PACKAGING RESEARCH AT THE U. S. FOREST PRODUCTS LABORATORY

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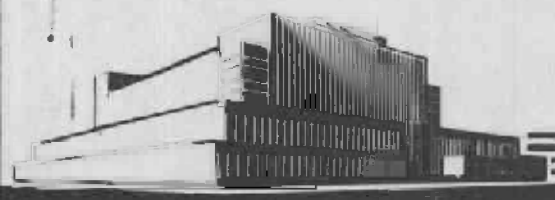

FOREST PRODUCTS LABORATORY
MADISON 5, WISCONSIN

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
In Cooperation with the University of Wisconsin

PACKAGING RESEARCH AT THE U. S. FOREST PRODUCTS LABORATORY[1]

Forest Products Laboratory,[2] Forest Service
U.S. Department of Agriculture

Summary

Research in packaging has been carried on at the U.S. Forest Products Laboratory practically from the day the Laboratory began operating 52 years ago at Madison, Wisconsin. Since shipping containers have been primarily a product either of wood or wood fiber it was inevitable that the first research laboratory in the world dedicated to research on wood would either make early plans for packaging research or quickly be drawn into such research.

The principles that serve as the foundation of good packaging practices today were developed at the Laboratory particularly during World Wars I and II. Its research also has developed the fundamentals of fiber container engineering as well as provided the basic test methods and instrumentation devices for the evaluation of new package designs, methods, and materials. The Laboratory staff also is directly responsible for setting up packaging courses for the Armed Forces and training instructors to continue these courses on a permanent basis.

Introduction

The Forest Products Laboratory is a research unit of the Forest Service, U.S. Department of Agriculture. Even before the Federal Forest Service was founded it was clearly recognized that wise and efficient use of wood and fiber coming from the forest was an inseparable part of any sound long-term program for proper management of forest raw materials. In 1910, lacking Congressional support for the building of a national laboratory in the Washington, D.C. area, the Forest Service accepted an offer of a building and operating assistance from the University of Wisconsin. Research, including packaging research, that had been developed in isolated units in five different universities and colleges was brought under one roof and a comprehensive pattern of forest products research that has been a world model since was started.

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[1] Original report written in September 1956 by F. J. Champion, former Forest Products Laboratory staff writer.

[2] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

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The accomplishments of the Laboratory during the intervening 52 years attest to the soundness of its planning. Many millions of dollars, estimated at $70 for every research dollar spent, have been saved to industrial and domestic users of wood through improvements in methods of wood harvesting, grading, seasoning, working, structural engineering, painting, preservation, gluing, pulping, and chemical conversion. Paired with the dollar savings is a conservation of wood that can be measured in the billions of cubic feet of this vital resource.

The Packaging Engineer and His Job

The packaging engineer stands at a unique vantage point in the national economy. Not only is he a key force in the $20 billion packaging industry, but his constructive concern for economies in lumber use can be reflected in better use of the more than 6 million board feet of lumber used in packaging and in significant economies in the use of the 18 million tons of wood fiber in paper and paperboard products. He also is in an effective position to reduce the $119 million cost of loss and damage claims that burden the railroads and unknown claims that plague other transportation agencies, which indirectly affect the consumer. The economies he can effect in container and packaging costs are the last in the chain of production that a manufacturer can use to lower the overall cost of his product. Aside from these opportunities and challenges, the packaging engineer exerts a considerable influence on the serviceability and satisfaction found in the multi-billion dollar total of all goods shipped in packages.

World War I Period

Among the 45 men and women who started the Forest Products Laboratory a full-time packaging engineer was a little hard to find. In the engineering field, the basic properties of American woods were still to be tested and cataloged. But World War I came along in 1918 and suddenly the Forest Products Laboratory was besieged by the Armed Forces for help with packaging trouble. The United States was in an export war for the first time. The domestic package, even the commercial export package, was quickly revealed as unfit to fight, for Mars is a moronic packer, a fiendishly destructive stevedore, and a bad warehouseman.

