(2)

US Army Corps of Engineers
Construction Engineering Research Laboratory

AD-A190 377

USA-CERL TECHNICAL REPORT N-87/24
December 1987
Standard Methods to Assess Human and Community Response to Impulse Noise

Expedient Methods for Rattle-Proofing Certain Housing Components

by
Paul D. Schomer
Steven D. Hottman
Frederick M. Kessler
Rachel K. Kessler

Occupants of buildings located in areas of high-level impulse noise usually report that the main annoyance factor is the rattle produced by house components upon vibration. This type of noise is associated with helicopter flybys and blast overpressure from artillery and other military training operations. Methods are needed for mitigating rattles in both existing structures and future construction.

This report analyzes several different building elements to identify individual components contributing to rattle. Elements studied include windows, doors, wall-mounted objects, bric-a-brac, ductwork, gutters, and light fixtures, among others. In general, the primary source of rattle is any small gap between two hard surfaces that are subject to vibration from an exterior noise source. Upon excitation, these surfaces can impact each other, producing the sound. Other rattle sources are identified and methods are recommended for eliminating or reducing noise from the individual elements.

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved
OMB No 0704-0188
Exp Date Jun 30 1986

1a REPORT SECURITY CLASSIFICATION Unclassified	1b RESTRICTIVE MARKINGS
2a SECURITY CLASSIFICATION AUTHORITY	3 DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution is unlimited.
2b DECLASSIFICATION/DOWNGRADING SCHEDULE	
4 PERFORMING ORGANIZATION REPORT NUMBER(S) USA-CERL TR N-87/24	5 MONITORING ORGANIZATION REPORT NUMBER(S)
6a NAME OF PERFORMING ORGANIZATION U.S. Army Construction Engr Research Laboratory 6b OFFICE SYMBOL (If applicable)	7a NAME OF MONITORING ORGANIZATION
6c ADDRESS (City, State, and ZIP Code) P.O. Box 4005 Champaign, IL 61820	7b ADDRESS (City, State, and ZIP Code)
8a NAME OF FUNDING/SPONSORING ORGANIZATION OCE 8b OFFICE SYMBOL (If applicable) DAEN-ZCE	9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c ADDRESS (City, State, and ZIP Code) The Pentagon Washington, DC 20310-2600	10 SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO 4A162720; PROJECT NO A896; TASK NO A; WORK UNIT ACCESSION NO 009

11 TITLE (Include Security Classification)

Expedient Methods for Rattle-Proofing Certain Housing Components (U)

12 PERSONAL AUTHOR(S)

Schomer, Paul D.; Hottman, Steven D.; Kessler, Frederick M.; Kessler, Rachel K.

13a TYPE OF REPORT	13b TIME COVERED	14 DATE OF REPORT (Year, Month, Day)	15 PAGE COUNT
Final	FROM ____ TO ____	1987, December	53

16 SUPPLEMENTARY NOTATION

Copies are available from National Technical Information Service.
Springfield VA 22161

17 COSATI CODES

FIELD	GROUP	SUB-GROUP
24	02	

18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number)

impulse noise,
buildings,
vibration

19 ABSTRACT (Continue on reverse if necessary and identify by block number)

Occupants of buildings located in areas of high-level impulse noise usually report that the main annoyance factor is the rattle produced by house components upon vibration. This type of noise is associated with helicopter flybys and blast overpressure from artillery and other military training operations. Methods are needed for mitigating rattles in both existing structures and future construction.

This report analyzes several different building elements to identify individual components contributing to rattle. Elements studied include windows, doors, wall-mounted objects, bric-a-brac, ductwork, gutters, and light fixtures, among others. In general, the primary source of rattle is any small gap between two hard surfaces that are subject to vibration from an exterior noise source. Upon excitation, these surfaces can impact each other, producing the sound. Other rattle sources are identified and methods are recommended for eliminating or reducing noise from the individual elements.

20 DISTRIBUTION/AVAILABILITY OF ABSTRACT ☐ UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT ☐ DTIC USERS	21 ABSTRACT SECURITY CLASSIFICATION Unclassified
22a NAME OF RESPONSIBLE INDIVIDUAL Dana Finney	22b TELEPHONE (Include Area Code) (217) 352-6511 ext 389 22c OFFICE SYMBOL CECER-IMT-E

DD FORM 1473, 84 MAR — 83 APR edition may be used until exhausted. All other editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE

Unclassified

FOREWORD

This work was performed for the Assistant Chief of Engineers, Office of the Chief of Engineers (OCE), under Project 4A162720A896, "Environmental Quality Technology"; Task A, "Installation Management Strategy"; Work Unit 009, "Standard Methods to Assess Human and Community Response to Impulse Noise." The OCE Technical Monitor was LTC James Stratta, DAEN-ZCE.

The investigation was conducted by the Environmental Division (EN) of the U.S. Army Construction Engineering Research Laboratory. Frederick Kessler and Rachel Kessler are with FMK Technology, Inc., Bound Brook, NJ.

Dr. R. K. Jain is Chief, EN. COL Norman C. Hintz is Commander and Director of USA-CERL, and Dr. L. R. Shaffer is Technical Director.

CONTENTS

FIGURES

FIGURES (Cont'd)

TABLE

EXPEDIENT METHODS FOR RATTLE-PROOFING CERTAIN HOUSING COMPONENTS

1 INTRODUCTION

Background

The recent trend toward siting off-installation housing and other noise-sensitive land uses in areas exposed to high impulsive noise levels has produced a major concern among Army planners. Noise impact due to off-installation land uses must be minimized in accordance with the Installation Compatible Use Zone (ICUZ) program, as described in Army Regulation (AR) 200-1.[1] The ICUZ program uses blast noise zone maps generated by the blast noise computer prediction program BNOISE, which was developed by the U.S. Army Construction Engineering Research Laboratory (USA-CERL).[2]

Impulsive noise presents unique problems compared with common, continuous noise sources such as fixed-wing aircraft, vehicles, trains, and factories. Long-term research by USA-CERL and other organizations has indicated that the main annoyance factor for impulsive blast noise is the rattle it produces when it excites building components.[3] This rattle can be caused by vibrating windows, bric-a-brac, light fixtures, doors, and structural elements.

Elimination of these rattles could eliminate some, if not all, of the annoyance for building occupants. Quantitatively, quieting the rattles could produce a 10-dB or greater noise reduction; in terms of the ICUZ program, this reduction would be enough to change a zone from completely unacceptable for housing to completely acceptable.

Technology is available for shielding structures against common, continuous noise sources. However, while the impulse noise problem is not an entirely new area, research into mitigation of this noise has failed to produce effective control methods. Many of

---

[1]Army Regulation (AR) 200-1, *Environmental Quality: Environmental Protection and Enhancement* (Headquarters, Department of the Army [HQDA], 15 June 1982).

[2]P. D. Schomer, et al., *Blast Noise Prediction, Vol I: Data Bases and Computational Procedures*, and *Vol II: BNOISE 3.2 Computer Program Description and Listing*, Technical Report N-98/ADA099440 and ADA099335 (U.S. Army Construction Engineering Research Laboratory [USA-CERL], March 1981).

[3]P. D. Schomer and R. D. Neathammer, *Community Reaction to Impulse Noise: A 10-Year Research Summary*, Technical Report N-167/ADA159455 (Revised) (USA-CERL, 1985); P. D. Schomer, *Predicting Community Response to Blast Noise*, Technical Report E-17/ADA773690 (USA-CERL, December 1973); P. D. Schomer and R. D. Neathammer, *The Role of Vibration and Rattle in Human Response to Helicopter Noise*, Technical Report N-85/14/ADA162486 (USA-CERL, July 1985); P. N. Borsky, *Community Reactions to Sonic Booms in the Oklahoma City Area, Vol II, Data on Community Reactions and Interpretations*, AMRL-TR-65-37 (U.S. Air Force, 1965); K. D. Kryster, P. J. Johnson, and J. P. Young, *Psychological Experiments on Sonic Booms Conducted at Edwards Air Force Base*, Final Report, Contract No. AF49(638)-1758 (National Sonic Boom Evaluation Office, Arlington, VA, 1968); G. A. Luz, R. Raspet, and P. D. Schomer, "An Analysis of Community Complaints to Noise," *Journal of the Acoustical Society of America*, Vol 73, No. 4 (April 1983).

these theoretical analyses were done in the late 1960s and early 1970s to study structural response to sonic booms. In general, the theoretical procedures did not take into account nonlinear effects of large impulse noise and therefore resulted in idealized data. The most complicated structure analyzed was a simple box with an opening.

Techniques are needed for rattle-proofing structures located in areas of high-level impulse noise. The technology should cover both retrofitting of existing structures and preventive measures for new buildings.

Purpose

The overall purpose of this work is to develop methods for preventing rattles inside housing located in areas of blast noise. This report identifies expedient methods the Army can use to help solve existing problems. The development and refinement of an experimental test facility and procedures for studying the impulse noise problem systematically and empirically are reported in USA-CERL IR N-87/25.

Approach

USA-CERL surveyed the literature and several companies that manufacture different building elements. The focus was on doors, windows, picture frames, bric-a-brac, and similar items. Findings were analyzed with respect to the Army's specific needs and the most promising methods were recommended as an immediate solution to existing problems. These results will be combined with those in IR N-87/25 for supporting further research and development.

Mode of Technology Transfer

Recommendations developed in this volume will have direct impact on implementation of the ICUZ program. Information will be summarized in a pamphlet that will be disseminated at ICUZ training courses and used by the U.S. Army Environmental Hygiene Agency (USAEHA) in assisting installations with operational noise problems.

2 ANALYTICAL METHODS

Identification of Major Rattle Sources

For this study, the rattling in homes was assumed to be excited by large-impulse noise--specifically, that from helicopter overflights or blast overpressure due to ground blasting or artillery.

Next, elements within structures which are subject to low-frequency excitation were identified. This information was based on earlier work that quantified building vibration and rattle levels using experimental data; these data were collected during tests on USA-CERL's Biaxial Shock Testing Machine (BSTM).[4] For these tests, USA-CERL had modified the BSTM so that sonic pulses simulating low-frequency blast overpressure could be generated. Inside the BSTM facility and about 12 ft from the actual test platform, a 19 ft 8 in. by 14 ft 6 in. residential-type building was constructed using conventional materials and methods. However, it was built on a small scale, consisting of only one room, the overhead roof structure, and the foundation.

Data from the tests were analyzed using a dynamic response model (the classical method for predicting modal response) and empirical methods. The study concluded that the primary modal vibration pattern for walls depends greatly on the bending stiffness of the vertical studs; the pattern for floors and ceilings depends on the bending stiffness of the horizontal joists. Resonance frequencies that were excited ranged from 10 to 40 Hz.

Models were then developed to quantify the sound-pressure-induced rattle of windows and doors, picture frames, and bric-a-brac. Figure 1* shows the model used to predict window and door rattle due to the gap normally present between the window/door and frame (especially in sliding glass windows and doors). Rattle occurs when the following relationship is true:

$$p(f) > (6.28 \times f)^2 \, [m X_R / J(f) T(f)] \qquad \text{[Eq 1]}$$

where p(f) is sound pressure, f is frequency, m is window mass, X_R is the rattle space, J(f) is a vibroacoustic coupling factor, and T(f) is the sinusoidal response of the window at frequency f. At low frequencies, T(f) and J(f) approach unity and the critical sound pressure increases as the square of the frequency. This trend is approximated in Figure 2 based on experimental work by Tokita and Nakamura.[5]

Picture frames and hanging mirrors can be modeled as shown in Figure 3; Figure 4 shows measured rattle thresholds for wall plaques.[6] At low frequencies (below 100 Hz), wall accelerations of less than 0.03 G are required to make the plaque move away from

---

[4] L.C. Sutherland, *Low Frequency Response of Structures*, Wyle Research Report WR 82-18 (Wyle, Inc., May 1982).

*Tables and figures are located at the end of the report, starting on p 23.

[5] Y. Tokita and S. Nakamura, "Frequency Weighting Characteristics for Evaluation of Low Frequency Sound," *Proceedings, 1981 International Conference on Noise Control Engineering, 6-8 October 1981* (1981).

[6] H. D. Carden and W. H. Mayes, *Measured Vibration Response Characteristics of Four Residential Structures Excited by Mechanical and Acoustical Loadings*, NASA TN D-5778 (National Aeronautics and Space Administration, April 1970).

the wall and rattle. These data agree with Wyle's models for hanging angles of 0.13 to 0.4 degrees.

Dishes, cups, saucers, and other bric-a-brac placed on shelves can be caused to rattle if the objects are stacked and their surfaces are not in full contact so that they can rotate or rock relative to each other. Acceleration loading (vertical) of less than 1 G can produce the rocking. On the other hand, for objects resting in full contact at all points, an acceleration of more than 1 G is required to cause a vertical deflection or gap to generate the rattle. The sound power from a point-driven infinite plate has been derived (Equation 2):

$$W_{approx.} = 0.84V^2 \rho C_L t^2/c \qquad \text{[Eq 2]}$$

where V is the root mean square velocity of the driving point, ρ is the mass density of the plate, C_L is the longitudinal speed of sound in the plate material, t is the plate thickness, and c is the speed of sound in air. No experimental data supporting or calibrating this plate rattle model have been found.

Windows or doors can be directly excited by blast overpressure or helicopter low-frequency sound. However, their interior spaces are excited only by the transmitted wave, which is attenuated by the building structure. During summer, with the windows and possibly doors open, the interior sound pressure will tend to be dominated by direct sound transmission through the open door or window. In the winter, interior sound may be influenced by wall transmission loss.

When considering outer wall openings (windows and doors), in the case of low-frequency components of the outdoor blast wave or helicopter sound for which the wavelength is well below the perimeter of the opening, the transmission loss will be on the order of about 3 dB or less. For the excitation frequency range where the wavelength is approximately comparable to the perimeter of the opening, an amplification can occur and the transmission loss can be considered negative, with a value of -3 dB. At high frequencies, the attenuation approaches zero and no loss occurs at the opening.

For this study, the main elements considered subject to excitation from large-impulse noise were windows, doors, ceilings, building accessories such as gutters and downspouts, and miscellaneous decorator items such as hanging pictures and bric-a-brac. Table 1 lists each category with specific components that are likely to rattle.

Manufacturer Survey

For the major items identified in Table 1, several manufacturers were contacted to obtain product information. (Appendix A lists these manufacturers.) The general comment from most companies was that their product does not rattle. No manufacturer designs these items with rattle reduction as a specific goal; however, careful analysis of the product literature has revealed that some items are designed with features that are superior to others in reducing the potential to rattle. Items for which information was received are analyzed in Chapters 3 through 5. Results from the literature were used as input to this analysis.[7]

---

[7] L. C. Sutherland; L. C. Sutherland, B. H. Sharp, and R. A. Mantey, *Preliminary Evaluation of Low Frequency Noise and Vibration Reduction Retrofit Concepts for Wood Frame Structures*, Wyle Research Report WR 83-26 (June 1983).

3 WINDOWS

There are seven basic types of windows: fixed, casement, awning (or hopper), sliding, double-hung, jalousie, and pivoting. Figure 5 shows these window types. Each window was analyzed for sources of rattle and possible solutions. In addition, the range of Sound Transmission Class (STC) was estimated for each window type. The STC values are based on information in the literature;[8] manufacturers did not provide these data.

Fixed Window

The main source of rattle is the gap between the glazed stationary sash and the fixed frame. Calking and/or weatherstripping and installation of a mechanical clamp should eliminate most of the rattling. The STC value is rated at 29 to 47. These windows are judged to be acceptable for use on Army housing in areas of high-level impulse noise.

Casement Window

Details for this window are in Figure 6. Potential rattle sources are the spaces between the closed hinged sash and fixed frame and between two hinged sashes when they are closed but not clapped (dogged). Possible solutions are: (1) install weatherstripping along the perimeters of both hinged sashes (use rubber, open-cell foam, or soft elastomeric weatherstripping); (2) keep windows closed tightly so that the weatherstripping is clamped, or leave them completely open (i.e., not in contact with the frame). The STC rating is 29 to 47. These windows can be considered acceptable.

Awning

The sources of rattle, possible solutions, STC rating, and acceptability are the same as those for casements. An awning is depicted on a fixed window in Figure 5.

