COMPRESSION WOOD: IMPORTANCE AND DETECTION IN AIRCRAFT VENEER AND PLYWOOD

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COMPRESSION WOOD: IMPORTANCE AND DETECTION

IN AIRCRAFT VENEER AND PLYWOOD[1]

Properties

Compression wood is an abnormal type of wood formed on the lower side of leaning trees of softwood species. It does not form in hardwoods. Compression wood has inferior strength properties, particularly in tension, stiffness, and shock resistance. All bending properties are likely to be erratic since the tensile strength is relatively low. Compression wood is denser than most normal wood, thus its ratio of strength to weight is unfavorable for use in aircraft parts.[2] Compression wood shrinks and swells excessively along the grain.

Plywood with compression wood in one face ply may warp excessively due to greater longitudinal shrinkage in the compression-wood ply than in the normal wood on the opposite face. Excessive swelling of compression-wood plies will cause panels to warp in a similar manner. The relatively low strength and high longitudinal shrinkage are likely to affect adversely the strength properties of aircraft plywood incorporating compression wood, particularly its stability within the usual range of moisture content variations to which it is subjected in service.

Typical compression wood has relatively wide annual rings and unusually wide summerwood which seemingly does not appear so dense and hornlike as normal summerwood. This results in a lack of contrast between summerwood and springwood giving a lifeless appearance to compression wood, particularly when dry (fig. 1). On surfaces of veneer and plywood, compression wood usually has a yellowish or slightly brownish color when dry and a reddish color when wet. Streaks of varying widths of compression wood on quarter-sliced surfaces frequently are interspersed among streaks of normal wood, which usually has narrower annual rings, as is shown in figure 2, but occasionally compression wood is present entirely across such surfaces.

Variations of compression wood occur from pronounced forms of distinctly abnormal wood to borderline forms resembling normal wood in appearance, particularly normal wood with wide summerwood. The pronounced forms

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[1] This report is one of a series of progress reports prepared by the Forest Products Laboratory relating to the use of wood in aircraft. Results here reported are preliminary and may be revised as additional data become available.

[2] Structure, Occurrence, and Properties of Compression Wood. U.S.D.A. Tech. Bul. 546, illus. 1937.

of compression wood seriously affect strength and stability of aircraft parts whereas the borderline forms usually are slightly lower in strength properties than is normal wood.

Restrictions on Use for Aircraft

Compression wood in amounts known to affect seriously the strength and stability is not permitted in aircraft. Limited amounts of compression wood, however, do not seriously affect the strength properties of plywood for aircraft parts. Experience has shown that it is difficult to obtain large quantities of softwood material entirely free from compression wood. Satisfactory utilization of softwood species for a critical purpose, such as aircraft, requires that only the unsuitable material be excluded.

Compression wood is restricted in veneer and plywood for aircraft construction on the basis of the width of the streaks[3] in which it occurs. In general, the restriction on width of the streaks of compression wood tends to exclude the pronounced forms that are seriously inferior to normal wood in strength properties and to permit only small amounts of borderline forms that differ very slightly from normal wood. Pronounced compression wood frequently extends across many annual rings while borderline forms frequently are limited to intermittent occurrence in a few rings separated by normal wood.

Methods of Detection

By Reflected Light

Ordinary visual inspection is satisfactory for detecting much of the compression wood that exceeds the permissible limits in veneer and plywood. Its yellow or brownish color, particularly in light-colored species such as spruce, noble fir, and western hemlock, and the unusually wide summerwood without marked contrast with the springwood, particularly when dry, readily identify much compression wood. However, the accurate detection of compression wood frequently is difficult in veneer and plywood that has a naturally reddish-colored heartwood, as for example, some Douglas-fir. This species, to a greater extent than the others commonly used for aircraft parts, also has relatively large percentages of summerwood, even in normal wood which may be confused with compression wood unless carefully inspected.

Wide annual rings alone are not sufficient basis for suspecting compression wood. While compression wood, however, may have narrow annual rings, much of it has wider rings than the normal wood of the same

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[3]Army-Navy aeronautical specification plywood and veneer; aircraft flat panel MIL-P-6070, March 29, 1950.

piece (fig. 2). This, together with unusually large percentages of summerwood lacking contrast with the springwood, identifies, or is, at least, reason to suspect the presence of compression wood.

By Transmitted Light

A simple method for positive detection of compression wood has been developed.[4] When veneer with compression wood is held to a bright light, the summerwood is opaque or transmits light only faintly, while normal summerwood usually is highly translucent. The opacity of compression wood is due to the discontinuous structure of its fiber walls resulting from microscopic checks existing in compression wood. These checks dissipate the light passing into the wood, while in normal wood light is transmitted by the continuous fiber walls. Figure 3 shows typical compression wood (left) and normal wood (right) in veneer. These photographs were made (upper) by reflected light, as seen in ordinary visual inspection, and (lower) by transmitted light.

