A TECHNOLOGICAL APPROACH TO BUILDING SECURITY

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CALIFORNIA MODLE BUILDING SECURITY ORDINANCE

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FOREWORD

Burglary is the most common serious crime committed in California. In 1976 there were 465,000 reported burglaries, representing more than one-half of the serious felonies reported for that year. In 1976, 68 percent of all burglaries were residential burglaries. Since 1966 the burglary rate has increased 70 percent.

Building security measures are an effective means of preventing burglaries. Crime prevention programs involving the installation of effective locks, doors, and windows have been successful in reducing burglaries in the areas in which they are operational.

This report, prepared by the California Crime Technological Research Foundation, in conjunction with the California Department of Justice, is the result of three years of intensive research into building security. The results of this work provide the basis for the development of meaningful building security standards. It is required reading for anyone who is interested in developing a building security program, or in drafting a building security ordinance or code.

The report reflects the standards which could be established under ideal conditions. In practice it may be necessary to impose less than ideal standards because of the state of the art and because of cost considerations. To provide an example of a building security code containing the practical compromises necessary in this field, Appendix A has been added to the report. It contains a model building security code which was drafted by the California Crime Prevention Officers' Association. We believe this model code represents a reasonable approach to building security standards, and recommend its use as a model for the development of local building security ordinances.

There are many ways to fight crime, but the best way is to prevent it in the first place. We hope that this report will help to prevent burglaries in California.

Attorney General
State of California

TABLE OF CONTENTS

TABLE OF CONTENTS (cont'd.)

TABLE OF CONTENTS

TABLE OF CONTENTS

SUMMARY AND CONCLUSIONS

Testing Approach

A systems approach was formulated for developing building security performance standards wherein door and window assemblies were treated as barrier systems comprised of interdependent components (resistance parameters) common to established construction practices. The standard characteristics of the typical man imposing threats to building security were defined in terms of the limits of his physical capabilities both with and without tools. Building security threats related to forced entry of exterior doors were characterized and the critical condition was determined to be shoulder impact loading. A procedure was also developed for relating the dynamic load strength of a barrier system to an equivalent static load strength for use in evaluating the system by conventional structural tests.

Doors

The structural evaluation of standard exterior door systems, under static and dynamic loads, demonstrated they will not withstand man's capability for forced entry without additional reinforcements.

1. Doors intended to meet building security standards should have metal reinforcement at the maximum concentrated load locations. These are all on the latch-side edges of door and frame: Latch and deadbolt plates, striker plates, and flush bolt attachments in the case of double doors. Wood is an excellent material for many structural applications including doors but tests showed that local failures in wood at the highly concentrated load areas occur long before the full potential capacity of the bulk of the door is reached. (Splitting of wood along striker or latch plate screw lines was a common occurrence.) The tests demonstrated that this problem may be greatly alleviated by attaching a light sheet metal channel with screw fasteners at such locations.

2. Hollow core exterior doors were determined to be entirely too susceptible to "punch-through" and were found to deflect excessively under load which caused the lock bolt latches to roll off the striker plates. It was demonstrated that even paper honeycomb cores increase the strength and stiffness greatly over that of the hollow core type designs.

3. Structural tests showed that minor differences in installation details of door frames and framing, particularly in nailing and shimming, may make major differences in the strength and stiffness parameters that determine resistance to forced entry.

4. The addition of a deadbolt will greatly increase a door system's strength to resist impact loads. Besides increasing the locking feature security, a deadbolt decreases the maximum concentrated reactive load (equal to 1/3 of the applied load) and stress by sharing the door latch-side reaction with the knob latch, which would otherwise have to resist it at this single concentrated location. This is particularly important in view of the fact that most residential and light commercial exterior doors open inward so there is no possibility of help from a stopper strip in distributing the impact load reaction.

Locks

Laboratory tests evaluated eighteen different techniques which are used in defeating locking systems by force and manipulation. The measurements obtained in these tests were used to develop a performance test criteria for certifying lock equipment. Tests performed on 105 door lock systems demonstrated that typical exterior door locks and padlocks are inadequate to resist the various forced entry threats.

1. The results of hammer impact tests showed that typical lock systems were vulnerable to the threat.

2. Tests using twisting tools revealed that many types of cylindrical knob locks and deadbolts were unable to withstand torsion loads.

3. Forty-five percent of the locks tested for resistance to lock cylinder pulling tools failed. Those lock cylinders that resisted the threat generally were either of hard enough material to prevent inserting the puller screw or soft enough material to allow the puller screw to strip out.

4. Lock cylinder drilling and sawing tests determined that lock cylinders made of material Rockwell C 48 or harder will resist these threats. Also, the results of padlock shackle cutting tests showed that padlock shackles heat treated to Rockwell C 56 will preclude cutting by bolt cutters.

5. High temperature tests with oxygen-propane and oxygen-acetylene torches applying heat to padlock shackle showed that some padlocks could resist the oxygen-propane torch but none were able to withstand the oxygen-acetylene flame. Los temperature tests using liquid Freon, propane, and nitrogen showed that embrittlement with liquid nitrogen made all the locks tested susceptible to hammer impact loads.

6. Lock picking tests were conducted using 180 lock cylinders manufactured by ten different companies. These tests showed that some locks could be picked as quickly at two seconds and that they could be picked quickly both by hand or with picking guns.

Sliding Glass Doors

Tests of conventional sliding glass doors indicated the doors are highly vulnerable to both a prybar and glass attack; however, tests revealed that with some fairly simple changes to the accessories hardware, the basic structure of a typical commercial door is adequate to resist the maximum anticipated prybar threat of 3000 pounds. Although it was not the intent of this project to specify design requirements, these test results clearly indicate that some modifications to present, typical sliding glass door design configurations will be necessary to meet the performance test requirements.

Specifically, these changes would include:

1. Deadbolts at the top and bottom of the sliding door.

2. Improved structural anchoring of the deadbolts to the framing.

3. Stronger latches.

4. The addition of a spacer strip along the top rail to prevent excessive vertical lift.

5. Improved jamb attachment to the wall framing.

6. In addition, it was determined that the soft aluminum stiles and rails are vulnerable to local tearing by the sharply concentrated forces of an actual prybar; therefore, to achieve adequate resistance to this type of damage by a prybar, it will probably be necessary to incorporate some type of a barrier to prevent the prybar from contacting the aluminum members in certain likely target areas such as the stile and jamb in the latch area.

7. The tests showed that a locking system with tensile capacity to anchor the sliding panel to the fixed panel and frame is needed to increase resistance to removal by prying between sliding and fixed panels. In commercial practice, this could be accomplished by some device such as providing deadbolt assemblies having "ball-detent" pins.

Sliding Glass Windows

Sliding glass window tests revealed that, although the burglar threat force is lower, the window is more vulnerable because of the lower breaking strength and smaller thickness of glass in the windows, i.e., 3/32-inch nominal, whereas the door tempered glass nominal was 3/16-inch. As with sliding glass doors, the window test series clearly demonstrated the necessity of modifications for currently typical sliding glass windows to withstand the test load equivalent to the maximum anticipated break-in threat. These modifications would include:

1. The use of well designed deadbolts - one at the top and one at the bottom for blocking against vertical and horizontal movement of the window.

2. The addition to the window frame (jambs, head, and sill) on the inside of strong blocks or brackets to prevent sliding panel removal by inward pushout.

Glazing Panels

The series of tests of glazing panels revealed that currently marketed glazing materials for residential doors and windows are incapable of resisting burglary break-in threats for which realistic values have been determined. This inadequacy applies even in the case of commercially designated "burglar resistant" panels which were found to be more "burglar retardant" than "burglar resistant" as compared to ordinary window glass. It appears that only one currently used homogenous material, the polycarbonate plastic, is a practical consideration to meet the maximum anticipated break-in threat and then only with a significant increase in thickness.

SECTION I. INTRODUCTION

A. Historical Perspective

In August of 1972, the California Crime Technological Research Foundation (CCTRF) undertook a research and testing program aimed at developing building security equipment performance standards for private residences and small commercial structures. The program was begun in response to a request from the Attorney General's Building Security Commission (BSC) for technological support in developing sound standards.

The BSC took the position that attempts by local governmental agencies to implement burglary prevention standards have generally lacked technical input because of funding limitations. The prevention standards developed by these agencies had been formulated by the consensus of opinion of those involved and the criteria were not necessarily based on engineering data, test substantiation or design analysis. Even so, these codes and ordinances resulted in reduced crime. It was felt that with engineering research used as the basis for defining security system performance levels, the threat posed by an attacker attempting to enter a building could be greatly reduced.

In June 1972, CCTRF was asked by the Attorney General to provide the needed technological input for standards development. Specifically, CCTRF was requested to:

Research performance standards for door, lock and window systems on the basis of:

1. The ability of a man to attack and forcibly enter a closed premise.

2. The resistance properties of common building components when subjected to attack.

B. Purpose

CCTRF's purpose in this program was to provide technical input to the BSC; input in the form of recommending performance standards for the BSC to consider in its recommendations to the Legislature or other bodies; input which was technologically sound and which was cognizant of security equipment's present performance levels and man's capabilities to thwart that security level.

In addition, CCTRF desires to bring to the attention of those interested, the security capabilities of door, lock and window systems. This is done not to frighten people (for in many instances security is less than satisfactory) but is done to educate local and state governmental officials, builders, security equipment manufacturers and users to the fact that security is a function of <u>system</u> performance and that present performance needs considerable improvement to stand the tests that man can give it.

C. <u>Scope</u>

1. Technical

This report is concerned with door, lock, and window systems of private residences and light commercial structures.

Door and window systems were the focus of the program because they are the logical means of ingress. Between 1971-1973, over 94% of the burglaries committed in a representative sample of California urban areas indicated that either a door or window was the point of entry. If these structures can be hardened to resist present methods of attack commonly used by criminals, a reduction in burglaries is likely to occur. Also, if the professional burglar can be delayed in gaining entry, the probability of apprehension is increased.

In the program, major efforts included, but were not limited to, the following:

First, the characterization of building security threats. This included rating man's physical capabilities (e.g., shoulder impact) and his capabilities using tools (e.g., pry bar, pipe wrench) when attempting surreptitious entry.

Second, the program concentrated on exterior doors (evaluation of the most critical threat and its point of application) and the evaluation of door attachments (i.e., hinges and locks).

Third, the framing systems surrounding doors were investigated and tested (i.e., construction, stiffness). An extensive testing program into the resistance capabilities of locks under seventeen types of threats was undertaken.

Fourth, the complete testing of sliding glass doors, windows, and glazing systems was completed.

2. Social

This program transcends its laboratory and technical orientation. It is a pioneering effort to develop a technical data base which will direct and support policy development, allowing society to cope with its rapidly changing social environment -- an environment which has made the homeowner and businessman vulnerable to criminal attack. CCTRF recognizes that this technical data base is new to the criminal justice field and is only now being developed. At the same time, however, it is our contention that the means to its development is available from both the public and private communities. Technology transfer is a reality CCTRF brings to this program and plans to use in its continuing efforts to further develop the data base.

D. Format

The documented results of the program include the history of the project, the approach taken in its performance, a definition of security system resistance parameters, and a summary of test results.

E. Systems Approach

A systems approach was formulated wherein door and window assemblies were treated as systems so minimum functional levels of performance could be specified for the total unit.

The door and/or window assembly is viewed as being comprised of many interrelated and interdependent components which will be referred to as a system. In most cases, when an attack is made against a door or window system, the immediate impact is concentrated in an area of the system, but its energy is quickly spread throughout, being absorbed in different degrees by the components of the system. As an example, when a door system is kicked close to the lock, the shock of that impact is not only felt by the lock, but also by the door, its hinges, the door jamb and framing, etc. Depending upon the construction and type of materials used in the system, the distribution and absorption of the impact's energy on the system will vary within the system. Evaluating a door or window system in terms of determining its security capabilities then goes far beyond looking only at a lock. When viewed as a system, the door or window assemblies look somewhat like that proverbial chain where total strength is dependent upon the weakest link.

It was obvious from the beginning that if doors and windows were to be made more burglary resistant, attention had to be focused on more than just locks. It was our approach to test the systems, determining where their weakest point lay, strengthen that point, test again to find the next weakest point and continue in that manner until the system had been strengthened to the point where, ideally, when it failed, the total system failed at once and above the loading corresponding to standard threats.

This type of approach supports the strengthening of all the links in the security system. The scope of the program did not allow testing a large number of each barrier system to obtain a data sample size suitable for statistical analysis. Consequently, a system approach of performing a series of tests on one type of test article provides the additional data needed for confirming the validity of the overall test results and developing building security standards.

The research effort employed involved many groups and individuals from all areas to assist with problem identification and in determining technical requirements. While all of the agencies contacted will not be identified here, major participants from representative areas will be listed to give the reader an indication of the breadth of the research program. It is also important to point out that these standards were developed with the necessary input from groups which will feel the impact of building security codes. Groups which participated include:

BUILDING SECURITY COMMISSION

The BSC is comprised of legal, police, planning, architectural and technical experts and has been given authority by the Attorney General, Evelle J. Younger, to generate building security standards.

OFFICE OF CRIMINAL JUSTICE PLANNING

OCJP is the state agency responsible for criminal justice planning in California and is also the recipient of Law Enforcement Assistance Administration (LEAA) funds. OCJP participated in the planning of the project and provided an $85,000 first year, $200,000 second year, and $96,000 third year grant to CCTRF to foster OCJP's statewide crime prevention efforts.

DEPARTMENT OF JUSTICE - BUREAU OF CRIMINAL STATISTICS

BCS provided CCTRF and BSC with the statistical data base upon which decisions regarding specific targets for research were based.

NATIONAL BUREAU OF STANDARDS

NBS, funded by LEAA, is performing a research program similar to this one; however, NBS is writing component specifications in contrast to the functional specifications proposed by CCTRF. NBS and CCTRF see the programs as complementary and are coordinating their efforts to produce the best possible results.

AMERICAN SOCIETY FOR INDUSTRIAL SECURITY

ASIS, a society representing users of security equipment, has provided project input through the participation of the past chairman of the ASIS Physical Security Committee, Mr. Theodore H. Johnstone. Guidance was provided in both the philosophical as well as the technical areas of approach to security. Input was especially valuable in the lock picking resistance area.

INTERNATIONAL CONFERENCE OF BUILDING OFFICIALS

CCTRF has sought and received input from ICBO through its Fire and Safety Subcommittee and through its participation on the Building Security Ad Hoc Committee. ICBO is concerned with the development and maintenance of building codes and sees the area of building security as one of its concerns.

AMERICAN SOCIETY FOR TESTING AND MATERIALS

CCTRF has participated with the ASTM Security System and Equipment Committee F-12 through joint meetings with the Western Subcommittee on locking devices. These ASTM committees are composed of security equipment manufacturers who are interested in supporting a voluntary consensus type of standards for the industry.

PRIVATE INDUSTRY

The interest of private industry, especially security equipment manufacturers, has been quite high. Their participation has proven very beneficial. Their interest in upgrading security levels is obvious not only from their contribution of items to be tested (e.g., locks, doors, windows, etc.), but also from their input on testing methodology and findings to date.

OFFICE OF THE STATE FIRE MARSHALL

The State Fire Marshall's Office has participated in the area of problem identification and the identification of possible areas of conflict between security oriented and fire and life safety oriented issues (e.g., quick exit versus delayed entry).

LOCAL AGENCIES

The genesis of what the state is doing in this program is directly attributed to the concern and action of local law enforcement and fire safety agencies. The attack on burglary through development of codes at the local level is what sparked much of the state and federal efforts in attacking burglary. In addition to input regarding local codes, a greater appreciation of the crime of burglary was achieved when CCTRF laboratory personnel were allowed to view in the field crime scene investigations. The Sacramento Police Department allowed CCTRF engineers to study successful burglaries firsthand.

SECTION II. TESTING APPROACH

This program addressed the task of improving building security through an increase in access hardenability of locks, doors, and windows. To achieve this goal, a system approach to the task was formulated. The block diagram below depicts the system components.

	(THREATS)		(BARRIERS)
Man	+ Techniques/Tools	+	Resistance of Entry Barriers (Doors & Windows)

Thus, man endowed with specific physical and mental capabilities, increased or not with the mechanical advantage of various devices, must in the form of threats overcome the entry barrier resistance to gain entry. If physical engineering terms are used to quantize the parameters identifying man, threats and entry resistance, the ability to gain entry reduces to the following building security margin of safety (2)* equation:

$$E = \left(\frac{R}{M} - 1\right) \times 100$$

Where:
E = Entry security safety margin (%)
R = Resistance to entry
M = Man's threat

Thus, when E is positive, the resistance exceeds man's capabilities and entry is not possible with the percentage of security safety margin given. If E is negative, entry is possible and the percentage of lack of security safety margin is defined.

In the development of performance standards, this approach of comparing defined burglary threats against resistance characteristics of specific types of barrier systems is used as the basis for setting performance values. The following discussion describes the types of threats posed against physical barriers and the resistance levels of those barriers.

A. Threats

1. Standard Man

The basis of all threats is man's characteristics. His basic movements must be studied to determine

* Numbers refer to references in Appendix.

lifting, pushing, kicking, pulling, gripping and twisting capabilities so actual forces created during physical attack on barriers can be computed. These basic capabilities have been established, both with and without tools, based on extensive data developed for NASA (3). A standard man has been selected to represent an above average threat in terms of physical statute, muscle tone, and manual dexterity. He would be generally representative of the upper 20 percentile of males in these attributes. This was felt to be a preferred alternative to an average man, and could still be reasonably within the scope of most burglars. Additionally, the favorable laboratory conditions allow the standard man to generate threats greater than those encountered in most field situations. The definition of the standard man is given in Figure 1.

2. Types of Threats

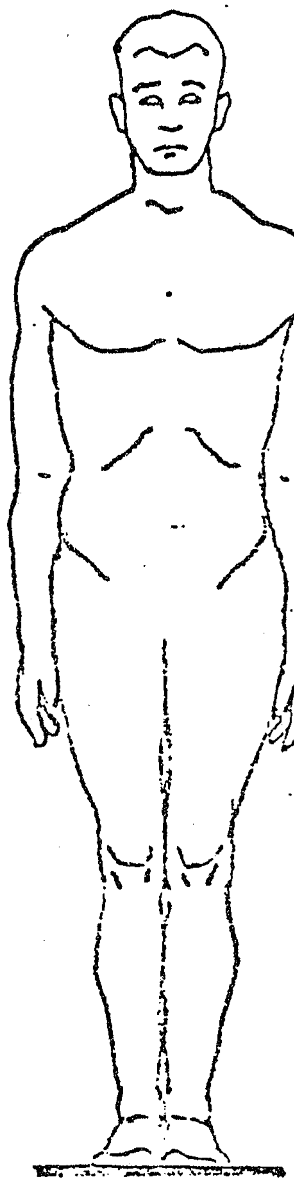
Attack methods selected for analysis represent those used in over 90% of forcible entries in California during 1972 (1). These threats are classified in five ways. They may be used separately or in any combination by an attacker.

a. Trickery -- Acquisition of the message (key or combination) by an unauthorized user through devious means. Example: the use of deception, fraud, conversion, but does not include damage to the system.

b. Circumvention -- The bypassing of the physical security system without resorting to force or manipulation. Example: Methods that bypass the interpreter, such as entry through openings in an enclosure left unguarded. "Jumping" the ignition circuit of an automobile is a common circumvention method used by car thieves.

c. Force -- The damaging or destroying all or part of the physical security system. Example: Force is used on all parts of the system except the key. Force can be used to completely destroy a system, or any part or it may be applied to slightly deform a part, or parts, to gain passage.

FIGURE 1



STANDARD MAN

WEIGHT - 180 LBS.
HEIGHT - 6 FT.
MUSCLE TONE:

1. LIFT CAPABILITY - 150 LBS.
2. GRIP - 85 LBS.
3. ARM STRENGTH - (ONE ARM)

PULL - 52 LBS.	UP - 24 LBS.
PUSH - 50 LBS.	DOWN - 26 LBS.
OUTBOARD - 17 LBS.	INBOARD - 22 LBS.

d. Manipulation -- The process of operating a lock to an unlocked condition by means other than specifically planned. Example: Manipulation is entirely confined to attempting to get the interpreter to accept a false message. Lock picks, manipulation keys, and decoders are used to find a message acceptable to the interpreter.

e. Robbery -- The taking of property in the possession of another by means of force or fear. Example: Forcing the authorized possessor to surrender his key or combination.

Force is of primary importance to this research, and has been broken down into sub-categories based partially upon statistics provided by the Bureau of Criminal Statistics from selected California agencies during 1972 (1). Analysis of these sub-categories has afforded the development of the threat breakdown shown in Figure 2. Manipulation and circumvention also present significant burglary problems and are considered in this program to the extent that common methods are identified.

B. Analysis of Threats

1. Static and Dynamic Loading

The capabilities of the average adult male, either bodily or using the tools commonly employed by burglars, had to be characterized and quantified. These capabilities, once determined, became the threats used in this report.

Of the local building security ordinances currently in effect, those that do specify tests do so in terms of static loads. However, most of the threats applied to doors and windows are dynamic in nature. Consequently, the evaluation of those threats, as applied to entrances or points of access has been made in terms of energy. For example, a load is static when the time used in its application is relatively long; that is, the load is slowly and progressively increased to its maximum value. An example of a static loading, is that provided by a bumper jack, actuated between the jambs of a door attempting to bend and spread the jambs. A hammer blow, a foot kick or a shoulder impact, on the other hand, are examples of dynamic loads.

FIGURE 2

TYPES OF THREATS

1. Force

    a. Shoulder Impact
    b. Foot Impact
    c. Lifting
    d. Pry Bar
    e. Pipewrench
    f. Screwdriver
    g. Pullers
    h. Pliers
    i. Hammer
    j. Drift Punch
    k. Bumper Jack Spreader
    l. Hoof Nippers
    m. Freezing
    n. Bolt Cutter
    o. Drill
    p. Torch
    q. Sawing
    r. Thrown Missile
    s. Battering Ram
    t. Wedge
    u. Pipe
    v. Shoveknife
    w. Glass Cutter
    x. Spring Punch

2. Manipulation

    (Includes picking and Loiding)

3. Circumvention

2. Energy and Dynamic Force

Taking "shoulder impact" as a typical dynamic threat, the input energy is approximately that acquired by the weight of the man with the velocity that he has when impacting the door. The input kinetic energy of that man, at the moment of impact, is expressed by:

$$U_i = 1/2\ (w/g)\ v^2 \ . \ . \ . \ . \ . \ . \ . \ . \ . \ (i)$$

Where U_i = the input kinetic energy, expressed an in-lbs.

w = weight of man (lbs.)

g = gravity - 386 in x sec^{-2}

v = velocity of the man at the time of impact in x sec^{-1}.

Immediately after the impact, the input energy of the man, U_i is transformed into several energies:

U_L = Energy lost in the impact in form of local deformations and heat

U_R = Energy received by the door assembly

U_M = Energy retained by the man causing the shoulder impact, such that:

$$U_i = U_L + U_R + U_M \ . \ . \ . \ . \ . \ . \ . \ . \ . \ (ii)$$

Considering Rayleigh's Method (4) of energy analysis for a dynamic system, the energy received by the door, U_R, is instantaneously transformed into the kinetic energy accelerating the mass of the door. The kinetic energy, in turn, is reacted by the potential energy developed from the elastic deformation of the door and support structure.

The potential energy acquired by the door in the deformed shape may be expressed in terms of an equivalent spring constant, K (lbs/in), which can be measured for each door configuration at a pre-determined loading point. The potential energy of deformation under dynamic load can be expressed as:

$$U_R = 1/2(K)\ (d_d^2) \ldots\ldots\ldots\ldots \text{(iii)}$$

Where U_R = Potential energy received by the door assembly (in-lb)

K = Equivalent spring constant (lb/in)

d_d = Maximum dynamic deflection of door at loading point (in.)

The equivalent spring constant of the door, K, is measured by determining the deflection, d, of the structure at the predetermined loading point as a function of an applied static load, F_s, such that:

$$K = F_s/d \ldots\ldots\ldots\ldots \text{(iv)}$$

Later in dynamic tests, the dynamic deflections, d_d versus time are recorded by means of an oscillograph at the loading point. Since the values of d_d and K are known, U_R may be determined from the equation (iii). Now we can define an equivalent dynamic force, F_d, such that:

$$F_d = (K)\ (d_d) \ldots\ldots\ldots\ldots \text{(v)}$$

Where F_d represents the force that would deform the door to a potential energy level of U_R, such that:

$$U_R = 1/2(K)\ (d_d^2) = 1/2(F_d)\ (d_d)$$

F_d is the value referred to as <u>dynamic force</u> in the present report and is the load which will be used to conduct static load tests on the door designs.

It should be noted that static tests made, using the values of dynamic force as a static force, were on the safe side due to slightly larger values (in our cases) of allowable stresses that could be applied to materials in general under dynamic loading. Hence, in static tests of door assemblies, the acceptance tests called for using the higher force (dynamic value) in conjunction with the lower strength of the structure.

If the maximum value of test energy applied to cause the door to fail because of a given threat (U_a) is compared to the expected input energy of the man for the same threat (U_i), the building security margin of safety for that threat can be determined. For example:

$$E = \left(\frac{R}{M} - 1\right)100$$

Therefore, when $R = U_a$

$M = U_i$

$$E = \left(\frac{U_a}{U_i} - 1\right)100$$

= Entry security safety margin (%)
20

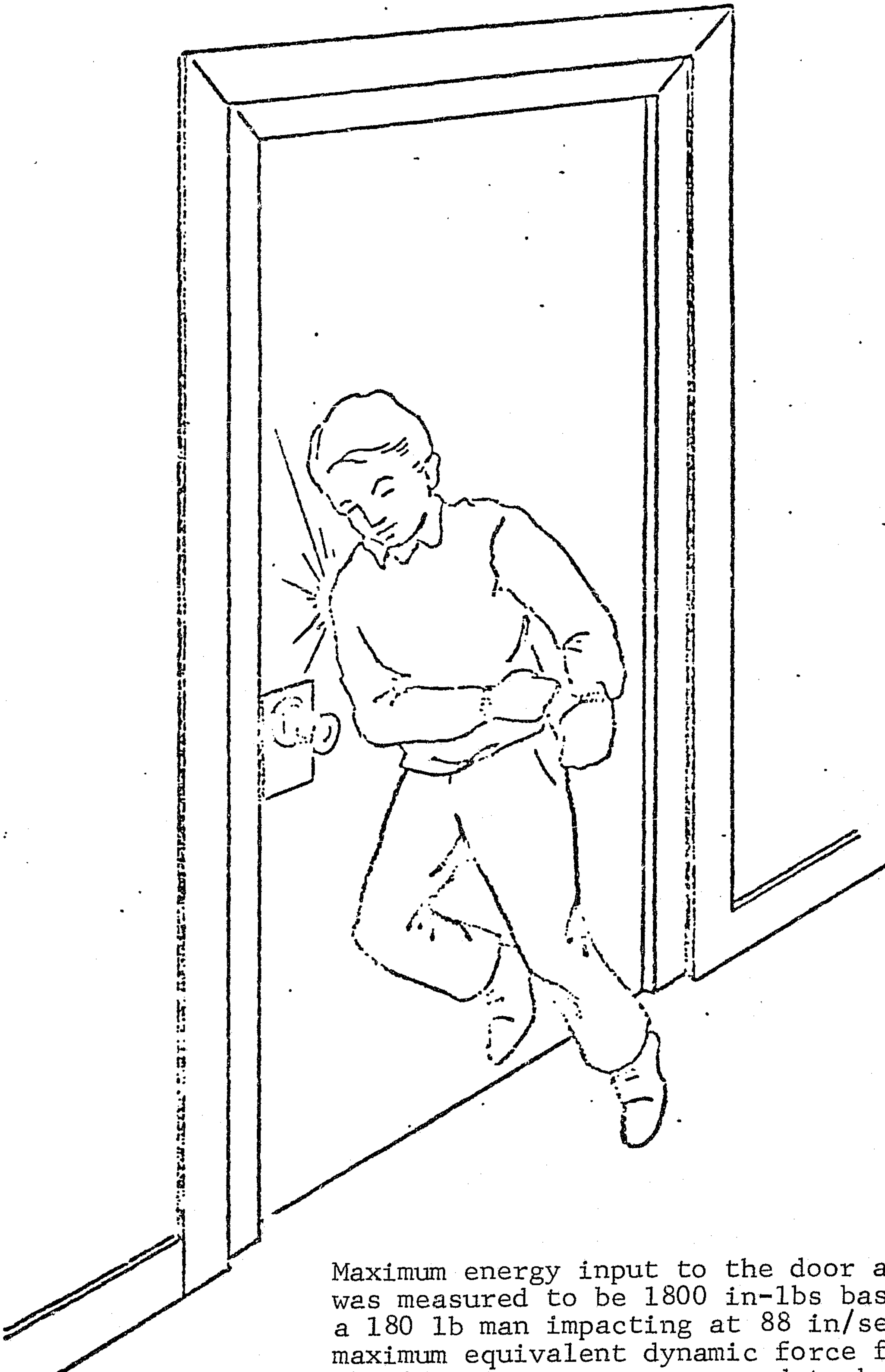
C. Specific Threats

1. Exterior Doors

The common threats subjected to exterior doors by the standard man have been studied and tested in order to quantify them in engineering terms. The objective was to determine the forces or amounts of energy most likely to be deployed in each of the threats. During this phase of the program, the threats investigated and their corresponding values, in terms of forces or energies, were established.