But the packaging engineers at the Forest Products Laboratory and their colleagues in industry, faced with life-or-death need for basic packaging facts, sweated out the necessary research and came up with answers adequate to World War I logistic needs. In the process they built on principles that lie

at the foundation of good packaging today. Out of that World War I period came the now well-accepted classification of American woods into four groups on the basis of their utility in containers, the concept of the 3-way crate corner, the basic principles of crate bracing, vitally improved nailing and strapping schedules, and a number of the tests that have been accepted as standard in the container industry ever since. The principles were outlined in 1930 in USDA Technical Bulletin No. 171, "Principles of Box and Crate Construction," an old publication but still a sound packaging primer. Fostered by the activities of the Forest Products Laboratory container division of that period a number of commercial container testing laboratories were founded and began a vital service to industrial packaging.

Oldtimers who were in and around the old Forest Products Laboratory "box lab" of 1918 can still recite the principles with which they were indoctrinated: Reduced loss and damage, use of less lumber and cheaper lumber, reduced size of containers, and reduced fabrication and packing costs.

Reviewing the problems of the war period, Benedict Crowell, Assistant Secretary of War and Director of Munitions, said, ". . . The packing service branch of the Quartermaster Department was established . . . at the Forest Products Laboratory at Madison, Wisconsin. The school started in July 1918, and before the armistice came it had graduated 400 students from its 6-weeks' course.

"Now, while it was important that Army supplies reached the other side in good condition, it was soon seen that of even greater importance would be the economy that might be effected in shipping space by the scientific packing of goods. This obscure and little known packing service branch was really one of the most important agencies in the whole war organization, since the results which it accomplished in the saving of ship space were nothing short of astonishing. These economies came at a time when the German submarines were still highly destructive. . .The American packing service, in saving thousands of "tons" of shipping space, in reality offset the operations of the U-boats over a considerable period of time."

The Not-So-Roaring Twenties

At the end of World War I it could be said that most of the elementary engineering of the wood box had been completed. The same could not be said for fiber containers. Fiber containers had been in the industrial picture for a number of years and they figured as inner packs in the war effort sufficiently to convince the Forest Products Laboratory staff that the very A, B, C's of fiber package engineering were yet to be established. Circumstances, however, decreed that this field of research was not to be the object of a fully manned

and well-implemented attack. The Forest Products Laboratory container research staff was soon "demobilized" to the point where it consisted of C. A. Plaskett and T. A. Carlson. Plaskett died in 1935 and Carlson, "Tac" to his many friends, carried on singlehanded for a long period. During the 'tween wars period Plaskett and Carlson, in spite of occasional assignments to nonpackaging projects, continued to advance the knowledge of packaging with respect to such commodities as canned goods, furniture, explosives, and farm implements, and they developed and published significant data on methods for observing and evaluating transportation hazards. But there is little doubt that the most important thing accomplished was the slow but certain development of fiber container engineering. Progress was made in evaluating component parts of fiberboard in relation to container service. Carlson developed the Carlson score tester and developed compression tests on tubes simulating fiber cartons, and the direction of research that was to zoom during and after World War II began to take shape.

World War II Period

With the Nation's acceptance of realities prior to 1941 and finally with the Pearl Harbor attack, the packaging laboratory was a veritable David confronted with an army of Goliaths. Success is not measured in manpower but rather in man results, but in the space of months the packaging staff at the Forest Products Laboratory grew from Carlson's man-and-a-half effort to a program employing 120 persons, some 35 of whom were on field assignments to military and industrial facilities all over the continental United States and in the various war theatres. Staff was recruited, equipment assembled, new quarters occupied, and a vast and effective research, testing, and specification writing task went forward without waste motion with results indispensable to the war effort. Among other accomplishments some 16,000 persons, mostly civilian but also including military ranks from private to general, were trained in the elements of packaging for overseas shipment.

Of all the calamitous circumstances of the United States' entrance to World War II the unreadiness of our export shipping preparation for a global war was not the least. Called in by Army, Navy, and Air Force, packaging engineers were confronted with arsenals and depots stocked by the mile with war material in packs barely suited for domestic shipment, let alone shipment to tropical beaches and arctic outposts. For the most part no packing specifications existed beyond a requirement that the item in question must be packed for shipment. The faith of war equipment producers in their old peacetime export packing was unbounded, and largely unfounded. To take a tragic case in point, shipments of antiaircraft fire directors, each huge instrument grievously needed and each valued at about $45,000, were being damaged to a point of

worthlessness in shipment to the eastern seaboard, not to mention shipment to the war theatre. From such beginnings, the wartime packaging program for the military developed at the Forest Products Laboratory and moved on to effectiveness at the war's end and in the ensuing era of readiness since.