In thin, 3-ply panels, as well as in veneer, compression wood can be detected in the face plies by the relative amounts of light transmitted, provided the ply containing compression wood is toward the observer and dark-colored heartwood of such species as yellowpoplar and sweetgum is not included in the panel. Figure 4 shows, in a 3-ply panel, typical compression wood (left) and normal wood (right) photographed by reflected light (upper) and by transmitted light (lower). The wide summerwood in the compression wood is opaque, and narrow summerwood in the normal wood is translucent as are similar summerwood bands in veneer (compare figs. 3 and 4). The method is satisfactory in both veneer and plywood with thicknesses up to at least one-eighth of an inch. This range in thickness includes most of the 3-ply panel constructions permitted by Army-Navy specifications for aircraft plywood.[2]

The accurate identification of compression wood in doubtful pieces--a difficult procedure by ordinary inspection in reflected light--is facilitated by the use of transmitted light. This is particularly true of normal wood that is reddish in color and has relatively large proportions of summerwood as a result of favorable growth conditions. Figure 5 shows pieces of veneer that are identified, in transmitted light, as compression wood and normal wood, respectively, by the relative opacity of the summerwood of compression wood (lower left) and the relative translucence of normal wood (lower right). Although the summerwood of the veneer on the right has a reddish color in transmitted light, it is about as translucent as the springwood of the same annual rings. There is reason to question whether or not compression wood is present in each of the pieces of veneer shown in figure 5 when they are examined by ordinary visual inspection, but the compression wood and the normal wood photographed in figure 5 are accurately identified by their appearance in transmitted light.

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[4]Simple Device for Detecting Compression Wood. Report No. 1390. Forest Products Laboratory, Madison, Wis. December 1941.

Variations of Light Transmission

Light intensities supplied by electric lamps must be varied with the thicknesses of veneer and plywood in order to detect compression wood accurately. The amount of light from 50- and 60-watt lamps frequently is sufficiently bright for use with 1/48-inch and sometimes 1/32-inch veneer. Lamps with 100-watt intensities usually are required for thicknesses of 1/32 inch to 1/16 inch, while 150- and 200-watt intensities are needed for 1/14- to 1/10-inch veneer and for plywood up to 1/8 inch thick.

Stains, such as sap stain due to fungi or to chemical changes in the constituents of the wood which appreciably darken it, also absorb light. This interferes with the method of detecting compression wood by transmitted light for the opacity of discolored areas may be confused with the opacity of the summerwood of compression wood. Stained areas in veneer and plywood, however, can be identified readily in reflected light by careful visual inspection.

The summerwood of compression wood is definitely more opaque than the springwood. In contrast, normal summerwood is as translucent if not more so than the springwood.

The amount of light transmitted by the summerwood of compression wood depends principally on the abundance of the microscopic checks in the compression wood. Pronounced forms, which have many microscopic checks in the summerwood, are definitely opaque whereas borderline forms are less opaque as a result of fewer checks. The springwood of both is somewhat translucent in transmitted light. Normal summerwood is at least as translucent as the springwood even though light transmission is reduced by natural colorations of the heartwood. Summerwood that is reddish in color in transmitted light and nearly equally translucent with its springwood, should not be confused with borderline forms of compression wood in which the summerwood is appreciably darker than the springwood. The use of increased intensity of the light assists in avoiding confusion of normal wood that has a reddish color in transmitted light with compression wood in which the light transmission in the summerwood is definitely reduced.

Construction and Use of Light Box

A controlled source of light such as the light box shown in figure 6 is necessary for the accurate detection of compression wood by transmitted light in veneer and thin, 3-ply panels of plywood. The construction of a light box is shown in the dimensional drawings of figure 7.

It is preferable to make the light box out of hard asbestos board about 1/4 inch thick. The box can be built of wood, however, provided the front, back, and sides are lined with asbestos board to eliminate the danger of fire from overheating of the electric lamp. Hard asbestos board usually can be obtained from dealers in builder's supplies. Ventilation holes to prevent overheating of the box are bored in both sides of the box. These are covered on the inside of the box with a baffle set about 1/8 inch away from the sides so as to confine the light within the box but still permit ventilation. The box is provided with a sliding cover to reduce the length of the opening from front to back to less than 10 inches for the examination of veneer that is less than this width (fig. 7).

The light box has a 3-contact socket in order to use 3-way electric lamps which provide for three intensities of light without changing the lamps. The intensity of the light is controlled by two single-pole switches at the front of the box as is indicated in figure 7. These switches control the lighting of the two filaments separately in the 3-way lamps so that either or both filaments may be lighted at one time. Such lamps are now manufactured with intensities of 50-100-150 watts and 100-200-300 watts, a range of intensities of light sufficient for the accurate detection of compression wood in veneer of different thicknesses from 1/48 inch to 1/10 inch and in thin plywood, permissible for aircraft construction, up to about 1/8 inch.[2]

The light box can be used most conveniently when it is set so that its top is flush with the top of a table that is at least as long, if not longer than the veneer to be examined. This permits the sheets of veneer to be slid endwise for examination over the light source since compression wood frequently does not extend the full length of the sheet. It is practical to insert the light box into the table top by using right-angle brackets fastened to the sides of the box at each corner (fig. 6). The top of the brackets should be flush with the top of the box and sunk into the top surface of the table boards to provide a working surface without projections to catch the veneer as it is being handled.

The veneer is placed over the opening at the top of the light box for examination to detect compression wood. It is not necessary that the box be in a darkened place but if it is not, the use of a viewing device, such as is shown on top of the box in figure 6, usually is required for accurate detection of compression wood. This simple viewing device can be made of fiberboard as shown in figure 8. After the viewing device is cut and folded it can be held together with paper fastening staples or gummed tape. The smaller end is cut so that it sets flatly against the veneer at an angle of about 10 degrees from the vertical axis of the viewing device (fig. 6).

Experience has shown that much of the veneer with compression wood in amounts that exceed the permissible limits for aircraft veneer and plywood is detected in ordinary visual inspection by reflected light. In doubtful pieces, however, the use of the light box facilitates the segregation of veneer with compression wood in excessive amounts without the exclusion of veneer that is suitable for aircraft construction. It is practical to use the light box to detect compression wood both in wet veneer as it comes directly from the slicer and also in the veneer after it has been dried. Wet veneer, however, requires a less intense light for the identification of compression wood than does dry veneer of the same thickness.