FIGURE 3

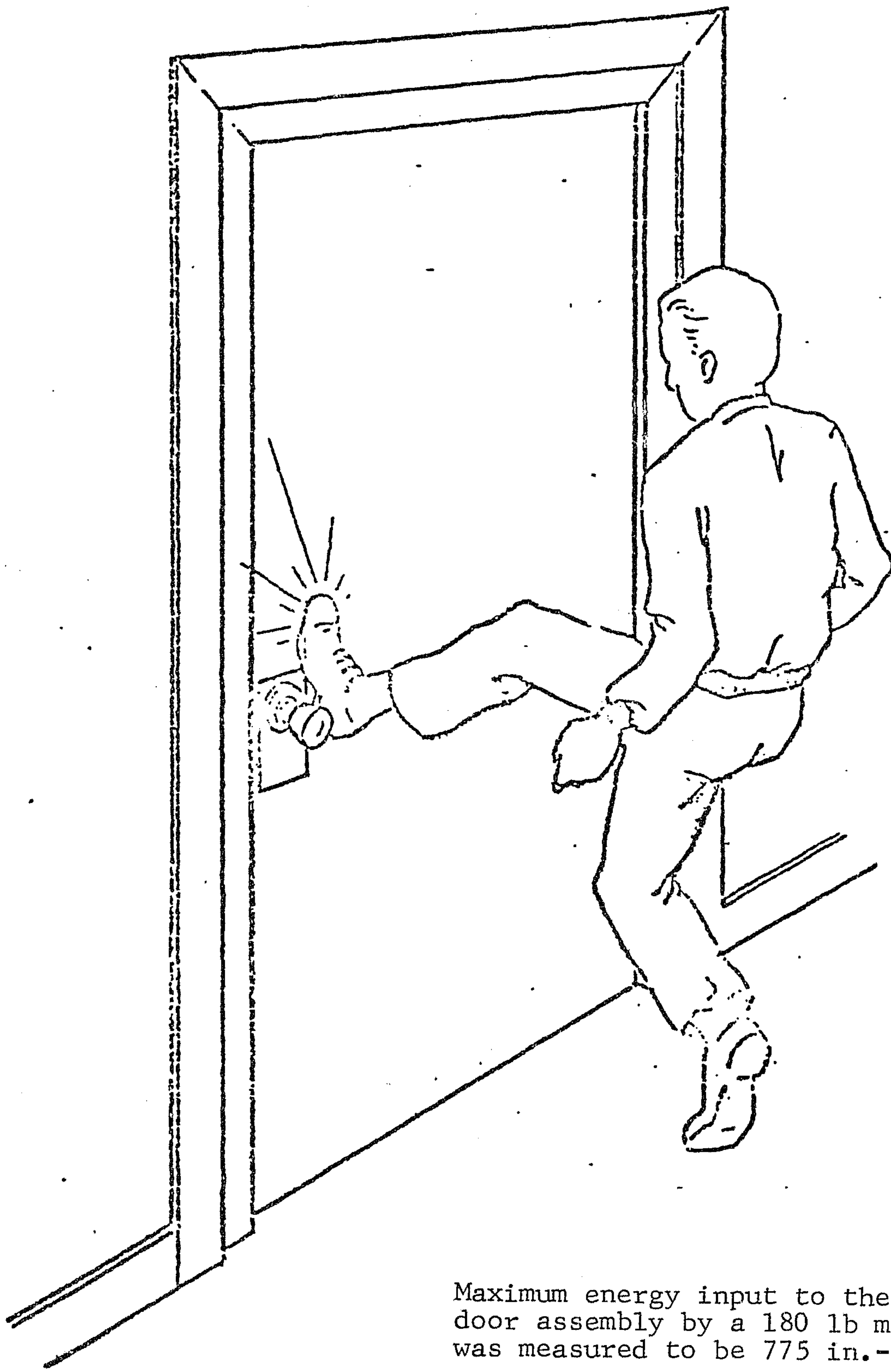
THREAT NO. 1 - SHOULDER IMPACT



Maximum energy input to the door assembly was measured to be 1800 in-lbs based on a 180 lb man impacting at 88 in/sec. The maximum equivalent dynamic force from a shoulder impact was measured to be no greater than 1500 lbs for all types of doors tested.

FIGURE 4

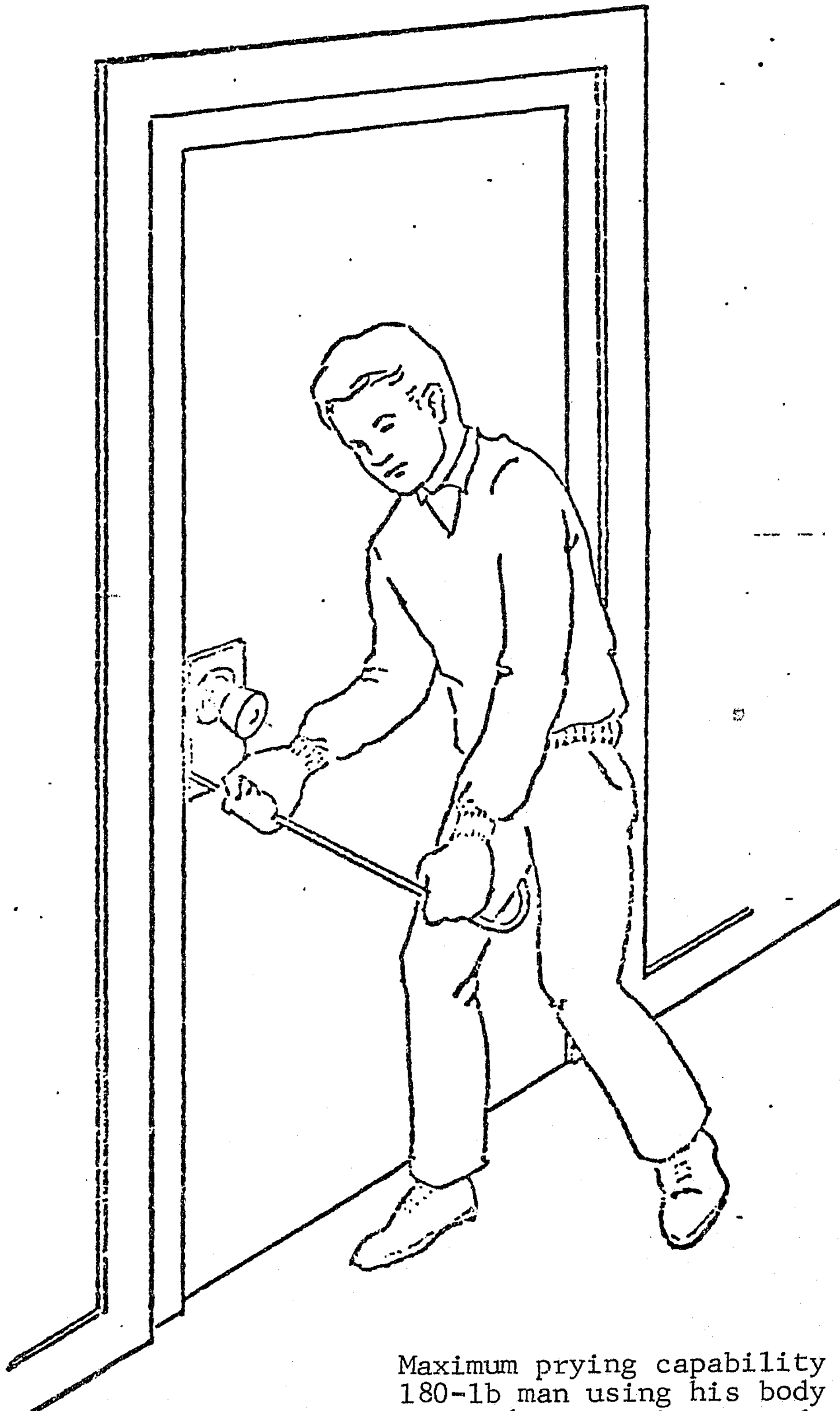
THREAT NO. 2 - FOOT IMPACT



Maximum energy input to the door assembly by a 180 lb man was measured to be 775 in.-lbs.

FIGURE 5

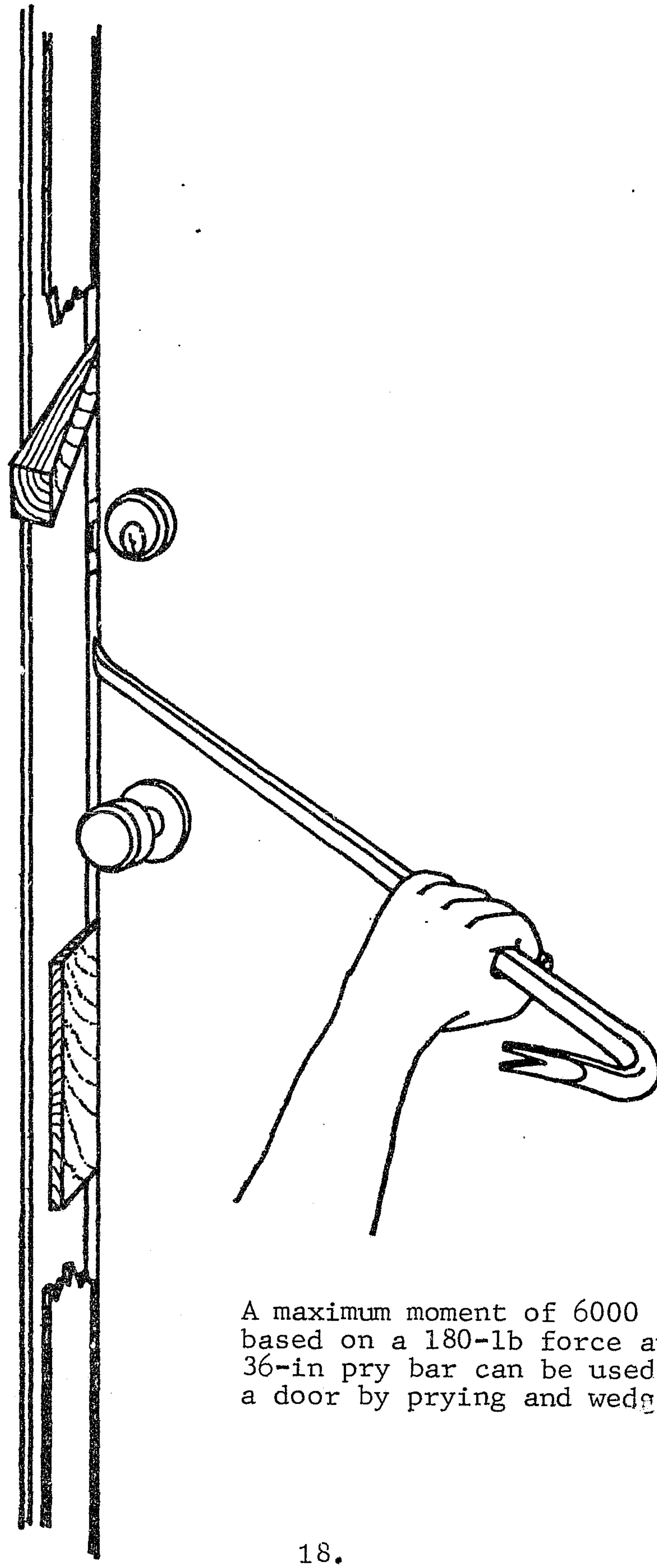
THREAT NO. 3 - PRY BAR (PRYING)



Maximum prying capability of a 180-lb man using his body weight on a 36-in pry bar was determined to be a 6000 in.-lbs moment producing a 3000 lb force.

FIGURE 6

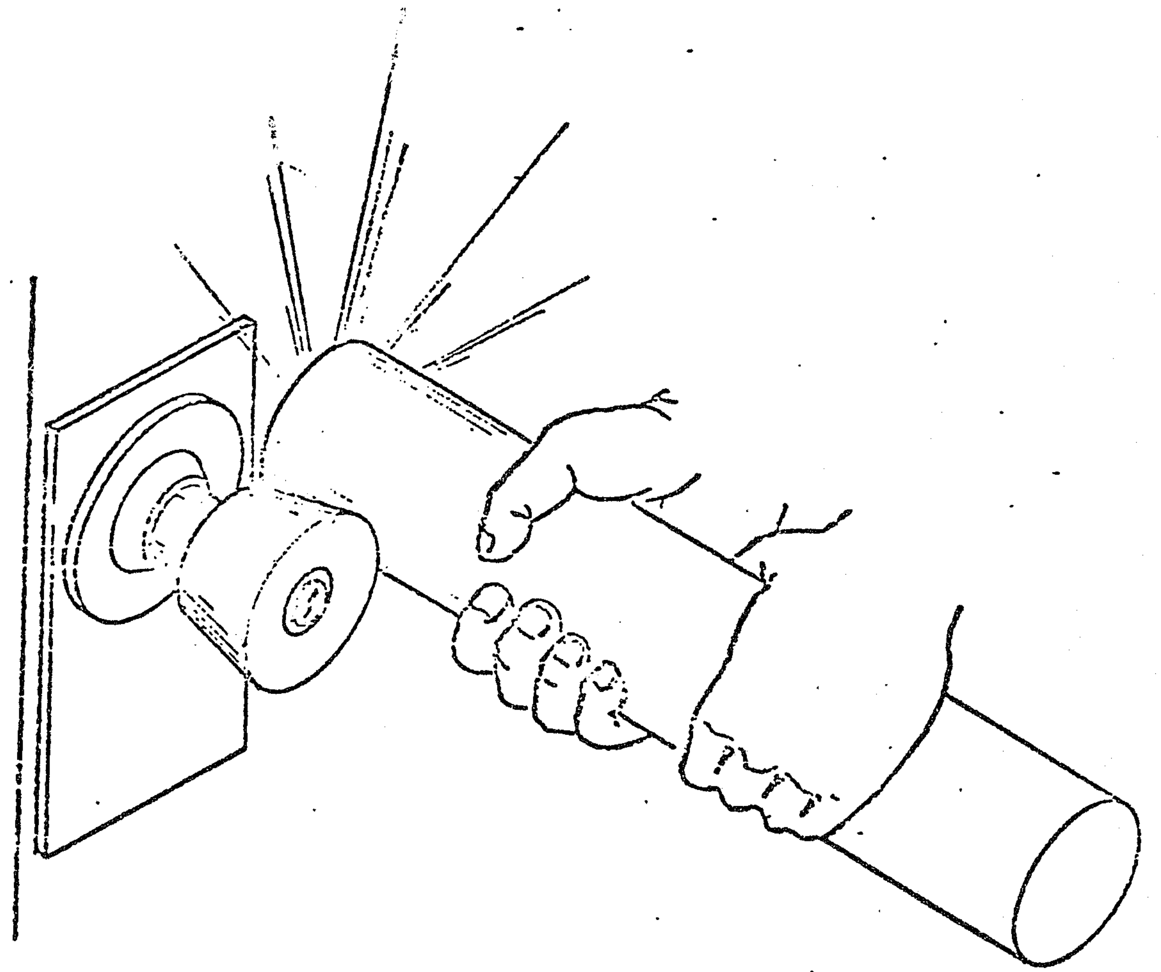
THREAT NO. 4 - PRYING AND WEDGING



A maximum moment of 6000 in.-lb based on a 180-lb force and a 36-in pry bar can be used to jimmy a door by prying and wedging.

FIGURE 7

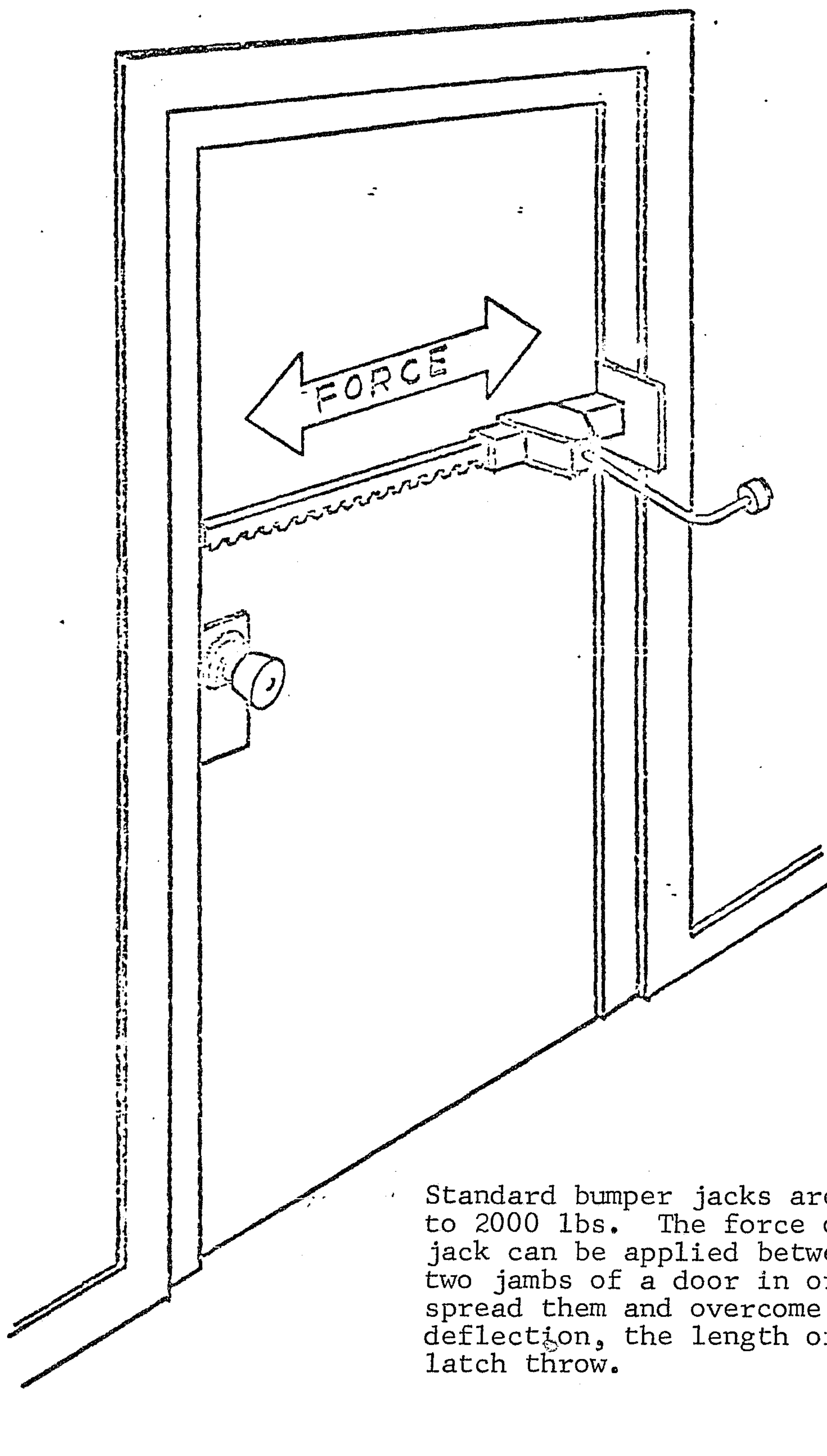
THREAT NO. 5 - (16-LB) BATTERING RAM



Considering a 15-lb steel bar as being a typical ram, the maximum energy input to a door assembly or a lock assembly was determined to be 1050 in.-lbs.

FIGURE 8

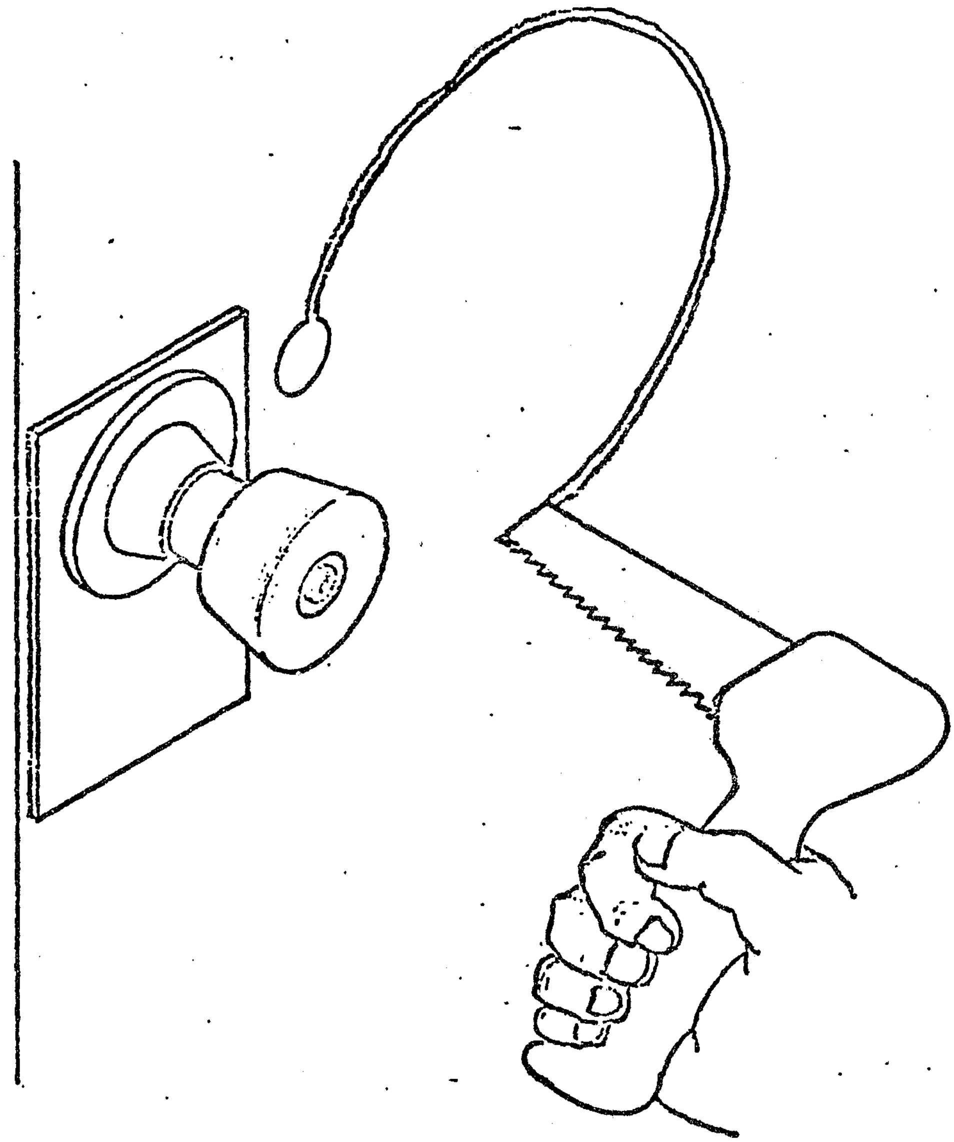
THREAT NO. 6 - BUMPER JACK SPREADER



Standard bumper jacks are rated to 2000 lbs. The force of the jack can be applied between the two jambs of a door in order to spread them and overcome, by deflection, the length of the latch throw.

FIGURE 9

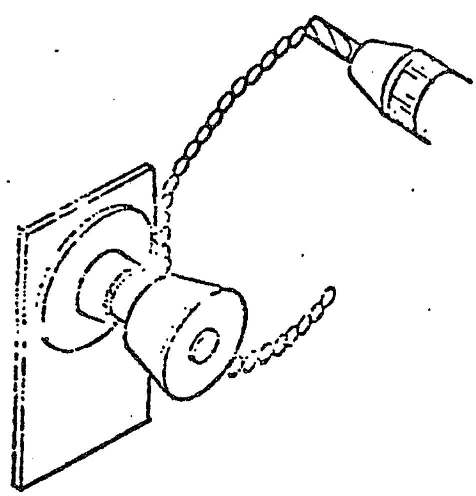
THREAT NO. 7 - SAWING



A brace and bit and a key hole saw can be used to cut an access hole in a door. The cutting force used on the saw is 26 lbs.

FIGURE 10

THREAT NO. 8 - DRILLING



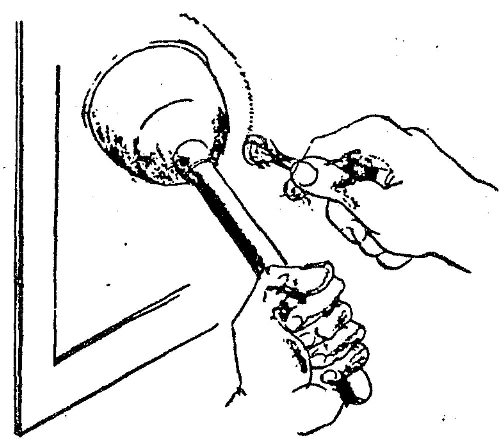
A hand or electric drill with 50 lbs of thrust applied can be used to drill a series of holes for an access hole in a door.

FIGURE 11

2. Glass Systems

The threats subjected to the glazing system of exterior doors and windows are as follows:

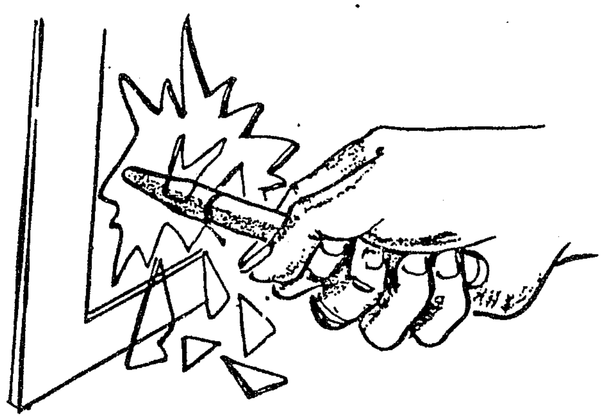
THREAT NO. 9 - GLASS CUTTER



An access hole can be cut with a glass cutter and a rubber plunger.

FIGURE 12

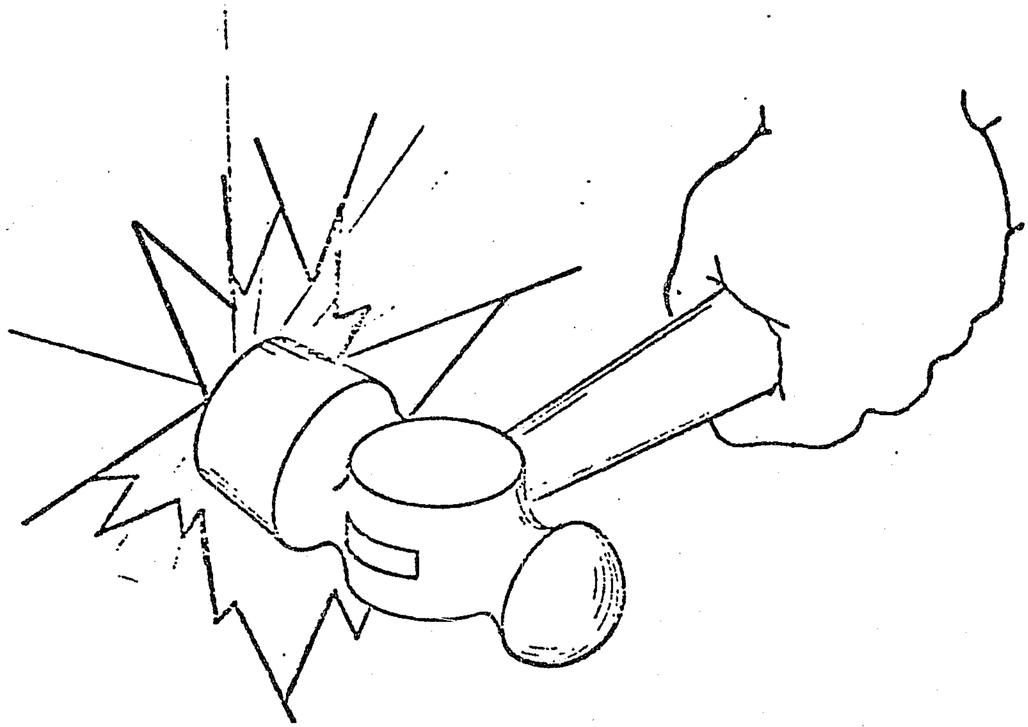
THREAT NO. 10 - SPRING LOADED PUNCH



A spring loaded punch can be used to fracture tempered glass and allow access.

