. 54. - Example of faulty workmanship in the selection of material for the pallet's posts. Note lack of wood bearing area for nailing and load support in the most important structural member of the pallet assembly. Neg. No. 41-8.

Fig. 55. - Actual photograph of a pallet scrap heap. Most damaged pallets are the result of poor workmanship and nailing techniques at the time of pallet manufacture. Neg. No. 151-1.

2.9 **PALLET INSPECTION CHECK LIST.** The following inspection report form has been prepared primarily to effect a method wherein inspection of nailed wood pallets may be standardized. It is intended to be used by pallet inspectors and manufacturers as a system of checking items of specification and contract requirements in military pallet procurements.

PALLET INSPECTION CHECK-LIST

PALLET NUMBER	MATERIAL									QUALITY										WORKMANSHIP									
	Specified woods only	Moisture content	Nails - type and size	Advanced decay	Excessive warp	Pitch and holes	Wane or bark	Shakes and season checks	Knots and Knotholes	Cup or twist	Specified length and width	Specified thickness	Exposed surfaces dressed	Boards parallel to sides	Pieces squarely cut	Pallet perfect rectangle	Center bottom boards	Chipped or torn grain	Splits and wood grain	Chamfering and strap slots	All pieces S2S	Deckboard spacing	Branding	Nailing	Total Defects
1																									
2																									
3																									
4																									
5																									
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COMMENT ON REVERSE

DEPARTMENT OF DEFENSE
PALLET INSPECTION CHECK-LIST

This Inspection Check-List is furnished as a guide to the Inspector and as an aid to tabulation of defects. Before inspecting any lot of pallets, the Inspector should have with him a copy of the applicable specification and be thoroughly familiar with each element thereof.

Applicable Specification Number: _____ **Contract Number:** _____

Contractor's Name: _____ **Address:** _____

Delivery Destination: _____ **Lot Number:** _____ **of** _____ **Lots.**

Number of Pallets Inspected: _____ **Number of defective pallets allowed:** _____ **No. defective in lot:** _____

ACCEPTED/REJECTED

Date: _____ _____

(Inspector's Signature)

INSPECTOR'S COMMENTS:

DEPARTMENT OF DEFENSE

- - - -

PALLET INSPECTION
CHECK LIST

- - - -

The following specifications are applicable to this check list and the inspector should be thoroughly familiar with such specifications. This check list is not intended as a replacement for, but rather as a guide to utilization of the specification:

MIL-P-15943 (S and A) Amend. 2 - 3 May 1951
MIL-P-15011C (S and A) - 23 Jan. 1953
MIL-P-16496 (S and A) - 27 July 1951
Fed. Spec. NN-P-71 - 23 Sept. 1947

Defects	35	34	33	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	PALLET NUMBER
																																				Are specified woods used throughout?
																																				Is all lumber sound, free of advanced decay or excessive warp?
																																				Is pith firm and tight?
																																				Is wane or bark on all pieces within specified range?
																																				Are shakes within allowance?
4																																				Are season checks within allowance?
																																				Are all holes within specified allowance?
																																				Are all knots and knotholes within specified size?
																																				Are all splits within specified range?
																																				Is cup or twist within specified allowance?
																																				Is chipped or torn grain within specified allowance?
																																				Are all pieces of specified length?
																																				Are all pieces of specified thickness?
																																				Are all pieces of specified width?
																																				Are all boards S2S with saw marks removed?
																																				Do center bottom board(s) meet specifications?
																																				Is the moisture content of

NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	Total Defects:
Do center bottom board(s) meet specifications?																																				
Is the moisture content of all boards 22%, or less?																																				
Is the moisture content of all posts and stringers 26%, or less?																																				
Is the type, number, size and length of each nail as specified?																																				
Is the manner and location of nailing as specified?																																				
When specified, is clinching performed properly?																																				B
Are all components square, and of uniform thickness?																																				
Is the spacing of top and bottom deck boards proper?																																				
Does the grain of the wood run as specified?																																				
Are pallets properly branded?																																				
Does the completed pallet form a perfect 90° rectangle with all boards parallel to the sides?																																				
Are bottom deck boards properly chamfered?																																				
Are all exposed surfaces dressed?																																				
Do strap slots meet all specifications?																																				

Contractor: ________ Contract Number: ________

Address: ________ Inspection Lot No. ____ of ____

Delivery Destination: ________ Number pallets inspected: ________

Number of Defects Allowed: ____ Number of defects in lot: ____ Accepted: ____ Rejected: ____

Date: ________ Inspector's Signature: ________