Double-Hung Window

Figure 7 shows details of this type of window. The primary sources of rattle are: (1) the gap between the sash and track, (2) counterbalances (spring or weights), (3) hardware for locking upper and lower windows together, and (4) the gap where the two windows meet. The STC value is estimated at 29 to 47. These windows should be avoided for new construction and as replacements in areas of high-level impulse noise. To reduce problems on existing structures, the following measures can be taken:

- Eliminate the gap between the sash and track using plastic inserts or weatherstripping
- Place the spring or weights inside a soft, plastic jacket

---

[8] S. F. Weber, et al., *Method for Assessing Costs of Noise Control Requirements in Multifamily Residential and Educational Buildings*, PB82-140047 (U.S. Department of Commerce, December 1981).

- Mount hardware solidly with firmly secured screws

- Place weatherstripping on the upper or lower window to fill in the gap when windows are closed.

Windows designed with thermal protection against heat loss will tend to rattle less as surface-to-surface contact is eliminated. All surfaces that may contact the windows or the fixed frame should be covered with a soft, elastomeric material or weatherstripping.

Sliding Window

These windows essentially have the same problems as double-hung windows except that the sliding type does not have counterweights. They also should be avoided for new construction and as replacements. Possible solutions are the same as for double-hung windows (Figure 8).

Jalousie

Figure 9 shows details of the jalousie window. These windows have numerous surfaces (edges of individual window elements) that are in contact when the unit is closed. If these surfaces do not make smooth, consistent contact, vibration of the elements will cause rattling. In addition, the opening/closing mechanism has gears and linkages that can contact each other and produce a rattle. These windows should be avoided on new construction and as replacements. To reduce rattling on existing windows, each end of the individual glass elements should be encased in a clear, soft plastic sleeve which is bonded to the glazing. The operating mechanism, however, is almost impossible to silence without major redesign. All bushings should be snug, gears should have no backlash, linkages should be encased in soft, plastic sleeves, and the mechanism should be well maintained. No STC value was estimated for this window.

Pivoting Window

When this type of window is open, any clearance in the pivot between the bushing and the shaft will be a source of rattle. When the window is closed, but not completely snug, the rotating sash frame can contact the fixed frame and produce rattling (see Figure 10). The STC range is from 29 to 47. Pivoting windows should be avoided in new construction and as replacements. To reduce rattling on existing windows, the bushing should have minimum clearance. Teflon® bushings are easy to operate and also minimize the sound excitation. Weatherstripping should be placed along the fixed frame to eliminate metal-to-metal (or wood) contact when the window is almost closed.

Skylights

Roof skylights that can be opened (Figure 11) are to be avoided for two reasons: (1) their sound transmission loss is very poor and (2) the mechanism used to open these units for ventilation is difficult to quiet because it consists of a long rod and a linkage. In addition, the window hinge and opening/closing mechanism have clearances so that the hinge pin and socket and the mechanism linkage, gears, and bushings can make contact and thus rattle. The window perimeter is large and, if not tightly secured when closed, window elements can impact the frame when the skylight is excited by an impulse.

The solution for reducing rattle of a skylight's hinges and operating mechanism is similar to that for a jalousie window. All possible contact between the glazing and the frame must be eliminated by using weatherstripping or gaskets.

Shutters

Shutters used in conjunction with windows can be a source of rattle. Some shutters are for decorative purposes only and are fixed permanently to the home's exterior. If the shutter is well made and attached properly and securely to the structure, the rattle should be minimal. But, if the shutter is operable (i.e., can be opened and closed), it is a potential source of rattle.

Specifically, the individual wooden shutter elements can vibrate in their grooves and also contact adjacent shutter elements. Hinges that have excessive clearance also can rattle. In addition, the shutter in either the open or closed position can impact against the outer wall of the window frame.

Operable shutters should not be considered for new construction or as enhancements to existing structures in the high-impulse noise areas. To reduce rattles on existing structures, some type of elastomeric cushion must be installed along the perimeter of the shutter and individual shutter elements. The hinge must be well made, and plastic inserts to reduce hinge pin clearance should be used. The opening/closing mechanism should be treated in a way similar to that for a jalousie window.

Triple-Track Storm/Screen Window

A special type of sliding window--the triple-track storm and screen--is used commonly throughout the United States. The quality of manufacture for these units varies from high to very poor.

Inherent in the design of the triple-track storm and screen windows is the ease by which each unit slides in its tracks. There are large clearances between the window and the groove or channel. The window is held in the track by a spring-loaded detent that snaps into one of several grooves in the window frame so that the individual window can be positioned at different heights.

The individual glazing or screen is installed using a bead of plastic or rubber to hold it in the aluminum window. No window putty or sealant is used. Thus, the glazing or screen can vibrate and impact the window and the window can vibrate and impact the frame.

Triple-track storm and screen windows should be avoided on structures located in blast noise areas. A complete redesign would be required to reduce or eliminate the potential rattling of these units. Glazings would have to be installed securely in the window and the window should slide in a channel that has a soft, plastic insert to eliminate metal-to-metal contact. The spring-loaded locking mechanisms would need to be redesigned so that individual parts do not rattle. It would be difficult to retrofit homes with triple-track screen and storm windows to prevent rattling.

4 DOORS

The doors analyzed in this study were categorized by the way in which they operate: swinging, bypass sliding, surface sliding, pocket sliding, and side-hinge folding. Figure 12 briefly describes each operating category. Garage doors and cellar doors are included in this discussion (Figure 13 and 14). There are 10 physical types of doors: flush, paneled, French, glass, sash, jalousie, louvered, shutters, screen, and Dutch. Figure 15 briefly describes each type.

Exterior doors can be excited directly by a blast wave whereas interior doors are excited by wall, ceiling, and floor vibrations. The discussion of rattle sources and solutions is divided into the seven door types by operating mode followed by the 10 physical types.

Doors Grouped by Function

Swinging Door

Figure 16 shows this type of door. Rattle sources are: (1) perimeter contact points between the door and the jamb and sill, (2) the clearance at hinge pins, and (3) hardware, including automatic door-closing mechanisms. The STC value is rated at 20 to 51. These doors are acceptable when the following measures are taken during installation or retrofitting:

- Weather-proof the jamb and sill to eliminate contact during vibration
- Jacket the hinge pins in soft plastic
- Improve hardware as discussed in detail below under **Hardware.**

Bypass Sliding Door

Rattling can occur in these doors at perimeter contact points between the two doors and between the individual doors and channels in which they slide (Figure 17). Doors that hang from ceiling channels have free play that allows the two door sections to make contact easily. These doors are acceptable for use in areas of high-level impulse noise. However, the following steps should be taken in installation or retrofitting:

- Install a weather-proof material at all possible points of contact
- Use plastic channels, preferably with a Teflon® liner to reduce friction and counteract the snug fit between the door (or rollers) and channel required to eliminate the rattling
- Do not hang doors from rollers or wheels in ceiling tracks.

Surface Sliding Door

This type of door has a major source of rattle in that any part of the unit can make contact with the wall. In addition, floor and ceiling vibration can produce rattling because these doors slide directly on a floor track or inside an overhead track directly or from a roller mechanism (Figure 12).

Surface sliding doors should be avoided. If they are used, some material must be installed on the back of the door to keep the door away from the wall, yet allow relative motion between the two. Felt, weatherstripping, rubber, or similar materials should be used to minimize this contact. Roller or wheel mechanisms that connect the door to the ceiling to allow it to hang and slide should not be used. Floor tracks should be very snug and, if possible, lined with a Teflon® insert.

Pocket Sliding Door

These doors are essentially the same as surface sliding doors except that the pocket sliding type can also contact both walls (Figure 18). These doors are not recommended for areas of blast noise. If they are used, the same preventive measures described for surface sliding doors apply.

Side-Hinged Folding Door

Figure 19 shows this type of door. Rattling can occur if the hinges connecting the doors to each other and to the wall are constructed poorly and if there is excessive clearance between hinges and pins. In addition, when closed, the door can contact the jamb and/or the edge of the mating door; when it is open, the two door sections are folded against each other and can make contact at any point on the surfaces. These doors must be supported by an overhead channel where, as with sliding doors, the support element and channel can come into contact upon vibration. Side-hinged folding doors can be used when the following measures are used:

- Keep doors separate from the jamb and from each other using buttons of elastomeric material such as weatherstripping
- Make sur[illegible] hinges are installed with minimal clearance
- Install plastic sle[illegible]es around the hinge pins
- Avoid loose overhead support that allows the doors to have excessive swinging motion; use snug channels in the floor to support the door and reduce rattle due to the overhead structures.

Single-Section Garage Door

When closed, this door con[illegible] the building jamb and coul[illegible] rattle along that point. This type of garage door [illegible] from a curved overhead rail (Figure 13). The weight of the door is counter[illegible] by two [illegible]ge springs that are stretched when the door is closed and compressed when it [illegible] open. These springs are retained in a loose swivel joint so that they can rotate rel[illegible] door and to the support structure. In addition, if an electric garage doo[illegible] this appliance is a further source of rattle.

Single-section garage doors are acceptable when the following steps are taken to reduce the potential for rattling:

- Install weatherstripping to eliminate the contact between the door and jamb
- Make sure the overhead track and track roller are installed with minimal clearance
- Install a plastic insert in the track or use plastic wheels and r[illegible]llers

- Encase the springs in plastic sleeves and insure that the swivel joint bushings have minimum clearance; if not, install a plastic insert

- Use electric garage doors designed with minimal linkage clearance and make sure all bushings are snug. Loose linkages can be jacketed with plastic and plastic bushing inserts can be used.

Multiple-Section Garage Door

These doors have most of the same rattle sources as the single-section door. An added source is the hinge elements between sections. These doors should be avoided for construction in areas of impulse noise. If they are used, all of the same rattle-proofing measures described above should be done. In addition, hinge pins should be jacketed in plastic and clearance should be minimized.

Cellar Door

Cellar doors can be considered essentially in the same way as swinging doors. The solutions to reduce rattle also are the same. Figure 14 shows a typical cellar door.

Doors Grouped by Physical Type

In general, doors with inserts can rattle when the inserts are installed loosely, as is often true with decorative panels. All panels, glass, jalousie, shutter, and louver elements should be installed firmly and permanently. If they are not, a rubber or plastic coating can be placed on the edge that contacts the door to help reduce rattles. One manufacturer's approach to thermal sealing is an example of a design that would also reduce rattling (Figure 20).

Flush Door

Figure 16 shows details of this type of door. If the flush door is solid, there are no sources of rattle. With a hollow-core door, outer panels can vibrate against the inner frame if the panels are not bonded firmly to the frame. These doors are acceptable for use on structures located in blast noise zones. The STC rating is estimated at 20 to 51. To reduce rattles in the hollow-core type, make sure the outer panels are bonded firmly to the frame.

Panel Door

This type of door is basically the same as the flush door (Figure 15) except that an additional rattle source can occur if panel inserts are not installed properly and can contact the frame. Loose panels can be excited to rattle at their resonance frequencies. These doors are acceptable when the same rattle-reducing step is followed as described for the flush door; in addition, if the panels are loose, install a plastic or rubber coating to weight the panel and use damping techniques where the panel's inner surface edge makes contact with the door.

French Door

This type of door has all of the same rattle sources described for the panel door. In addition, the vertical surface of one door contacts the other door's jamb, providing another source of rattle. The hardware connecting the two door sections also can rattle upon excitation. The French door is not recommended for housing located in blast noise areas. If it is used, all steps prescribed for the panel door must be followed and weather-stripping should be installed on one section's jamb. Moreover, the hardware should be rattle-proofed as discussed under **Hardware** below.

Glass Door

This door can be considered to be the same as a panel-type door. It is acceptable and the same measures can be taken to reduce rattling.

Sash Door

This door also can be considered to be the same as a panel door. It, too, is judged to be acceptable and the same rattle-reducing methods apply.

Jalousie Door

These doors rattle due to the same sources described for panel doors. However, additional rattle sources make this design unacceptable for use in areas of blast noise. The jalousie elements can contact each other if the clearance between them is too small; also, if the jalousie is operated by an opening/closing mechanism, another rattle source is produced, similar to that of a jalousie window. If this door is used, the rattle prevention techniques for the panel door plus all those described for the jalousie window must be applied.

Louvered Door

This door is not recommended. It has all the same rattle sources as the panel door, requiring the same retrofitting measures in addition to those for the louvered window. However, louvers that have large spaces between the elements (i.e., the type used for ventilation) are satisfactory.

Shutter-Type Door

This door can be considered to have all the same properties and requirements as the louvered door. It is judged to be unacceptable for new construction or as a replacement; existing doors of this type can be rattle-proofed following the steps described for the louvered door.

Screen Door

Screen doors usually are lightweight units placed outside main entry doors. Screen wire can emit sound upon vibration. Also, the door hardware and the safety chain are rattle sources. These doors are not recommended. If they are used, the screen material should be made of plastic instead of aluminum. Hardware should be treated as described in **Hardware** below. The safety chain should be encased in plastic to eliminate contact with the door and between chain links.

Dutch Door

Rattle sources for this type of door are the same as those for the flush door, with two additions. The horizontal surface on one door section can contact the other section's jamb. The hardware connecting the upper door section to the lower section is the other source. Dutch doors are unacceptable for use in high-level impulse noise zones. If they are used, the same antirattle methods described for French doors apply, except that the surfaces are horizontal instead of vertical.

Hardware

Door hardware consists of locksets, closers, hinges, mail slots, bolts, holders, and floor stops (Figure 21 through 23). These units can rattle under impulse loading. Hardware should be well made, which unfortunately increases its cost. Clearances should be minimized. Linkages should be coated with a soft plastic and rotating members should have minimum pin and bushing clearances. Hinge pins should be coated with a plastic material.

Little can be done to silence lockset tongues that must fit into the jamb. When they are too tight, it is difficult to secure the door; when they are too loose, the tongue-and-groove clearance allows contact upon vibration. A soft plastic insert in the groove will help reduce rattles.

Improperly seated locksets will allow the door to loosely contact the jamb, which is another source of rattle. The best arrangement is to use a level handle that, when closed, applies a compressive load on the door's weatherstripping to insure good contact. Level handles are unsightly, however, and probably will not be used by the home owner.

Hinge pins and potentially contacting hinge surfaces should be coated with a soft plastic material to eliminate the contact but allow relative motion between elements.

5 CEILINGS AND MISCELLANEOUS ITEMS

Dropped Ceilings

Standard home ceilings constructed of plasterboard nailed to horizontal joists should not rattle. Some owners, however, may install dropped acoustical tile ceilings. The frame for the individual acoustical tiles and the wire connection from the ceiling joist to the frame may be sources of rattle. In addition, individual ceiling tiles, when placed loosely in channels of the frame, can vibrate and excite the frame. Also, a frame improperly welded or secured (bolted) at the joints can vibrate and emit sound. Figure 24 shows typical dropped ceiling construction.

Dropped ceilings should be avoided. To reduce rattle in existing dropped ceilings, the direct contact between the vertical wire and the joist and frame must be eliminated by placing elastomeric material at each end of the wire. Ceiling tile vibration can be reduced if the tile-to-frame fit is "forced."

Lighting fixtures on a dropped ceiling also can rattle. A metal lighting enclosure will rattle if the joints between sections are not well connected, that is, if the spot welds are far apart and the metal between them can make contact. Also, loose electrical connectors and junction boxes can vibrate against each other. Finally, a fluorescent lamp could be loosened by the impulse and vibrate in its socket.

A well built, properly installed lighting fixture should not be a source of rattle. Continuous welds or more numerous spot welds are required. Electricians must tighten all connections properly.

Other types of lighting fixtures hung from standard plasterboard ceilings are discussed under **Light Fixtures** below.

Picture Frames and Mirrors

Picture frames and mirrors hung from a single nail or other object by a loosely strung wire were addressed in the Wyle studies.[9] These items impact the wall when the wall's horizontal vibration produces enough acceleration for the frame or mirror to move from its position of rest against the wall. To eliminate this noise, a soft, open-pore plastic foam or rubber material should be glued to the wall side of the picture frame or mirror. Small pieces of weatherstripping with contact cement on one side can be used. The soft plastic foam or rubber material will not prevent the frame from moving from the wall but it will reduce or eliminate the sound emitted by the impact.

Bric-a-Brac, Dishes, and Items Placed on Shelves and Tables

One solution to the elimination of noise from bric-a-brac, dishes and cups, and other items placed on horizontal surfaces that contact the walls and floor is to isolate the shelf, bookcase, or closet from vibration. For example, rubber coasters could be placed under the legs of a table or cabinet. However, isolating a complete shelf or bookcase system is not feasible for home owners--particularly in homes where these units

---

[9] L. C. Sutherland; L. C. Sutherland, B. H. Sharp, and R. A. Mantey.

have already been installed. A possible way to reduce rattling of these items is to glue felt or soft, open-cell plastic foam pads on the underside of the bric-a-brac. Items stored one on top of the other can be isolated from each other using a doily made of felt or soft, open-cell plastic foam.