FIGURE 13

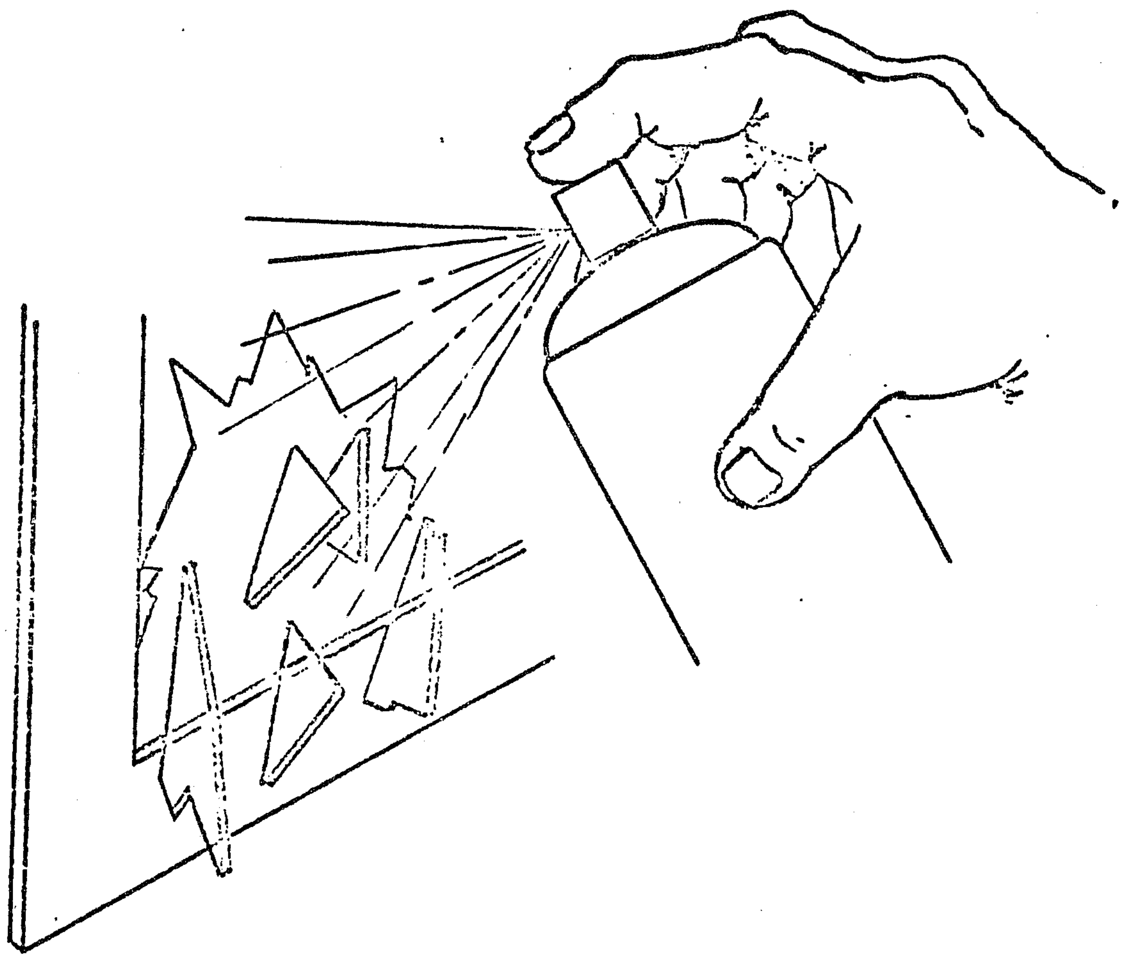
THREAT NO. 11 - HAMMER IMPACT



A man swinging a 1-lb hammer was measured to be able to apply a maximum energy input of 170 in.-lbs impact to a glazing system.

FIGURE 14

THREAT NO. 12 - THERMAL SHOCK



Liquid nitrogen can subject a freezing temperature of -320°F to the glazing resulting in shattering.

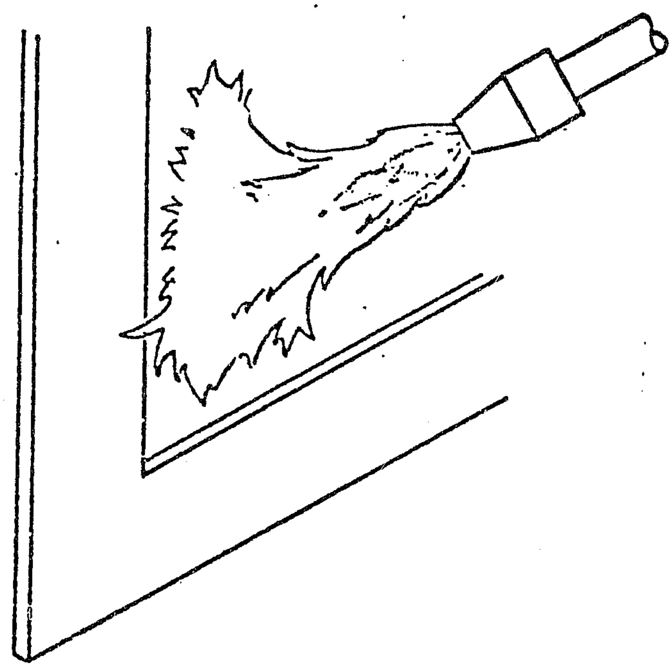
FIGURE 15

THREAT NO. 13 - THROWN MISSILE

A missile in the form of a brick can be used to fracture a glazing panel. The maximum input energy was measured to be 4200 in.-lbs.

FIGURE 16

THREAT NO. 14 - THERMAL SHOCK



A propane air torch can subject a maximum flame temperature of 3600°F to the glazing.

3. Lock Systems

The key or combination operated component in a locking system is vulnerable to attack in three fundamental ways:

a. circumvention

b. force

c. manipulation

Using these techniques our research on locks has indicated that there are at least 50 different ways to defeat common locking devices (5). Standards developed by the research program were directed toward the most common techniques employed under actual situations by burglars in California. It is recognized that any locking system can be defeated given time and proper circumstances.

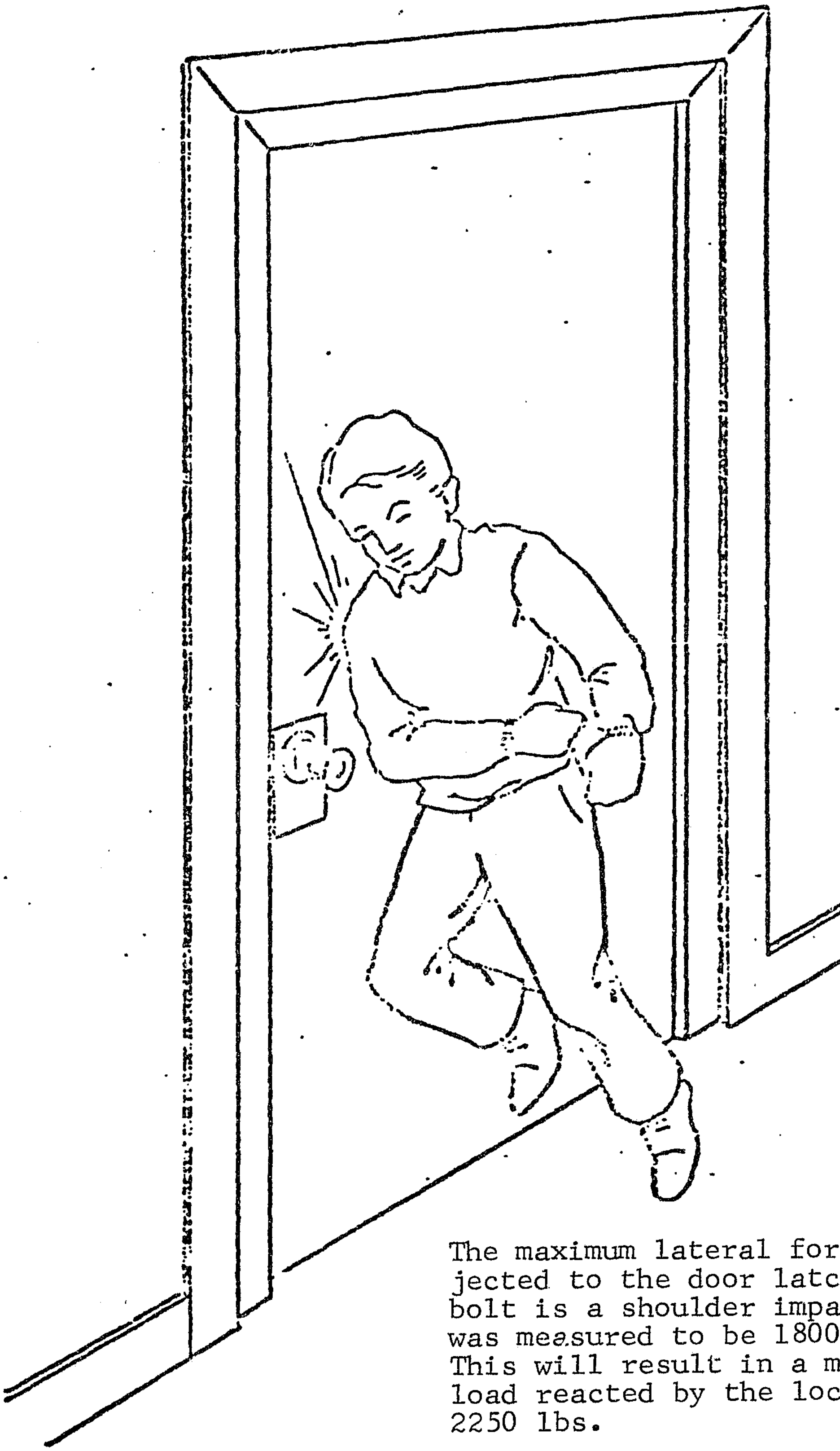
Key operated and combination locks vary greatly in their resistance to attack. For example, locks employing the same basic design principles as high security locks can use materials and manufacturing techniques which make them more susceptible to attack. Many locks can be defeated by simple prying tools, a few hammer blows, or quickly opened with simple manipulation tools (lock picks, try-out keys, manipulation keys, etc.). Many combination locks only have two tumblers (wheels) that can be operated by running through a very few combinations.

This report does not discuss specific lock manipulation threats in detail. However, approximately 20 different manipulation techniques (5), many of which present similar engineering problems, have been considered. The employment of specific design practices cannot totally protect against manipulation threats. However, considerable time may be required to defeat a lock, depending on the level of skill possessed by the operator and the resistance characteristics of the lock. Some of the more common manipulation threats are shimming, picking, rapping, impressioning, gunning, decoding, try-out and manipulation keys.

The burglary threats most commonly applied to door locks are:

FIGURE 17

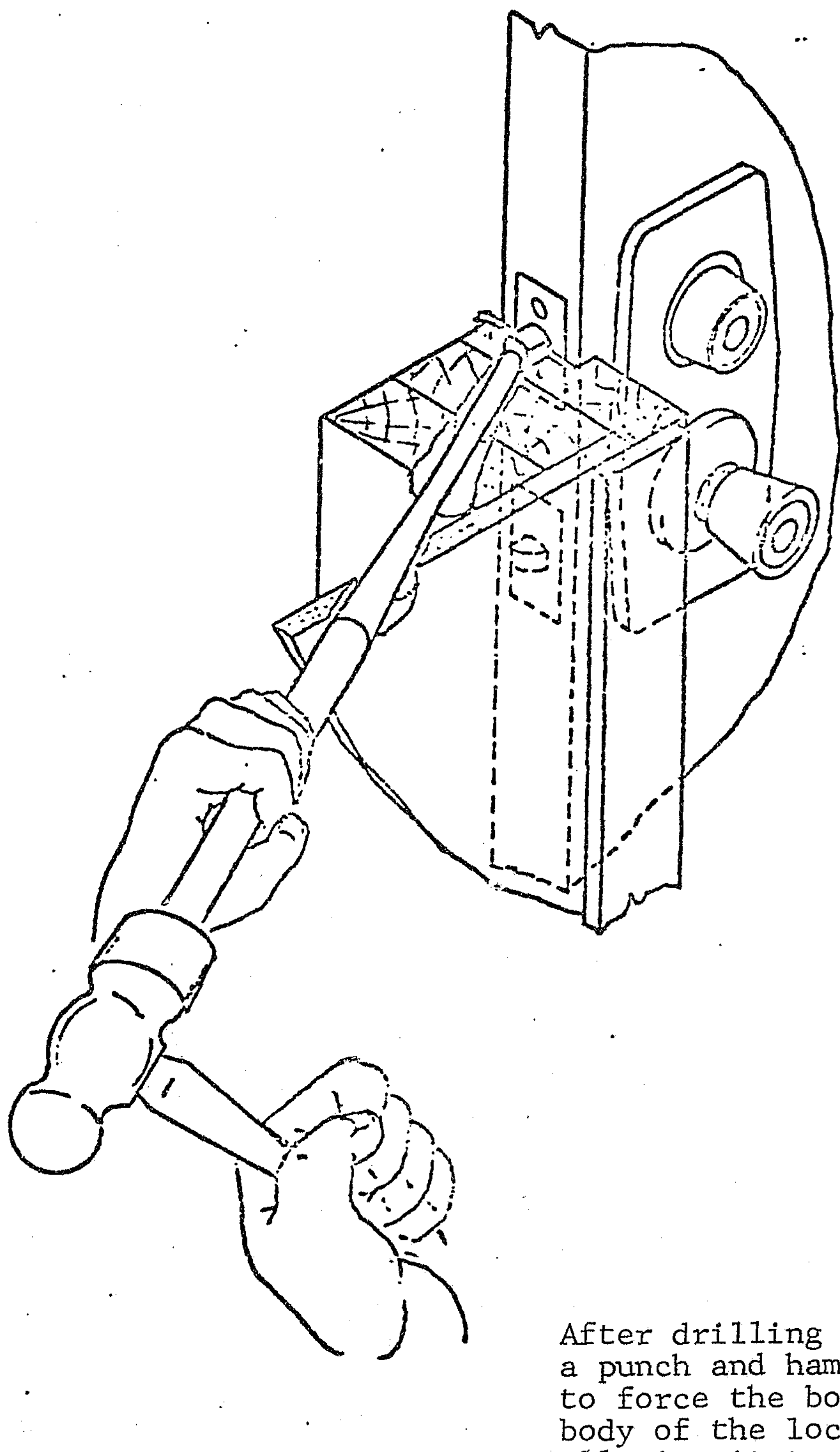
THREAT 15 - SHOULDER IMPACT



The maximum lateral force subjected to the door latch or bolt is a shoulder impact which was measured to be 1800 in.-lbs. This will result in a maximum load reacted by the lock of 2250 lbs.

FIGURE 18

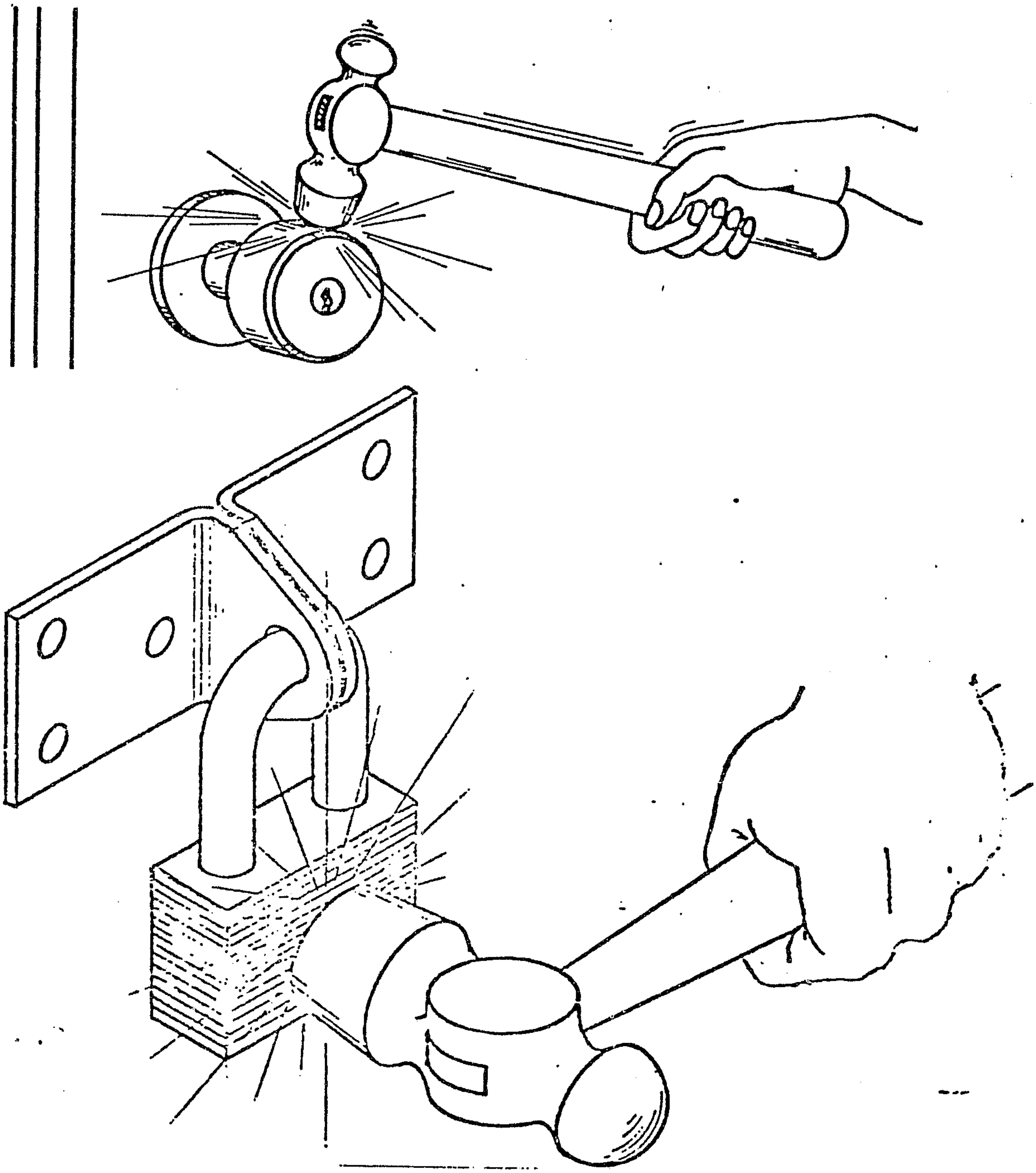
THREAT NO. 16 - DRIFT PUNCH AND HAMMER



After drilling an access hole, a punch and hammer can be used to force the bolt back into the body of the lock; thereby allowing it to clear the striker. The maximum load that can be applied is 170 in.-lbs of energy with a 1-lb hammer.

FIGURE 19

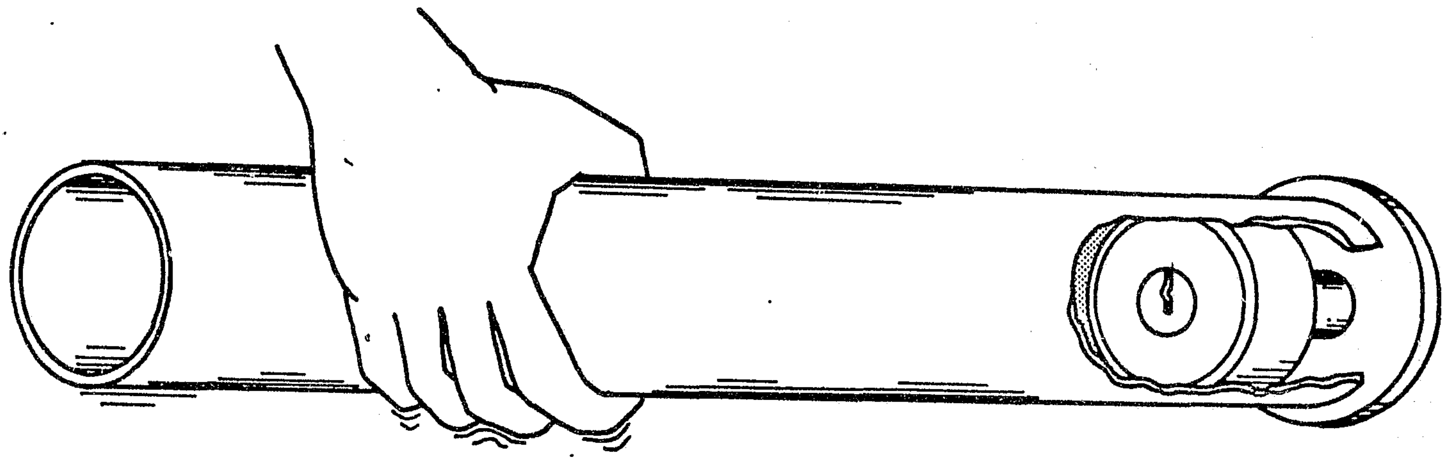
THREAT 17 - HAMMER IMPACT



A man swinging a 1-lb hammer can apply an energy input of 170 in.-lbs per blow to a lock in a door or a padlock.

FIGURE 20

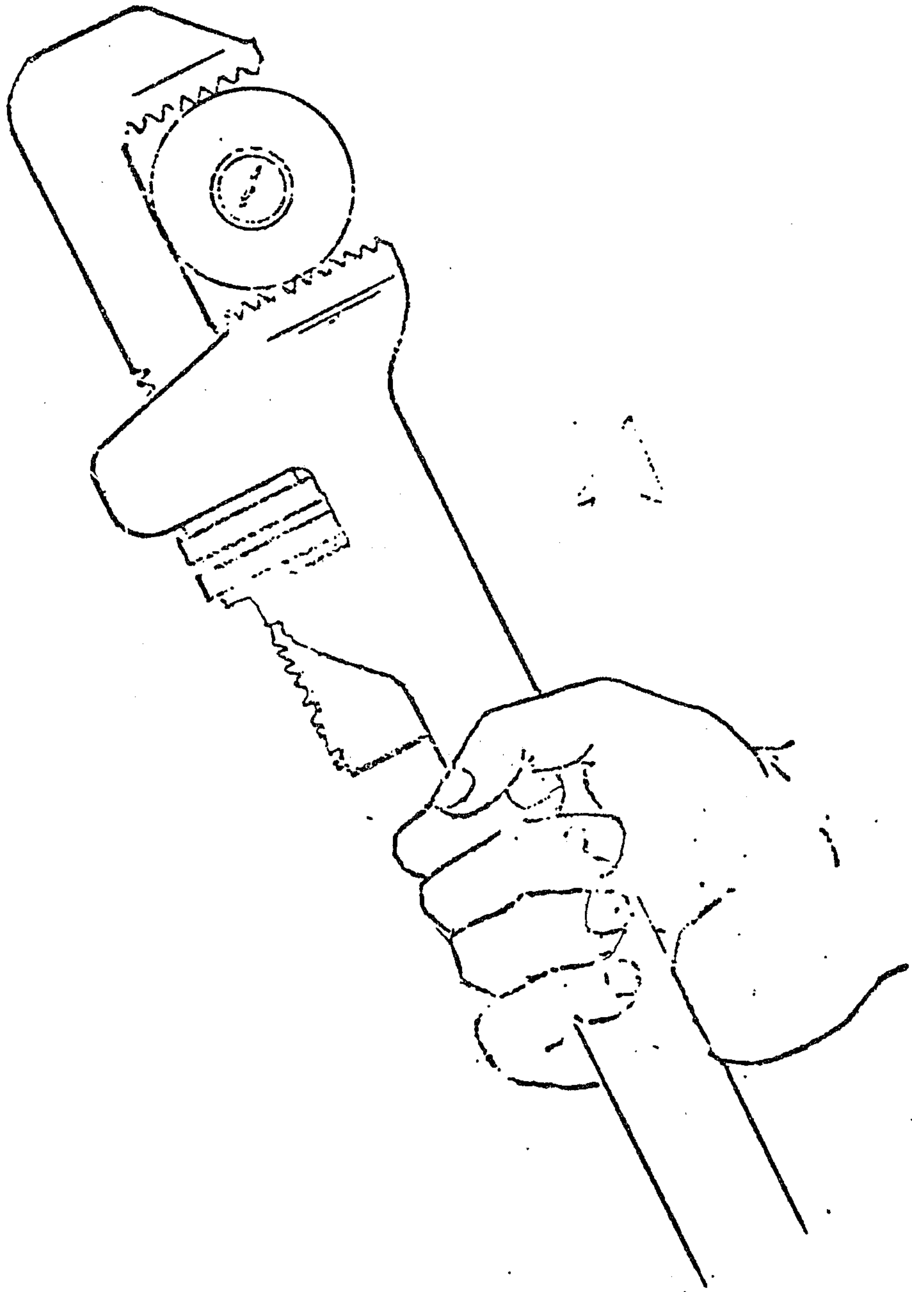
THREAT NO. 18 - PIPE ON DOORKNOB



A bending load can be applied to a doorknob or a door handle by slipping a length of pipe over the knob or through the handle. The maximum moment that can be applied is 3300 in.-lbs.

FIGURE 21

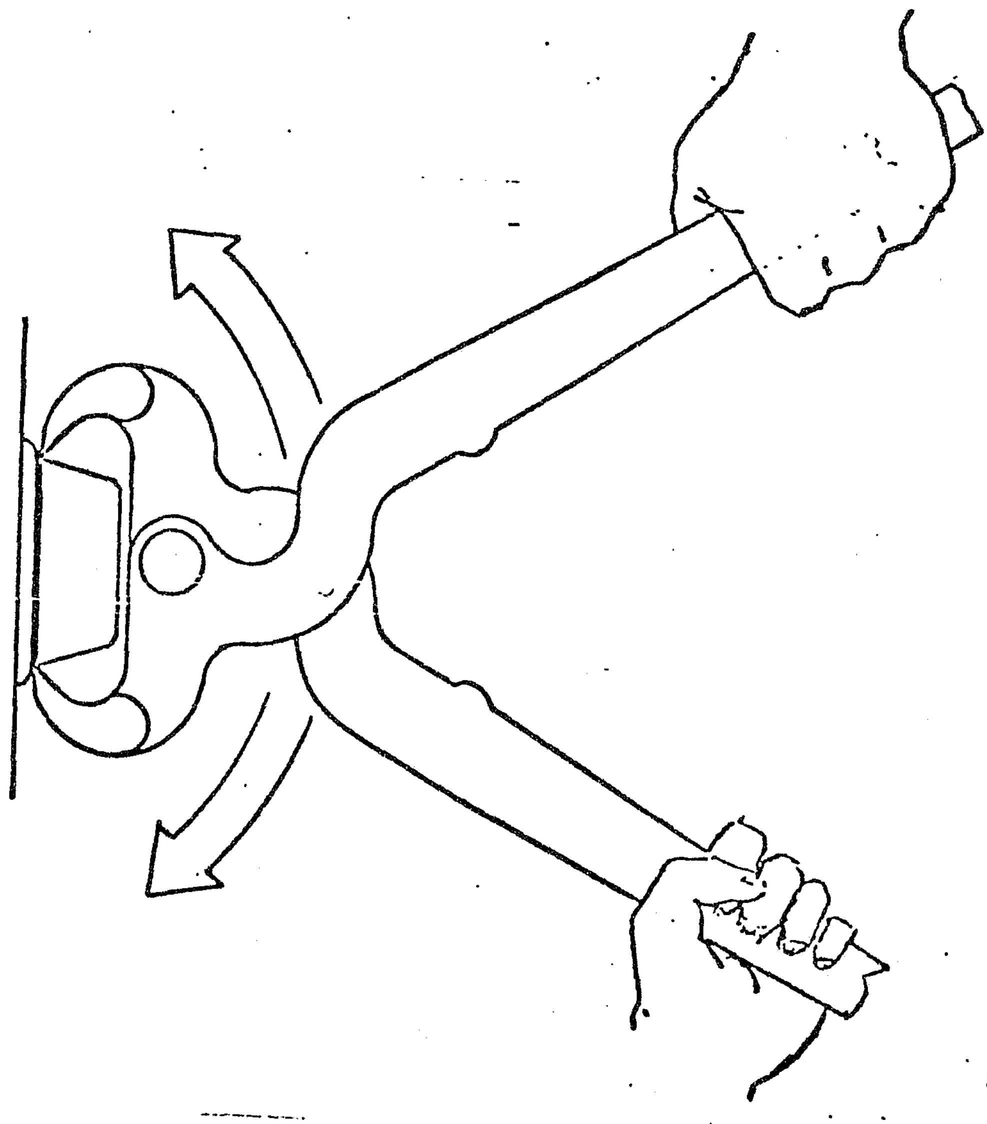
THREAT NO. 19 - PIPE WRENCH



With an 18-inch long pipe wrench (the maximum size considered easily concealable), a maximum torque of 3,300 in.-lbs can be applied to a doorknob or protruding deadbolt cylinder housing.