The story can be told here only most sketchily. The peacetime benefits that have accrued to domestic packaging in the form of Forest Products Laboratory know-how and equipment cannot be overestimated. At the end of World War II Brigadier General J. S. Hatcher, chief of the Ordnance Field Service of the Army, reflecting on the war period when, to paraphrase a radio commentator, " . . . the ton of cargo space is the most important unit of power in the United Nations' war," estimated that, as a result of the packaging program centering at the Forest Products Laboratory, four ships were moving the cargo that had in 1941 required five ships. On some ordnance items the volume displacement savings ran as high as 60 percent.

Some Wartime Accomplishments

The solution of detailed packaging problems by Laboratory workers was virtually a daily occurrence during World War II. Nevertheless, it is possible to point out a few highlights and to summarize larger tasks. Containers were developed for such articles as aircraft engines, artillery, small arms, superchargers, instruments, and aircraft components. Fifteen hundred packaging specifications were completed for the Ordnance Department and the Air Force. Many of these were based on proposals the Laboratory made originally in the late 1920's, which also supplied the principles behind the majority of current specifications.

Arising out of wartime needs also came development of requirements for skid bases for shipment and storage of machine tools and freight car loading methods for vehicles, tanks, ammunition, and automotive components.

In addition to the training of 16,000 persons in packaging, the Laboratory staff in the postwar period also set up and directed packaging courses at Rossford Ordnance Depot for a year while Depot instructors were being trained.

Bread-and-Butter Stuff

Over the long haul, in and out of war, bread-and-butter accomplishments have been numerous: The suitability of once little-used species (hemlock, aspen, white fir) for container construction have been determined; working standards

for knotty lumber in containers have been established; recommended sizes of flat straps and wires for use on wood shipping containers were set up; important factors affecting compressive strength of fiber boxes were determined; methods of fabricating waterproof case liners were developed; ventilation requirements for closed crates were worked out; rough handling hexagonal testing drums in 7-foot and 14-foot sizes were designed and scores went into service in commercial container laboratories; early cushioning studies based on static data were made and recently instrumentation for dynamic test methods employing pendulum, accelerometer, and oscillograph was completed; a method of predicting compressive strength of boxes based on the strength of component parts was developed; standard methods of drop testing containers were worked out; a solenoid-activated release mechanism was devised that releases the container so that it falls vertically; and drop testing methods that are more reproducible than older methods were proposed.

Recent Laboratory packaging research includes: modifications of large crates to make them adjustable and economical either for air or surface shipment; 5-year outdoor exposure tests of field picking (agricultural crop) boxes treated with various preservatives and water repellants; development of new pallet constructions, including bin pallets employed in the harvesting and shipment of agriculture products; evaluation of paper-overlaid veneer as panel material in cleated panel boxes; determination of the holding power of metal fastenings and adhesives under impact loading; preparation of design criteria for cushioning materials; and a thorough evaluation of double-wall and triple-wall fiberboard boxes.

Today's Packaging

Today, on the basis of 52 years of experience, including the periods of intensive testing and research under wartime pressures, the Packaging Research Unit of the Forest Products Laboratory can claim a degree of expertness in the packaging of almost every conceivable type of commodity and in every important type of container except the display package on the shelf. This experience embraces the design of boxes of all types, crates for items up to 30,000 pounds in weight and up to 50 feet long, boxes of plywood and veneer, inner packs resistant to moisture and corrosion under extremes of exposure to moisture and temperature, and fiberboard containers of constantly growing capacity and versatility. Progress in the design of fiber boxes has been especially significant in that principles have been worked out where it is now possible to select thickness and kind of components on the basis of commodity weight and size, humidity factors of transportation and storage and anticipated stacking in warehouse. An effective tool for fiber container design has been invented in the form of a circular slide rule type of calculator that enables the packaging engineer to run through a design problem in minimum time.

To carry on its research in packaging the Forest Products Laboratory has a well-trained and experienced technical staff of engineers, technologists, and physicists. Backstopping the packaging staff, of course, is the whole array of technical talent in the nonpackaging units, including experts in the pulp and paper field, in wood seasoning, preservation, plywood, strength properties, and wood coatings.

A portion of the funds supporting the Packaging Research Unit still derives from cooperative research for military agencies. Although some of the research for the military involves basic research, most of the problems deal with the shipment of specific items of materiel. In the areas of packaging research financed by the Forest Service, considerable basic packaging research is under way on fruit and vegetable containers, fiberboard containers, crates, container fastenings, and pallets.