Detection Before Slicing

Compression wood exceeding the limits permitted for aircraft plywood usually can be detected in the flitches before they are sliced for veneer. As seen on the surfaces of flitches, compression wood is identified by the same characteristics as in sliced veneer during ordinary visual inspection by reflected light, namely, wide summerwood that, however, does not appear dense and hornlike as does normal summerwood, together with a yellowish color when dry or reddish when wet. On the ends of flitches, relatively wide summerwood not sharply contrasted with the springwood of the same annual rings also indicates the presence of compression wood.

The positive identification of compression wood in occasional doubtful flitches is facilitated by the use of transmitted light. The opacity of the summerwood in thin cross sections of unsliced flitches identifies compression wood in the same way as in quarter-sliced veneer. It is usually preferable to cut cross sections about 2 inches long from the ends of the flitches. Thin cross sections about 5/32 inch in thickness then can be cut readily with a power-driven crosscut saw from the whole or any part of the cross section of the flitches. It is necessary to have the end-grain surfaces of the thin sections as smooth as possible.

When observed with a light intensity of about 100 watts the summerwood of compression wood in the thin cross sections is opaque while that of normal wood is translucent. Additional details on the detection of compression wood in thin cross sections of softwood lumber are given in Forest Products Laboratory Report No. 1390.

The use of cross sections for the detection of compression wood by transmitted light in unsliced flitches is recommended specifically for the occasional doubtful pieces encountered in plants where the mechanical facilities are readily available for cutting thick sections from the ends of flitches and thin, smoothly sawed cross sections from the thick sections. It is necessary to examine both ends of flitches since compression wood frequently does not always extend the full length. Occasional excessive amounts present in the middle of the length of flitches, not evident at the ends, cannot be detected until after the veneer has been sliced.

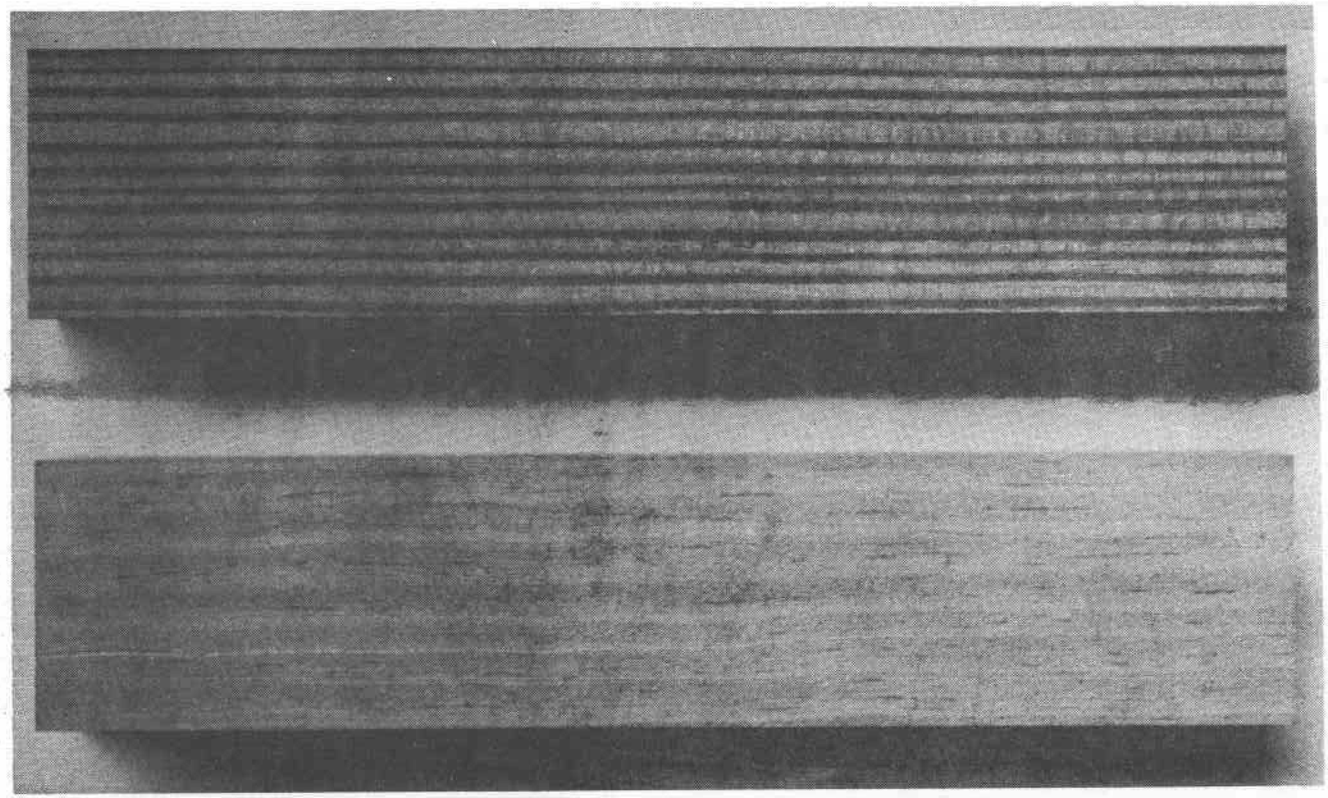

Figure 1.--Normal wood (upper) and compression wood (lower). Note the dense hornlike appearance of normal summerwood in comparison with that of compression wood, which has relatively wide summerwood that lacks contrast with the springwood and so gives a lifeless appearance to the compression wood as a whole.