Light Fixtures

Light fixtures that hang from the ceiling by a chain or flimsy structure (e.g., the type used with chandeliers) will vibrate and rattle when the ceiling vibrates due to impulse noise. Therefore, this type of light fixture should be avoided. Light fixtures should be secured firmly to the ceiling or wall. Lights with intricate metalwork or loose items also should be avoided. Little can be done to eliminate rattle from these light fixtures.

Curtain Rods, Shades, and Venetian Blinds

All types of curtain rods are inherently noisy upon vibration. The loose fittings that allow the curtains or drapes to be moved will vibrate in the curtain rod channel or along the tubular rods (such as shower curtain rods). To reduce rattle, the curtain rod channels should be lined with a plastic insert; a Teflon® insert will allow the elements to move in the channel if the fit is snug. Or, plastic tubular curtain rods and plastic or rubber rings for holding the curtain could be used.

Roller shades are preferred over blinds since the shades will not rattle. Venetian blind components will vibrate at their resonance frequency and, if close enough to an adjacent blind, will make contact. To reduce venetian blind rattle, open-pore plastic foam or rubber buttons can be placed at contact points. However, the inhabitants may find this addition unattractive, making the solution to venetian blind rattle difficult. Venetian blinds and similar blinds made of metal or hard plastic should be avoided.

Wall and Window Air-Conditioners

These units contain tubing and other elements, including the air-conditioner case, which will rattle when excited. The unit must be removed from its housing and, at every location where metal-to-metal contact is possible, open-cell plastic foam, similar to weatherstripping, should be placed. Some tubing could be wrapped in plastic; however, care must be taken not to interfere with the air flow. The fan clearance should be checked to insure that it does not contact the condenser.

Louvers in the air-conditioner housing should be separated. If there is a possibility that the louvers will make contact when closed, small foam buttons should be cemented to them.

Central Heating/Air-Conditioning Ducts

Central heating and air-conditioning ducts usually are constructed of light-gauge sheet metal in a circular or rectangular cross section. Most home ducts are rigid, although some parts of the ducting may be flexible (Figure 25). Locations where registers are attached to ceilings, floors, or walls are loading points which can excite the ducts to vibrate at their resonance frequency or excite components such as grilles, dampers, and joints to rattle.

Loosely assembled ducting should be avoided. All joints should be sealed with duct putty and covered with duct tape. Dampers should be covered with felt or covered with foam strip (similar to weatherstrip) at the contact points. Long runs and large rectangular ducts should be stiffened with an angle iron or other elements to minimize the drumming effect. If possible, register boots should be vibration-isolated from their contact points. At locations where ducts pass through walls, ceilings, or floors, the opening should be large enough to provide ample clearance and the cover plate, if used, should have its underside lined with foam plastic.

Gutters and Downspouts

These units will rattle when the individual components are connected loosely. Individual sections should be inserted tightly into their mates. Each section can be secured with a sheet-metal screw and the area, including the screw, should be wrapped with duct tape. It is preferable to use plastic, rather than metal, downspouts and gutters to reduce rattle noise. Downspouts and gutters should be attached firmly to the building to avoid loose contact with the walls and roof.

6 CONCLUSIONS AND RECOMMENDATIONS

Several housing components have been studied to find ways of reducing their tendency to rattle upon excitation by high-level impulse noise. This analysis has revealed some general conditions that contribute to an object's potential for rattling:

1. Small gaps between two hard surfaces allow the surfaces to impact upon vibration, which causes a rattle. Examples include the spaces between a door and jamb, a window and its track, and a shutter and the house exterior. Gaps also occur when hinges have too much clearance and hinge pins do not fit snugly. Certain types of components contain these gaps due to design; for example, French doors are designed such that several points of rattle are possible. Any part of a fixture which is not fastened securely will become a rattle source because of the space left between surfaces.

2. Hard objects attached directly to a wall or those placed on shelving which is fixed to a wall will rattle when the wall vibrates. In addition, cabinets and tables used to hold objects such as bric-a-brac will vibrate when the floor is excited by impulse noise, allowing the objects to rattle.

3. All objects hung from a ceiling by chains, wires, or rods are potential sources of rattle when the ceiling vibrates.

Based on these findings, methods for rattle-proofing these components are recommended. Appendix B contains a detailed list of "do's and don't's" for reducing rattles in a home. To summarize:

1. Eliminate small gaps wherever possible by using material such as weather-stripping and plastic encasements. Secure all loose parts or, again, use some kind of padding between the spaces. Small felt "buttons" can be used in many cases to quiet objects inconspicuously. Use plastic inserts in window and sliding door tracks to make the fit as close as possible while still allowing movement; Teflon® inserts work well because this material has a low friction value.

2. Picture frames, mirrors, and similar objects attached to the wall should have felt or foam weatherstripping cemented to the backside. Although this technique will not eliminate the vibration, rattling will not occur. Objects placed on shelves and tables or inside cabinets should have felt doilies or pads placed between contact surfaces, including those between stacked items.

3. Light fixtures, room dividers, and other ornamental objects should be attached firmly to the ceiling. However, to rattle-proof hanging fixtures which are already in place, small foam or felt buttons can be used to separate the links in a chain; or, chains, wires, and rods can be encased in a soft, clear plastic sleeve to prevent some of the rattling.

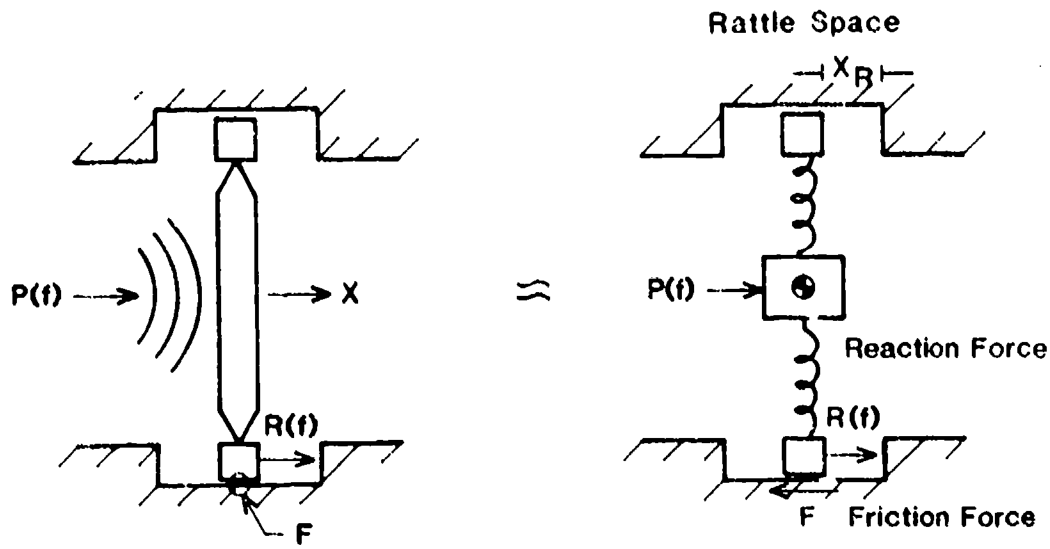


Figure 1. Conceptual dynamic model for a rattling window driven by an acoustic pressure P(f). (Source: L. C. Sutherland, *Low Frequency Response of Structures*, Wyle Research Report WR82-18 [Wyle Laboratories, May 1982]. Used with permission.)

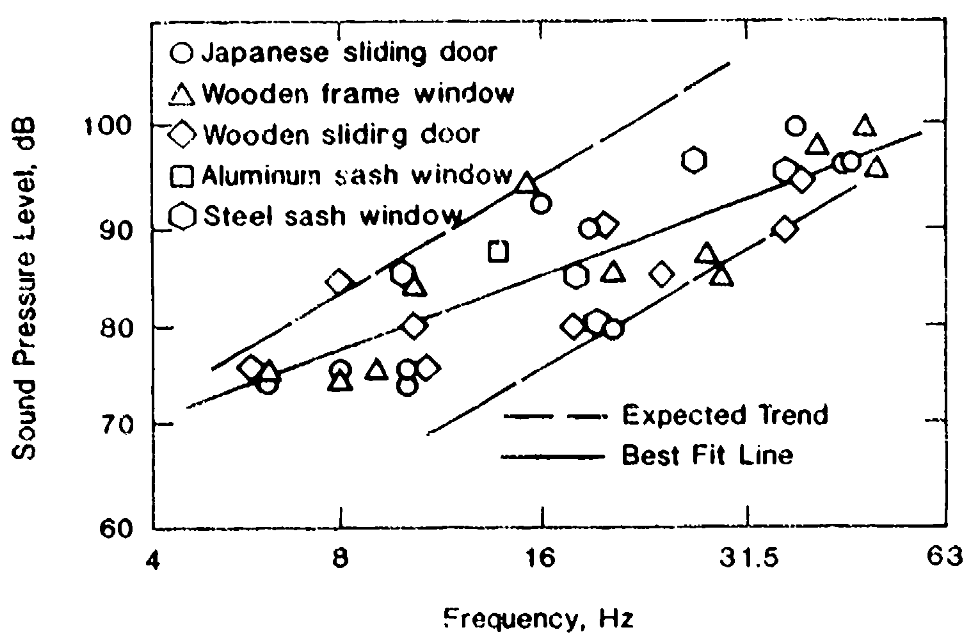


Figure 2. Experimental data on rattle threshold for windows and doors. (Source: Y. Tokita and S. Nakamura, "Frequency Weighting Characteristics for Evaluation of Low Frequency Sound," *Proceedings, 1981 International Conference on Noise Control Engineering* [Netherlands Acoustical Society, 1981]. Used with permission.)

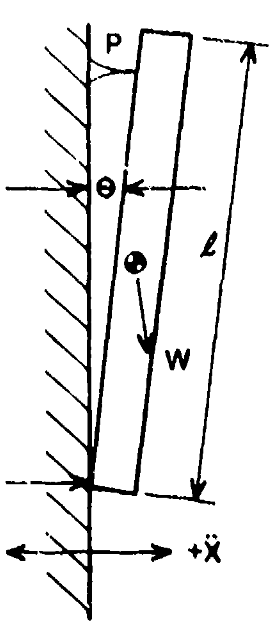


Figure 3. Mirror or picture hanging by suspension at P against vibrating wall. (Source: L. C. Sutherland, *Low Frequency Response of Structures,* Wyle Research Report WR82-18 [Wyle. Laboratories, May 1982]. Used with permission.)

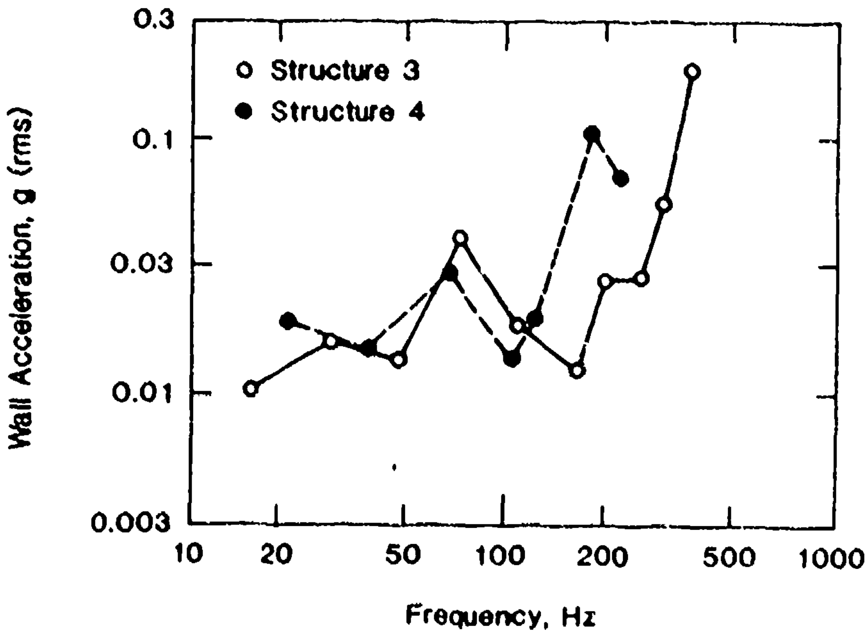


Figure 4. Wall accelerations at the rattle threshold for wall-hung plaques. (Source: H. D. Carden and W. H. Mayes, *Measured Vibration Response Characteristics of Four Residential Structures Excited by Mechanical and Acoustical Loadings,* NASA TN D-5778 [National Aeronautics and Space Administration, April 1970].)

Table 1

Specific Components Subject to Excitation by Large-Impulse Noise

---

Window and window systems

- Double-hung windows with springs or counterweights
- Window systems with loosely attached hardware
- Decorative inserts
- Internal shades or blinds
- Window elements sliding in oversized grooves
- Double- or triple-track storm and screen windows
- Worn weatherstripping, seals, and sealing materials

Door and door systems

- Sliding doors and screens
- Garage doors
- Windows in doors
- Door chains
- Doorknobs and locks
- Storm and screen doors
- Worn weatherstripping, seals, and sealing materials

Ceilings

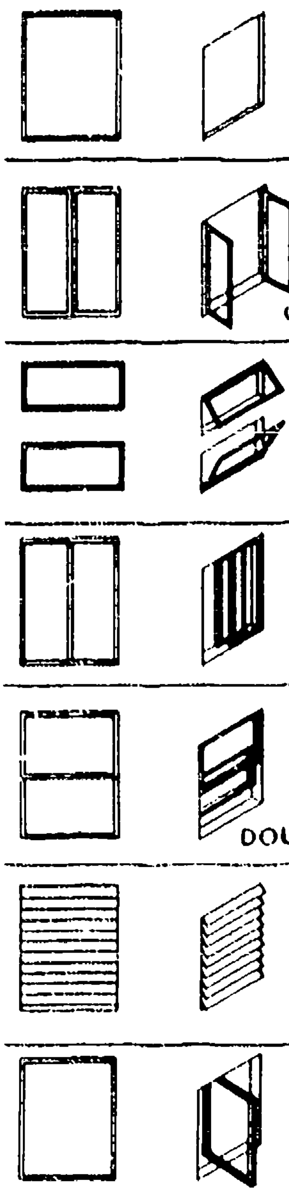
- Dropped ceiling with loose tiles
- Encased ceiling-light fixtures
- Tin or light material facade installed on ceiling

Outdoor items

- Shutters--both operating and decorative
- Patio and carport roofs
- Antennas
- Mail boxes and mail slots
- Gutters and downspouts

Indoor items

- Shades and rods
- Curtain and drapery rods
- Light fixtures and chandeliers
- Picture frames and singly supported mirrors
- Bric-a-brac
- China
- Curios
- Vertical and horizontal venetian blinds
- Movable room dividers (folding)
- Room and wall panels
- Loose items on counters and shelves (e.g., toaster, mixer)
- Poorly constructed furniture
- Material stored in closets (e.g., brooms and mops, tools, cans)
- Ventilation ducts and dampers
- Plenums and diffusers
- Cabinet doors
- Workshop tools and loose items on shelves and benches
- Closet and room doors (bifold, metal, and wood types)



	ventilation	
FIXED	0%	· consists of a frame and glazed stationary sash · when used in conjunction with operable window units, thickness of fixed sash should approximate cross-sectional dimensions of the adjacent operating sash
CASEMENT	100%	· operationg sash side-hinged, usually swinging outward pair of operating sash may close on themselves or on a vertical mullion · able to direct incoming ventilation
AWNING	100%	· similar to casement windows but hinged at top (awning type) or bottom (hopper type) · may be stacked vertically with sash closing on themselves or on meeting rails · able to direct incoming ventilation
HOPPER	100%	
SLIDING	50-66%	· may consist of 2 sash of which one slides horizontally (50% ventilation) or 3 sash of which the middle is fixed while the other 2 slide (66% ventilation)
DOUBLE-HUNG	50%	· sash move vertically, held in desired position by friction fit against the window frame or by various balancing devices · single-hung windows are similar with one sash fixed
JALOUSIE	100%	· similar to awning type windows · may be opaque or transparent · used generally in warm climates where ventilation is desired along with a flush appearance · able to direct ventilation
PIVOTING	100%	· similar to casement window but a top and bottom pivot is used instead of hinges · screening not possible

Figure 5. Window types by operation. (Source: F. D. K. Ching, *Building Construction Illustrated* [Van Nostrand Reinhold, New York, 1975]. Used with permission.)