Industry cooperation also supports a part of the unit's research and helps to broaden its experience in the packaging field. The Packaging Research Unit does not engage in routine testing or research of the type lying in the proper province of commercial testing and research laboratories. With respect to investigations which call for the special equipment, experience, and staff capabilities available and in areas where a significant segment of industry and the national welfare may benefit from the research the unit does carry on cooperative industrial research and has carried many such projects to profitable conclusions.

The Packaging Research Unit is equipped with 7-foot and 14-foot revolving drum testers, vibration machine, incline-impact tester, improved drop-test apparatus, pendulum-impact equipment, compression machines, electronic measuring devices, cushion resilience testing apparatus, controlled humidity rooms to maintain test conditions, hot, cold, and shower rooms, and numerous other devices for studying and testing properties and performance of a wide range of packaging materials. The Laboratory is equipped to make wooden boxes, crates, pallets, fiberboard boxes, interior partitioning and blocking material, and to accomplish heat sealing of films and barriers.

There is no vital segment of the transit packaging field that the Laboratory packaging staff has not touched upon. Although the staff has changed over its many years of existence it has maintained a hard core and continuity of effort that, as much as anything else, has established the professional attitudes and standards of the packaging engineer for its own workers and others as well.

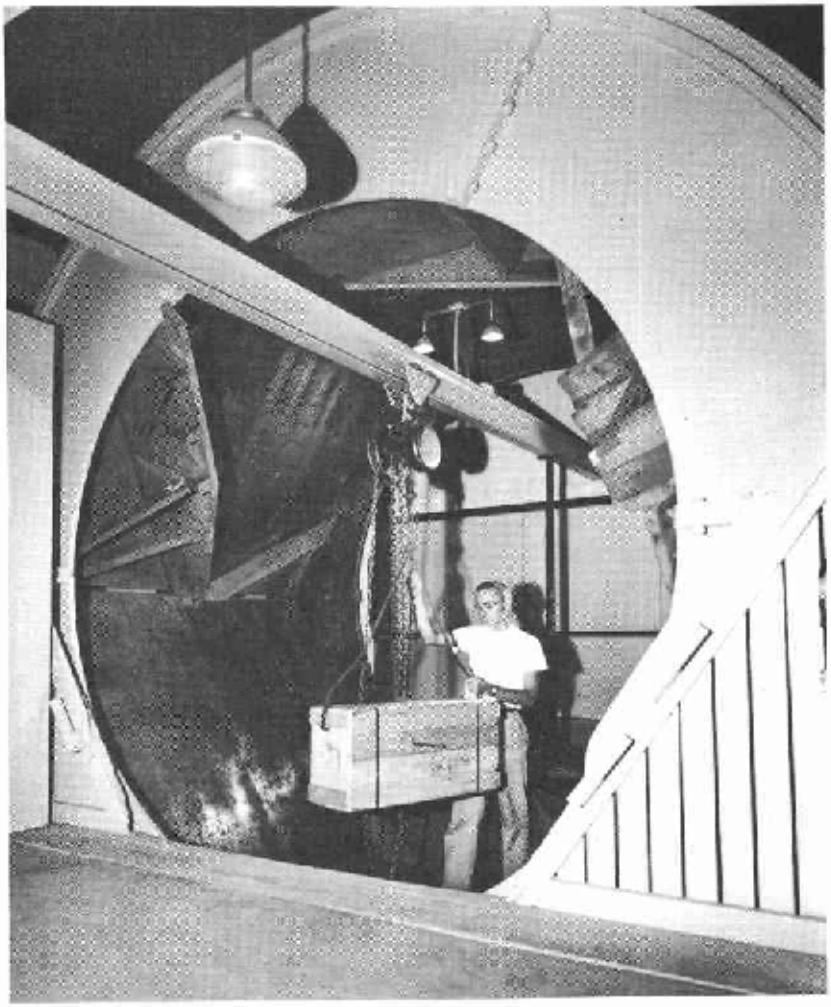

Figure 1. --Revolving hexagonal drum, a pioneer in its class.