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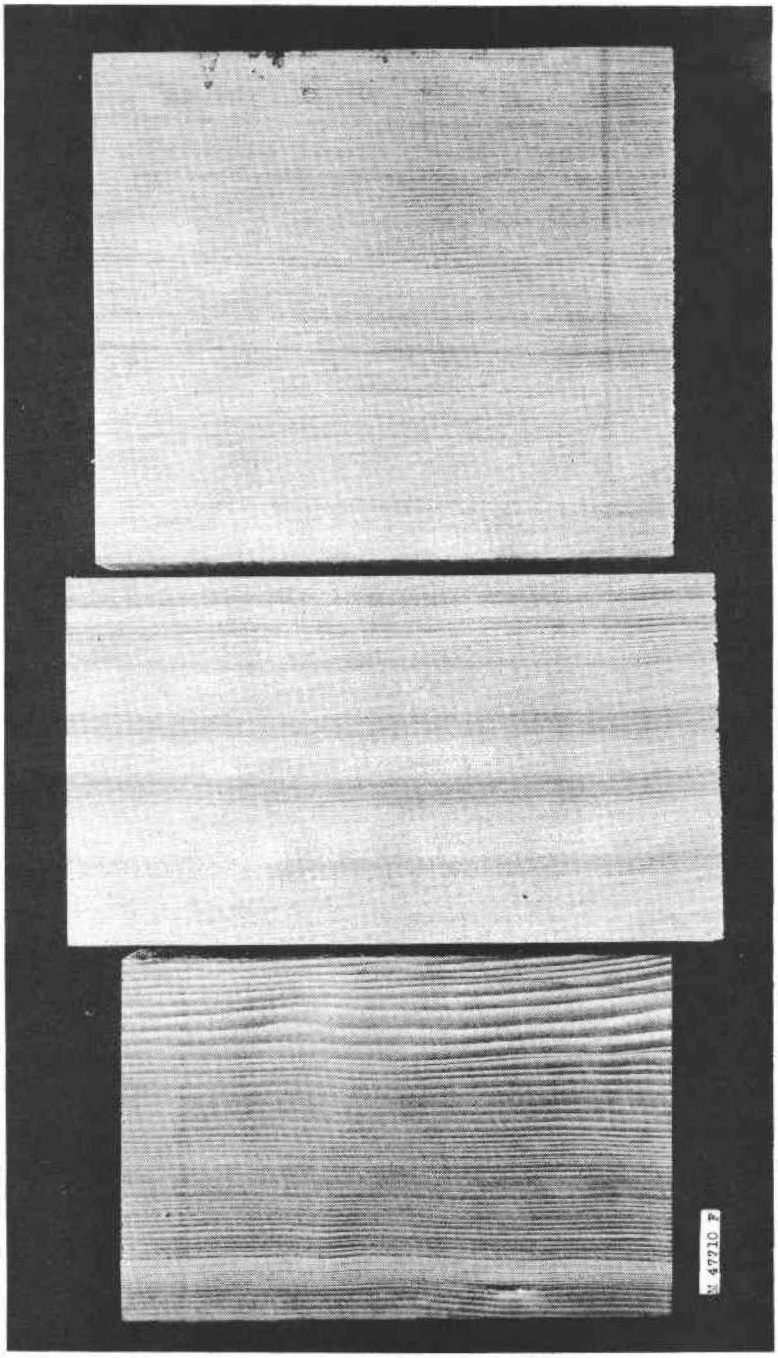

Figure 2.--Pieces of western hemlock containing compression wood in varying amounts: upper, occasional annual rings; center, streaks including several annual rings; and lower, practically the entire piece. The compression wood is identified by the wide annual rings and unusually wide summerwood.

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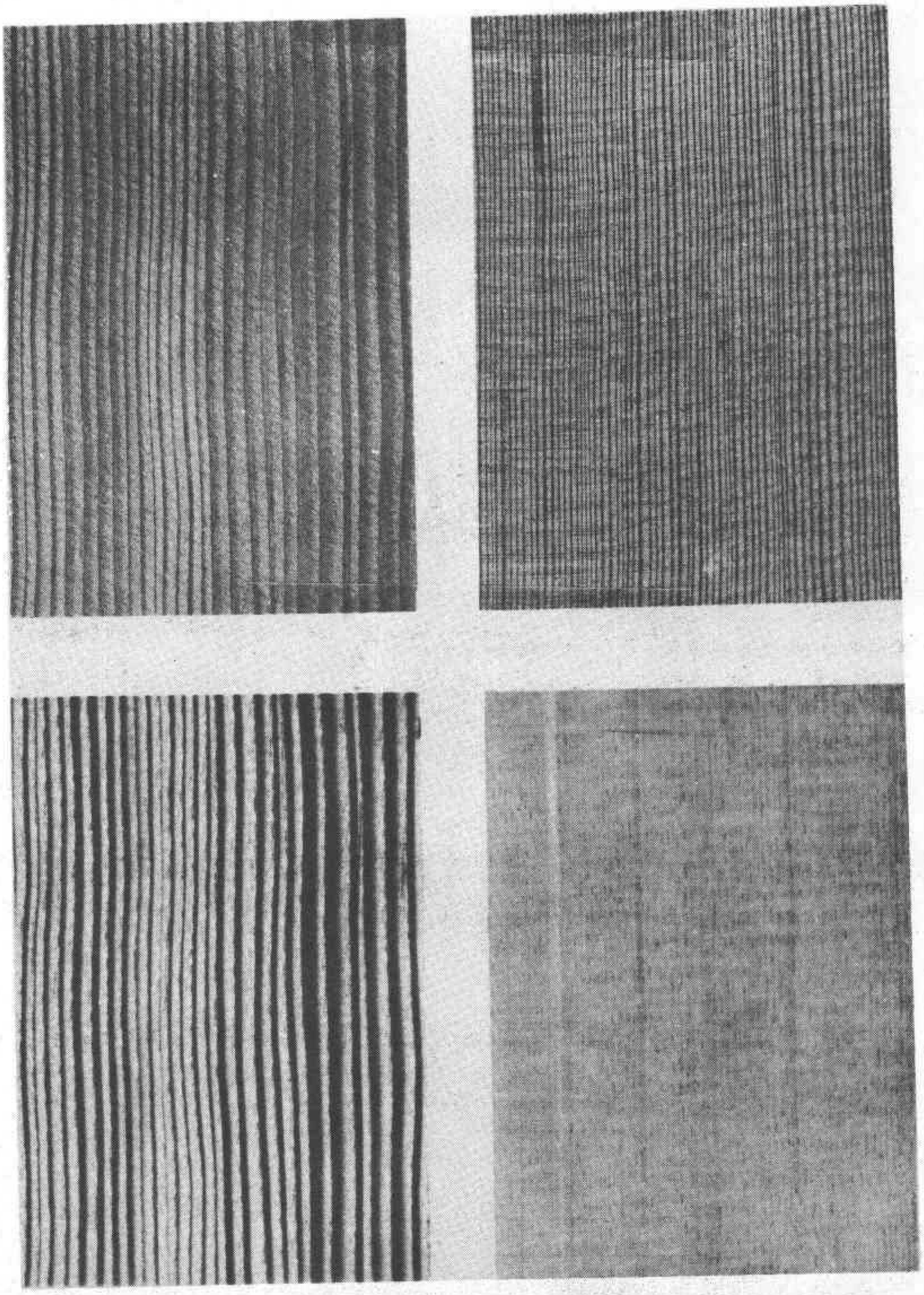