FIGURE 22

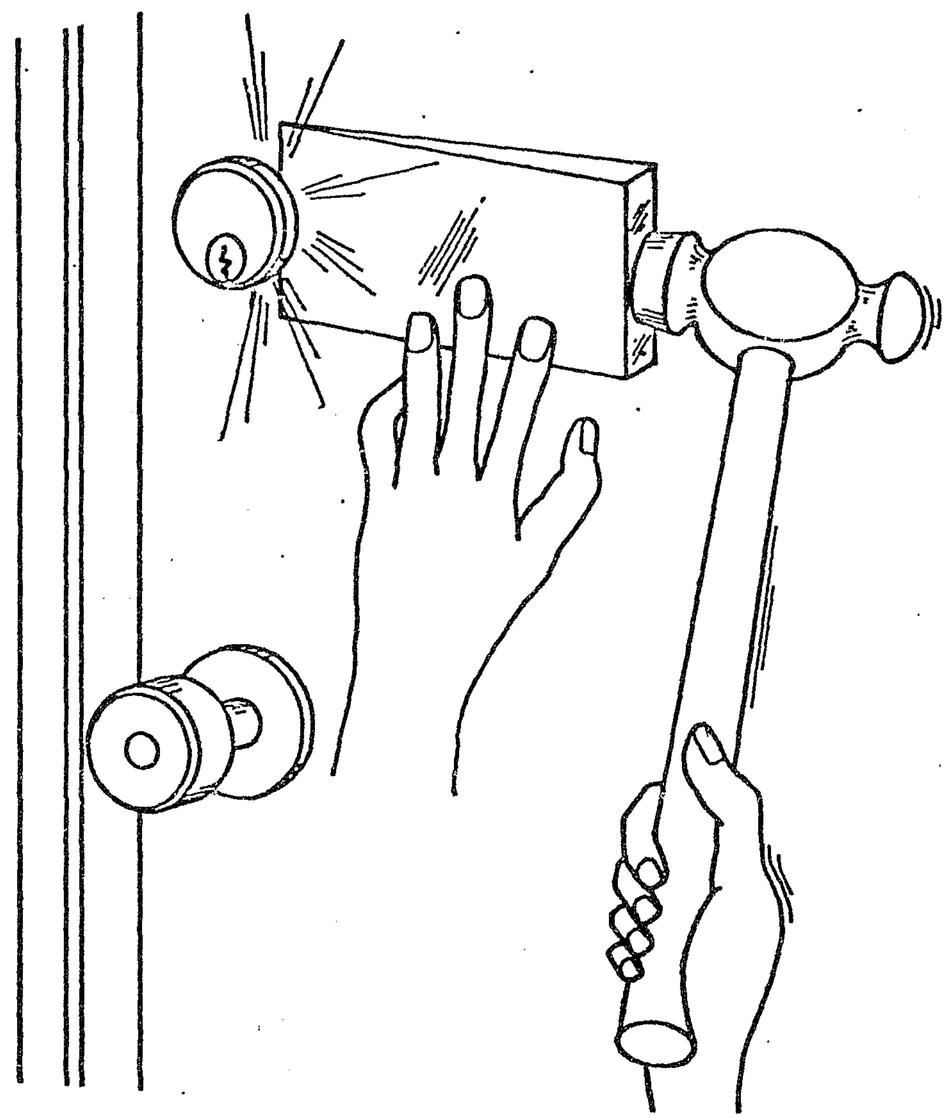
THREAT NO. 20 - MODIFIED HOOF NIPPER



A prying load can be applied to a protruding deadbolt lock cylinder housing or knob lock rose by a modified hoof nipper (ground for wider opening).

FIGURE 23

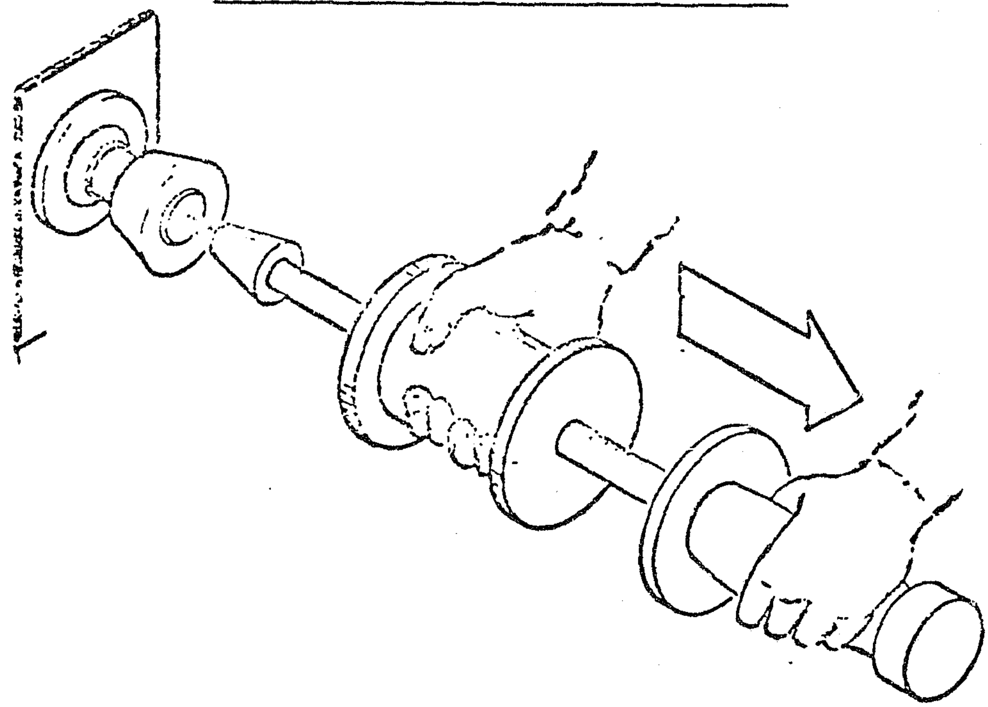
THREAT NO. 21 - PRYING OR WEDGING

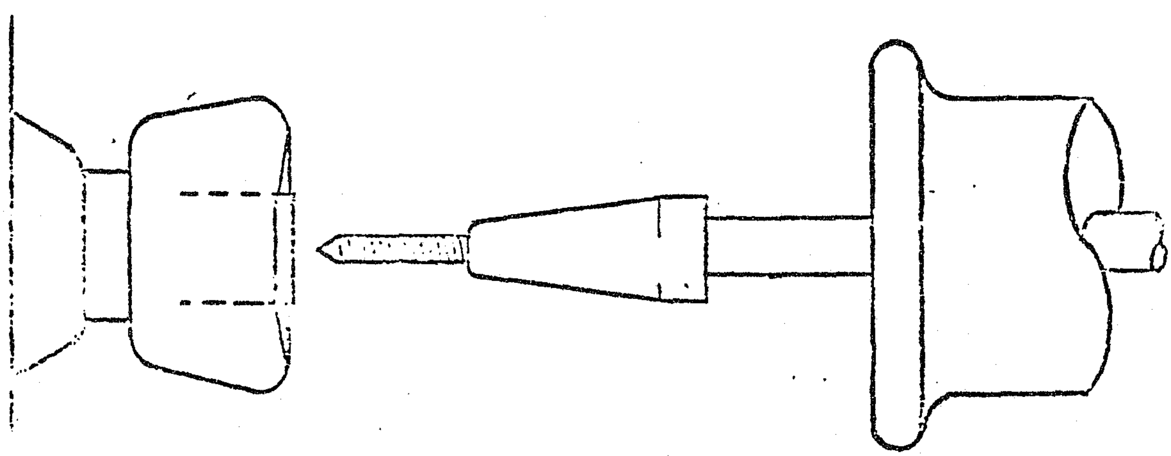


A prying load can be applied to a protruding deadbolt lock cylinder housing or knob lock rose by a steel wedge (chisel) or a pry bar. The maximum compressive wedging force which can be applied is 300 lbs.

FIGURE 24

THREAT NO. 22 - DYNAMIC PULLER

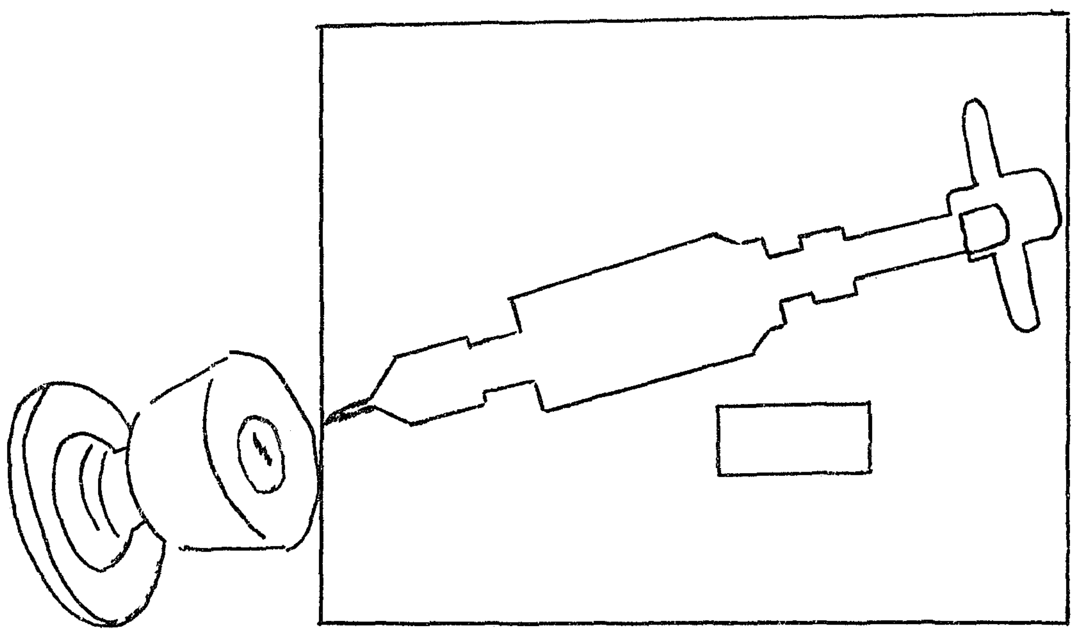




The "slide hammer" or "dent puller" is commonly sold for use in automobile body repair. It also serves as a tool to pull the plug or lock cylinder out of the lock body or housing, exposing the internal mechanism for operation by finger or screwdriver. With this tool, a hardened self-tapping screw is engaged fully in the lock dylinder's keyway. Tensile impact energy as great as 120 in.-lbs can be applied by operating the tool in its intended manner (2-1/2 lbs moving weight traveling 8 inches).

FIGURE 25

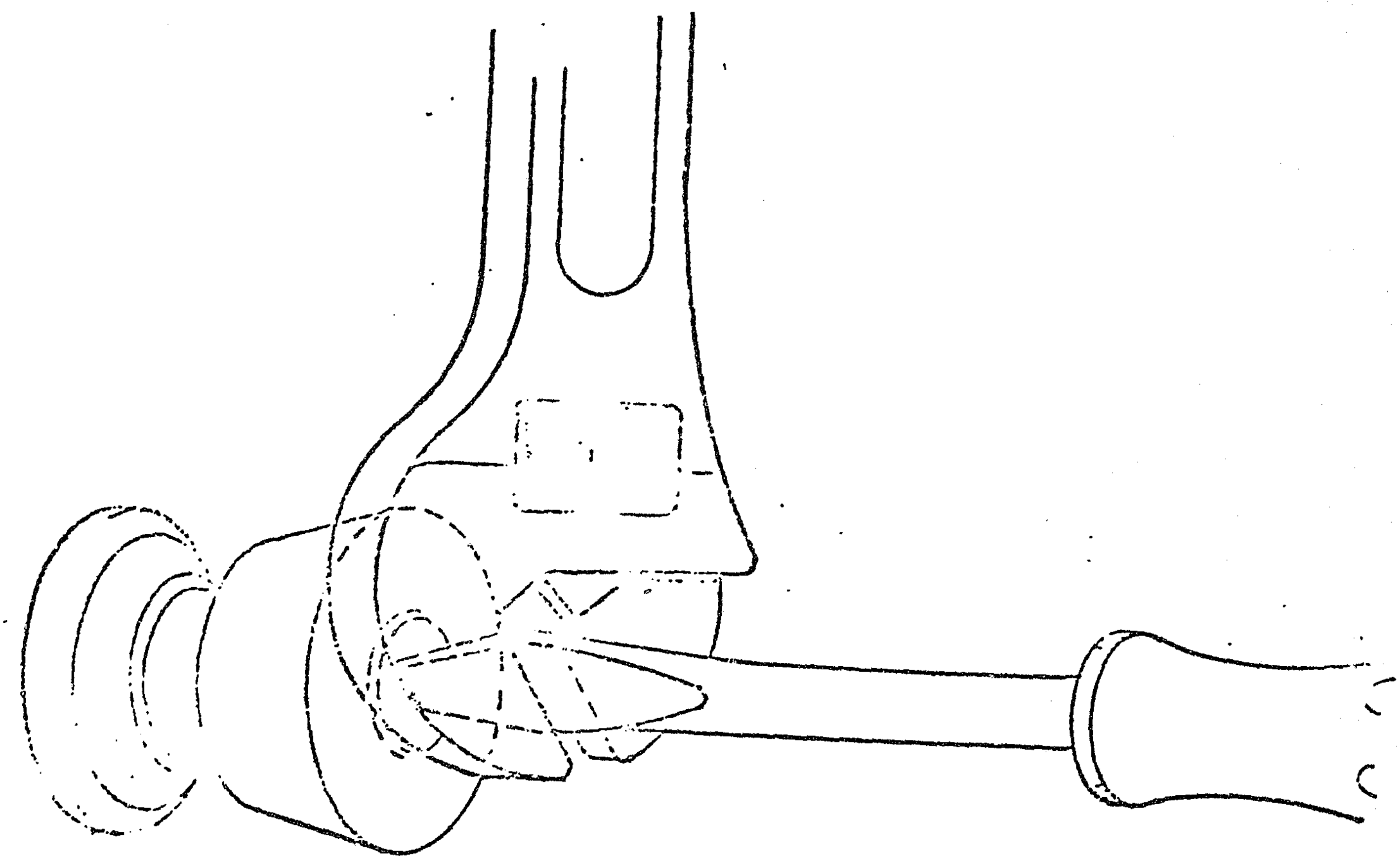
THREAT NO. 23 - STATIC PULLER



A tensile "puller" type tool made from a drill chuck, socket wrench and threaded shaft can be used to pull a lock plug or cylinder out of a lock housing. The maximum tensile force that can be applied is 2350 lbs.

FIGURE 26

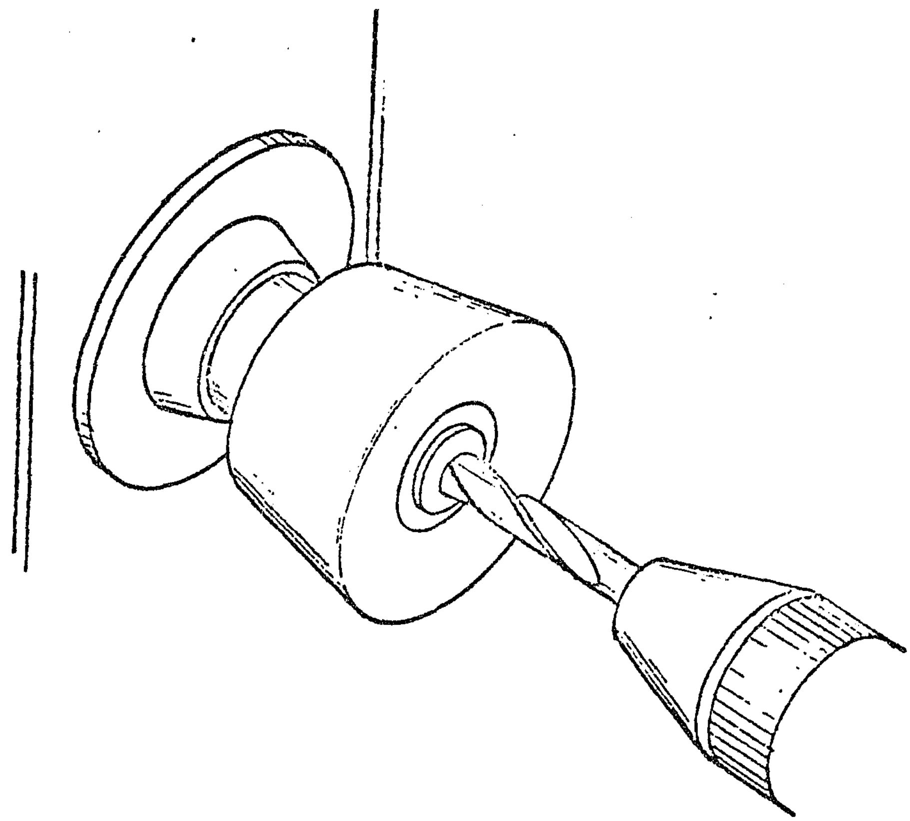
THREAT NO. 24 - SCREWDRIVER AND WRENCH



With a screwdriver (faces ground parallel) inserted in the key slot, a torque as great as 600 in.-lbs can be applied by using an adjustable wrench.

FIGURE 27

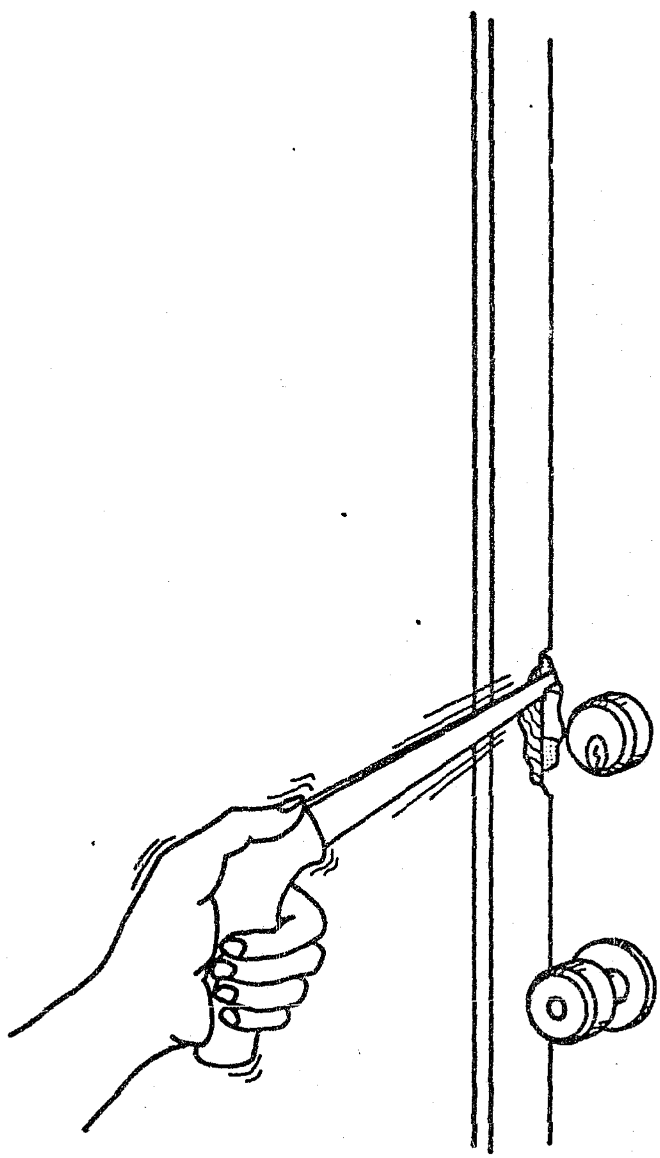
THREAT NO. 25 - DRILLING



A hand or electric drill may be used to drill a hole through the face of the lock cylinder to destroy the tumblers or drivers and allow operation of the lock. Also drilling an access hole through a padlock case may allow manipulation of the locking mechanism. The maximum thrust applied during the drilling of a lock is 50 lbs.

FIGURE 28

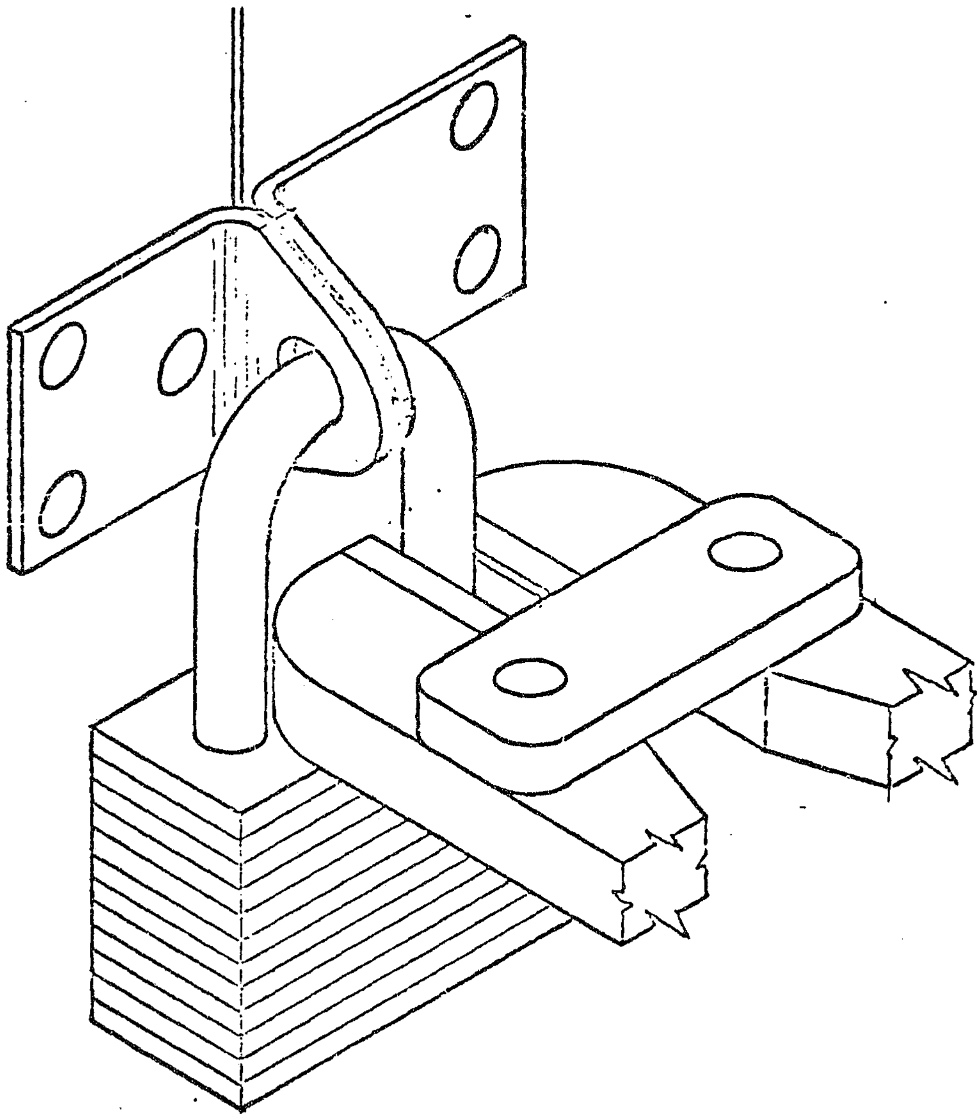
THREAT NO. 26 - SAWING



A hacksaw blade or keyhole hacksaw may be used to saw a deadbolt or a latchbolt if it is inserted between the door and the door jamb. Also, a hacksaw may be used to saw a padlock shackle. The maximum force applied during the sawing of a lockbolt or lock shackle with a hand hacksaw is 26 lbs.

FIGURE 29

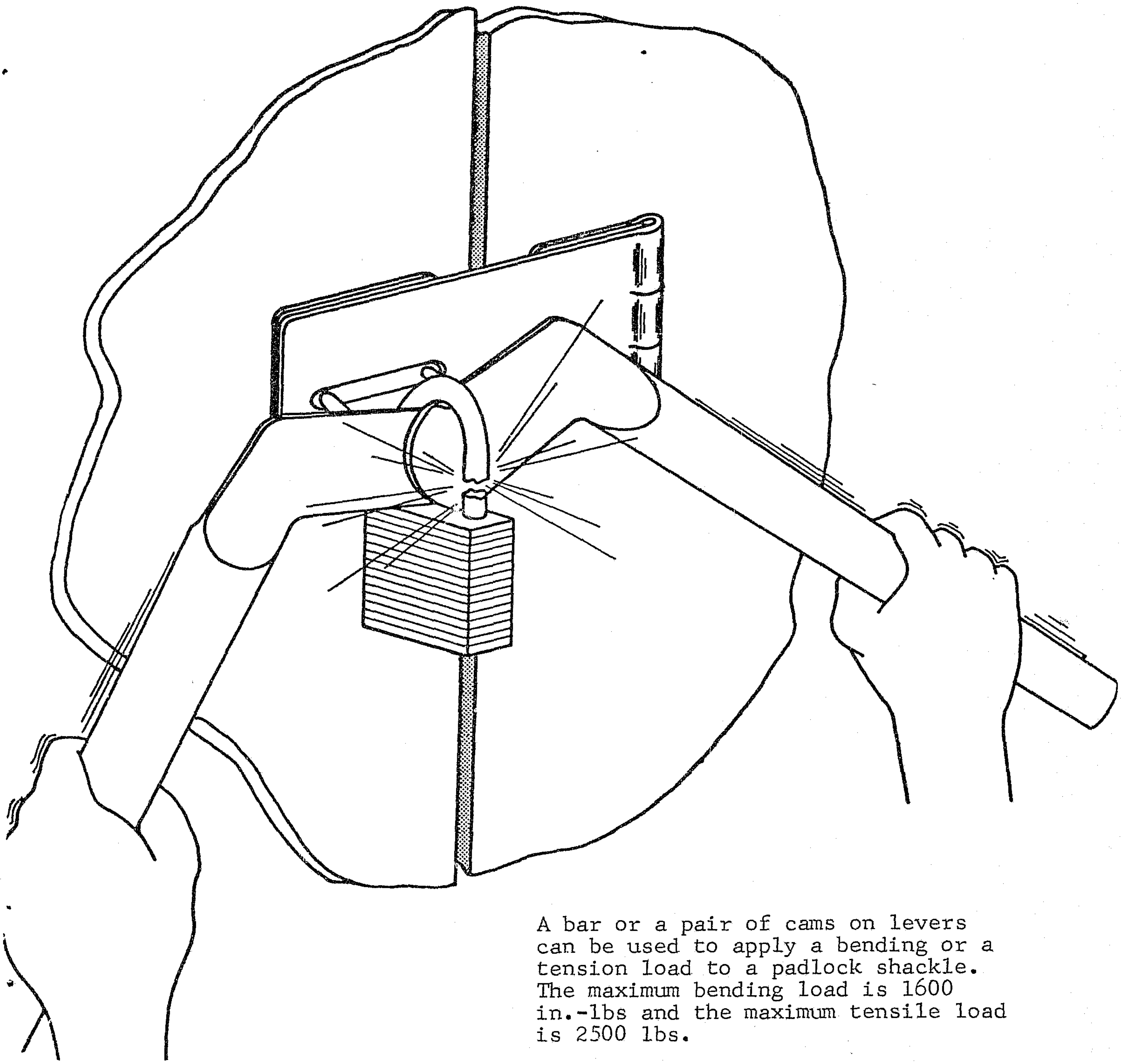
THREAT NO. 27 - BOLT CUTTER



A bolt cutter can be used to cut a padlock shackle. The maximum blade cutting force is 32,600 lbs for 180 lbs handle force.