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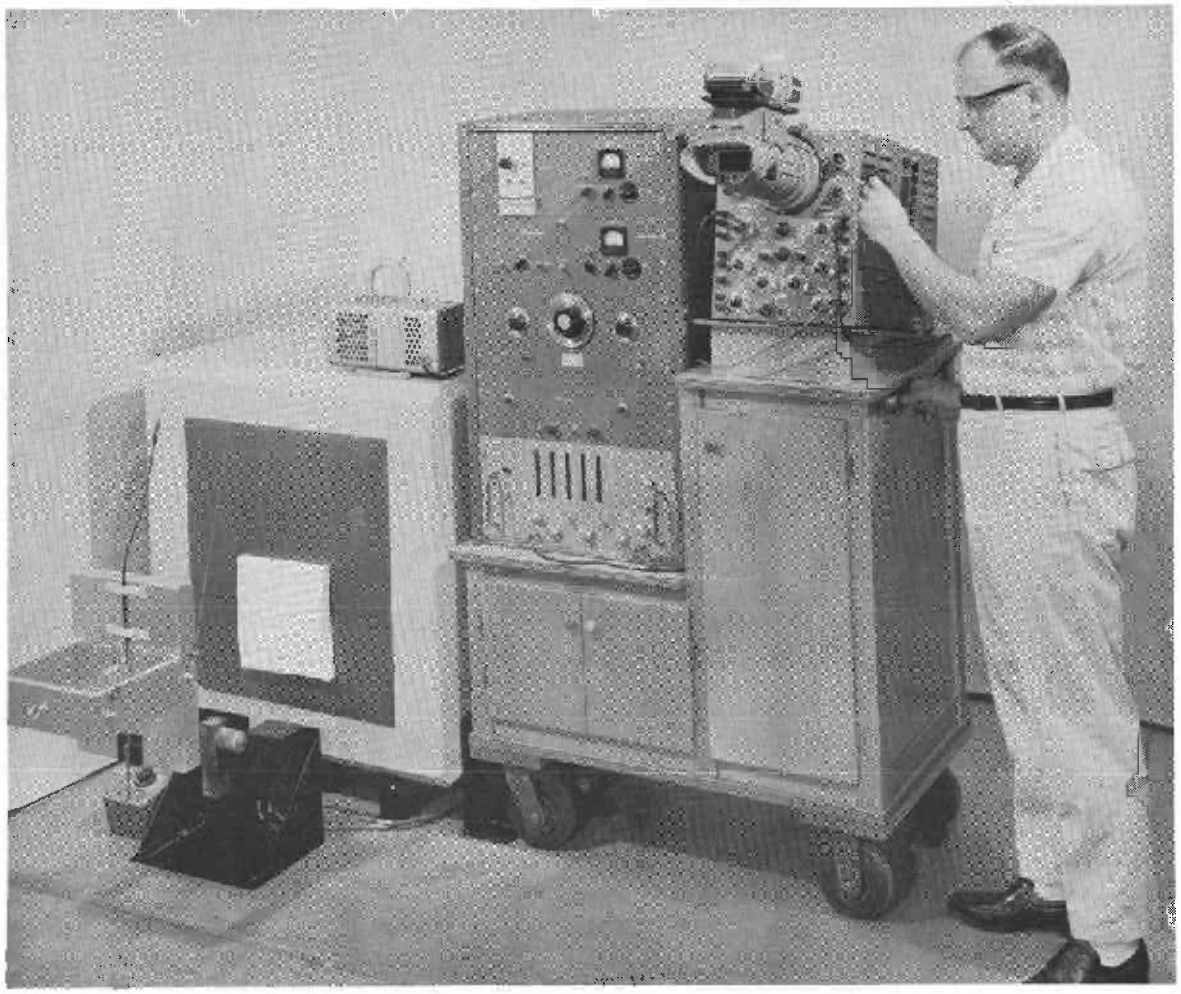

Figure 2.--Dynamic cushioning test apparatus showing pendulum, electronic counter, oscillograph, and Land camera.