Figure 3.--Two pieces of Douglas-fir veneer photographed (upper) by reflected light as seen in ordinary visual inspection and (lower) by transmitted light. Note in the lower photographs (left) the opacity of the summerwood of compression wood and (right) its translucence in normal wood, in which the summerwood is brighter than the springwood.

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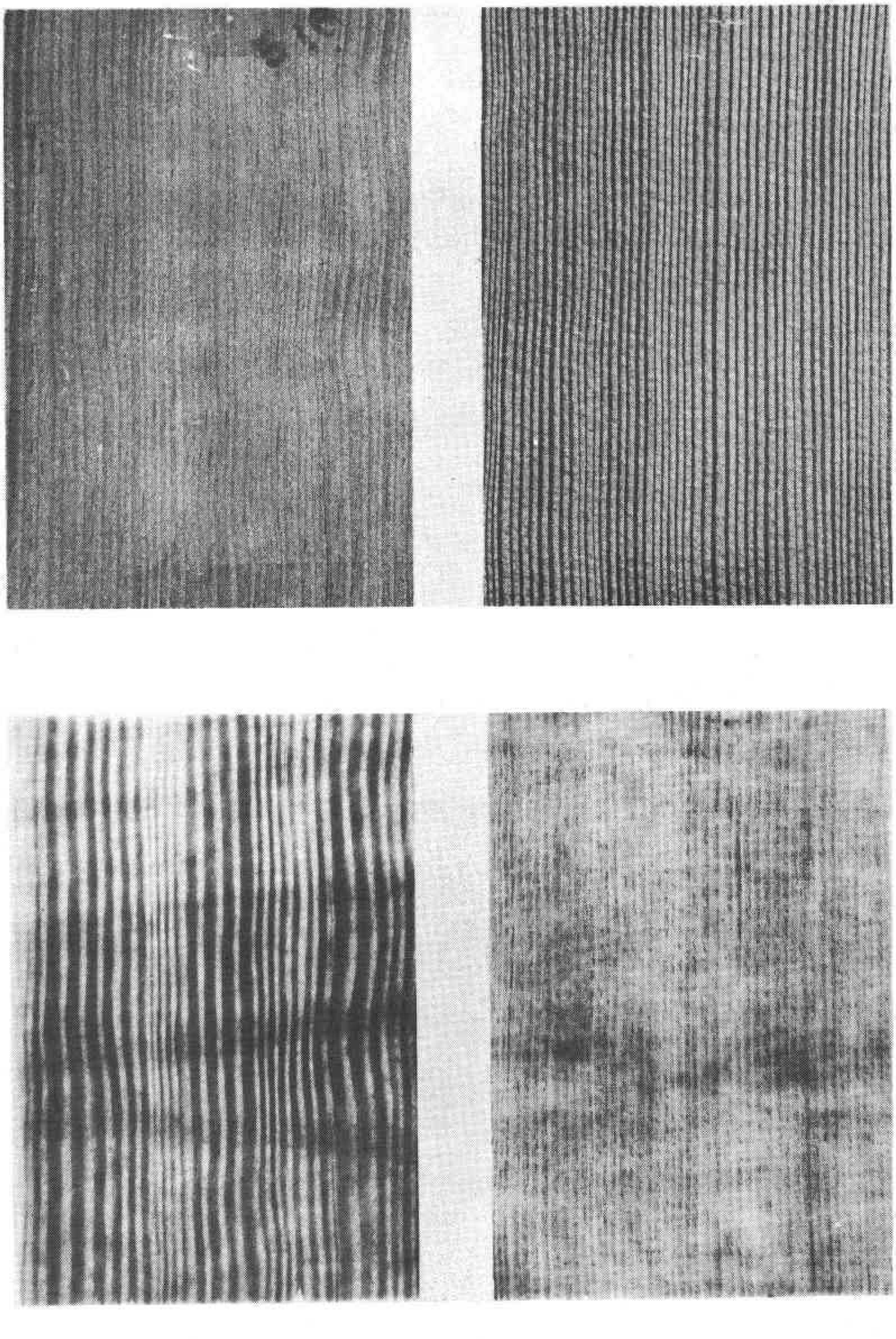

Figure 4.--Two pieces of 3-ply Douglas-fir plywood photographed (upper) by reflected light as seen in ordinary visual inspection and (lower) by transmitted light. Note in the lower photographs (left) the opacity of the summerwood of compression wood and (right) its translucence in normal wood, in which the summerwood is brighter than the springwood.