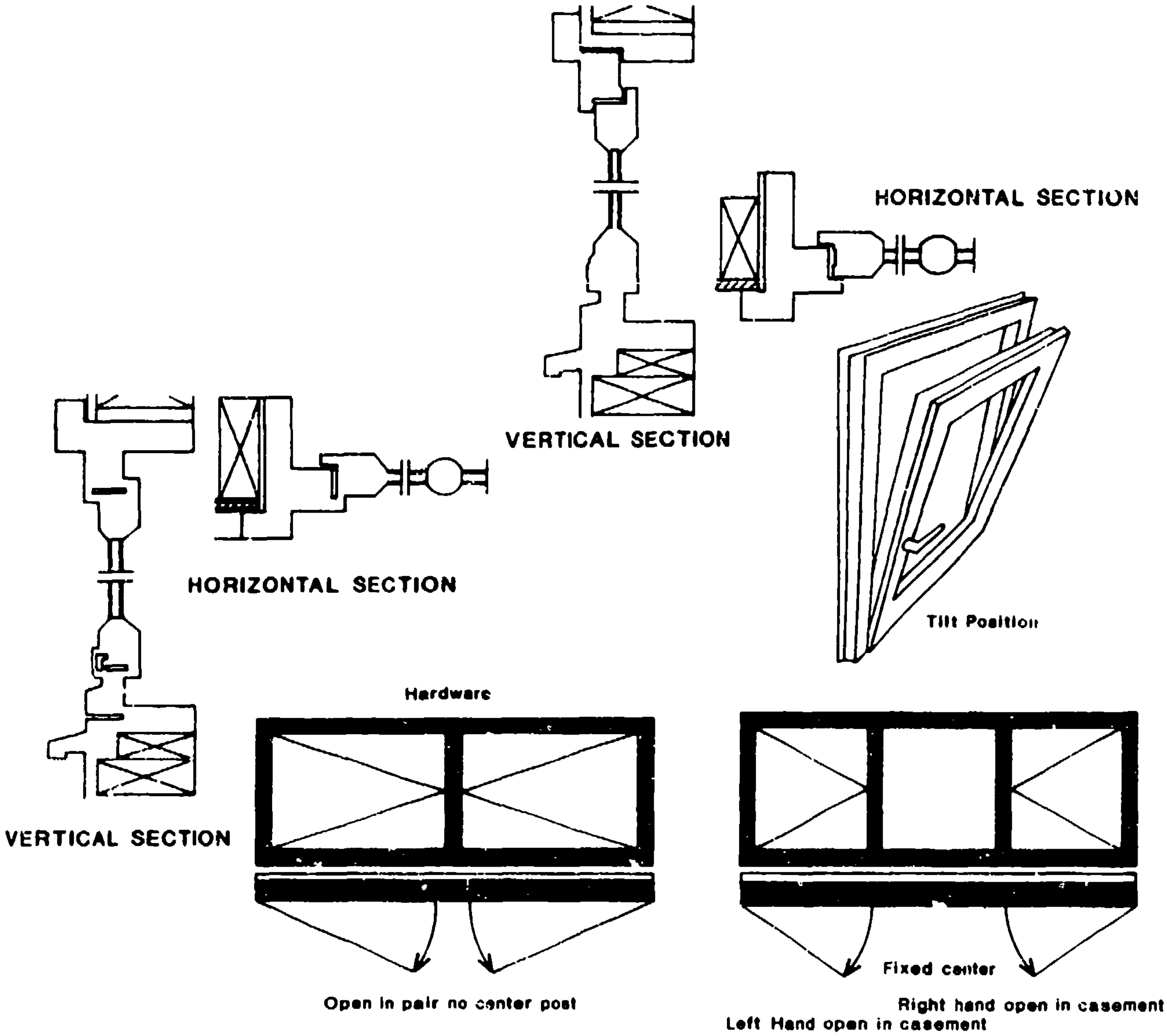


Figure 6. Casement window details.

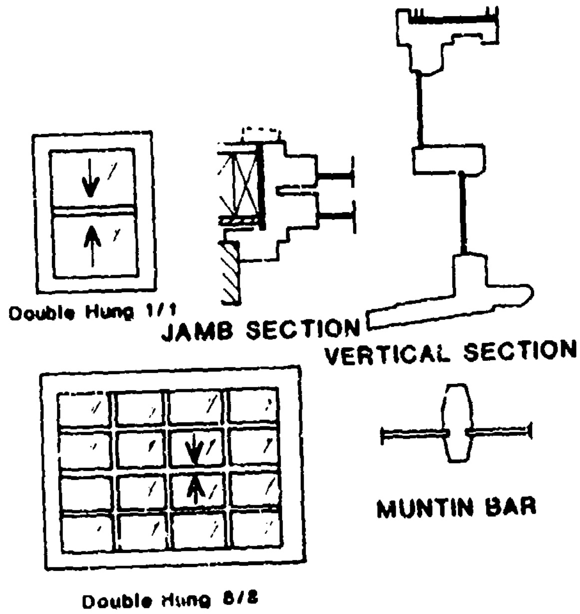


Figure 7. Double-hung, single-glazed window details.

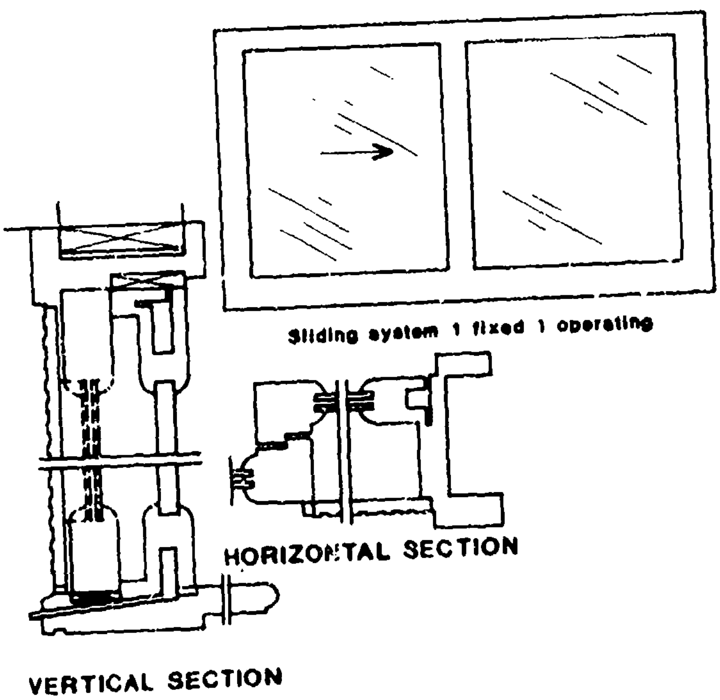
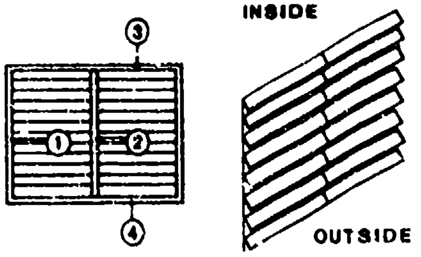


Figure 8. Sliding window details.



JALOUSIE

A JALOUSIE WINDOW (ALUMINUM) cons[illegible] of a series of operable overlapping glass louvers which pivot in unison. It may be combined in the same frame with a series of operable opaque louvers for climate control. It is used mostly in residential type constructions in southern climates, where maximum ventilation and flush exterior and interior appearance is desired.

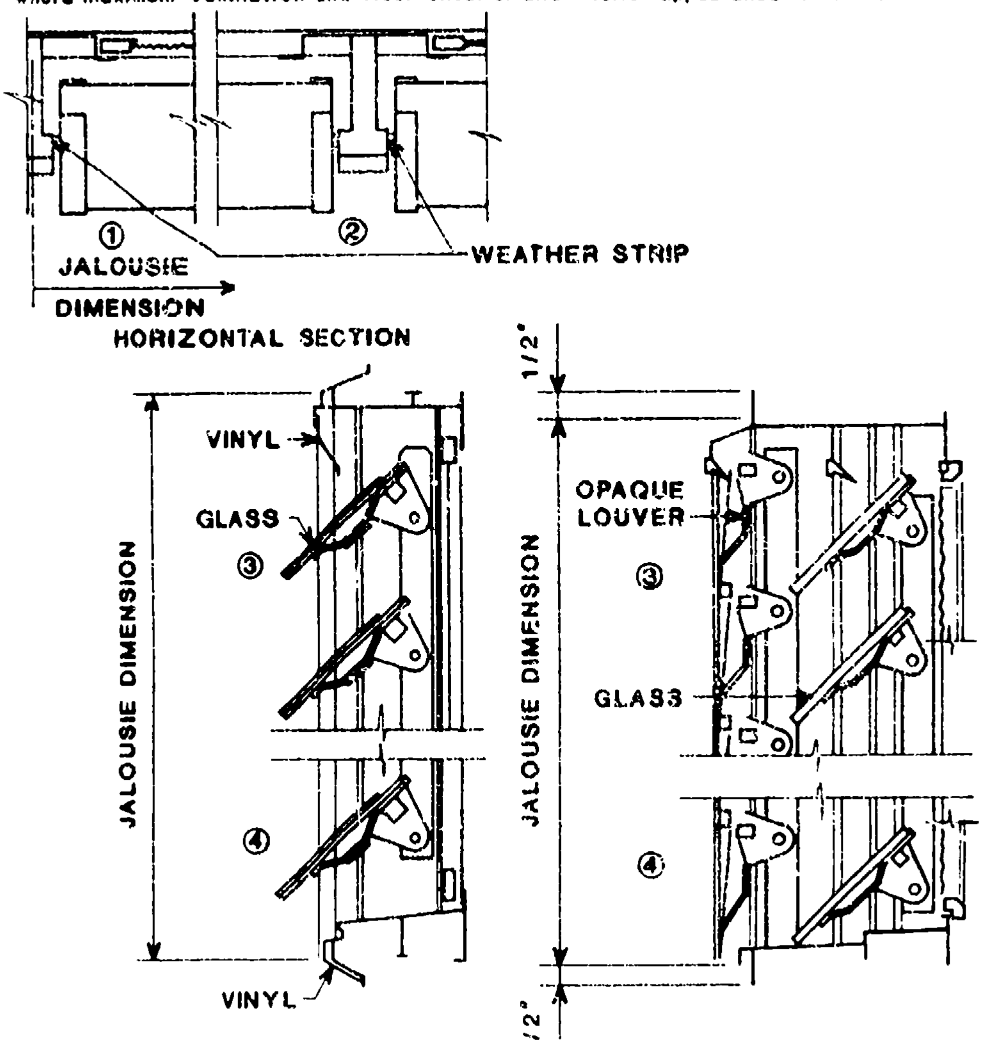


Figure 9. Jalousie window details.

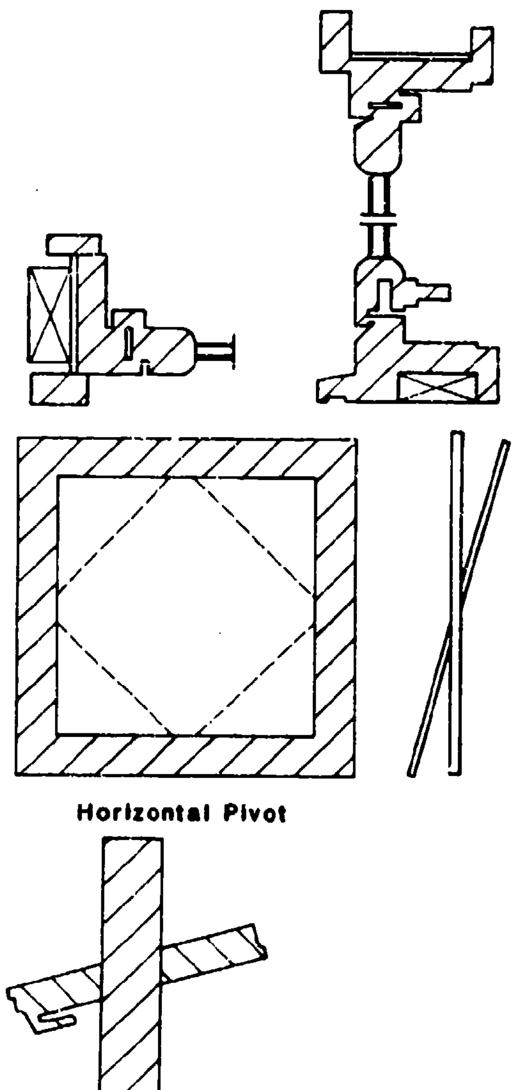
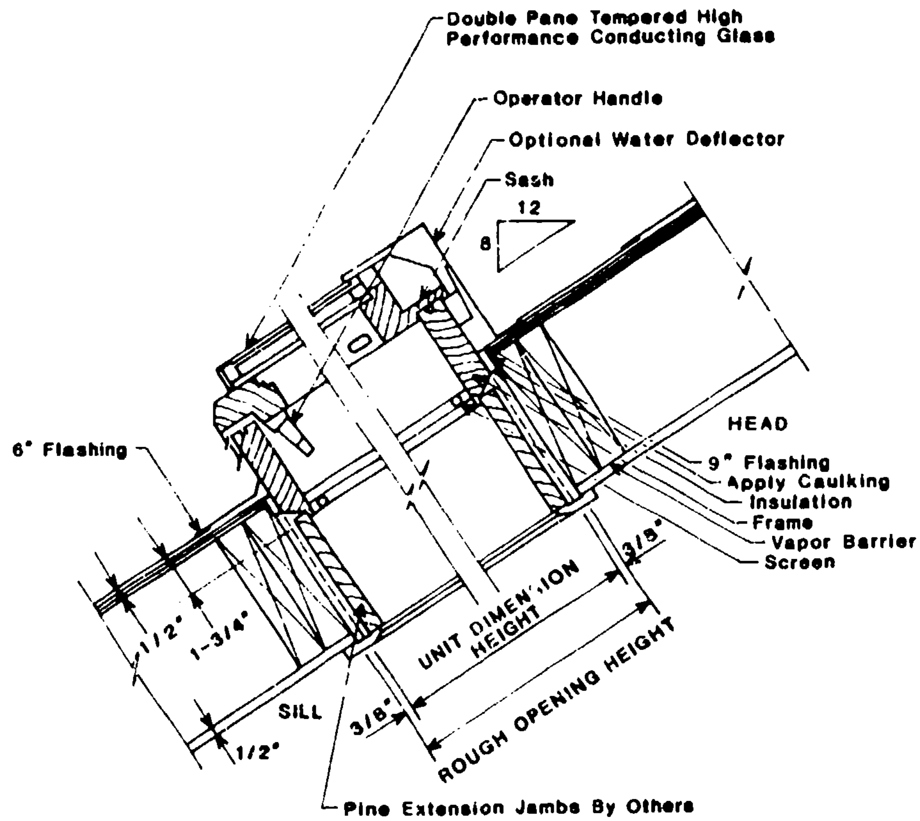
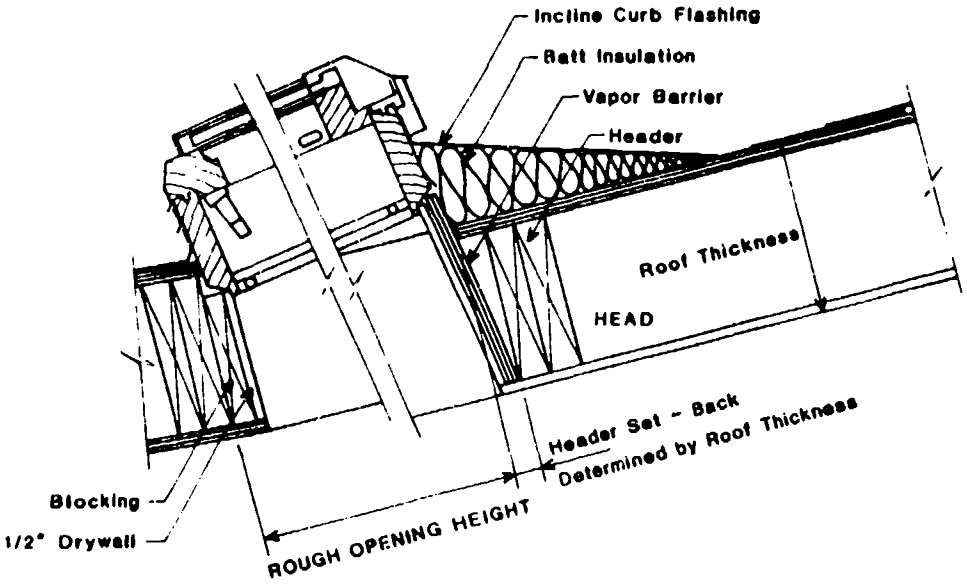


Figure 10. Pivoting window details.