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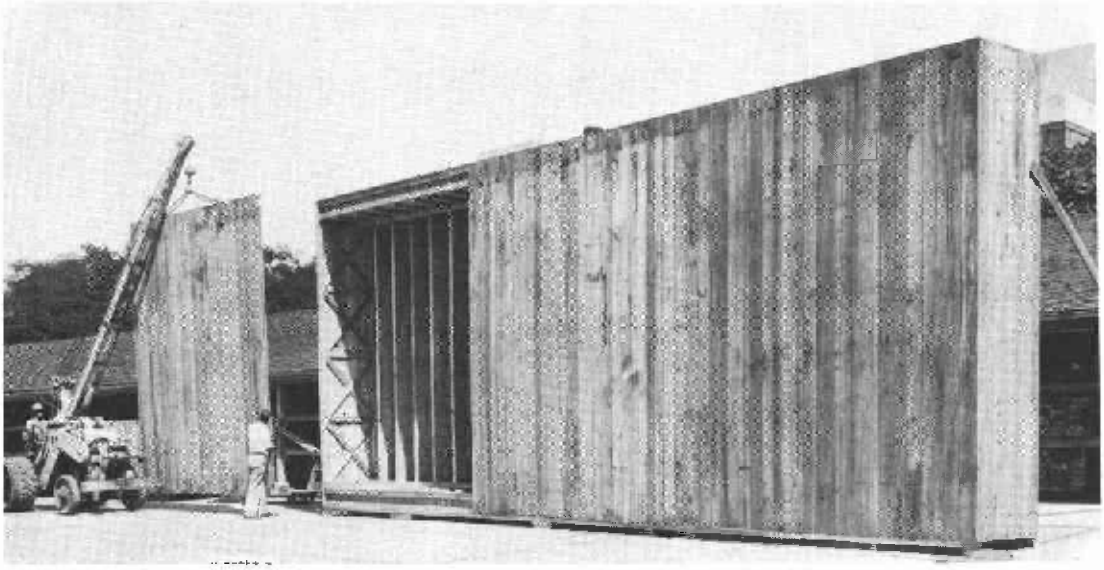

Figure 3. --The largest crate designed and tested for the military services was this giant, 4 feet by 16 feet by 48 feet.

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Figure 4.--Pendulum impact-tester, which has a 4,000-pound capacity, tests large crates, pallets, and other containers by impact against a concrete bulkhead.

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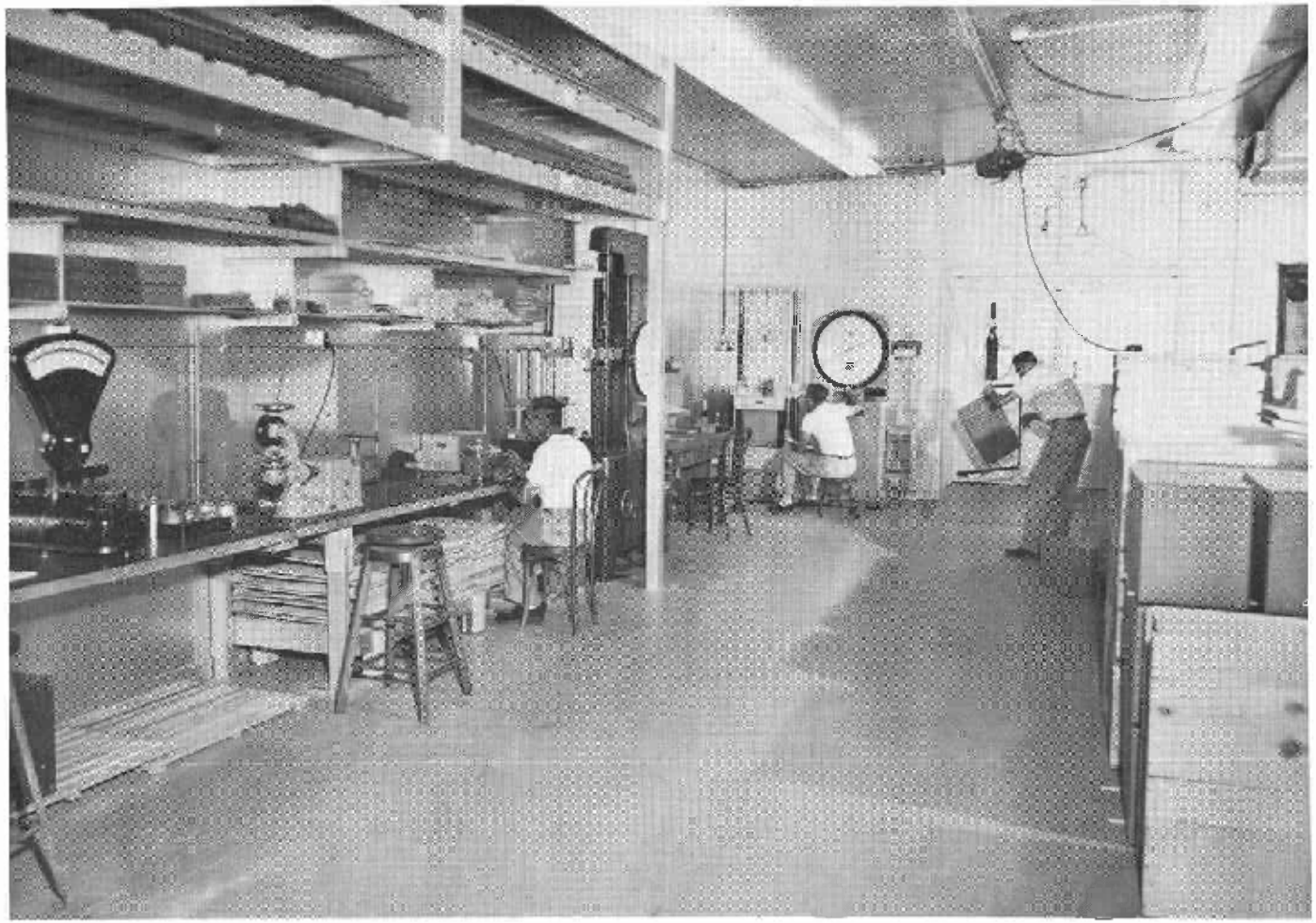