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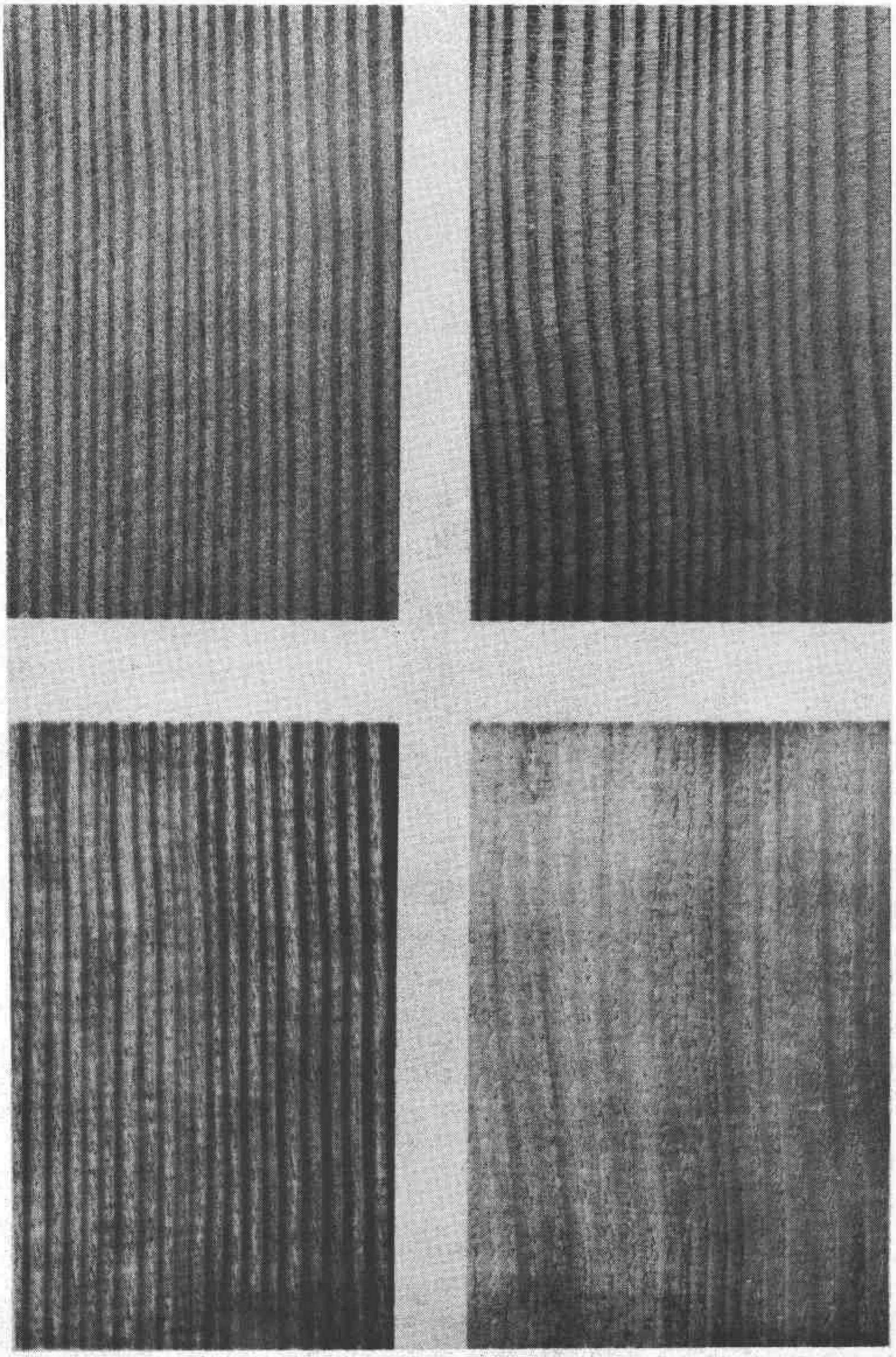

Figure 5.--Two pieces of Douglas-fir veneer photographed (upper) by reflected light as seen in ordinary visual inspection and (lower) by transmitted light. Note the relative opacity of the summerwood of compression wood (left) and the translucence of the summerwood of normal wood (right) which is about the same as the springwood.