SECTION A-A



VERTICAL DETAIL

Figure 11. Opening skylight ("roof window").

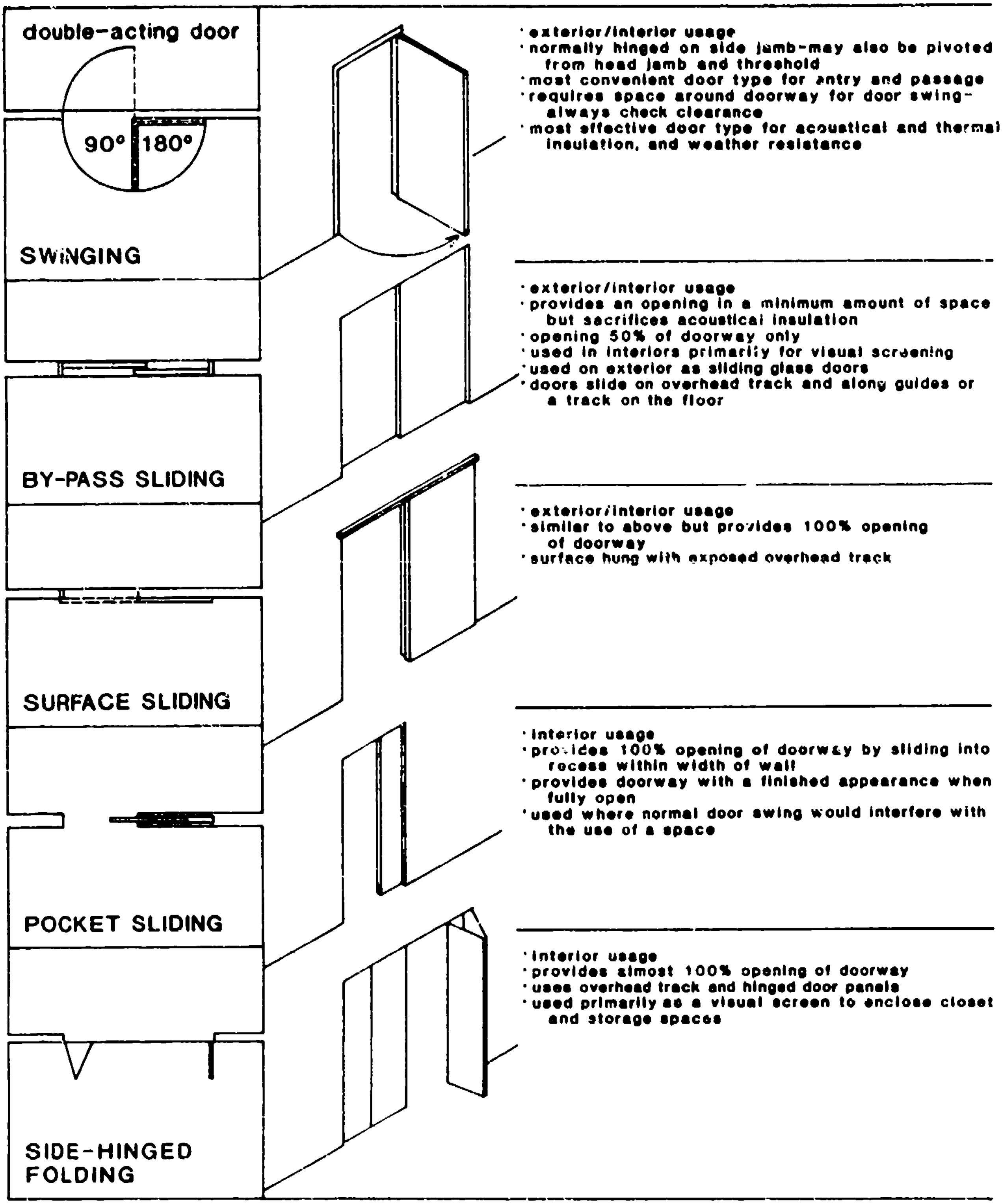


Figure 12. Door types by operation. (Source: F. D. K. Ching, *Building Construction Illustrated* [Van Nostrand Reinhold, New York, 1975]. Used with permission.)

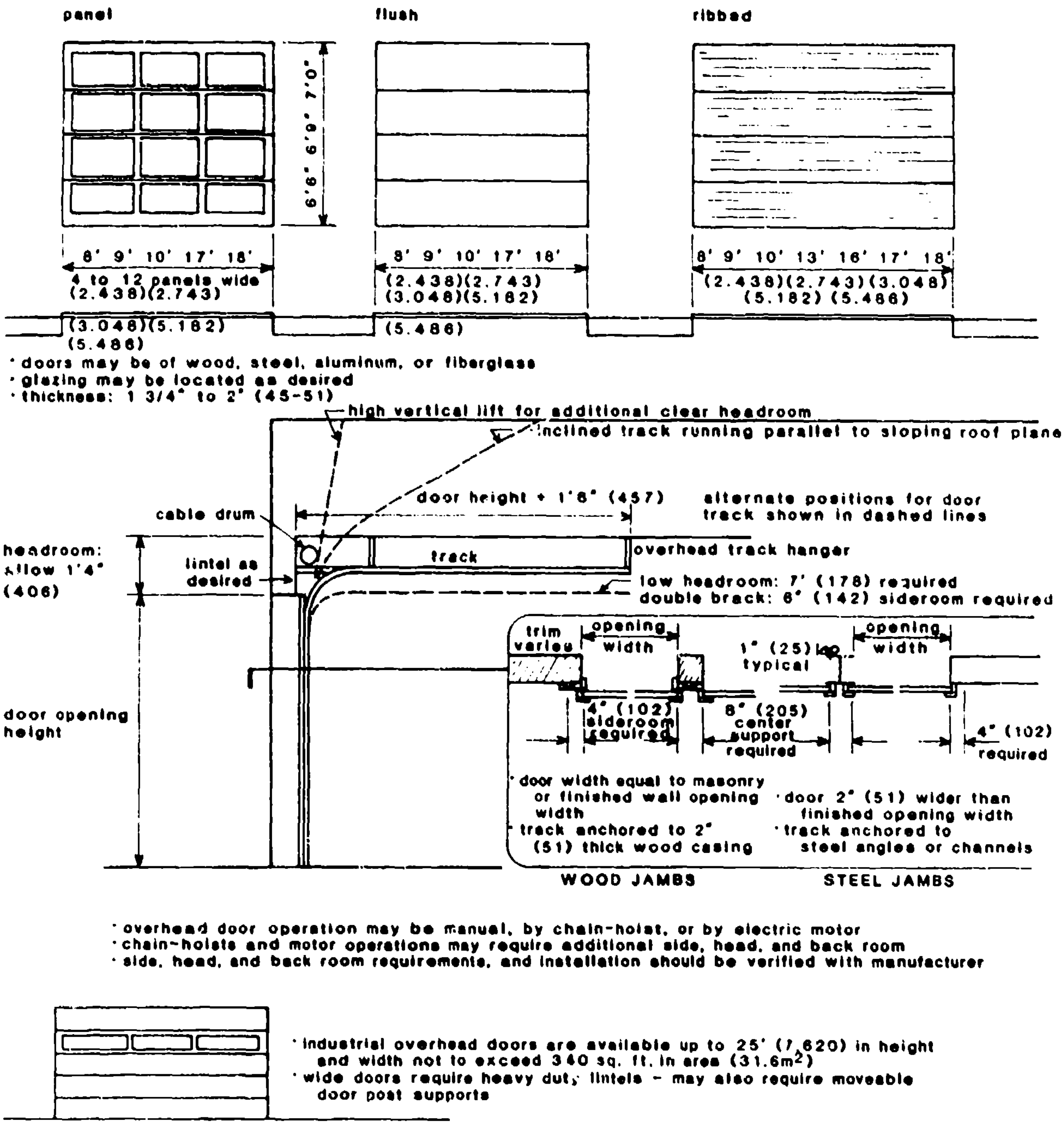


Figure 13. Garage and overhead doors. (Source: F. D. K. Ching, *Building Construction Illustrated* [Van Nostrand Reinhold, New York, 1975]. Used with permission.)

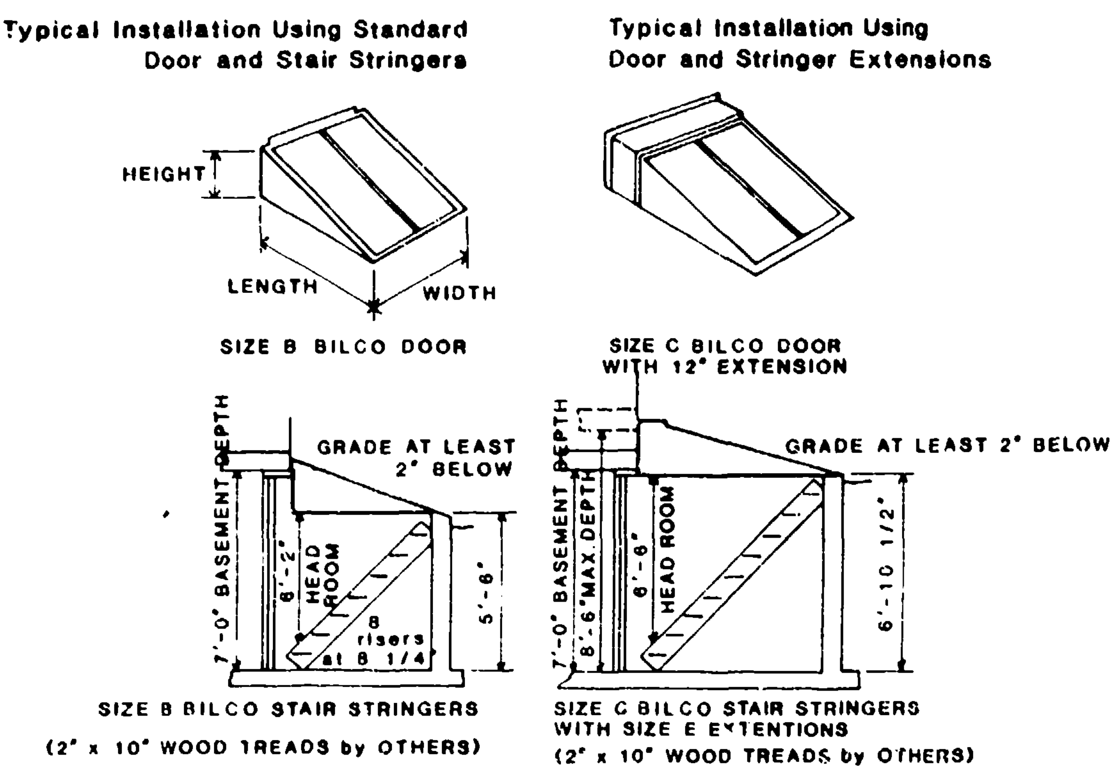


Figure 14. Typical cellar door.

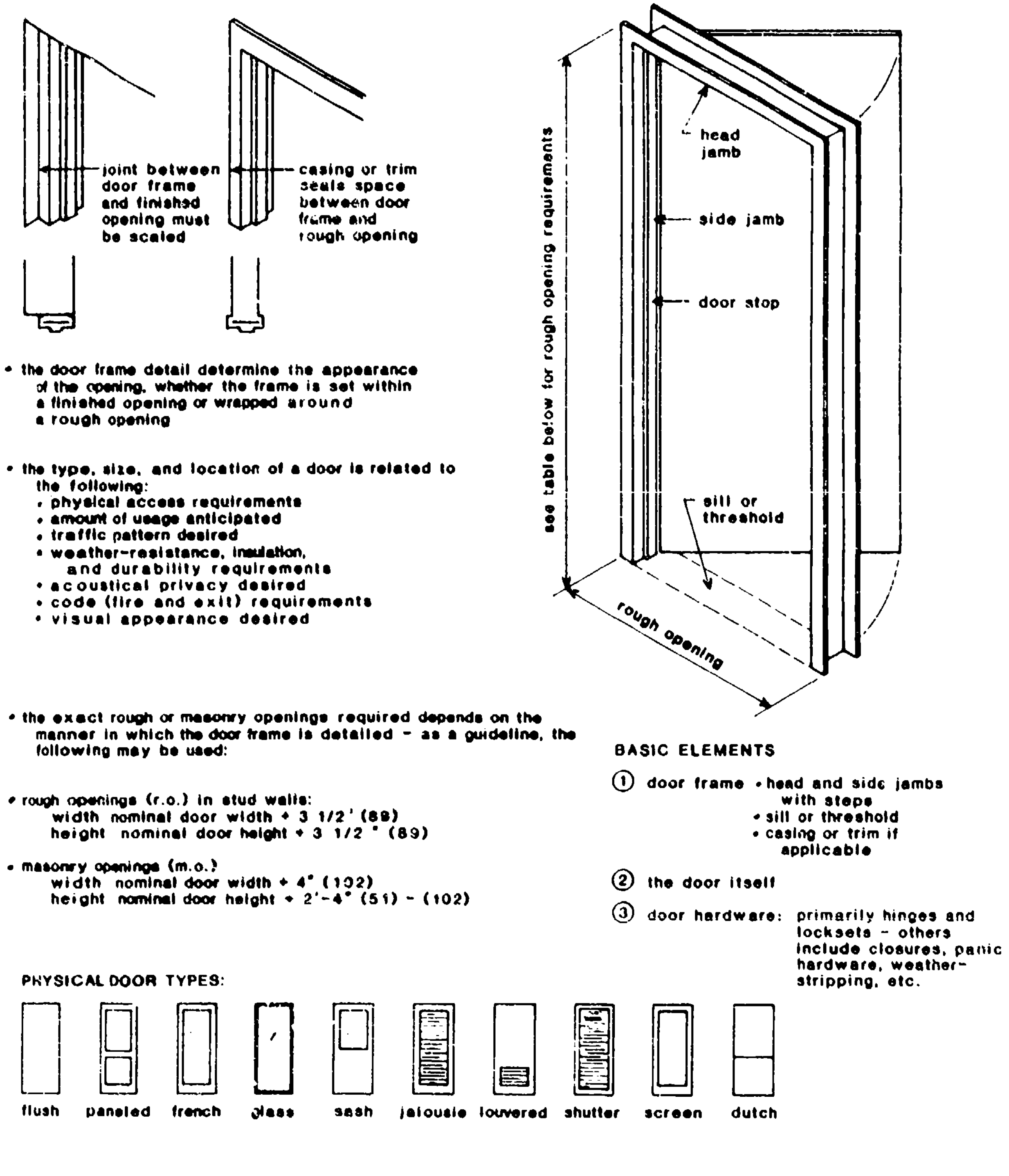


Figure 15. **Door types by physical design.** (Source: F. D. K. Ching, *Building Construction Illustrated* [Van Nostrand Reinhold, New York, 1975]. Used with permission.)