Figure 5.--The "humidity" room of the Packaging Research Unit, designed for tests at accurately controlled temperature and humidity.

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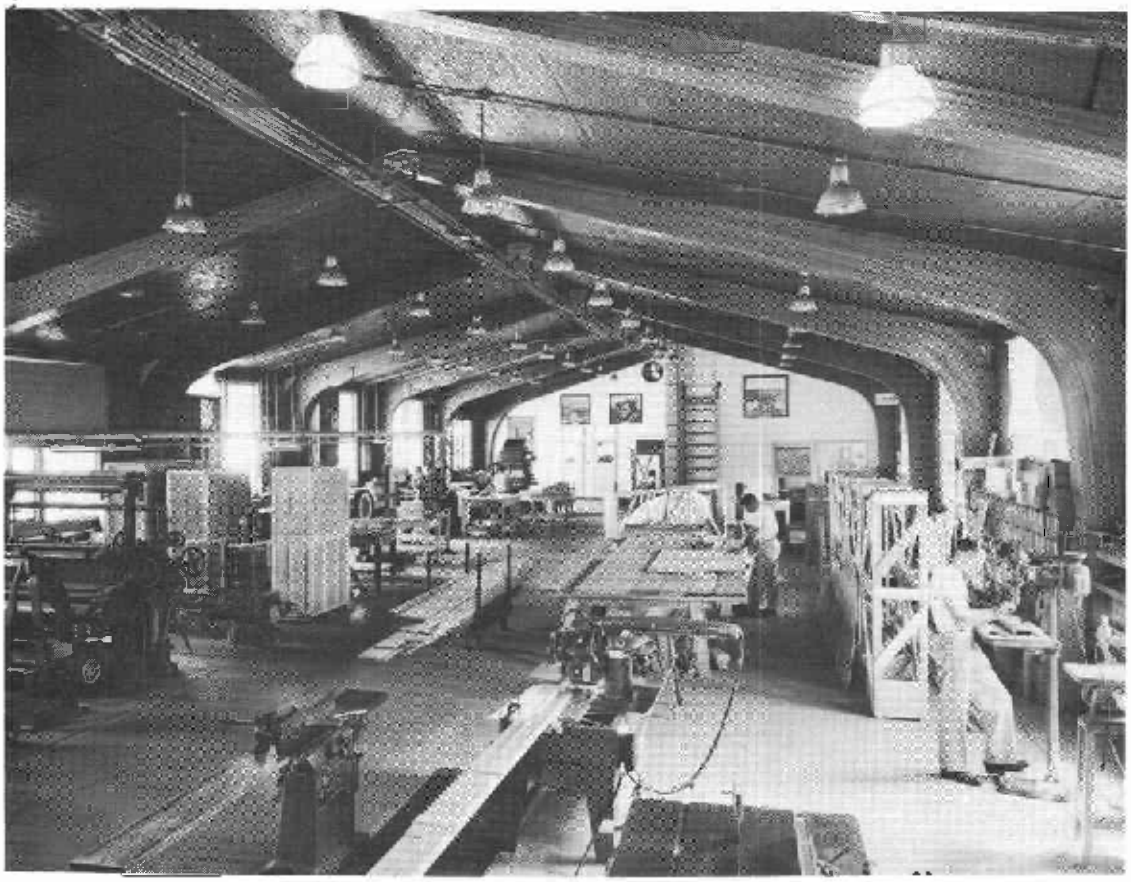

Figure 6. --General view of the main container testing laboratory.