FIGURE 30

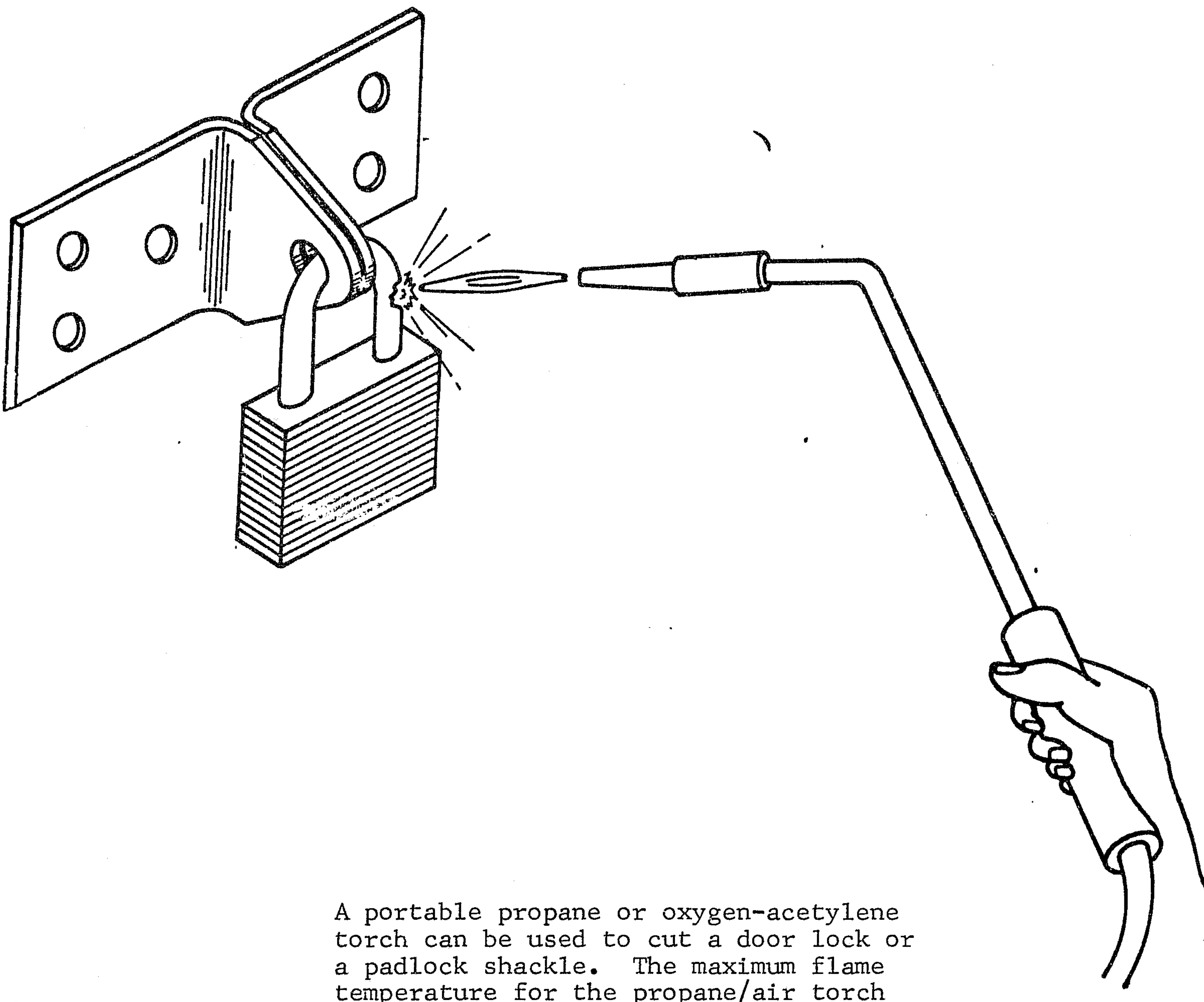
THREAT NO. 28 - SHACKLE PRYING



A bar or a pair of cams on levers can be used to apply a bending or a tension load to a padlock shackle. The maximum bending load is 1600 in.-lbs and the maximum tensile load is 2500 lbs.

FIGURE 31

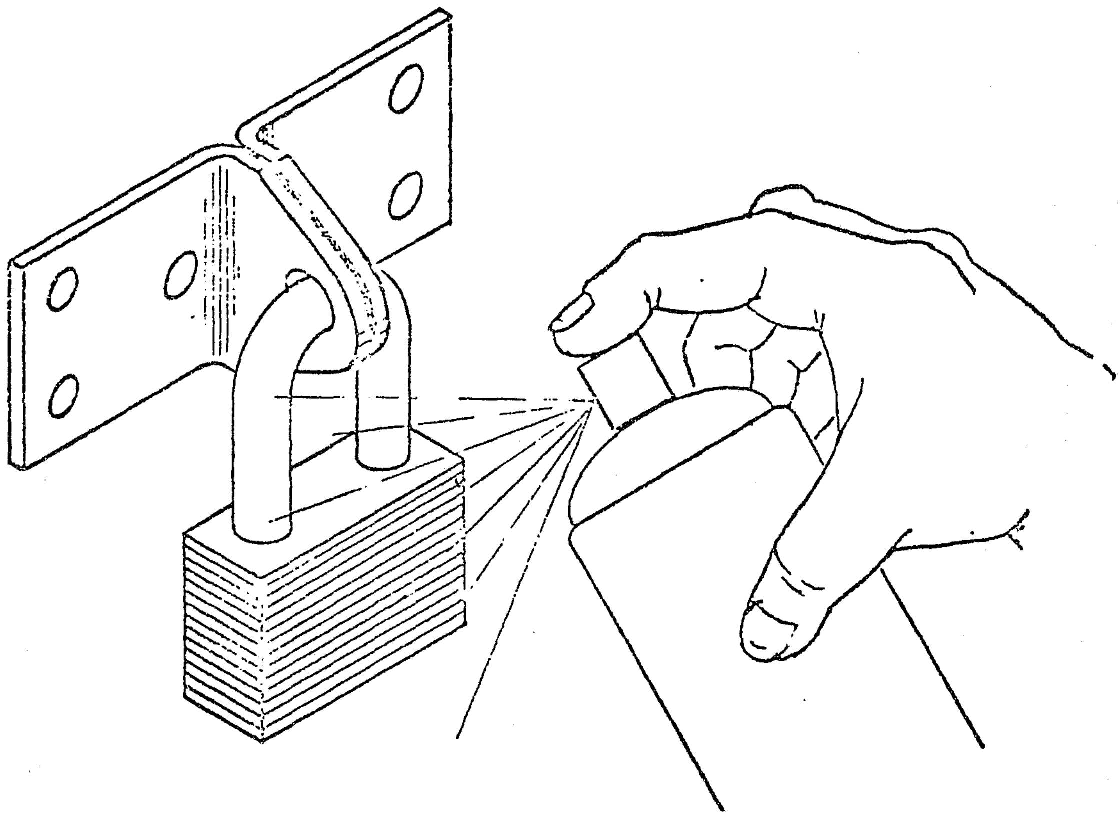
THREAT NO. 29 - TORCH



A portable propane or oxygen-acetylene torch can be used to cut a door lock or a padlock shackle. The maximum flame temperature for the propane/air torch is 3600°F and for the oxygen/acetylene torch approximately 6000°F.

FIGURE 32

THREAT NO. 30 - FREEZING

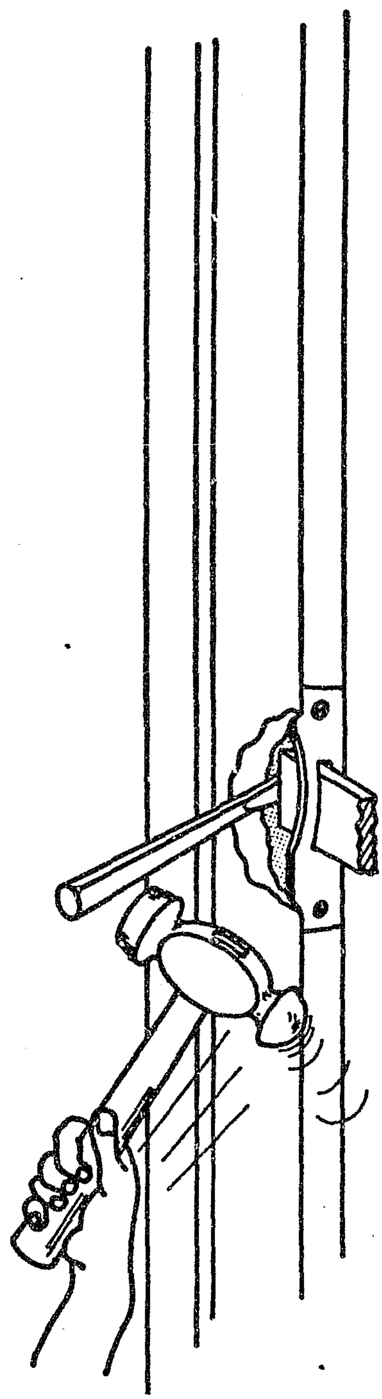


Liquid Freon, propane and nitrogen can be used to freeze a lock and make it susceptible to brittle fracture under the impact of a hammer. The temperatures of the liquids at atmospheric pressure are:

Freon 22	-45°F
Propane (C_3H_8)	-48°F
Nitrogen	-320°F

FIGURE 33

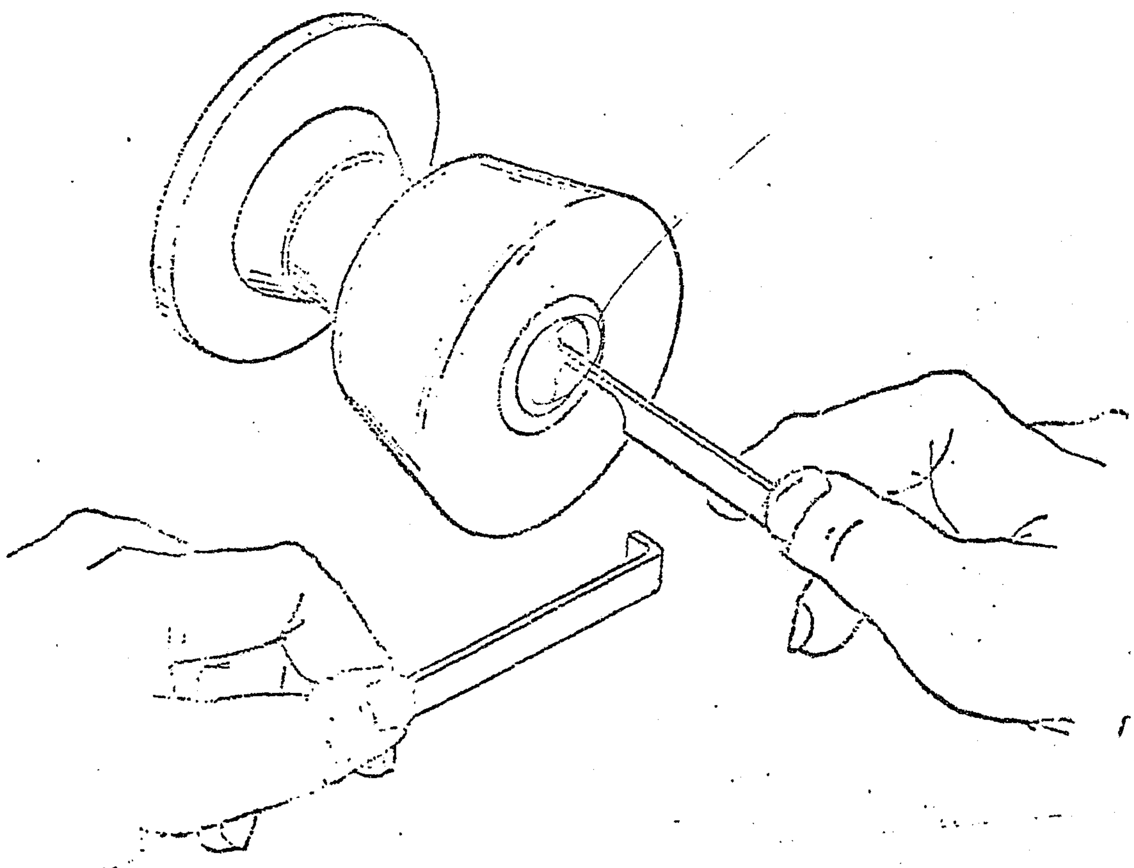
THREAT NO. 31 - JIMMY DEADBOLT



A chisel and hammer can be used to attain access behind a deadbolt strike plate. The prying impact load on the deadbolt is 170 in.-lbs.

FIGURE 34

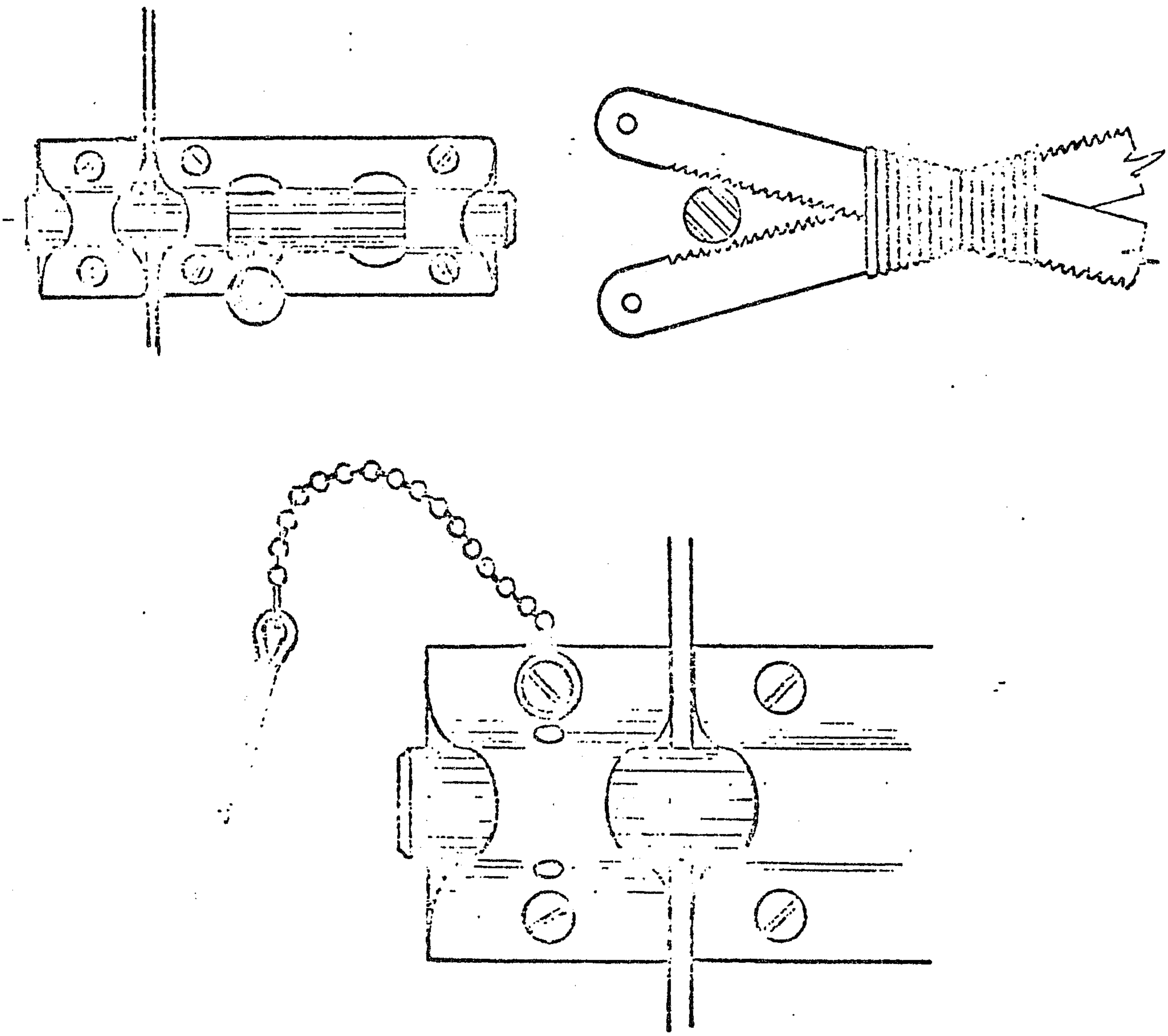
THREAT NO. 32 - LOCK PICKING



A lock cylinder may be picked with lock-picking tools, shimming, impressioning, a picking gun, decoding and try-out and manipulation keys.

FIGURE 35

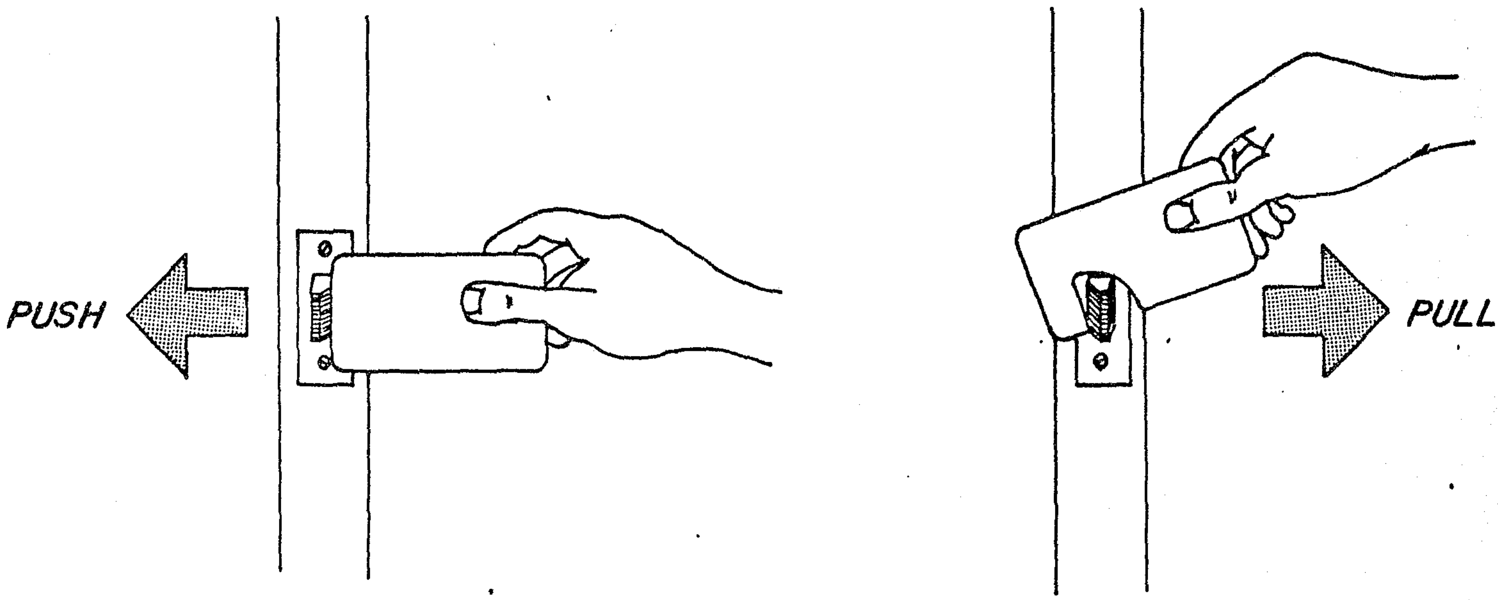
THREAT NO. 33 - HACKSAW BLADE



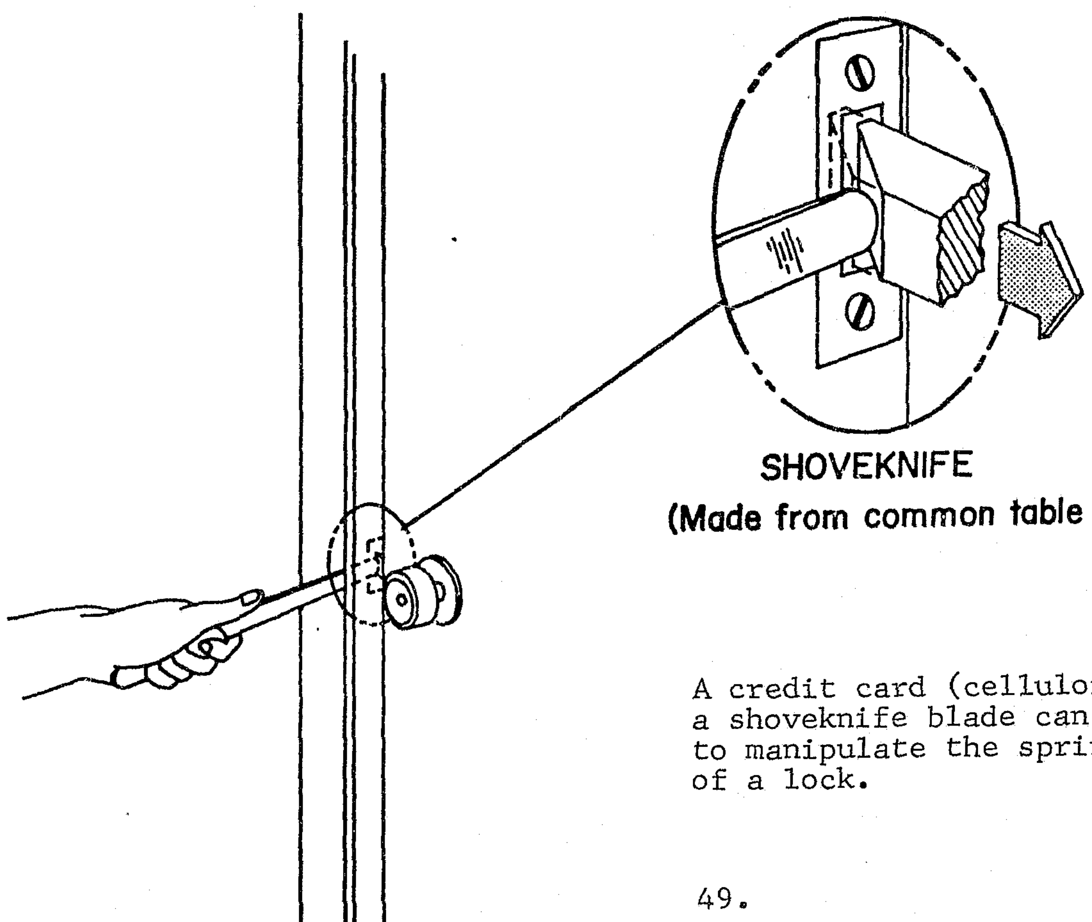
After the molding strip is removed or pried away, a hacksaw blade can be inserted between the door and door jamb and the bolt twisted to an open position. The applied torque is 120 in.-lbs.

FIGURE 36

THREAT NO. 34 - LOIDING



SHOVEKNIFE
(Made from plastic credit card)

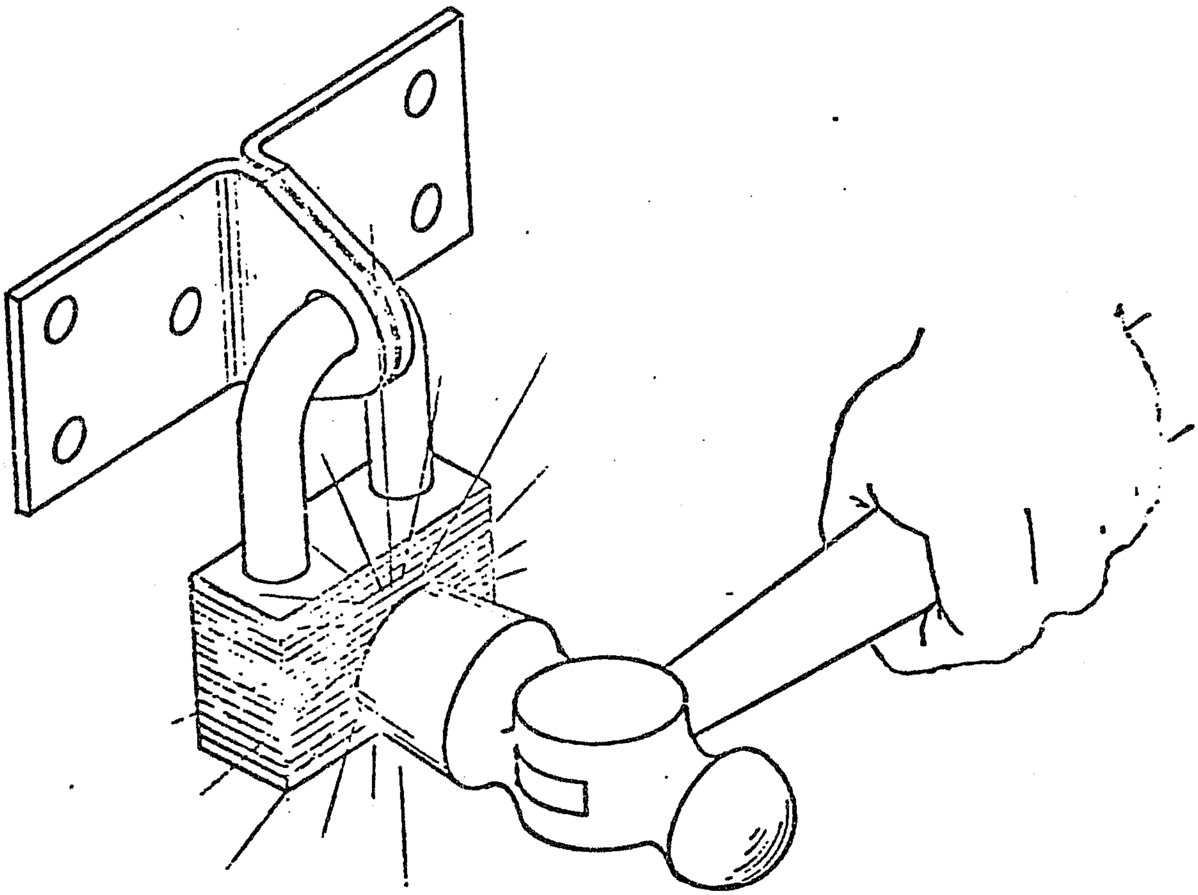


SHOVEKNIFE
(Made from common table knife)

A credit card (celluloiding) or a shoveknife blade can be used to manipulate the spring latch of a lock.

FIGURE 37

THREAT NO. 35 - RAPPING



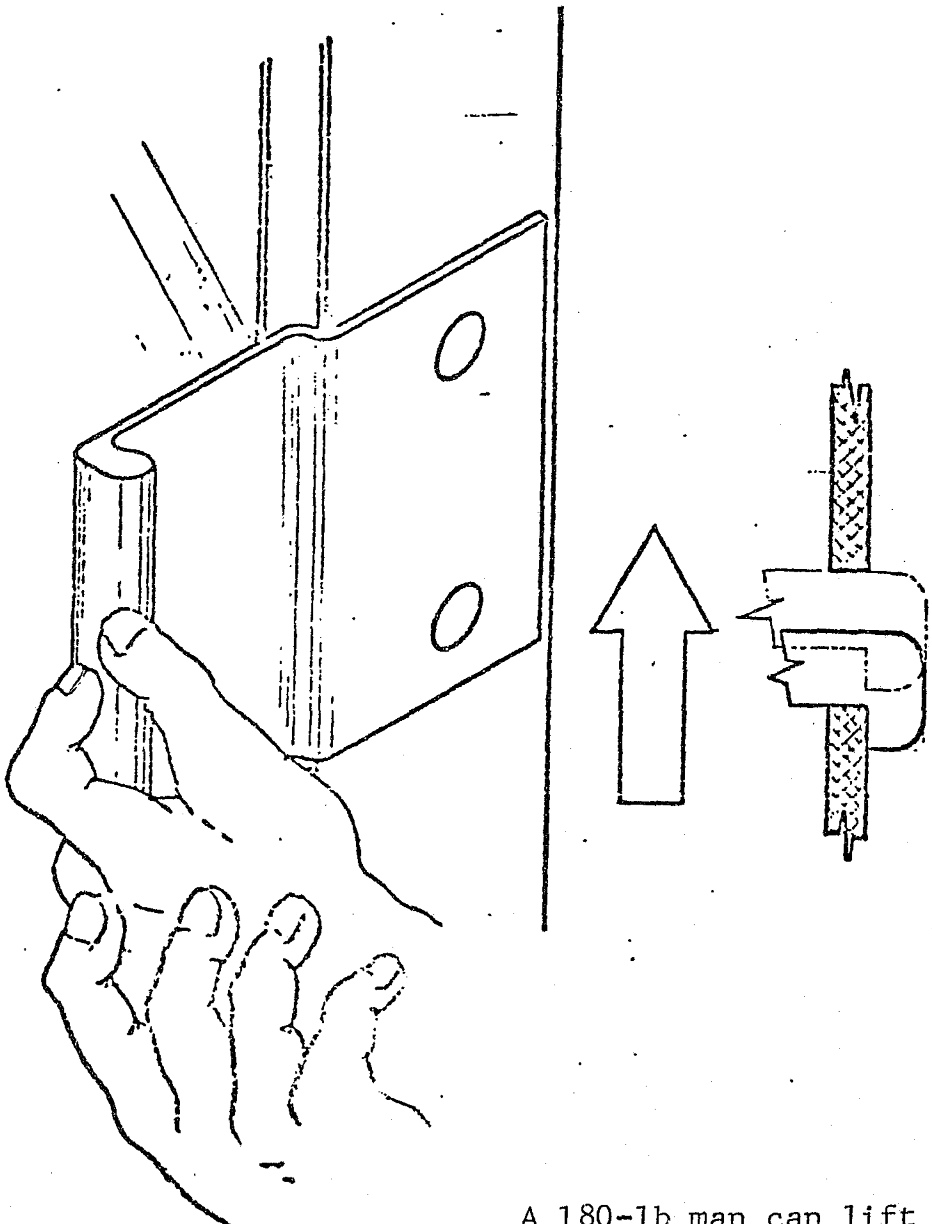
A padlock shackle can be held under tension and the lock housing "rapped" with a hammer to manipulate the lock open.