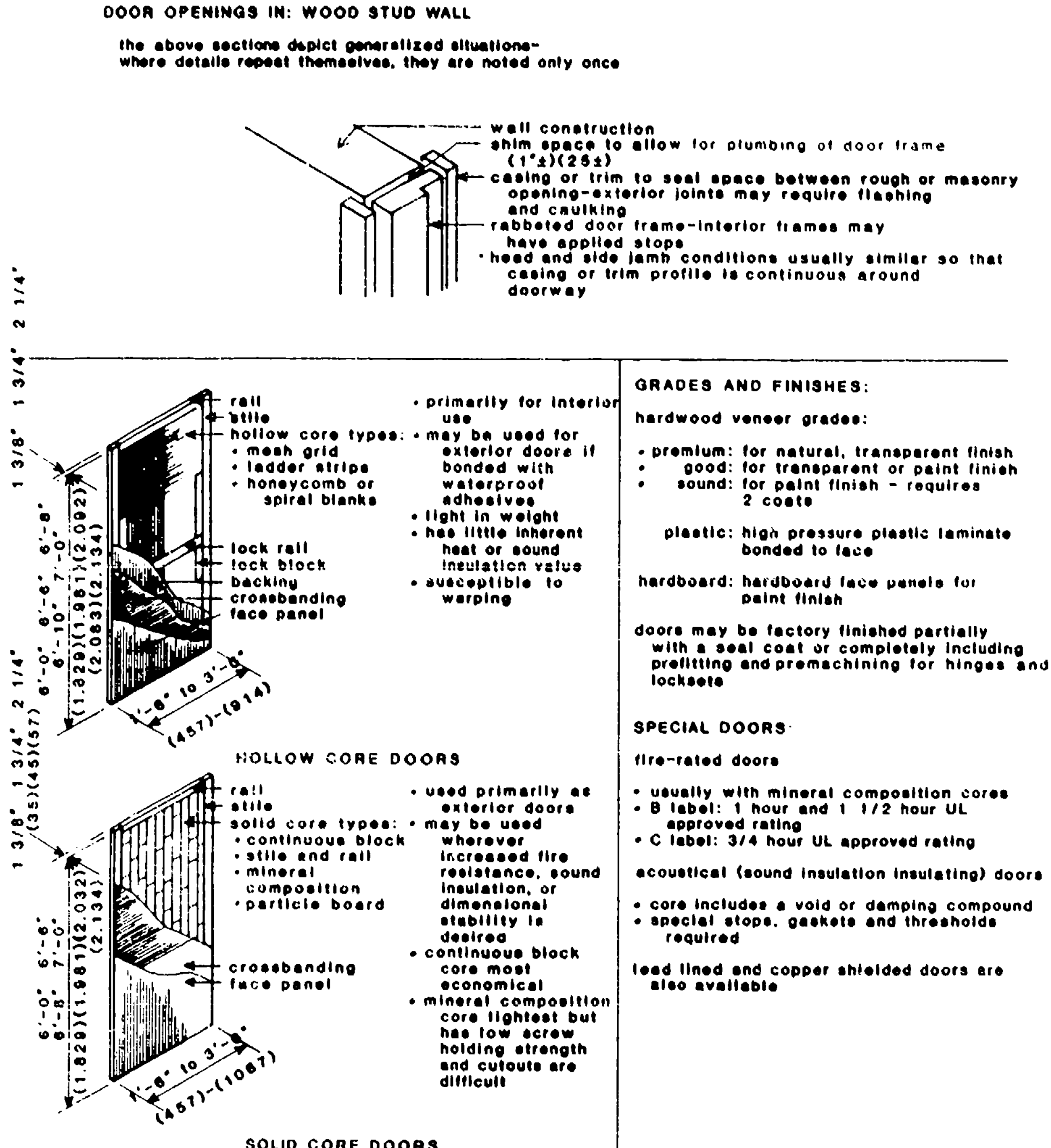


Figure 16. Wooden flush door details. (Source: F. D. K. Ching, *Building Construction Illustrated* [Van Nostrand Reinhold, New York, 1975]. Used with permission.)

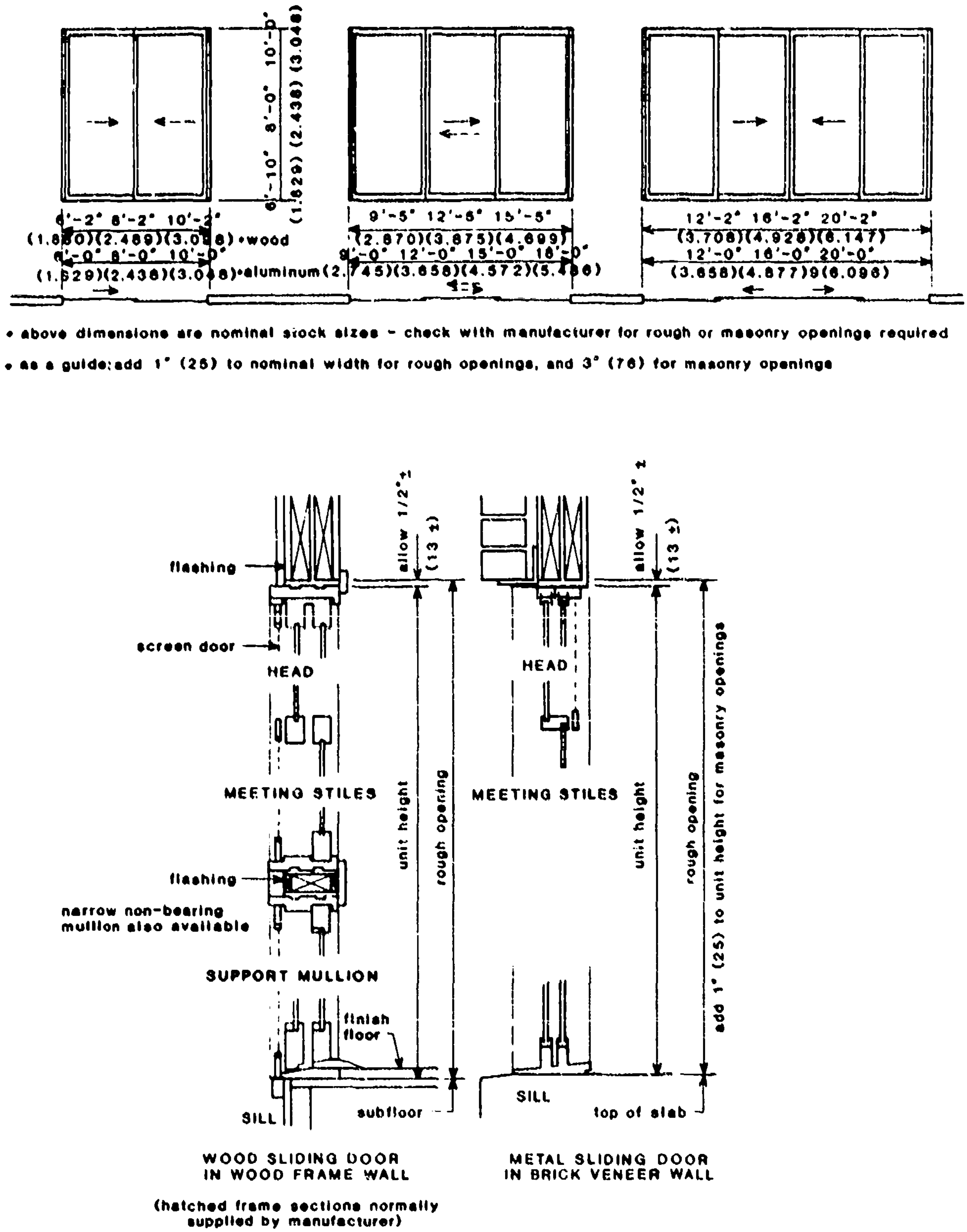


Figure 17. Sliding glass door details. (Source: F. D. K. Ching, *Building Construction Illustrated* [Van Nostrand Reinhold, New York, 1975]. Used with permission.)

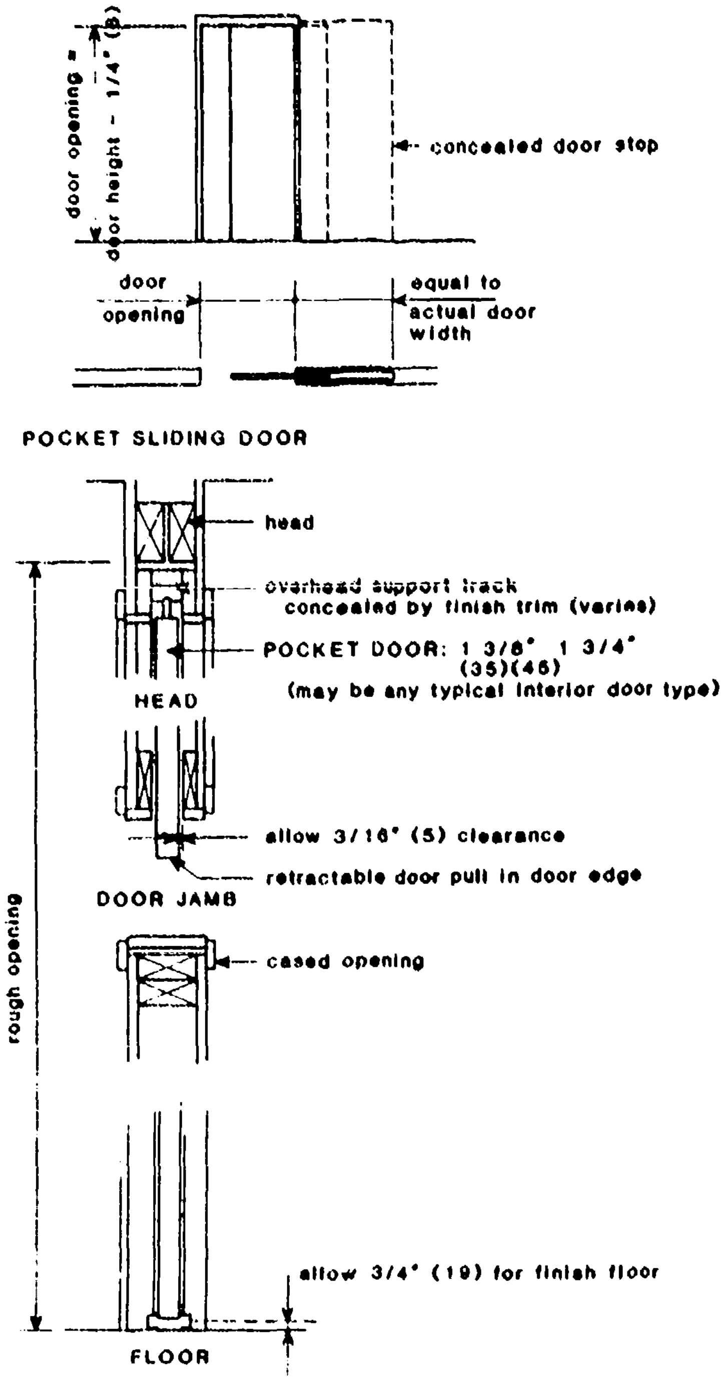


Figure 18. Pocket sliding door details. (Source: F. D. K. Ching, *Building Construction Illustrated* [Van Nostrand Reinhold, New York, 1975]. Used with permission.)

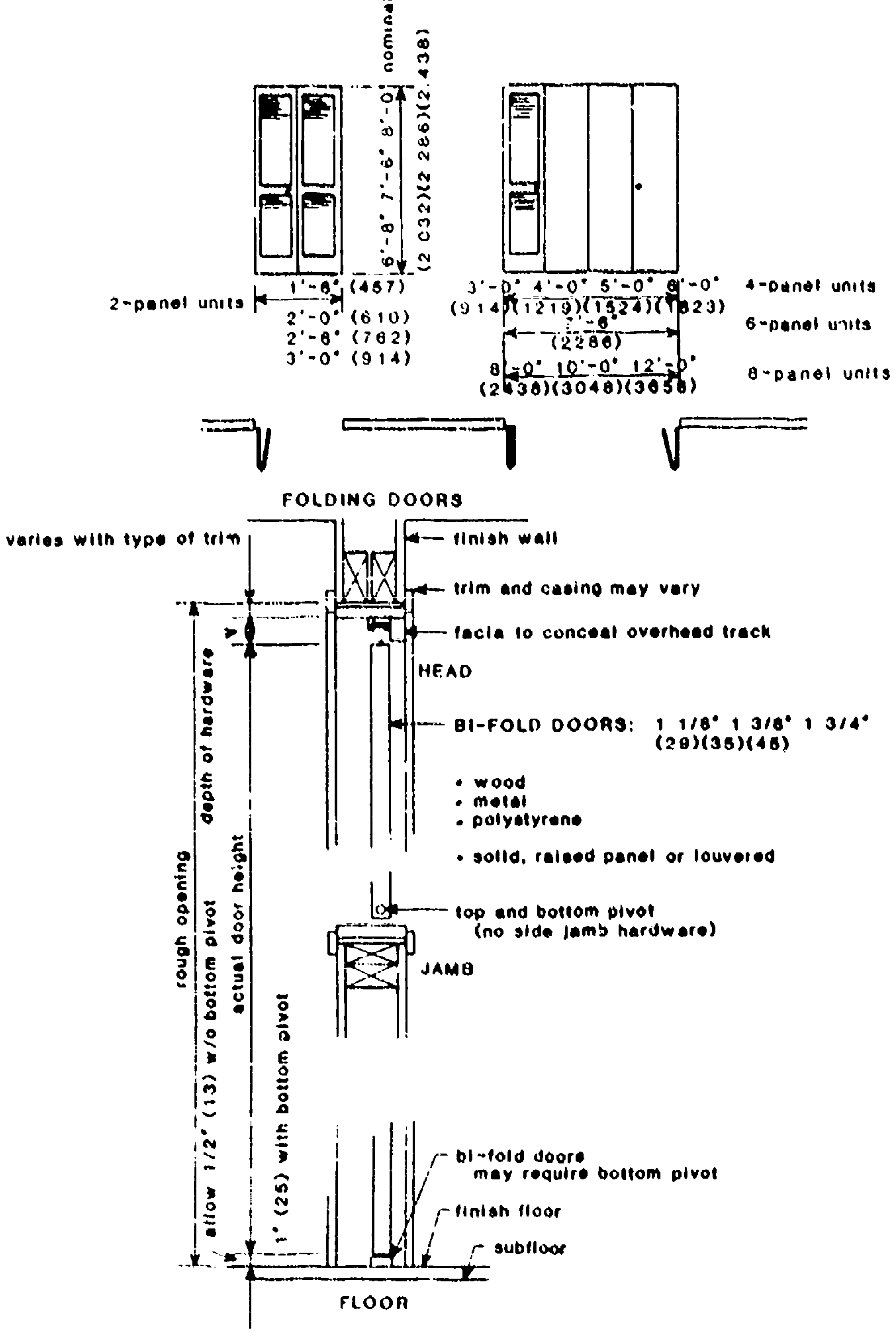


Figure 19. Folding door details. (Source: F. D. K. Ching, *Building Construction Illustrated* [Van Nostrand Reinhold, New York, 1975]. Used with permission.)

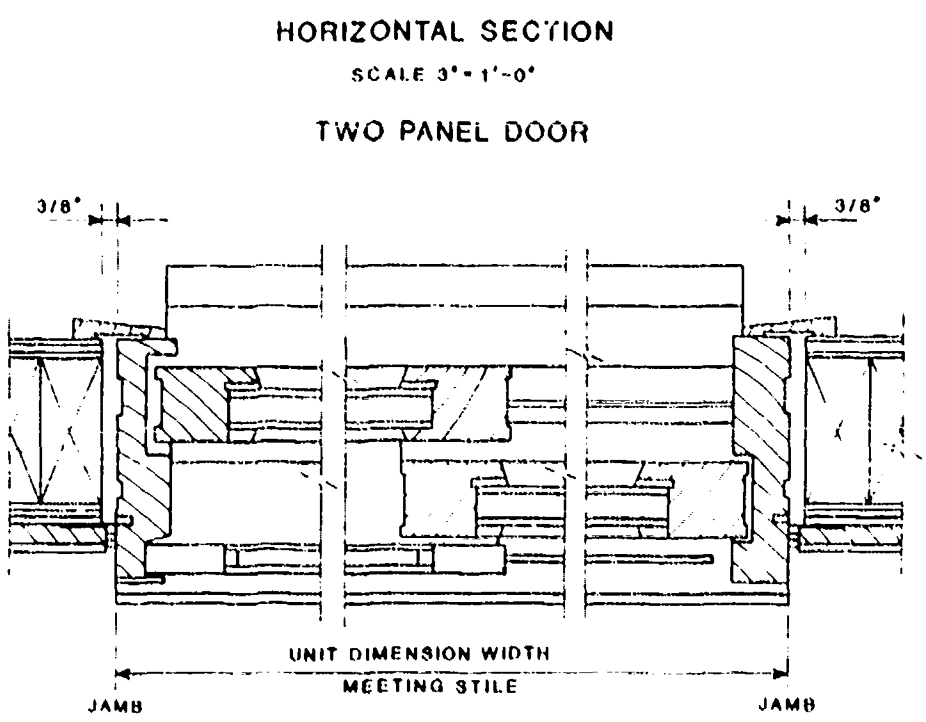


Figure 20. Example approach to thermal seals (weatherstripping).