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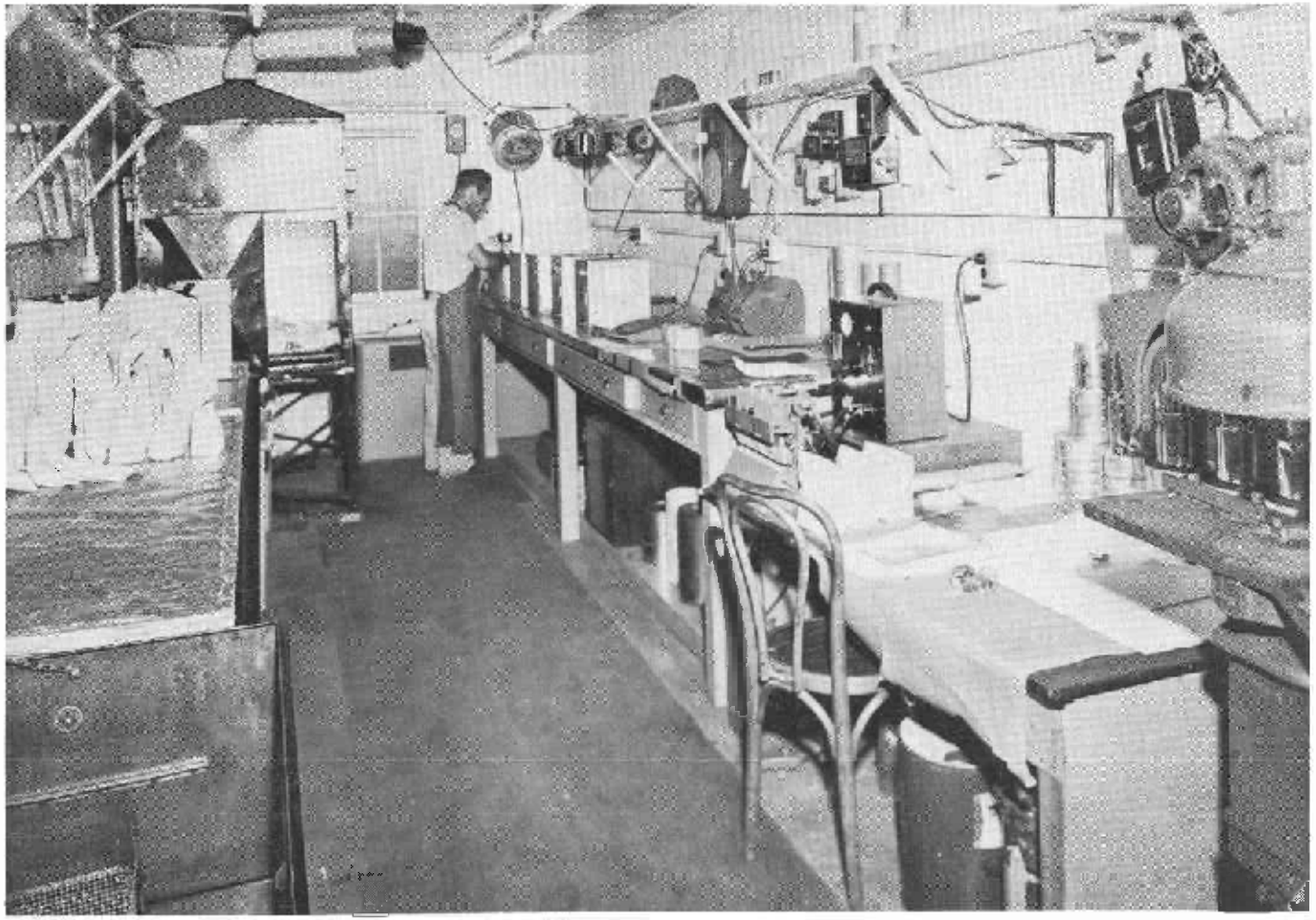

Figure 7.--Packaging preservation laboratory of the Packaging Research Unit.

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