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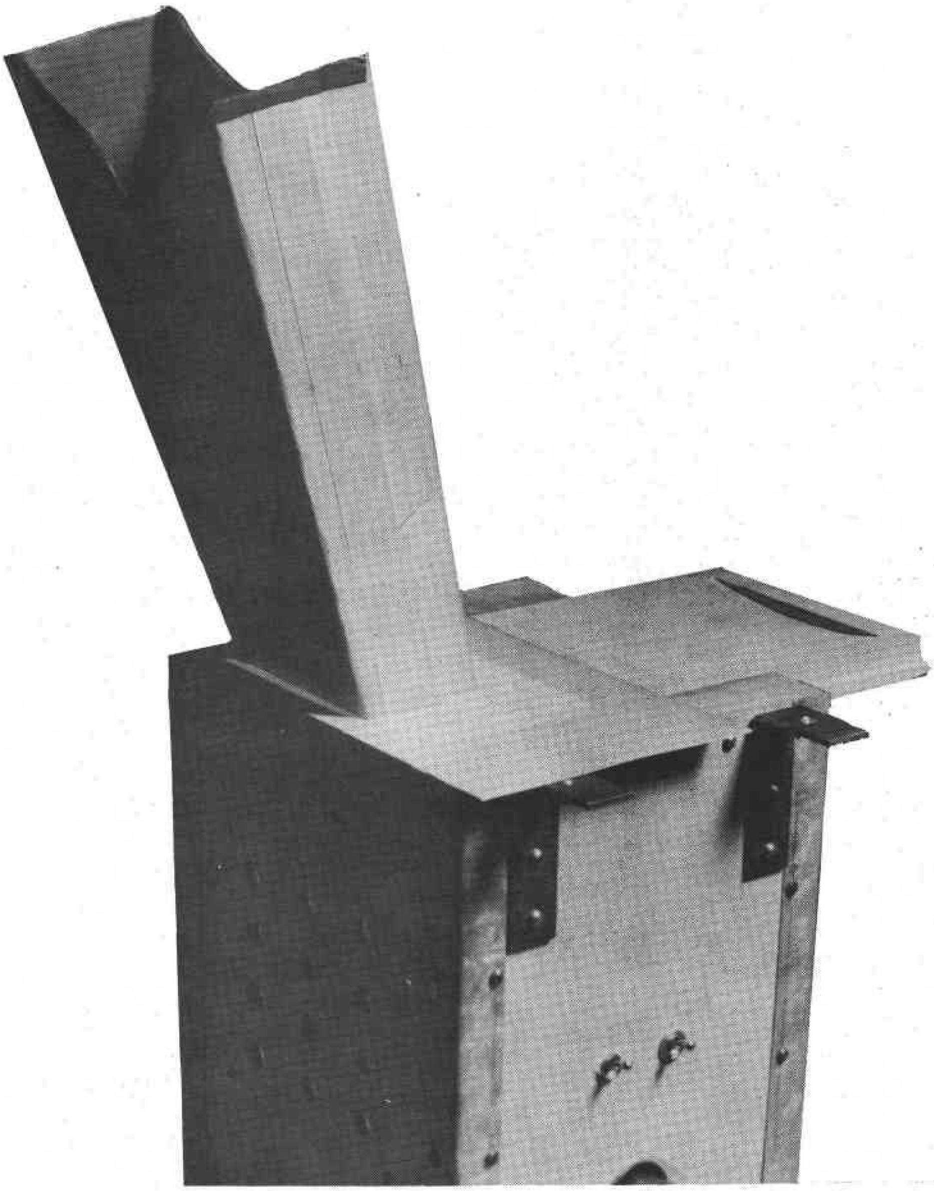

Figure 6.--Forest Products Laboratory light box and viewing device for detecting compression wood in veneer and thin 3-ply panels of plywood by transmitted light.

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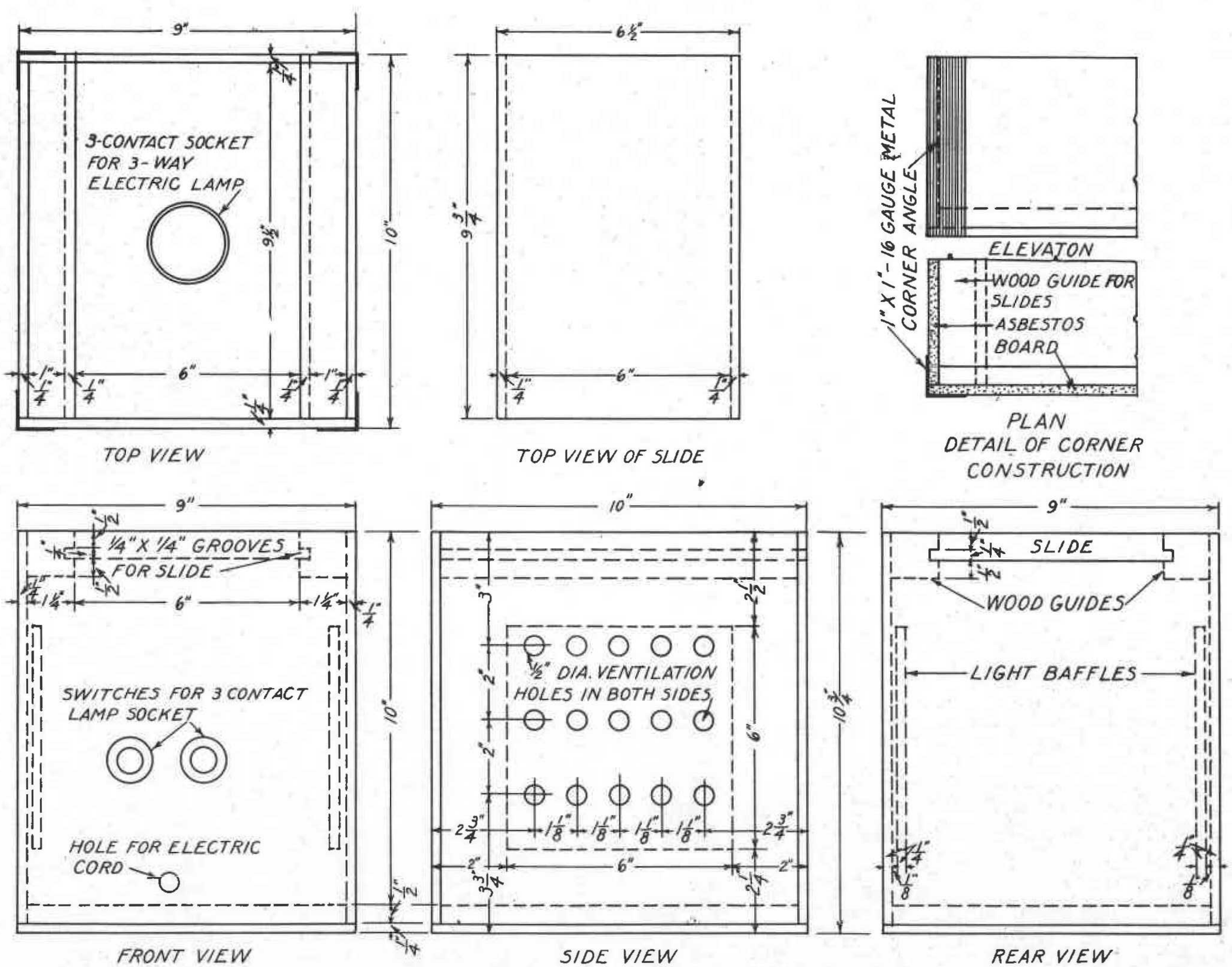