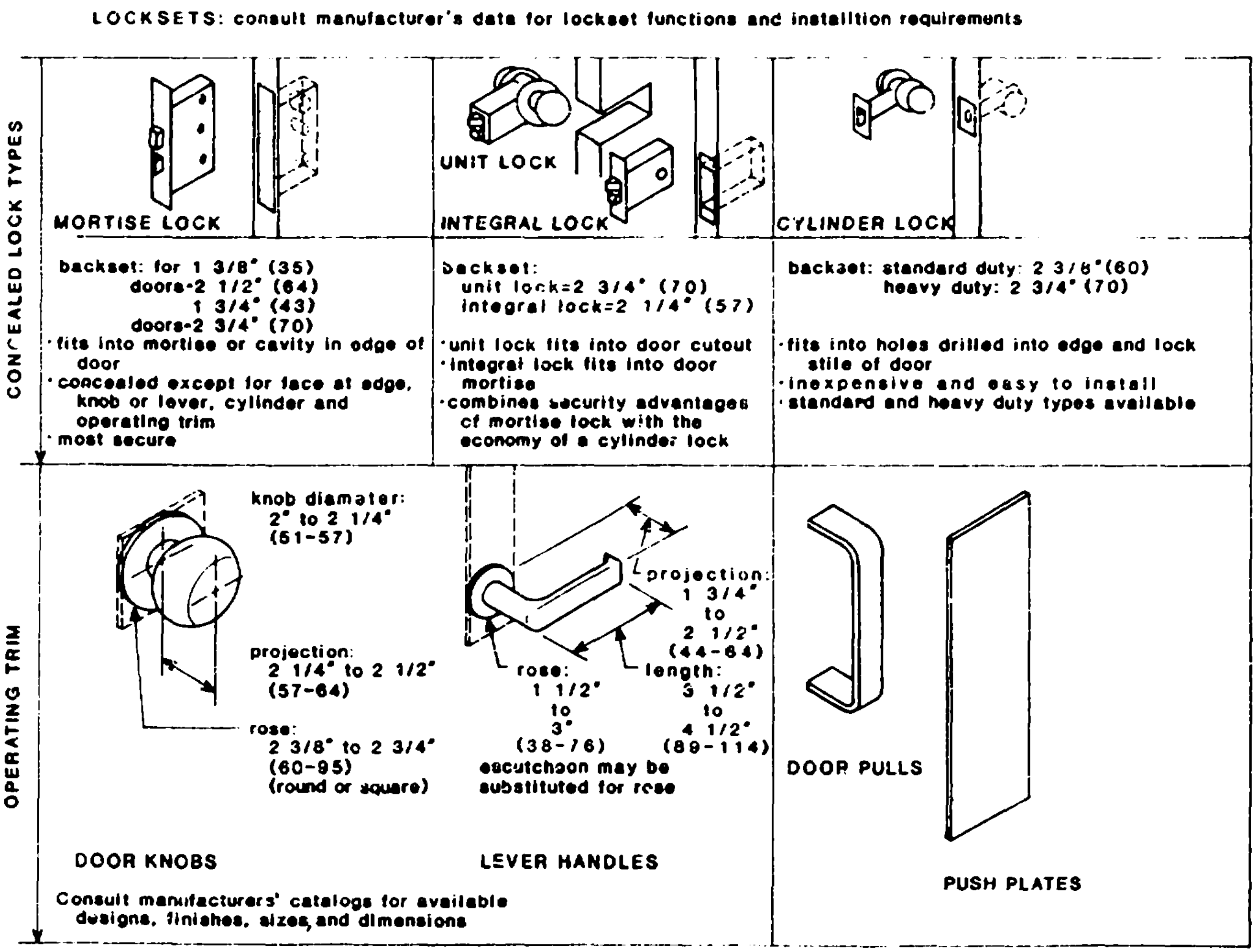


Figure 21. **Door locks, knobs, levers, and push/pull plates.** (Source: F. D. K. Ching, Building Construction Illustrated [Van Nostrand Reinhold, New York, 1975]. Used with permission.)

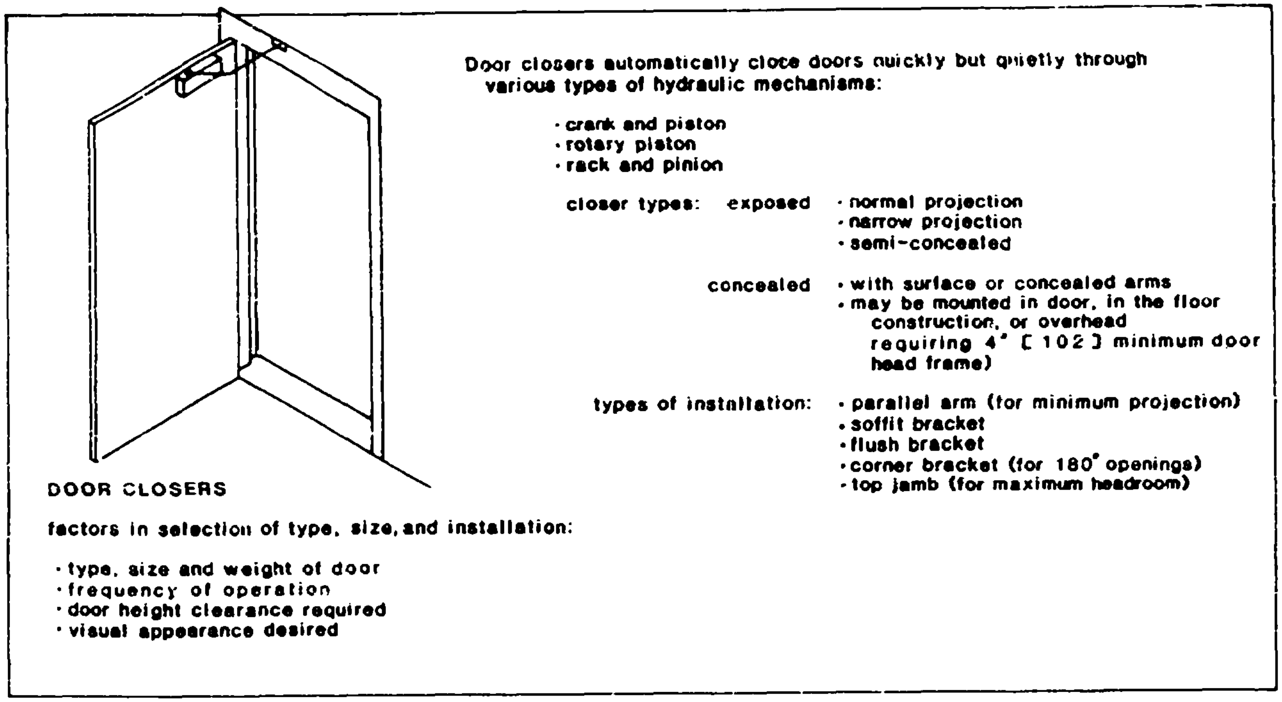


Figure 22. **Door closer.** (Source: F. D. K. Ching, Building Construction Illustrated [Van Nostrand Reinhold, New York, 1975]. Used with permission.)

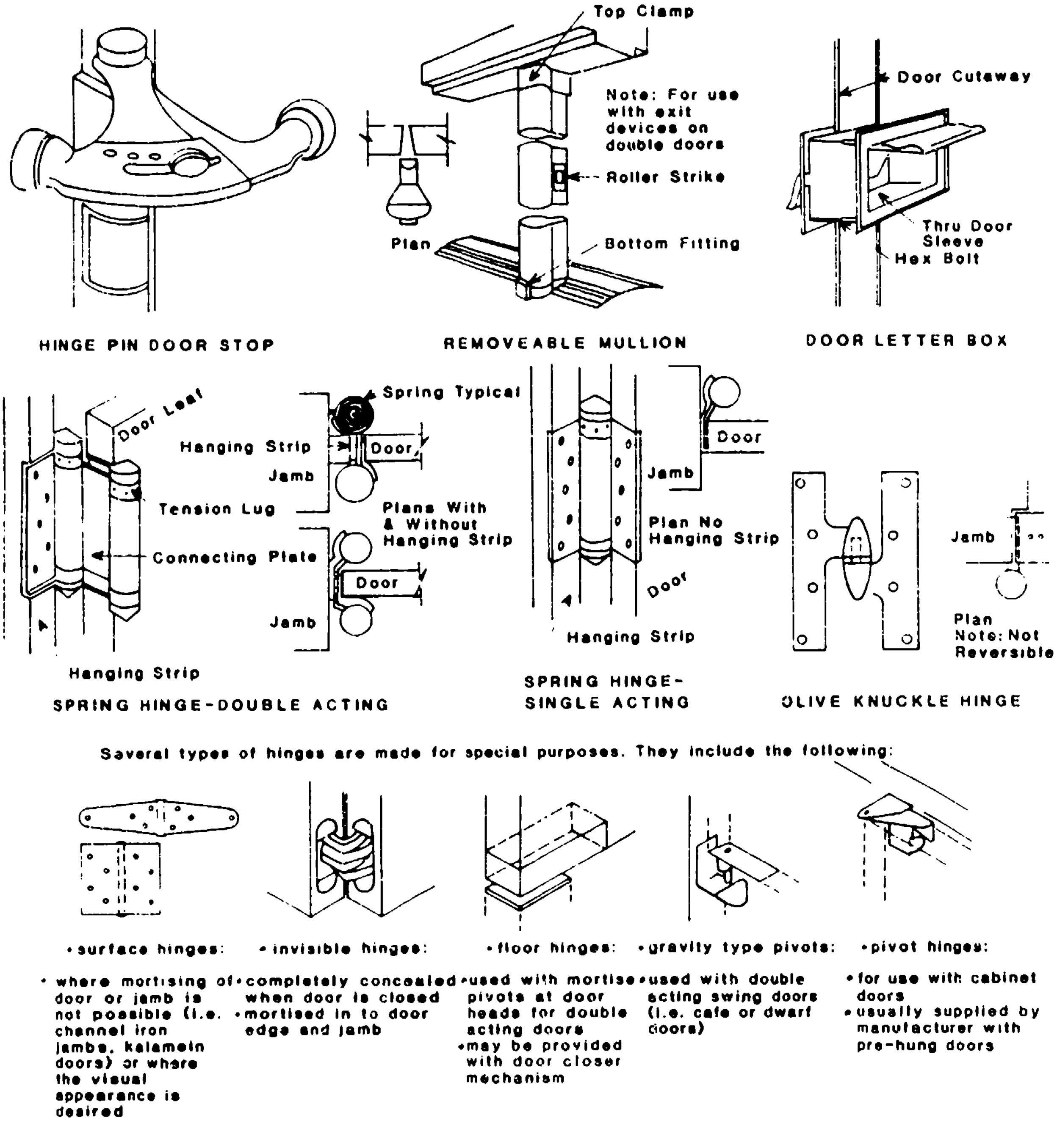


Figure 23. Miscellaneous door hardware. (Source: F. D. K. Ching, *Building Construction Illustrated* [Van Nostrand Reinhold, New York, 1975]. Used with permission.)

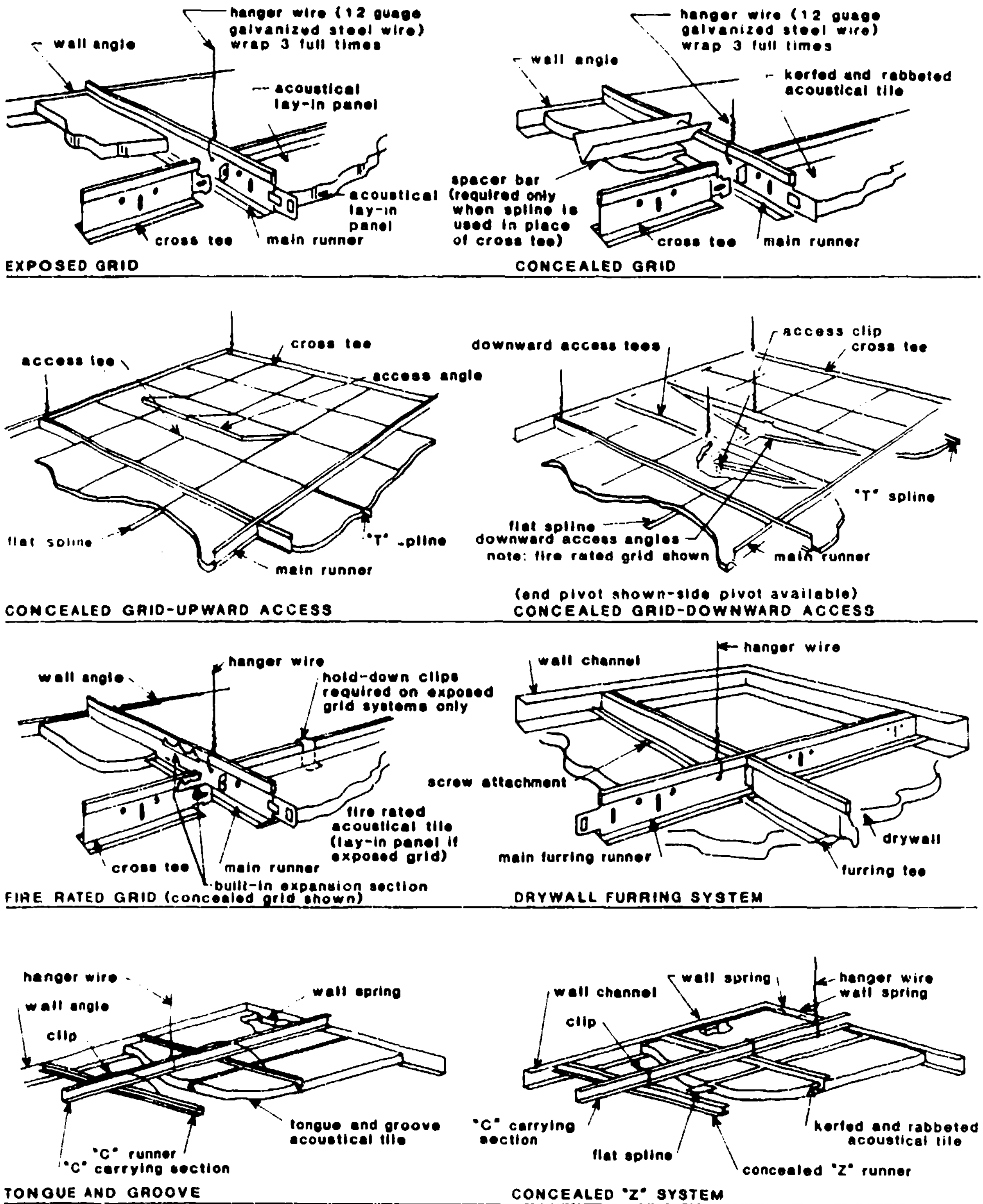


Figure 24. Acoustic dropped ceiling details.

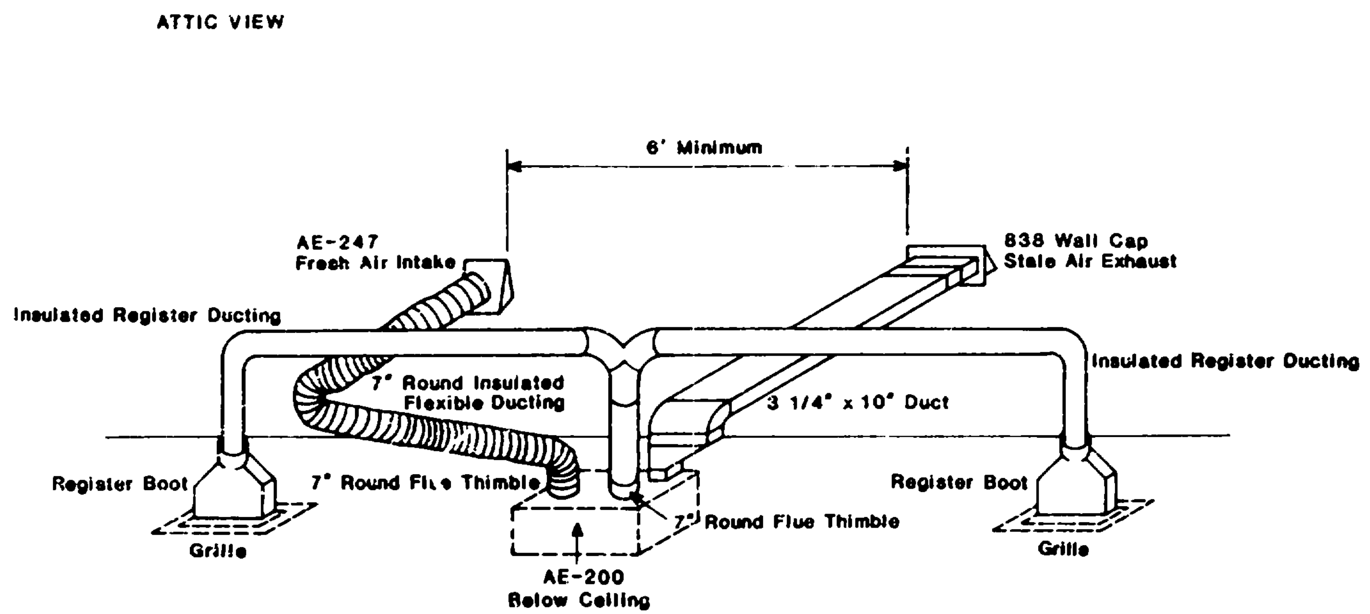


Figure 25. Heating duct details.