4. Glass Doors

The threats imposed on sliding glass doors and windows can be characterized as follows:

FIGURE 38

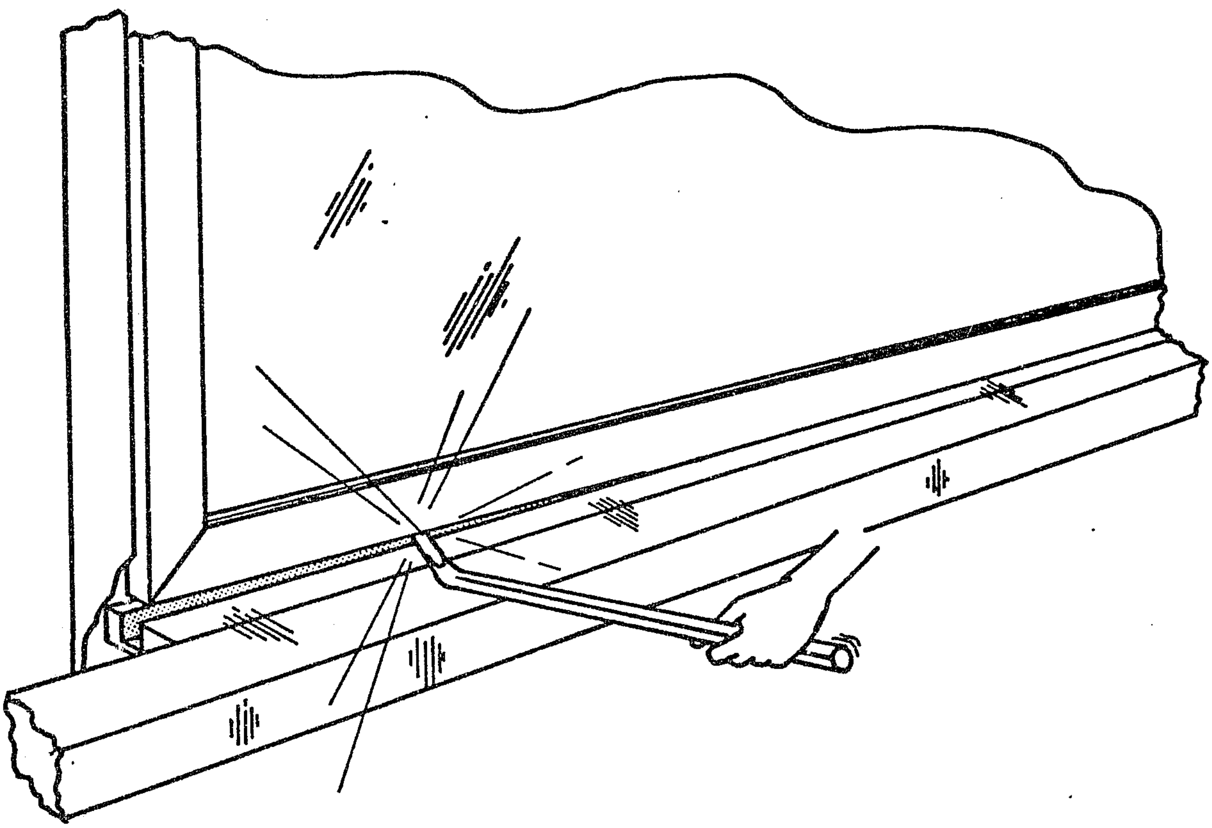
THREAT NO. 36 - LIFTING



A 180-lb man can lift a sliding glass door with a 150-lb force.

FIGURE 39

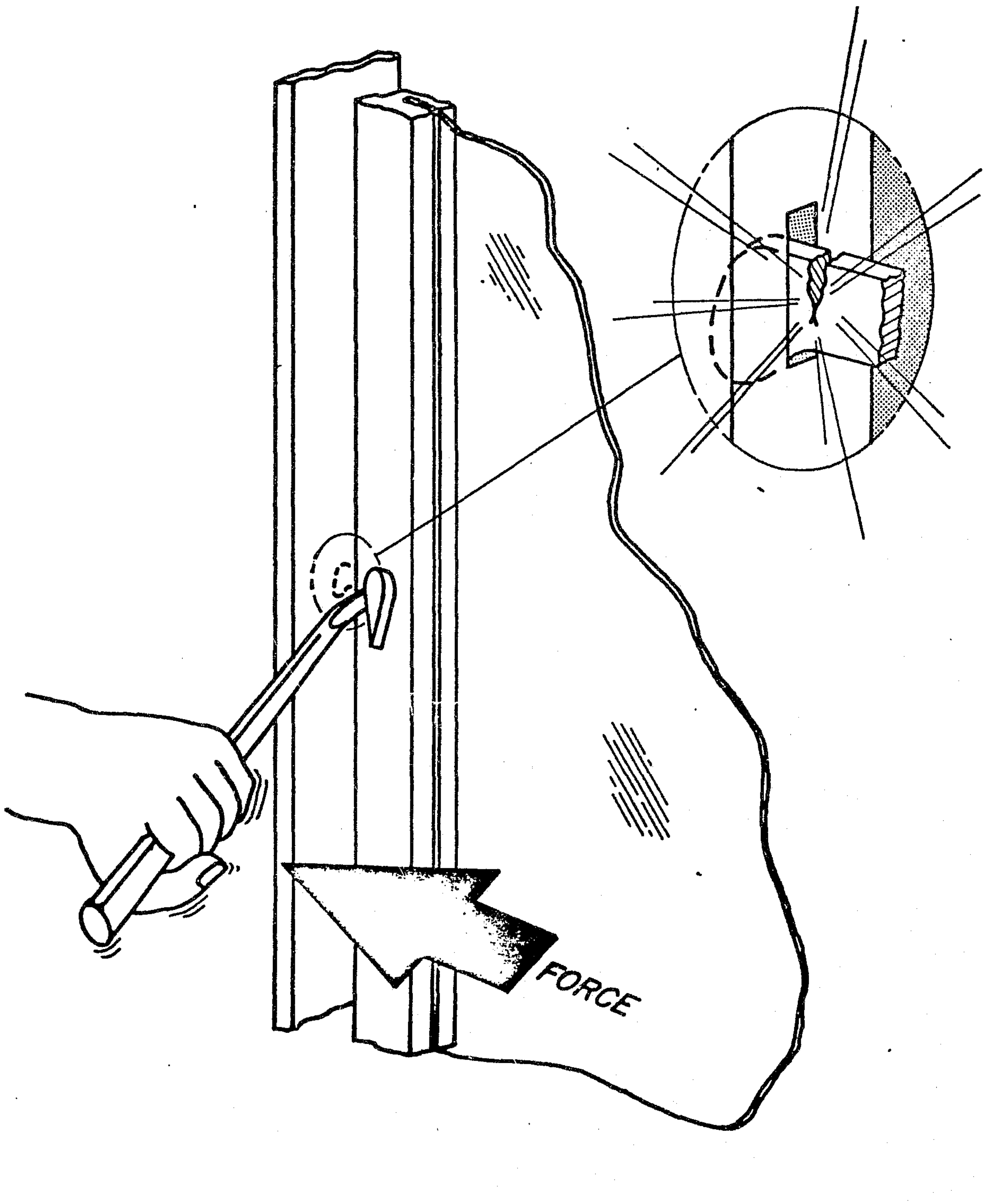
THREAT NO. 37 - PRYBAR LIFT ON SLIDING GLASS DOOR



A prybar can be used to lift a sliding glass door. The maximum applied moment is 6000 in.-lbs and the maximum applied force is 3000 lbs.

FIGURE 40

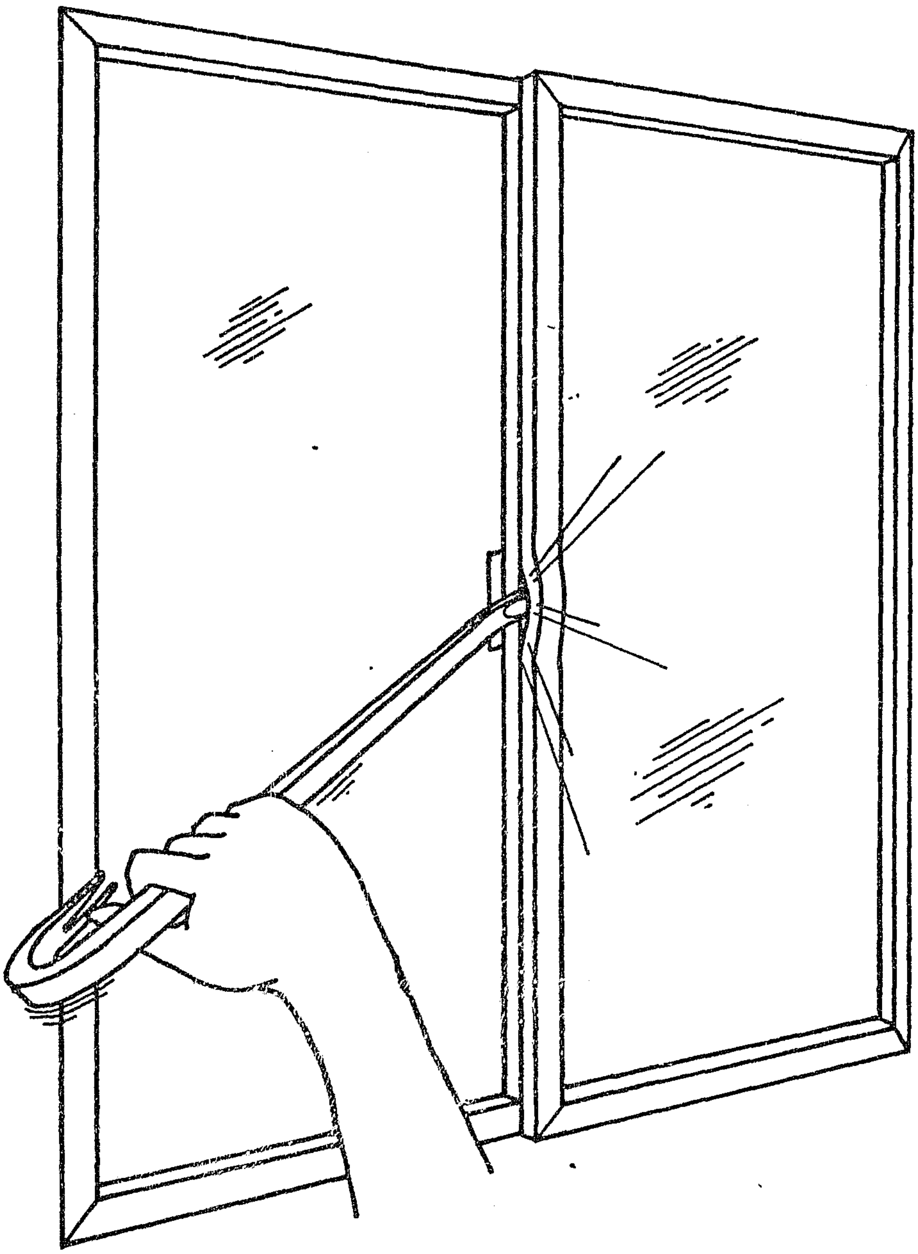
THREAT NO. 38 - PRYBAR ON SLIDING GLASS DOOR LOCK



A prybar attack on a sliding glass door handle or lock stile applies a 6000 in.-lbs moment or a 3000 lbs force on the door framing.

FIGURE 41

THREAT NO. 39 - PRYBAR ON SLIDING GLASS WINDOW LOCK



A prybar attack on a sliding glass window applies a 4000 in.-lbs moment or a 2000 lbs force on the window framing.

D. Resistance Capabilities of Barrier Systems

A better understanding of the resistance capabilities of a lock, door, or window assembly can be gained by identifying those components (resistance parameters) which are encountered in construction of the system and which influence its resistance to attack. In addition, the variables of each resistance parameter which influence the strength that the resistance parameter has on the total system can be defined.

1. Exterior Doors

Figure 42 summarizes the resistance parameters and related variables investigated in the door testing program. For any particular design a number of resistance parameters are involved. The configurations used in the testing program were limited to those which are commonly found in California construction. These configurations were duplicated in the laboratory and were subjected to threats simulating, as far as possible, actual field conditions.

2. Locks

The resistance capability of a lock is measured by both its strength and the length of time it can resist a threat.

Basic lock resistance parameters are summarized in Figure 43. The types of locks considered included the pin tumbler, disc tumbler, lever tumbler and combination lock configurations.

The pin tumbler lock cylinder, having tumblers arranged to follow each other in a line, one after the other, is the most commonly used key operated lock. The majority of the pin tumbler lock cylinders have five tumblers and from 15 to 40 thousand permutations. When six tumblers are used, the best configurations may have 300 thousand permutations. Different keyways can produce approximately 150,000 combinations in the five tumbler and three million combinations in the six tumbler locks. When more than six tumblers are used, the permutations and tumblers have different characteristics. A lock with seven tumblers and ten bitting intervals for each tumbler may have 10^7 or 10 million permutations if properly designed and constructed.

FIGURE 42

EXTERIOR DOOR RESISTANCE PARAMETERS

AND RELATED VARIABLES

A. Material (Any Component)

1. Wood
2. Metal (Composite)
3. Metal

B. Aspect Ratio (Door)

1. Width
   a. 36" single
   b. 72" double
   c. 96" sliding

2. Height
   80"

C. Thickness (Door)

1-3/8" - 2"

D. Door Frame

E. Type of Construction (Door)

1. Hollow Core
2. Solid Core
3. Metal Clad
4. Glass

F. Boundary Fasteners

1. Butt Hinges
2. T-Hinges
3. Dead Bolt
4. Spring Latch
5. Dead Latch
6. Bars

G. Method of Attachment of Fasteners

1. Screws
2. Mortise Joint
   a. Reinforced
   b. Non-Reinforced
3. Striker Plate Assemblies
4. Welding
5. Adhesive

H. Support Structure

1. Wooden framing (FHA)
2. Steel framing
3. Masonry construction
4. Precast/Prestressed concrete

I. Secondary Structures or Devices to Negate Threats

1. Method of trim
2. Materials of trim
3. Protective coverings for fasteners and openings

J. Local Reinforcement

Note: For any particular door system a minimum of one resistance variable is required from each parametric group.

FIGURE 43

LOCK RESISTANCE PARAMETERS

A. Material

   Brinell/Rockwell Hardness

B. Labyrinth Carrier (plug)

C. Labyrinth Passage (shear line)

D. Labyrinth Base-Element (tumbler)

   1. number tumblers
   2. number combinations or permutations
   3. bitting interval
   4. pins or drivers
   5. springs
   6. operational life
   7. distribution of master key wafers

E. Fixed Base (housing)

F. Locking Bolt

G. Barrier

H. Barrier/bolt Linkage

I. Keyway

J. Striker Plate

K. Tolerance

Locks (cont'd)

The pin tumbler cylindrical lock is the most convenient lock to use. The overall size of the lock makes it easy to install and service. Each lock can be operated by several different keys (master keying). These features have resulted in almost universal use of the mechanism in commercial buildings and private dwellings in the United States. Unfortunately, since its invention over 100 years ago, many ways for defeating it have been discovered. During this same period much was done to obviate the intent of the original design in the name of improved production techniques.

Other locks often used are the cylindrical disc tumbler lock, and the lever lock system.

- - - -

3. Glazing Systems

The barrier resistance parameters of glazing systems is summarized in Figure 44.

FIGURE 44

GLAZING RESISTANCE PARAMETERS

A. Glass Material

1. Sheet
2. Tempered
3. Safety Laminated
4. Wire Reinforced
5. Vigil Pane
6. Watchguard
7. Plexiglass
8. Lexan

B. Glazing Thickness

C. Aspect Ratio

D. Sash or Frame Material

1. Wood
2. Aluminum
3. Steel

E. Sash Configuration

F. Support Structure

G. Glazing Detail

E. Procedures

1. Method

Most of the testing completed during the program was on exterior doors, sliding glass doors and windows assembled in FHA-type framing systems. To accomplish this, a universal structural test frame was designed for testing any specific door or window system and instrumentation procedures were selected which were suitable for measuring the response of these systems to the spectrum of threats involved.

The scope of the program precluded conducting enough tests on each type of security system to perform statistical analyses of the results. Because of this the testing procedure provided for performing a variety of low level tests on each door, lock or window system prior to applying a failure load in order to obtain adequate data to substantiate the measured strength value.

The approach used in testing the exterior doors, sliding glass doors and windows was to first determine the weakest component in each system design under the worst threat condition. This was accomplished by conducting static load tests which measured the strength of the basic design and determined the initial failure mode. If the design failed at a static load level below that required for the threat loading, the failed component was redesigned and further static tests were conducted.

Prior to conducting dynamic or ultimate load tests on the basic and modified door and window systems, static load calibration tests were performed to measure the spring constant of the assembly. This data provided influence coefficients for the system in terms of an applied normal force.

In exterior door tests, subsequent tests were conducted applying low level dynamic loads simulating threats of foot impact; hammer impact; battering ram impact; and shoulder impact. The shoulder impact loads were increased above the expected threat value until failure occurred or the system resisted the attack with a margin of safety much greater than the applied threat. The data measured in these dynamic door tests allowed us to relate the dynamic strength with an equivalent static test load by means of the energy considerations described above.

In each security strength test of a door or window system a variety of lock systems were incorporated into the assembly to provide test measurements on lock equipment. In addition, special door and framing systems were constructed for conducting many of the eighteen different types of lock threat tests.

The procedure in testing locks was to first determine the feasibility of each type of threat, i.e., whether the threat as described could be used to defeat the lock. In some cases modifications of the threat and the burglar tools were required to successfully use the method. Next, the loads involved in accomplishing the threat were measured along with the time needed to make the forced entry. Finally, the threat was applied to the lock security system being tested to evaluate its resistance to the threat.

Glazing systems were evaluated for forced entry through a dynamic impact and the application of thermal shock. To facilitate testing and to provide test results that could be related to existing glazing impact test data, the glazing tests were conducted in a test fixture similar to that used by the ANSI Standard for glazing safety tests (6).

2. Universal Test Frame

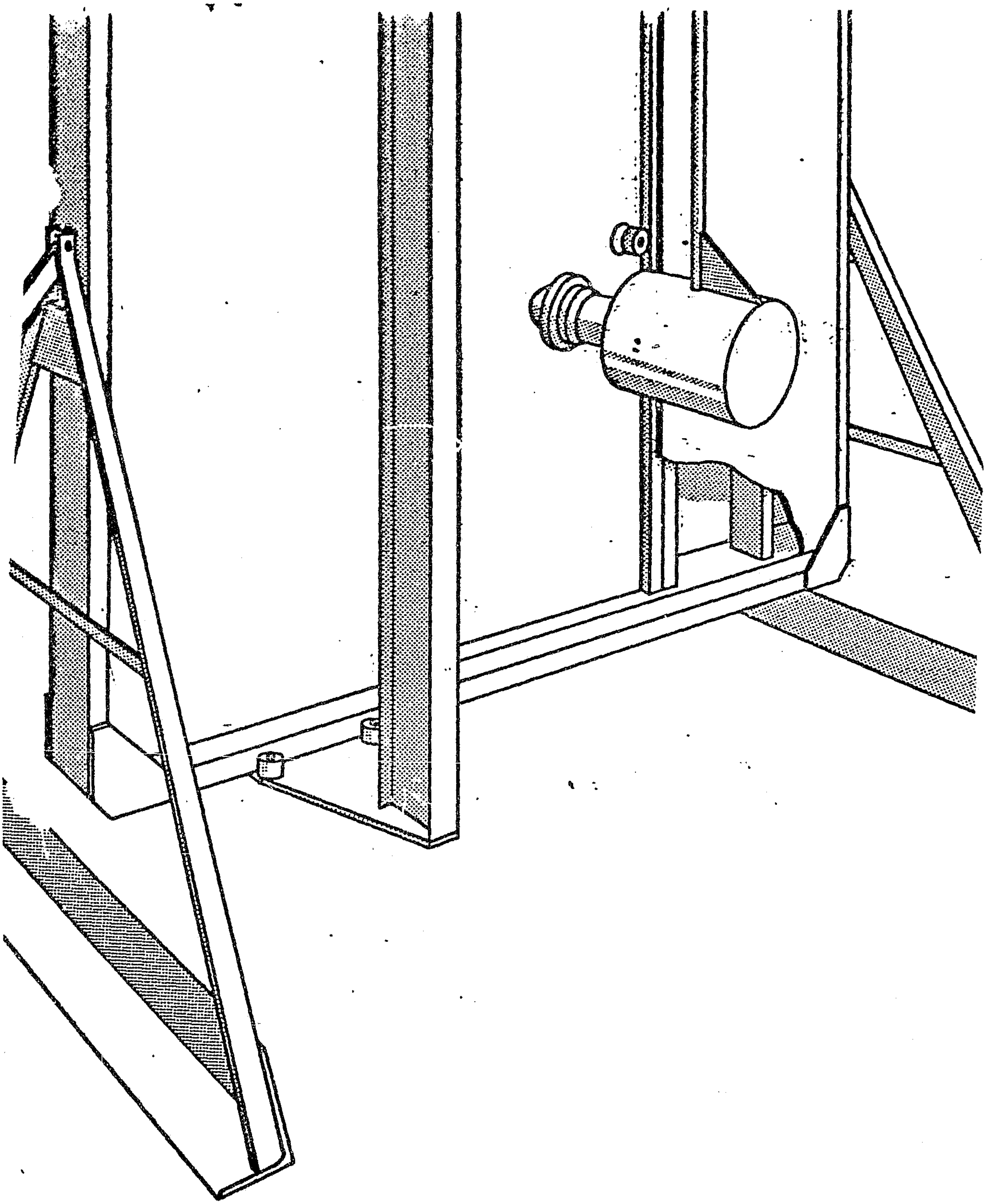
A universal test frame was designed for testing both door and window assemblies under either dynamic or static loads. The test frame was fabricated from structural steel with the supporting members arranged so that the structural rigidity of a building wall was simulated when the exterior door or window assembly was installed. The test frame allowed testing a series of door and window systems with one test jig.

The typical door system assembly in each test included the test door, the door frame, the adjacent framing and cripple studs, header, sheetrock and exterior plywood sheeting, frame wedges, etc.

The framing configuration used in this test series was in accordance with standard FHA specifications (7). Figure 45 shows the typical arrangement of the FHA-type exterior door framing support structure used in the test frame.

FIGURE 45

UNIVERSAL TEST FRAME



3. Impact Test Fixture

The test fixture used for testing glazing is essentially that specified in the ANSI Standard for safety glazing materials (7), except that it was designed for support with the test panels oriented horizontally rather than vertically. This allows the impact to be produced with a vertically free-falling impactor rather than a swinging object. The complete fixture is shown in Figure 46.

4. Lockbolt Test Fixture

A special test fixture was designed for testing lockbolts under end impact. The fixture was attached to a Riehle impact testing machine.

5. Vertical Impact Lock Fixture

A pipe frame fixture was constructed for conducting vertical impact tests on exterior door locks. Figure 47 shows a schematic of the fixture.

6. Padlock Shackle Test Fixture

Padlock shackles were tested in a special loading fixture which was designed to measure the load applied to the handle grips of a bolt cutter when cutting a specimen. The fixture applied load to the grips by means of cables, a winch and a load cell. The load cell output was monitored with an oscillograph recorder.

7. Exterior Doors

Figure 48 provides a matrix of the static and dynamic load tests conducted on exterior door systems during the program.

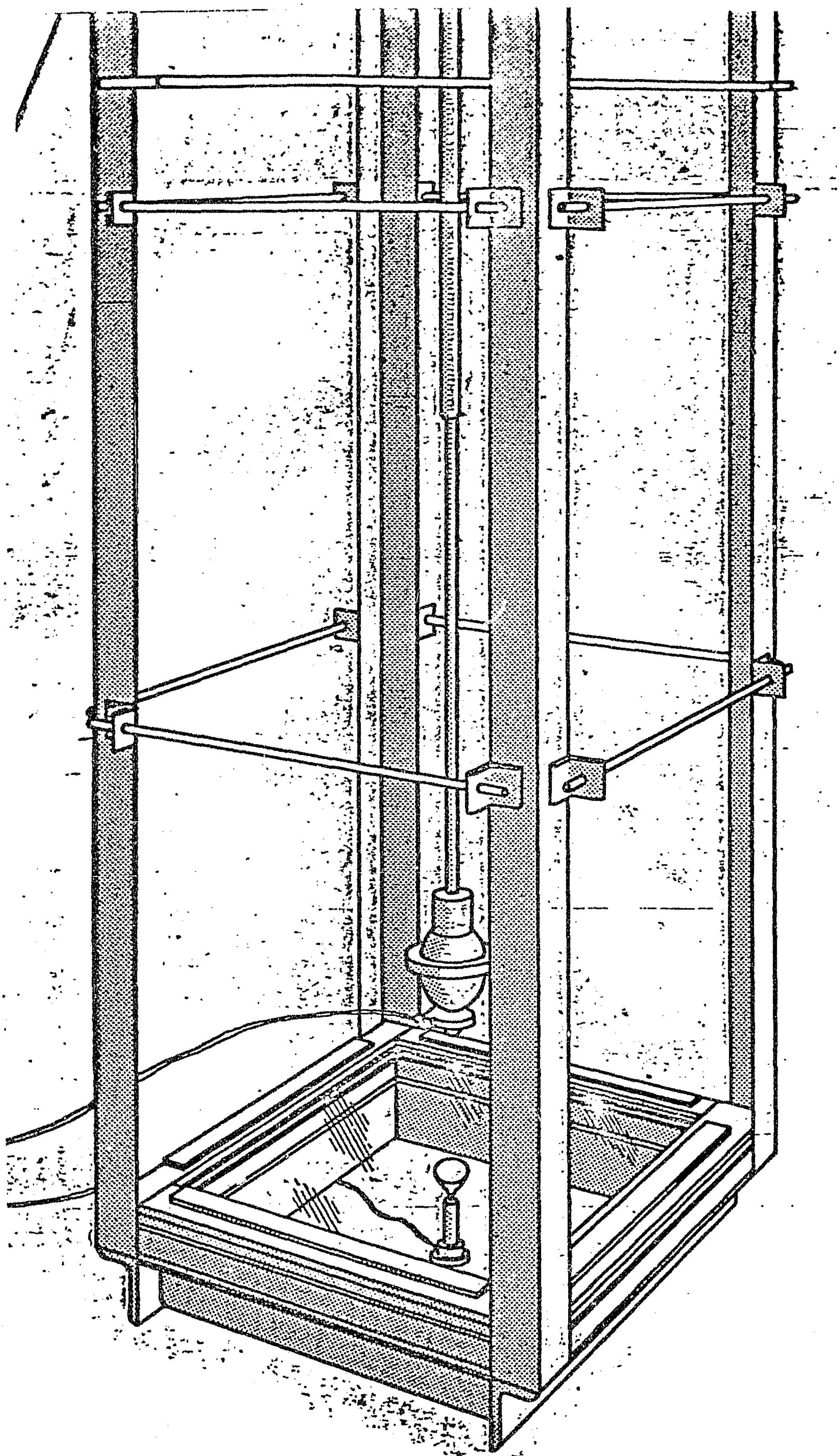
a. Static Strength

(1) Normal Loads

The first series of tests on the door assemblies established the structural strength and failure mode for typical hollow and solid core door configuration under loads applied to the door. Six different single door systems were tested to failure during eight separate tests.