Figure 7.--Dimensional drawings of the Forest Products Laboratory light box made of hard asbestos board for use in detection of compression wood in quarter-sliced veneer by transmitted light.

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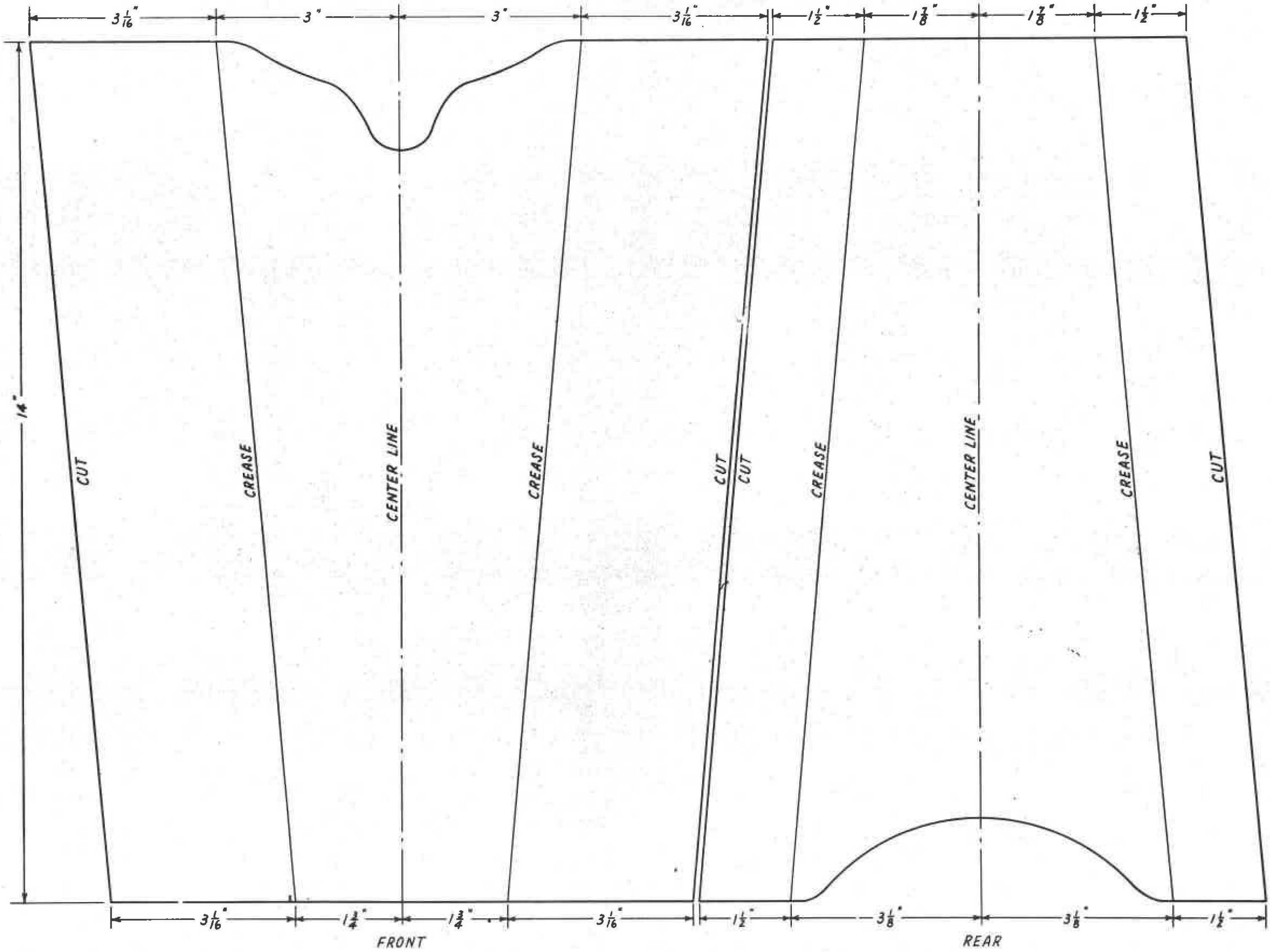

Figure 8.--Diagrams for cutting and folding corrugated fiberboard for a viewing device to reduce extraneous light during detection of compression wood by transmitted light.

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