REFERENCES

Army Regulation (AR) 200-1, *Environmental Quality: Environmental Protection and Enhancement* (Headquarters, Department of the Army [HQDA], 15 June 1982).

Borsky, P. N., *Community Reactions to Sonic Booms in the Oklahoma City Area, Vol II, Data on Community Reactions and Interpretations*, AMRL-TR-65-37 (U.S. Air Force, 1965).

Carden, H. D., and W. H. Mayes, *Measured Vibration Response Characteristics of Four Residential Structures Excited by Mechanical and Acoustical Loadings*, NASA TN D-5778 (National Aeronautics and Space Administration, April 1970).

Ching, F. D. K, *Building Construction Illustrated* (Van Nostrand Reinhold Co., New York, 1975).

Kryster, K. D., P. J. Johnson, and J. P. Young, *Psychological Experiments on Sonic Booms Conducted at Edwards Air Force Base*, Final Report, Contract No. AF49(638)-1758 (National Sonic Boom Evaluation Office, Arlington, VA, 1968).

Luz, G. A., R. Raspet, and P. D. Schomer, "An Analysis of Community Complaints to Noise," *Journal of the Acoustical Society of America*, Vol 73, No. 4 (April 1983).

Schomer, P. D., *Predicting Community Response to Blast Noise*, Technical Report E-17/ADA773690 (U.S. Army Construction Engineering Research Laboratory [USA-CERL], December 1973).

Schomer, P. D., and R. D. Neathammer, *Community Reaction to Impulse Noise: A 10-Year Research Summary*, Technical Report N-167/ADA159455 (Revised) (USA-CERL, 1985).

Schomer, P. D., and R. D. Neathammer, *The Role of Vibration and Rattle in Human Response to Helicopter Noise*, Technical Report N-85/14/ADA162486 (USA-CERL, July 1985).

Schomer, P. D., et al., *Blast Noise Prediction, Vol I: Data Bases and Computational Procedures*, and *Vol II: BNOISE 3.2 Computer Program Description and Listing*, Technical Report N-98/ADA099440 and ADA099335 (USA-CERL, March 1981).

Sutherland, L. C., *Low Frequency Response of Structures*, Wyle Research Report WR 82-18 (Wyle Research, Inc., May 1982).

Sutherland, L. C., B. H. Sharp, and R. A. Mantey, *Preliminary Evaluation of Low Frequency Noise and Vibration Reduction Retrofit Concepts for Wood Frame Structures*, Wyle Research Report WR 83-26 (Wyle Research, Inc., June 1983).

Tokita, Y., and S. Nakamura, "Frequency Weighting Characteristics for Evaluation of Low Frequency Sound," *Proceedings, 1981 International Conference on Noise Control Engineering, 6-8 October 1981* (1981).

Weber, S. F., et al., *Method for Assessing Costs of Noise Control Requirements in Multifamily Residential and Educational Buildings*, PB82-140047 (U. S. Department of Commerce, December 1981).

APPENDIX A:

MANUFACTURERS CONTACTED IN SURVEY

Ceilings

Conwed Corp.
Engineering Department
444 Cedar St., P.O. Box 64237
(612) 221-1100

Donn Corp.
Technical Services
1000 Crocker Road
Westlake, OH 44145
(216) 871-1000

Armstrong World Industries
P.O. Box 3001
Lancaster, PA 17604
(717) 39[illegible]-4402

Forms and Surfaces, Inc.
Ceiling Department
P.O. Box 5215
Santa Barbara, CA 93150
(805) 969-7721

Innovative Ceiling System
19901 Ventura Building
Engineering Department
Woodland Hills, CA 91364
(213) 710-1225

Nicholas-Homestead Inc.
3755 E. Main Street
St. Charles, IL 60174
(312) 377-7900

Alumax Interior Products
P.O. Box 40
Interior Products
Magnolia, AR 71753
(800) 643-1514

Kinkead Industries, Inc.
Marketing/Project Management
2801 Finley Road
Downers Grove, IL 60515
(800) 323-2274

Doors

Simpsom Timber Co.
3201 N.W. Lower River Road
P.O. Box 1336
Vancouver, WA 98660
(206) 696-4031

Modernfold Doors, Inc.
American Standards Co.
P.O. Box 310
New Castle, IN 47362
(317) 529-1450

Exterior Walls

Gold Bond Building Products
Div. National Gypsum Co.
2001 Rexford Road
Charlotte, NC 28211
(705) 365-0950

Hemisphere Steel Product Corp.
56 N. 11th St.
Engineering Department
Brooklyn, NY 11211
(718) 388-6705

Charles Mayer Studios
Engineering Department
168 Market St.
Akron, OH 44308
(215) 535-6121

Glen O'Brien, Inc.
5301 E. 59th Street
Kansas City, MO 64130

Selectra, Inc.
702 E. Washington Ave.
Engineering Department
Madison, WI 53703
(607) 257-9533

Transwall Corp.
143 Pennsylvania Ave.
Malvern, PA 19355
(215) 647-3040

Windows

Norandex
7120 Krick Road
Engineering Department
Cleveland, OH 44146
(216) 232-5500

Andersen Corp.
5th and Main Sts.
Bayport, MN 55003
(612) 439-5150

Louisiana-Pacific
Arch Products
324 Wooster Road North
Barberton, OH 44203
(800) 358-2954

Marvin Windows
P.O. Box 100
Architecture Dept.
Warroad, MN 56763
(800) 346-5128

Caradco Corp.
P.O. Box 920
Rantoul, IL 61866
(217) 893-4444

Windows and Doors

J. Zeluck Inc.
5300 Kings Highway
Engineering Department
Brooklyn, NY 11234
(718) 251-8060

APPENDIX B:

STEPS FOR PREVENTING BUILDING RATTLE

This information comprises a list of DO's and DON'T's for eliminating or reducing building rattle caused by low-flying helicopters and blast sound waves (e. g., artillery, quarrying, surface explosive charges). Many parts of the home are designed to slide, contact hard surfaces, or hang loosely. The low-frequency sound emitted from blasts and helicopters can cause vibration of walls, windows, doors, hanging mirrors and pictures, and bric-a-brac, which generates the familiar rattle sound.

Both the manufacturer and building occupant can take steps to improve home elements to reduce or eliminate the rattle. The occupant may not be able to accomplish as much as a manufacturer can, but he or she can look for the proper design when purchasing new or replacement products.

Windows

There are seven basic types of windows: fixed, casement, awning, sliding, double-hung, jalousie, and pivoting.

DO use a fixed window if outdoor air is not required.

DO use a casement or awning window which can be secured firmly against a gasket.

DO use gasket material liberally to reduce the gap between the sash and track and to soften the impact when these two components make contact. A second advantage is the improved reduction in heat loss.

DO encase the double-hung window sash weights in a soft plastic jacket to soften the contact when the weight vibrates.

DO apply a small felt disk to the lower edge of each jalousie window element to prevent window to window contact. Manufacturers should bond a soft plastic sleeve to the window edge to prevent heat loss and rattle.

DON'T allow the jalousie window opening mechanism to become loose and worn. All shafts should rotate in soft plastic bushings. All gear clearances should be minimized. Linkage should be encased in soft plastic sleeves.

DON'T allow the window hardware to loosen. Inspect the hardware periodically and apply preventive maintenance.

DON'T use a sliding, double-hung, jalousie, or pivoting window as a new or replacement window due to the gaps which exist between the sash and track.

Doors

Doors operate by swinging, bypass sliding, surface sliding, pocket sliding, and side-hinge folding. There are flush, paneled, French, glass, sash, jalousie, louvered, shuttered, screen, and Dutch doors.

DO use swinging paneled doors for the home exterior. Swinging and side-hinged folding doors should be used in the home.

DO use a single- rather than a multiple-element garage door. Weatherstrip the building jamb and allow minimum clearance between the overhead track and the roller. Encase the springs in soft plastic jackets.

DO avoid French, Dutch, jalousie, louvered, and shutter doors. If used, separate the door elements using soft plastic foam or weatherstripping-type materials.

DO use a plastic screen instead of a metal screen.

DO insure that the door hardware is in good repair. Minimize the gaps in lockset tongues where the tongue fits into the jamb. Insure that hinge pins are tight and coated with plastic. Place a soft plastic foam or felt strip on door mail slots to prevent hard contact.

DON'T use lightly constructed screen doors. Enclose the safety chain in a soft plastic sleeve and insure that the hardware is tight and in good repair.

DON'T use sliding doors, particularly the pocket sliding type. If sliding doors must be used, do not hang the door loosely from the ceiling but use a bottom track also. The gap between the track and the door should be minimized. A track liner of soft plastic or weatherstripping-like material will minimize contact.

Ceiling Systems

DO insure that enclosed lighting fixtures are well made with minimum gaps. Insure that the sheet metal housing is stiff and well secured at its contact points.

DON'T use a dropped acoustical tile ceiling. If one is used, insure that contact between vertical wires and joist and metal frame is eliminated.

DON'T use light fixtures that hang from the ceiling by a chain or similar device. Also, avoid light fixtures with loose elements.

Miscellaneous Items Including Bric-a-Brac

DO install soft plastic foam or weatherstripping-like material to the lower edge of the back of the hanging mirrors and picture frames to prevent direct contact by the frame or mirror with the wall.

DO separate small items placed on shelves, in closets, or on other horizontal surfaces from these surfaces by using small felt or foam disks or strips glued to the underside of the item.

DO separate plates placed horizontally on shelves using soft plastic foam doilies.

DO insure that window air-conditioners are installed properly. The refrigeration coils should be separated. Air intake and exhaust louvers should be separated by foam strips or disks.

DO keep downspouts and gutters in good repair. Insure that all seams are tight and covered with duct tape.

DON'T allow home heating ducts and registers to loosen. Use duct tape around all seams.

USA-CERL DISTRIBUTION

Chief of Engineers
ATTN: Tech Monitor
ATTN: CEIM-SL (2)
ATTN: CECC-P
ATTN: CECW
ATTN: CECW-O
ATTN: CECW-P
ATTN: CEEC
ATTN: CEEC-C
ATTN: CEEC-E
ATTN: CERD
ATTN: CERD-C
ATTN: CERD-M
ATTN: CERM
ATTN: DAEN-ZCE
ATTN: DAEN-ZCF
ATTN: DAEN-ZCI
ATTN: DAEN-ZCM
ATTN: DAEN-ZCZ

FESA, ATTN: Library 22060
ATTN: DET III 79906

US Army Engineer Districts
ATTN: Library (41)

US Army Engineer Divisions
ATTN: Library (14)

US Army Europe
AEAEN-ODCS/Engr 09403
ISAE 09081
V Corps
ATTN: DEH (11)
VII Corps
ATTN: DEH (15)
21st Support Command
ATTN: DEH (12)
USA Berlin
ATTN: DEH (12)
USASETAF
ATTN: DEH (10)
Allied Command Europe (ACE)
ATTN: DEH (3)

8th USA, Korea (19)

ROK/US Combined Forces Command 96301
ATTN: EUSA-HHC-CFC/Engr

USA Japan (USARJ)
ATTN: AJEN-DEH 96343
ATTN: DEH-Honshu 96343
ATTN: DEH-Okinawa 96331

416th Engineer Command 60623
ATTN: Facilities Engineer

US Military Academy 10966
ATTN: Facilities Engineer
ATTN: Dept of Geography & Computer Science
ATTN: DSCPER/MAEN-A

AMMRC, ATTN DRXMR-WE 02172

USA AMCCOM 61299-6000
ATTN: AMSMC-RI
ATTN: AMSMC-IS

AMC - Dir., Inst., & Servc
ATTN: DEH (23)
ATTN: AMCEN-A

DLA ATTN: DLA-WI 22314

DNA ATTN: NADS 20305

FORSCOM
FORSCOM Engr, ATTN: AFEN-DEH
ATTN: DEH (23)

HSC
ATTN: HSLO-F 78234
ATTN: Facilities Engineer
Fitzsimons AMC 80240
Walter Reed AMC 20012

INSCOM - Ch, Instl. Div
ATTN: Facilities Engineer (3)

MDW, ATTN: DEH (3)

MTMC
ATTN: MTMC-SA 20315
ATTN: Facilities Engineer (3)

NARADCOM, ATTN: DRDNA F 01760

TARCOM, Fac. Div. 48090

TRADOC
HQ, TRADOC, ATTN: ATEN-DEH
ATTN: DEH (19)

TSARCOM, ATTN: STSAS-F 63120

USACC, ATTN: Facilities Engr (2)

WESTCOM
ATTN: DEH, Ft. Shafter 96858
ATTN: APEN-IM

SHAPE 09055
ATTN: Surv. Section, CCB-OPS
Infrastructure Branch, LANDA

HQ USEUCOM 09128
ATTN: ECJ 4/7-LOE

FORT BELVOIR, VA 22060 (7)
ATTN: Canadian Liaison Officer
ATTN: British Liaison Officer
ATTN: Australian Liaison Officer
ATTN: French Liaison Officer
ATTN: German Liaison Officer
ATTN: Water Resources Support Ctr
ATTN: Engr Studies Center
ATTN: Engr Topographic Lab.
ATTN: ATZA-DTE-SU
ATTN: ATZA-DTE-EM
ATTN: R&D Command

CRREL, ATTN: Library 03755

WES, ATTN: Library 39180

HQ, XVIII Airborn Corps
and Fort Bragg
ATTN: AFZA-FE-EE 28307

Area Engineer, AEDC-Area Office
Arnold Air Force Station, TN 37389

Chanute AFB, IL 61868
3345 CES/DE, Stop 27

Norton AFB, CA 92409
ATTN: AFRCE-MX/DEE

AFESC, Tyndall AFB, FL 32403

NAVFAC
ATTN: Engineering Command (7)
ATTN: Division Offices (6)
ATTN: Naval Public Works Center (9)
ATTN: Naval Civil Engr Lab. (3)

NCEL
ATTN: Library, Code L08A 93043

Defense Technical Info. Center 22314
ATTN: DDA (2)

SETAF Engineer Design Office 09019

Engr Societies Library, NY 10017

Natl Guard Bureau Instl. Div 20310

US Govt Print Office 22304
Receiving Sect/Depository Copies (2)

US Army Env. Hygiene Agency
ATTN: HSHB-E 21010

National Bureau of Standards 20899

310
06/87

ENA Team Distribution

Chief of Engineers
ATTN: CEEC-CE
ATTN: CEEC-EA
ATTN: CEEC-EI (2)
ATTN: DAEN-ZCF-B
ATTN: CEEC-ZA
ATTN: CEEC-M (2)

HQ USAF/LEEEU 20332

AMC 22333
ATTN: AMCEN-A

Naval Air Systems Command 20360
ATTN: Library

Little Rock AFB 72099
ATTN: 314/DEEE

Aberdeen PG, MD 21010
ATTN: Safety Office Range Safety Div.
ATTN: U.S. Army Ballistic Research Lab (2)
ATTN: ARNG Operating Activity Ctr.

Edgewood Arsenal, MD 21010
ATTN: HSHB-MO-B

Ft. Belvoir, VA 22060
ATTN: NACEC-FB

NAVFAC 22332
ATTN: Code 2003

Naval Surface Weapons Center 22448
ATTN: N-43

Ft. McPherson, GA 30330
ATTN: AFEN-FEB

US Army Aeromedical Res Lab. 36362
ATTN: SGRD-UAS-AS

USA-WES 39180
ATTN: WESSE
ATTN: Soils & Pavements Lab
ATTN: C/Structures

Wright-Patterson AFB, OH 45433
ATTN: AAMRL/BB
ATTN: AAMRL/BBE

Human Engr. Laboratory 21010

Naval Undersea Center, Code 401 92132

Bureau of National Affairs 20037

Building Research Board 20418

Transportation Research Board 20418

Department of Transportation
ATTN: Library 20590

Federal Aviation Administration 20591

34
+37
10/87