FIGURE 46

IMPACT TEST FIXTURE



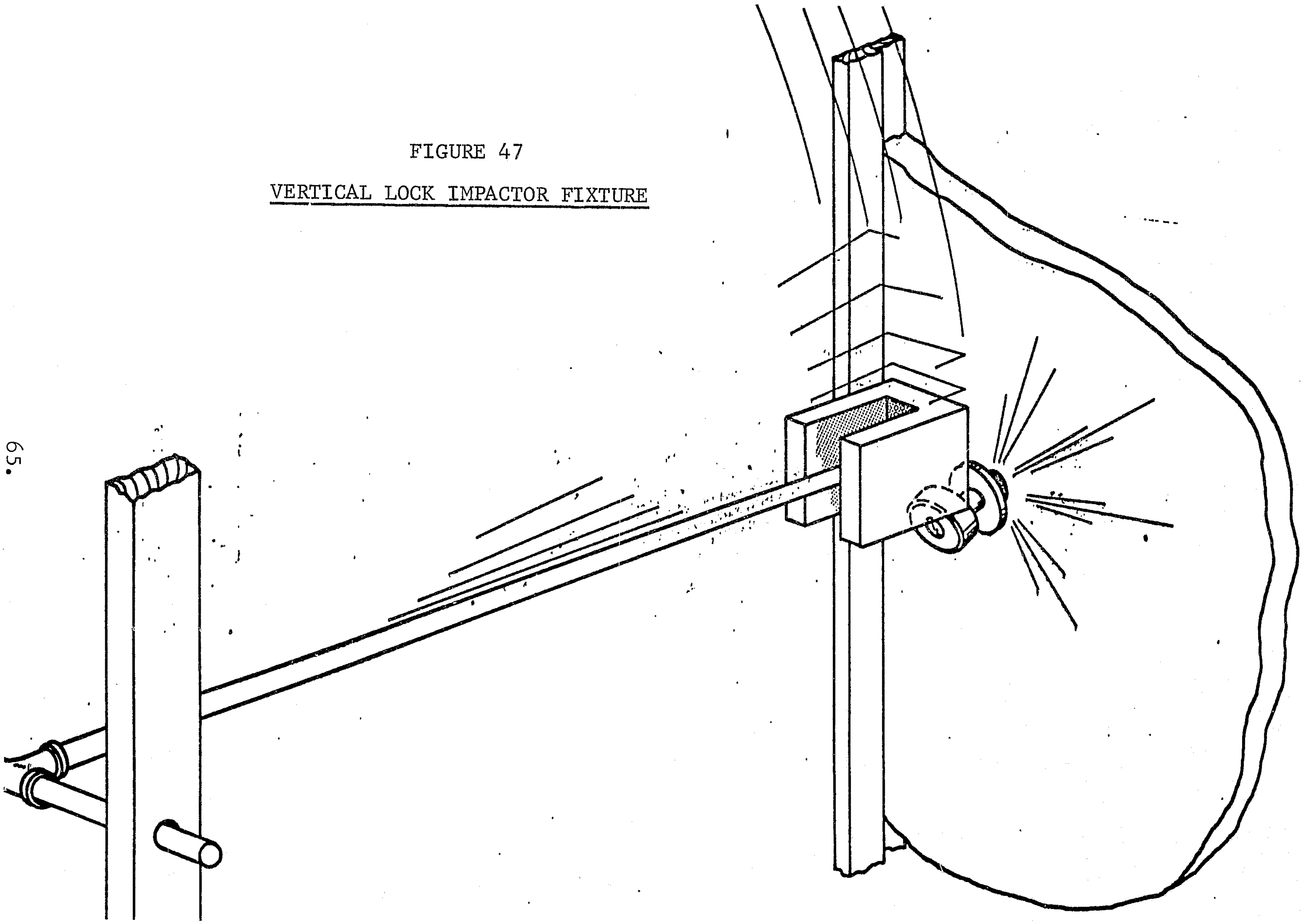
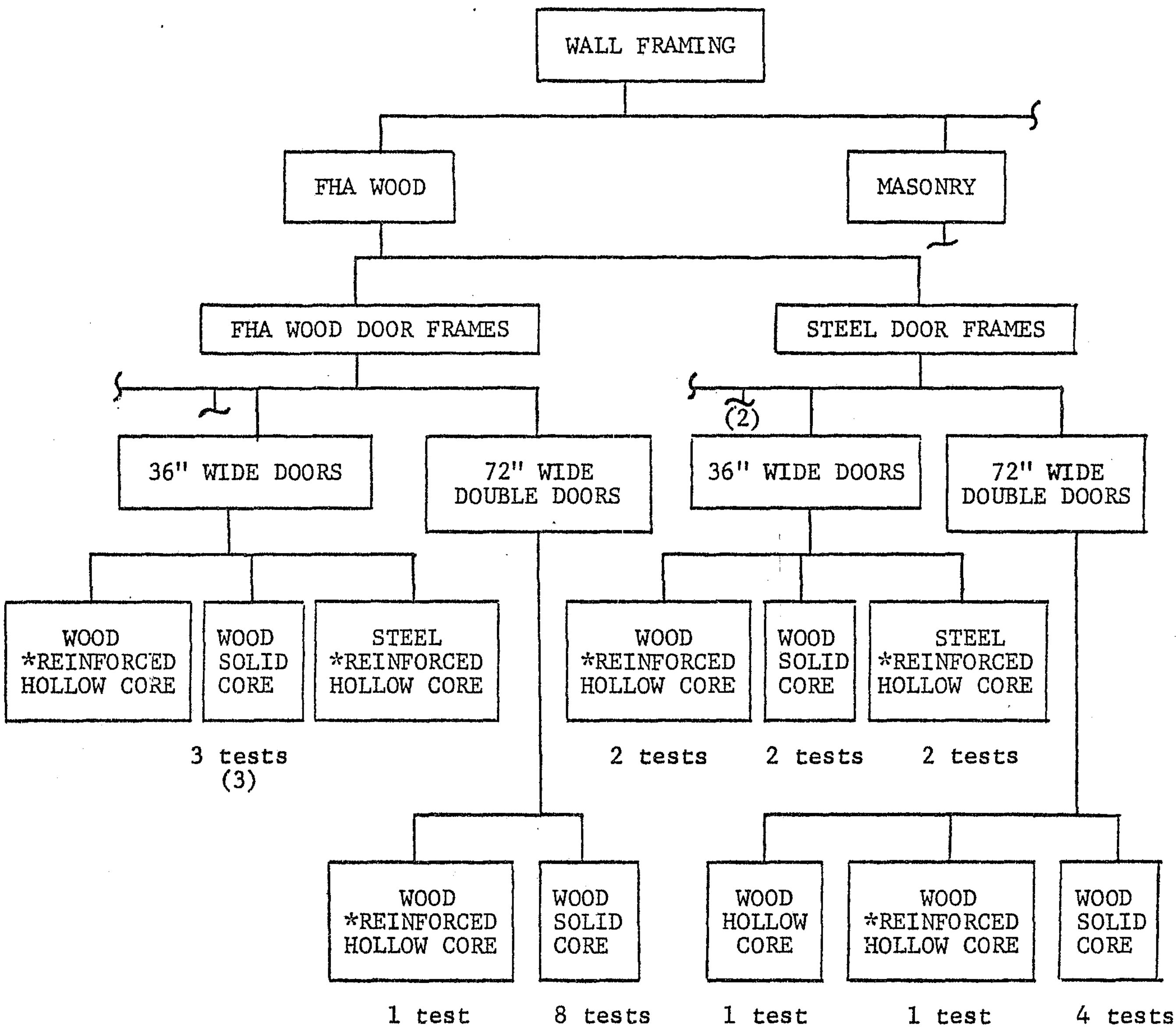


FIGURE 47

VERTICAL LOCK IMPACTOR FIXTURE

FIGURE 48

DOOR SYSTEMS TEST MATRIX (1)



Notes: (1) The dynamic response of these classifications will not be affected by different makes of door latches and hinges; however, local reinforcement at latches or a single latch vs a latch plus bolt system does have a significant effect on the door system.

(2) Three static and dynamic tests, No's. 201, 201 A & B, and 202 were made of a 30" wide metal door with paper honeycomb core.

(3) These three tests used metal clad solid wood core doors.

* Types of core reinforcements used were:

1. Paper honeycomb in 30" steel clad doors
2. Styrofoam in 36" steel clad door.
3. CCTRF (steel mesh) in wood doors.

These eight test configurations are summarized in Figure 49 which indicates the load application points and deflection measurement locations. After the first four static load tests, it was determined that the conventional lock striker plate was the weakest structural component. In each test, the wooden jamb split at the striker plate screw holes. Therefore, in order to determine the next weakest component, subsequent static tests were conducted with a modified striker plate (Design No. 1) as shown in Figure 50.

(2) Lateral Loads

Static load tests were conducted on the FHA door framing structure with and without wood and metal door frames to determine the structural rigidity under lateral loads. This loading condition simulated the threats, produced by a bumperjack and prybar. In each test, the deflection of the frame under incremental loads was measured with an extensiometer.

b. Dynamic Strength

The strength of an exterior door assembly in a wall frame structure under dynamic loads is difficult to accurately predict by theoretical analysis because the supporting wall frame structure is redundant. The loads at the hinges and the latch vary with the amount of load applied, the point of application and the door structural rigidity. The energy absorbed by the assembly (door and framing) varies not only with the load and its point of application, but in the case of dynamic loading also with the type of door and the velocity of the impact. Figure 51 shows these conditions by depicting how the various components of a door system translate and rotate under the influence of dynamic loads.

Since most threats applied to exterior doors are dynamic loads, the main objective of the dynamic tests was to measure dynamic strength

FIGURE 49

EXTERIOR SINGLE DOOR - STATIC TEST CONFIGURATIONS (FHA FRAMING)

RESISTANCE PARAMETERS / TEST NUMBER	1	2	3	4	5	6	7	8	9
1. Door Material	Wood (DF)	Wood (DF)	Wood (DF)	Wood (DF)	Wood (DF)	Wood (DF)	None*	Wood (DF)	None
2. Door Aspect Ratio	36"Wide 80"Long	36"Wide 80"Long	36"Wide 80"Long	36"Wide 80"Long	36"Wide 80"Long	36"Wide 80"Long	None*	36"Wide 80"Long	None*
3. Door Thickness**	1-3/4"	1-3/4"	1-3/4"	1-3/4"	1-3/4"	1-3/4"	None*	1-3/4"	None*
4. Door Frame Thickness	1-1/2"	1-1/2"	1-1/2"	1-1/2"	1-1/2"	1-1/2"	1-1/2"	1-1/2"	1-1/2"
5. Type of Construction	Hollow Core	Hollow Core	Hollow Core	Hollow Core	Hollow Core	Hollow Core	None*	Solid Core	None*
6. Boundary Fasteners	Butt Hinges	Butt Hinges	Butt Hinges	Butt Hinges	Butt Hinges	Butt Hinges	None*	Butt Hinges	None*
7. Method of Fastener Attachment	#9x3/4"	#10x1-1/2"	#9x3/4"	#9x3/4"	#9x3/4"	#9x3/4"	None*	#9x3/4"	None*
8. Type of Support Structure	FHA	FHA	FHA	FHA	FHA	FHA	FHA	FHA	FHA
9. Striker Plate Reinforcement	Standard	Standard	Standard	Standard	CCTRF Design #1	CCTRF Design #1	CCTRF Design #1	CCTRF Design#1A	None
10. Latch Fastener	Deadlatch	Deadlatch	Deadlatch	Deadlatch &Deadbolt	Deadlatch	Deadlatch with door edge stiffened	Simulated Doorlatch	Deadlatch	None
11. Component Tested	Lower Hinge	Upper Hinge	Lock	Knobset/ Deadbolt	Striker Plate	Striker Plate	Striker Plate	Door System	Door Frame
12. Load Application Point	Adjacent Lower Hinge	Adjacent Upper Hinge	Adjacent Doorknob	Adjacent Doorknob	Adjacent Doorknob	Adjacent Doorknob	Striker Plate	Adjacent Doorknob	Center Door Jambs
13. Load Direction	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Lateral
14. Deflection Measurement Monitored	Lower Hinge	Upper Hinge	Lock	Lock	Lock	None	None	Lock	Door Jambs

* Door Frame Test Structure Only; Door not in Test Setup.
** Wood Used - White Pine

FIGURE 50

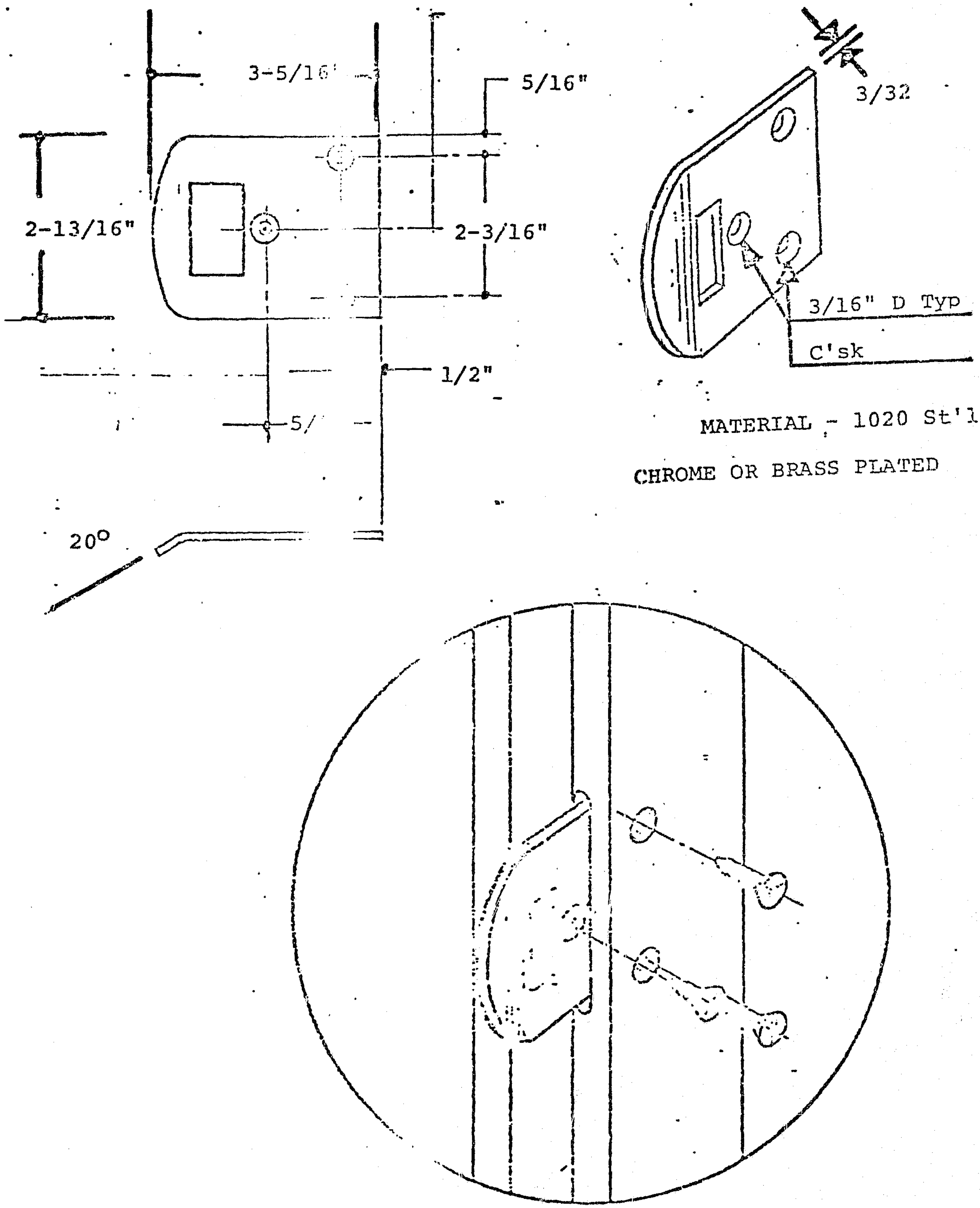
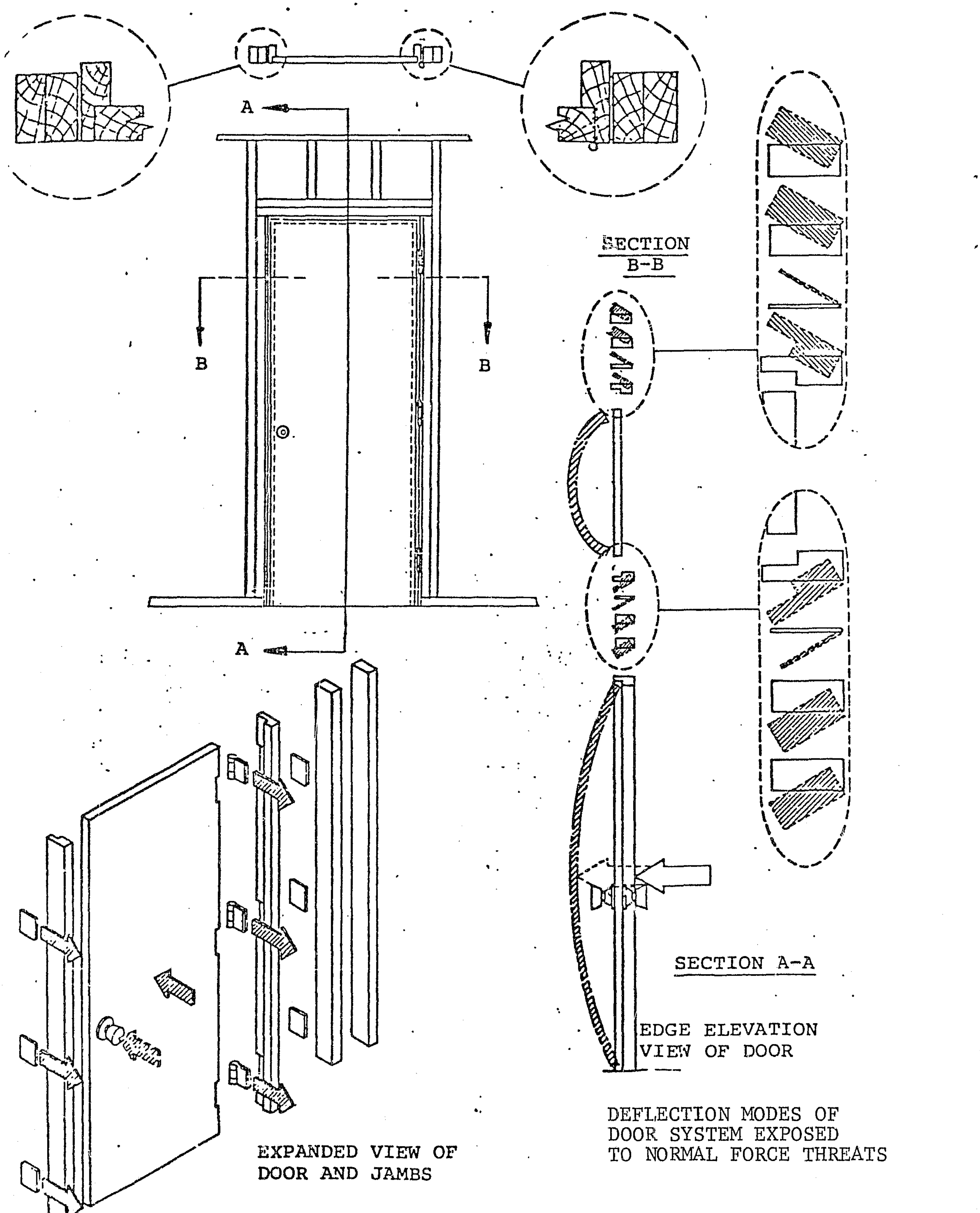

3-5/16"
5/16"
2-13/16"
2-3/16"
1/2"
5/
20°
3/32
3/16" D Typ
C'sk
MATERIAL - 1020 St'l
CHROME OR BRASS PLATED

FIGURE 51



A
A
B
B
SECTION
B-B
SECTION A-A
EDGE ELEVATION
VIEW OF DOOR
DEFLECTION MODES OF
DOOR SYSTEM EXPOSED
TO NORMAL FORCE THREATS
EXPANDED VIEW OF
DOOR AND JAMBS

and relate it to measured static load strength by means of energy considerations described previously. This resulted in defining an equivalent "dynamic force" which can be used for conventional static load structural tests.

A second objective of dynamic tests was to determine the energy received by each door configuration and the associated equivalent applied "dynamic force" for the typical dynamic input load threats of a shoulder impact; foot impact; hammer impact and battering ram impact.

Twenty-nine different door system configurations were tested under dynamic and static loads as indicated in Figure 52.

In each test the FHA minimum standard door framing was constructed and installed in the universal test frame. Extensiometers were installed at the location indicated in Figure 53. Incremental static loads were applied at Location No. 1 to calibrate the extensiometers; to establish force distributions and to evaluate deflection data. The static, as well as the impact loads, were applied at a location 12 inches from the latch. This area was considered as the most probable for impacting in attempts to force entry. In one test, actual shoulder impacts were applied at 18 inches from the latch to evaluate the influence of the loading location.

Finally, if a door configuration withstood the dynamic threat loads imposed on it, it was tested to failure with a static load to determine the failure mode and ultimate strength.

8. Lock Systems

The lock systems tested were keyed locks for exterior doors and padlocks which were constructed to be used on residential garage doors. Lock tests were performed in two different test series; the first series were exterior door tests. In each exterior door load test a lock was assembled in the door and was tested in conjunction with the door. In many of these tests the lock was the component of the door assembly that failed; especially at high load levels. The second test series was the measurement of the effect of eighteen different

FIGURE 52

EXTERIOR SINGLE DOOR DYNAMIC TEST CONFIGURATIONS

Test No.	Door Material	Door Width	Door Frame	Type of Door Construction	Type of Latch Reinforcement	Type of Knoblatch	Type of Deadbolt
10	Wood	36" wide	Wood	Hollow Core	None	Kwikset 600 DL	---
11	Wood	36" wide	Wood	Solid Core	None	Kwikset 600 DL	Weiser D9370
12	Wood	36" wide	Wood	Solid Core	CCTRF	Schlage G51PD	---
13	Wood	36" wide	Wood	Hollow Core	CCTRF	Schlage G51PD	---
14	Metal	36" wide	Metal	Metal	None	Schlage A51PD	---
15	Metal	36" wide	Metal	Metal	None	Kwikset Model 680	---
16	Metal	36" wide	Metal	Metal	None	---	Kwikset #685
17	Metal	36" wide	Metal	Metal	None	Schlage D51PD	---
18	Metal	36" wide	Metal	Metal	2-3/8" Bolts	Schlage D51PD	---
19	Wood	72" wide	Metal	Std. Solid Core	None	Schlage D51PD	---
20	Wood	72" wide	Metal	Std.Solid Core	Rein.doubler wraped over edge, door edge rein. with"U" channel	Schlage D51PD	---

-continued-

FIGURE 52

EXTERIOR SINGLE DOOR DYNAMIC TEST CONFIGURATIONS

Test No.	Door Material	Door Width	Door Frame	Type of Door Construction	Type of Latch Reinforcement	Type of Knoblatch	Type of Deadbolt
21	Wood	72" wide	Metal	Std. Solid Core	---	Schlage D51D2	None
22	Wood	72" wide	Metal	Std. Solid Core	---	Kwikset 680	PF Corbin 830-1451
23	Wood	72" wide	Metal	Std. Solid Core	Rein. doubler wraped over edge, door edge rein. with "U" channel	Arrow 1001PTX	Weber D9470S
24	Solid Core Reinforced	72" wide	Metal	CCTRF	Latch Stiffners. Alum. "T" Sect. "U" channels on flush bolts	Schlage Series G	
25	Solid Core Reinforced	72" wide	FHA	CCTRF	Door edge rein. Alum. "T" Sect. "U" channels on flush bolts	Schlage Series G	
26	Wood	72" wide	FHA	Std. Solid Core	None	Arrow Deadlatch	Arrow 921K
27	Wood	72" wide	FHA	Std. Solid Core	"U" channel rein.	Arrow Deadlatch	Arrow 921K
28	Wood	72" wide	FHA	Std. Solid Core	"U" channel rein.	Arrow Deadlatch	Arrow 921K
29	Wood	72" wide	FHA	Std. Solid Core	"U" channel rein.	Arrow Deadlatch	Arrow 921K

-continued-

FIGURE 52

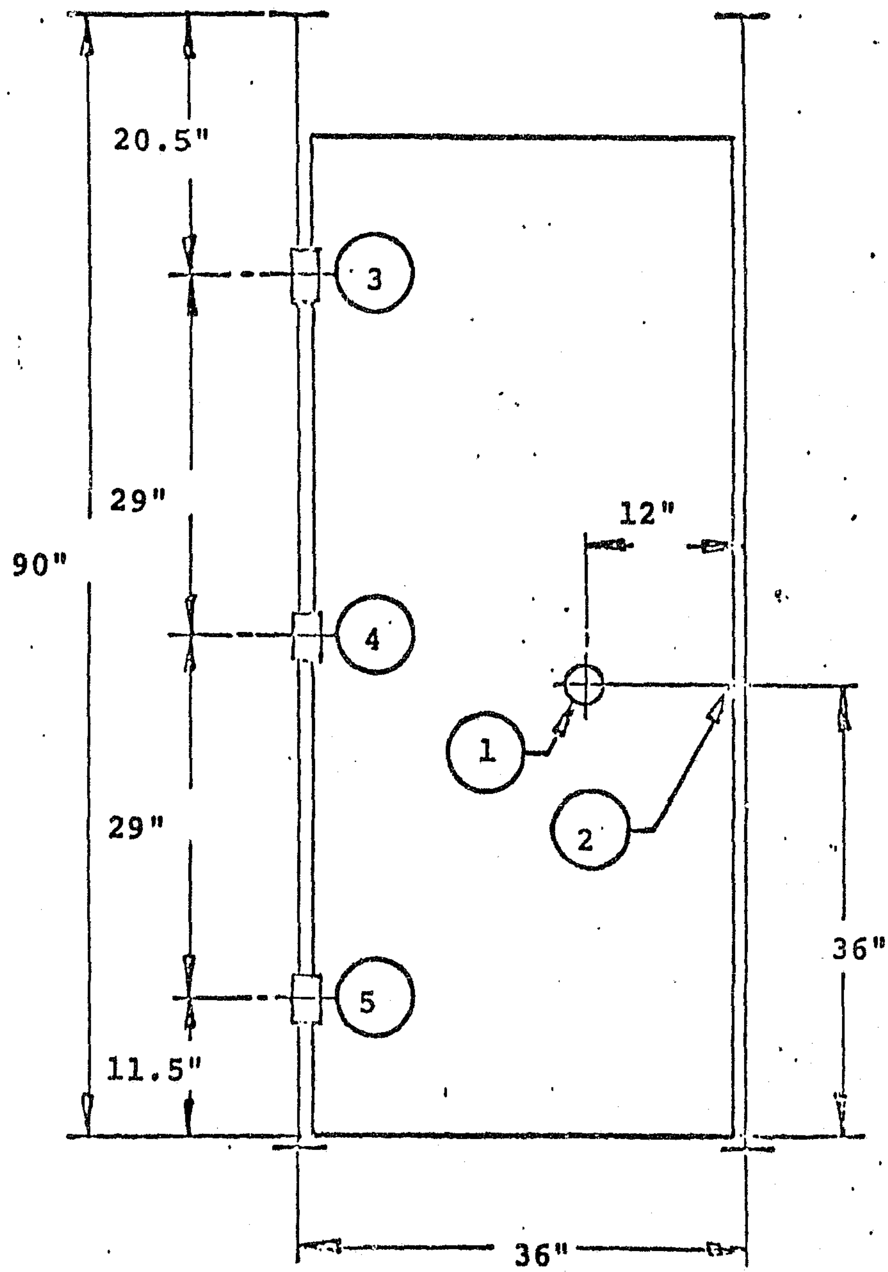
EXTERIOR SINGLE DOOR DYNAMIC TEST CONFIGURATIONS

Test No.	Door Material	Door Width	Door Frame	Type of Door Construction	Type of Latch Reinforcement	Type of Knoblatch	Type of Deadbolt
30	Wood	72" wide	FHA	Std.Solid Core	"U"Channel Rein.	Arrow Deadlatch	Arrow 921K
31	Metal Clad Wood	36" wide	FHA	Solid Core	None	Arrow Deadlatch	Schlage B360P
32	Metal Clad Wood	36" wide	FHA	Solid Core	Door edge rein. at both edges	Arrow Deadlatch	Schlage B360P
33	Metal Clad Wood	36" wide	FHA	Solid Core	Door edge rein. at both edges	Arrow Deadlatch	Schlage B360P
34	Wood	36" wide	Ternes Metal	Std.Solid Core	None	Arrow Deadlatch	Schlage B360P
35	Wood	36" wide	Ternes Metal	Std.Solid Core	"Mag"rein. on latches	Arrow Deadlatch	Schlage B360P
36	Solid Core Rein.	36" wide	Ternes Metal	CCTRF	None	Corbin 8301451	Schlage B360P
37	Solid Core Rein.	36" wide	Ternes Metal	CCTRF	"Mag"rein. on latches	Corbin 8301451	Schlage B360P

FIGURE 53

DYNAMIC LOAD DOOR TESTS

LOCATION OF EXTENSIOMETERS AND LOAD INPUT



LEGEND

No.	Item
1	Load Point
2	Latch
3	Upper Hinge
4	Middle Hinge
5	Lower Hinge

CONTINUED

1 OF 3

types of threats to lock systems. These measurements included determining threat loads, determining the degree of burglary resistance of typical lock products; and determining the testing procedures required for qualifying lock products as being capable of resisting the threats. Figure 54 shows a test matrix for the lock tests conducted during the program.

9. Sliding Glass Doors

Twelve different tests were completed on a typical aluminum framed sliding glass patio doors during the test program. The main object of the tests was to establish realistic performance requirements for structural resistance to forced entry and determine test methods that adequately simulate the threat and evaluate the resistance. In general, loadings consisted of force applied to the glazing panel frame perpendicular to the plane of the panel and vertically and horizontally in the plane of the panel. In two preliminary tests on glass doors, combined shock loads on the door handles were conducted to evaluate the anticipated range of load threats. Figure 55 depicts the initial combined load test setups. Figure 56 provides brief descriptions of the test configurations for the sliding glass doors. In some tests, the capability of the complete door to resist simulate forced entry loading by prying with a pry bar was evaluated.

Other threats to which sliding glass door glazed panel assemblies may be subjected include high temperature (torch) and low temperature (LN_2) thermal shock, hammering spring punching, hole sawing, and various combinations of these techniques. These conditions are covered under the glazing panel tests.

All tests were performed in a "universal test frame," which is a heavy steel fixture that frames sufficient space to accommodate standard (FHA) wall framing for accepting a variety of door and window sizes.

Instrumentation to monitor deflections was generally located at the load application point and/or the latch, and at the top and bottom latch-side corners of the door. The hydraulic pressure of the load application ram was monitored simultaneously with deflections so that load/deflection curves could be plotted for the points of interest.

FIGURE 54

LOCK TEST MATRIX

Type of Lock System

	Threat Condition	Cylindrical Knob Set Lock	Unit Lock	Mortise Lock	Tubular Deadbolt Lock	Deadlock Latch	Interlock Deadbolt Lock	Flush Bolt Lock	Padlock
1.	Shoulder Impact	X	X	X	X	X	X	X	
2.	Lock Bolt End Impact				X				
3.	Hammer Impact	X	X	X	X	X	X		X
4.	Door Knob Bending	X							
5.	Knob, Lock Housing or Lock Rose Twisting	X	X	X	X	X			
6.	Lock Housing or Lock Rose Prying					X			
7.	Lock Cylinder Pulling	X	X	X	X	X	X		X
8.	Lock Cylinder Twisting	X		X	X	X			X
9.	Lock Cylinder Drilling				X				
10.	Deadbolt and Shackle Sawing				X				
11.	Shackle Cutting								X
12.	Shackle Bending or Tension								X
13.	Temperature Impact, Torch & Freezing								X
14.	Frame Spreading, Jimmying	X			X	X			

-continued-

FIGURE 54

LOCK TEST MATRIX

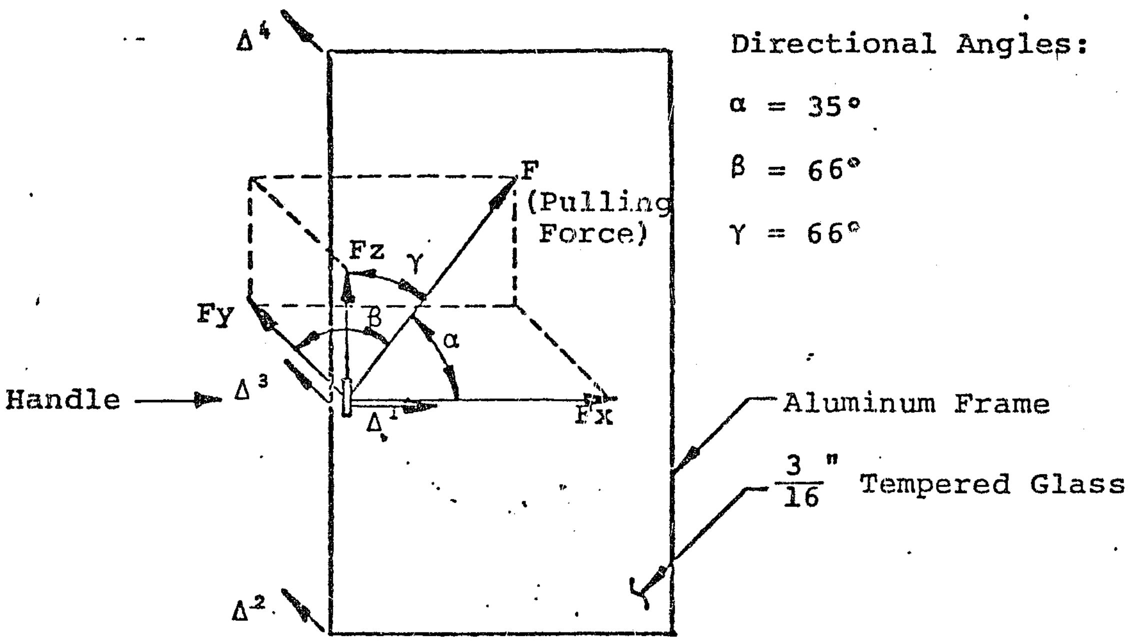
Type of Lock System

Threat Condition	Cylindrical Knob Set Lock	Unit Lock	Mortise Lock	Tubular Deadbolt Lock	Deadlock Latch	Interlock Deadbolt Lock	Flush Bolt Lock	Padlock
15. Picking								
16. Loiding	X	X	X					
17. Rapping								X

FIGURE 55

PRELIMINARY SLIDING GLASS DOOR TESTS
APPLIED TEST LOADS

TEST NO. 1



TEST NO. 2

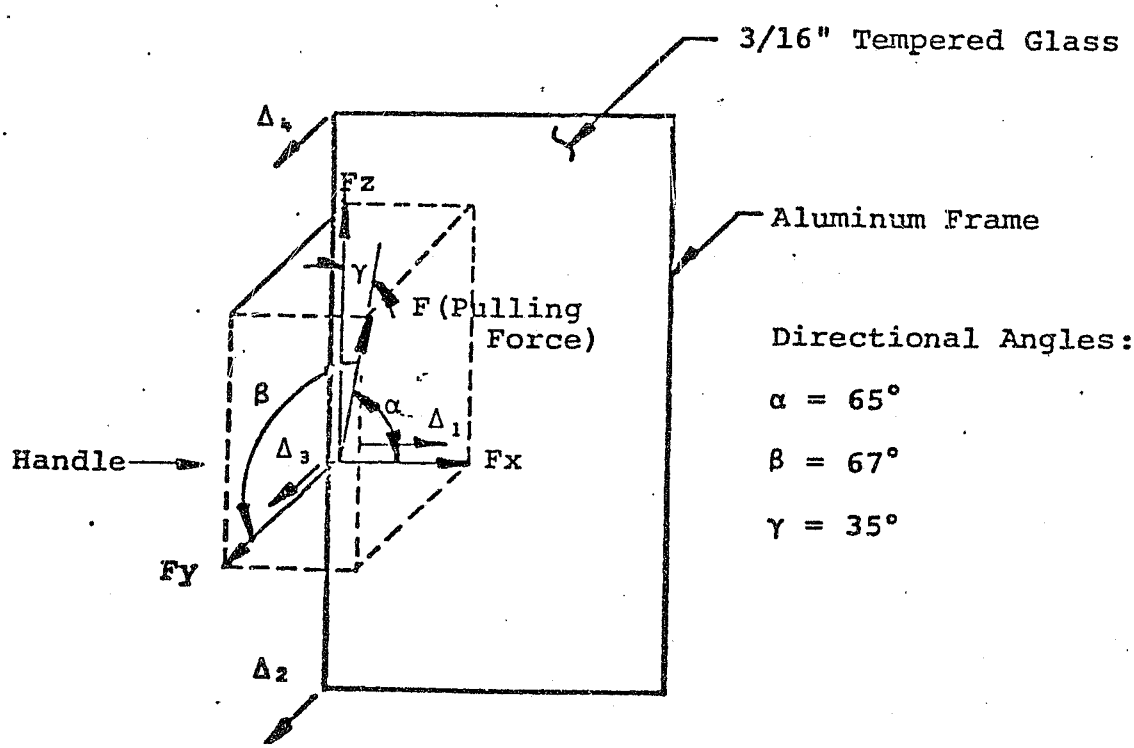


FIGURE 56

CCTRF SLIDING GLASS DOOR TESTS (1975)

Test No.	Date	Type of Test*	Description of Specimen Configuration and Test Setup**
226	1-13-75	Horizontal (In-Plane) Static Load	5' x 6'8" XO** door with tempered class and 6063-T5 Al extrusion structural members. Vendor stock door except one deadbolt added at bottom and 1/4" thick Al spacer strip along top of sliding panel. Door open 1-1/2" for loading fixture clearance.
227	1-13-75	Lateral Static Load	Same door assembly and installation as Test 226 except door was latched. (See footnotes for differences in loading and instrumentation.)
228	1-22-75	Vertical (In-Plane) Static Load	Same as Test 227 except for loading and instrumentation. (See footnotes.)
229		Horizontal (In-Plane) Static Load	Same type door except 6' x 6'8" XO and top deadbolt replaced by one identical to bottom one. Attachment of jamb to framing improved with additional screws in latch area. Different loading fixture than in Test 226 so door could be latched.
230	2-20-75	Horizontal (In-Plane) Static Load	Same as Test 229 except sliding panel top spacer strip increased to 3/8" thickness, latch replaced with one 3" wide, and anchoring of deadbolts to framing improved.
1	2-20-75	Prybar Test	Same as Test 230 except for loading and instrumentation. (See footnotes.)
2		Prybar Test	Same as Prybar Test 1 except 1" x 1" x 1/4" x 12" long steel angles were installed along both sides of jamb in latch area and 1/4" x 2" x 12" long steel plates sandwiched sliding panel stile in same area.
3		Prybar Test	Same as Prybar Test 2 except 1/4" bolts with tensile capacity anchoring sliding panel to fixed panel and frame.

-continued-

FIGURE 56

CCTRF SLIDING GLASS DOOR TESTS (1975)

Notes:

* Tests 226 through 230 used hydraulic jack to simulate loading situations that can be developed by prying with a prybar. Prybar tests 1 through 3 used actual prybar.

o Lateral test loads were applied perpendicular to sliding panel against outboard stile 6" above latch C_L.

o Horizontal test loads were applied in plane of sliding panel against outboard stile 6" above latch C_L.

o Vertical test loads were applied in plane of sliding panel against lower rail at midspan.

** Instrumentation in static tests consisted of strain-gaged reeds to monitor deflections in direction of load: 4 locations in Tests 226 and 227, 2 in Test 228, and 3 in Tests 229 and 230. (See Appendix C for locations.) See Figure 57 for schematic of XO door.

10. Sliding Glass Windows

Ten tests were conducted on typical aluminum framed sliding glass windows. As in the glass door tests, the objective of the tests was to establish realistic performance requirements for structural resistance to forced entry, and determine test methods that would adequately simulate the threat and evaluate the resistance. In general, loadings consisted of forces applied to the glazing panel frame perpendicular to the plane of the panel and vertically and horizontally in the plane of the panel. Figure 57 provides brief descriptions of the test configuration for the sliding glass windows. In some tests, the capability of the complete window assembly to resist simulate forced entry loading by prying with a prybar was evaluated.

All tests were performed in a "universal test frame," and instrumentation to monitor deflections was generally located at the load application point and/or the latch. The hydraulic pressure of the load application ram was monitored simultaneously with deflections so that load/deflection curves could be established.

The other glazing-type threats to which window panel assemblies may be subjected are covered under the glazing panel tests.

11. Glazing Systems

A series of tests were conducted for the purpose of evaluating the structural resistance of various glazing panel materials to various types of burglary break-in threats.

The glazing panels evaluated were 25-inch square plates of the following materials:

- 1/8" (Nominal) double strength window sheet glass
- 1/4" (Nominal) tempered glass
- 1/4" (Nominal) safety laminated glass
- 1/4" (Nominal) wire reinforced glass
- 5/16" (Nominal) Vigil Pane (trade name of Libby Owens Ford Company)
- 5/16" (Nominal) Watchguard (trade name of Pittsburgh Plate Glass Industries)
- 5/16" (Nominal) Plexiglass (trade name of (Rohm and Haas Company)
- 5/16" (Nominal) Lexan (trade name of General (Electric Company)

FIGURE 57

CCTRF SLIDING GLASS WINDOW TESTS (1975)

Test No.	Date	Type of Test*	Description of Specimen Configuration and Test Setup**
L1	2-20-75	Lateral Static Load	Vendor Stock Model A (Single Thickness Glass)
L2	2-24-75	Lateral Static Load	Vendor Stock Model B (Insulated Glass)
L3	3-20-75	Lateral Static Load	Vendor Stock Model A except Lexan glazing panel. Window frame (jambs, head, and Al sill) completely covered on outside by rolled section made from 1/8" AISI 1020 steel and secured to wall framing with 18 1/4" x 2" lag bolts. Two toggle bolts added tangent to top edge of sliding glass panel which had 1/8" Al strip bonded to it.
L4	3-20-75	Lateral Static Load	Same as Test L3 except 2 x 4 studs added full length each side of window making a total of 3 each side.
L5	3-21-75	Lateral Static Load	Same as Test L4 except plywood columns (horizontal) added top and bottom between sliding panel and wall framing at fixed panel side.
L6	3-21-75	Lateral Static Load	Same as Test L5 except built-up gusset plate stiffner added to outside of wall framing studs in attempt to prevent rotation.
V1	4-04-75	Vertical Static Load	Same as Test L6 except for load application and instrumentation (see footnotes).
V2	4-04-75	Vertical Static Load	Same as Test V1.
H1	4-22-75	Horizontal Static Load	Same as Tests V1 and V2 except for load application and instrumentation (see footnotes) and the addition of a .32 x .36 steel reinforcing bar inside the load bearing stile extrusion.

-continued-

FIGURE 57

CCTRF SLIDING GLASS WINDOW TESTS (1975)

Test No.	Date	Type of Test*	Description of Specimen Configuration and Test Setur
P1	Still to be performed	Prybar Test	Same as H1 except short steel angles added in severa locations inside to brace window frame to wall frami and prevent prybar attack from pushing sliding panel out in the inward direction.

Notes:

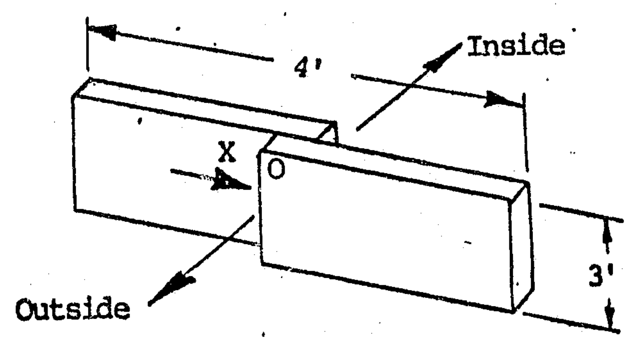
* All L, V, and H tests used hydraulic jack to simulate loading situation that can be developed by prying with prybar; P1 test will use actual prybar.

o L test loads were applied perpendicular to sliding panel at mid-height of outboard stile (at latch level).

o V test loads were applied in plane of sliding panel against center of lower rail by jack pushing up through hole in sill framing.

o H test loads were applied in plane of sliding panel against center of outboard stile by jack pushing inboard through hole in jamb framing.

** All assemblies tested were Type XO, 3' x 4' nominal size (see sketch below). Structural members (glazing panel stiles and rails and frame head, jambs and sill) are 6063-T5 Al extrusion. Instrumentation consisted of strain gaged reeds to monitor deflections in direction of load: 6 in L tests, 3 in H test, and 2 in V tests .



Schematic of XO window assembly. (Same arrangement designation applies to sliding glass doors.)

The last four items are commercially designated as "burglar resistant" glazing materials. Vigil Pane and Watchguard construction consists of two 1/8-inch nominal thickness glass panes sandwiching an 0.060-inch thick plastic interlayer. The last two are homogeneous plastics, Plexiglass being an acrylic and Lexan a polycarbonate.

The types of tests performed to simulate the various threats and evaluate the various panels' resistance to them were as follows:

> Static, concentrated compressive load against the center of the panel in gradually increasing magnitude until failure of panel occurred.
>
> Impact test with a measured weight dropped from various heights until panel fractured.
>
> Spring punch impact test performed with an actual spring punch.
>
> Impact with an actual hammer blow against the panel.
>
> Low temperature thermal shock tests performed by applying the flame of a Propane torch directly against the glazing surface.
>
> Various combinations of two or more of the above threats.
>
> Hole-saw cutting through the panel with a power tool (tested on Lexan panel only).

The first forced entry threat test, i.e., the first item listed above, could conceivably simulate pushing against the panel with a rod or other object. This is not a likely threat because there is considerable danger of injury unless a long rod is used. Also, there is not much possibility of achieving failure in any of the panels tested considering the two-arm push capability limit of the "standard man."

The primary purpose of the static tests was to determine fundamental structural characteristics required to evaluate the dynamic threats.

The second threat test was intended to evaluate the capability of the panel to resist the impact of an object thrown against the panel by the "standard man." Using what was considered a reasonable weight of missile and distance from window, hurling tests were performed by laboratory personnel and the motion was recorded by movie camera. The maximum kinetic energy was calculated and used as the critical thrown missile threat for all panels tested.

The simulation intent or purpose of the remaining above-listed items is self-evident. Not all of the individual threats or threat combinations were applied to each type of panel. Static, drop impact, and high temperature thermal shock tests were performed on all panel types. A matrix presenting a summary of all the tests is presented in Figure 58.

The test fixture used for the tests is essentially that specified in the ANSI Standard for safety glazing material, except that it was designed for support with the test panels oriented horizontally rather than vertically. As such, the impact was produced with a vertically free-falling impactor rather than a swinging object.

- - - -

FIGURE 58

SUMMARY OF GLAZING PANEL TESTS

	Glazing Panel Material	Static Force a	Drop Impact b	Spring Punch c	Hammer d	LN_2 e	Torch f	Hole Sawing g	LN_2 & Torch h	Torch & Hammer i	LN_2 & Hammer j	LN_2 & Torch & Hammer k
1	1/8" Double Strength Sheet Glass	X	X	X			X		X			
2	1/4" Tempered Glass	X	X	X			X		X			
3	1/4" Safety Laminated Glass	X	X	X		X	X					
4	1/4" Wire Reinforced Glass	X	X	X	X	X	X			X	X	X
5	5/16" Vigil Pane Laminated Glass	X	X	X	X	X	X		X	X	X	
6	5/16" Watchguard Laminated Glass	X	X	X			X			X		
7	5/16" Plexiglas (Acrylic)	X	X	X			X		X		X	
8	5/16" Lexan (Polycarbonate)	X	X	X	X		X	X	X	X	X	X

SECTION III. TEST RESULTS

A. Exterior Door Systems

1. Preliminary Static Load Tests

The results of the preliminary static load tests conducted on the doors are summarized in Figure 59 which defines the test configurations, load application points, failure loads and failure location.

In the first three tests on the hollow doors with a conventional latch, ultimate loads were applied at the upper hinge, lower hinge, and door knob. In each case, failure occurred in the wooden door jamb at the screw holes. The lowest failure load was 353 lbs. in Test No. 3 at the striker plate screws with the load applied at the door knob. In Test No. 4 with the load applied at the door knob and the latch system being both the knobset latch and a deadbolt, the failure load occurred at 724 lbs when the deadbolt failed. In the next two tests, Nos. 5 and 6, the striker plate was modified to increase the edge distance on the screw holes. The design modification is shown in Figure 50 (Striker Plate Design No. 1). Testing of this configuration with a knobset latch only did not appreciably increase the strength of the system.

In Test No. 5, the latch portion of the lock rotated and caused the door edge to fail at 371 lbs while in Test No. 6, with door latch reinforced against rotation, the latch failed at 372 lbs; therefore, in the next test (No. 7) a heavy steel bar was used to simulate the door latch to measure the strength of the striker plate re-design. In this design the striker plate resisted an applied load of 1,042 lbs before the door frame itself rotated excessively due to lack of exterior and interior wall sheeting.

Test No. 8 was conducted using a solid (particle board) core door and both a redesigned striker plate and door edge stiffener. These redesigned components are shown in Figures 50 and 60. Application of loads to this assembly at the door knob location was successful up to 1,192 lbs. At this load, excessive rotation and separation occurred in the FHA framing due to lack of inside and outside wall sheeting. Removal of the load showed no damage to any of the door components and the lock system was completely functional.

FIGURE 59

SUMMARY OF EXTERIOR SINGLE DOOR - PRELIMINARY STATIC LOAD TESTS

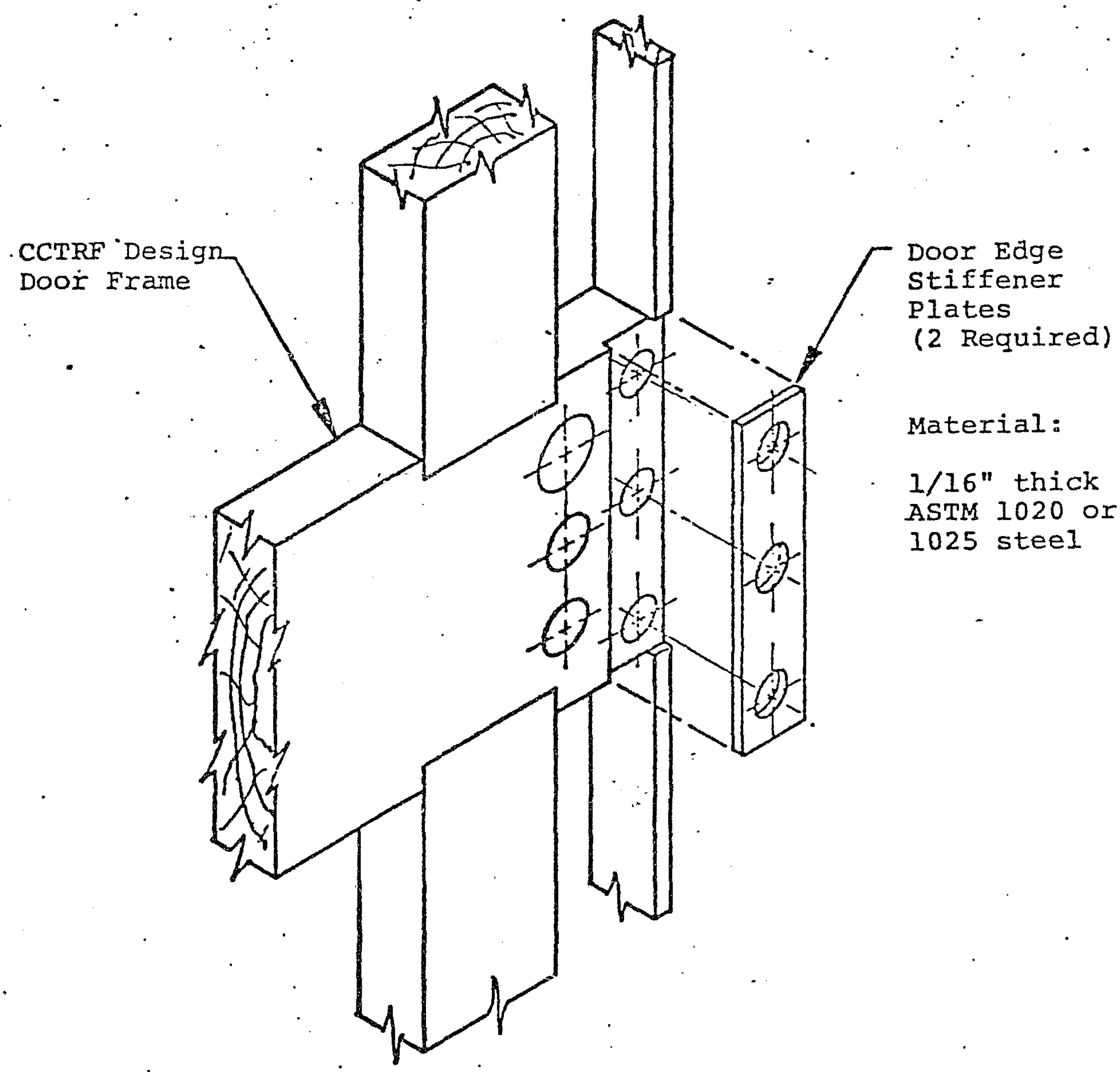
LOADS NORMAL TO DOOR (FHA FRAMING)

RESISTANCE PARAMETERS / TEST NUMBER	1	2	3	4	5	6	7	3
1. Type of Construction	Hollow Core	Hollow Core	Hollow Core	Hollow Core	Hollow Core	Hollow Core	None*	Hollow Core
2. Striker Plate Reinforcement	Standard	Standard	Standard	Standard	CCTRF Design #1	CCTRF Design #1	CCTRF Design #1	CCTRF Design #1A
3. Latch Fastener	Deadlatch	Deadlatch	Deadlatch	Deadlatch &Deadbolt	Deadlatch	Deadlatch w/door stiffener	Simulated Door Latch	Deadlatch
4. Component Tested	Lower Hinge	Upper Hinge	Lock	Knobset/ Deadbolt	Striker Plate	Striker Plate	Striker Plate	Door System
5. Load Application Point	Adjacent Lower Hinge	Adjacent Upper Hinge	Adjacent Doorknob	Adjacent Doorknob	Adjacent Doorknob	Adjacent Doorknob	Striker Plate	Adjacent Doorknob
6. Failure Location	Door Jamb Lower Hinge Screwhole	Door Jamb Upper Hinge Screwhole	Door Jamb at Latch	Latch & Lock Mechanism	Latch & Door edge	Latch Mechanism	None*	None
7. Measured Failure Load Capability	627 lbs	633 lbs	353 lbs	724 lbs	371 lbs	372 lbs	>1042 lbs	>1192 lbs

* Door frame test structure only; door not in test setup.

FIGURE 60

CCTRF DOOR EDGE STIFFENER PLATE DESIGN 1-A



2. Static Load Failure Tests

Figure 61 provides an overall summary of the final series of 17 static load tests as well as dynamic load tests. This summary describes the types of doors tested, the configuration of the supporting hardware, the failure load and failure mode.

In general, these tests indicated that the 2000 lb load provided by a bumper jack spreader could produce a deflection as great as 0.5 inch at the latch location and a prybar attack of 6,000 in.-lbs could result in a deflection of the frame at the same location. These deflections establish the length of the throw bolt required in the lock system to resist these threats.

It should be noted that the fire struts placed between studs in the FHA framing are from a structural point of view, very effective in resisting the spreading of the jambs by the "bumper jack" threat. For the same purpose, any shimming that may be required to fit the door jamb facings to the 2 x 4's frames should be extended to the areas opposite to the lock and to the hinges.

These results showed the range of spring constants measured for the test series was from a low of 234 lbs per inch (for a completely hollow core) to a high of 2,686 lbs per inch (for a solid wood core). In these static load failure tests, generally, the door experienced failure in a very local area of the door. After reinforcing these locally damaged areas, tests were usually resumed with subsequently dramatically improved results. The range of door failure loads, both before and after reinforcing, was from as little as 465 lbs to as much as 2,533 lbs. The smallest load which could be considered an ultimate failure load was that of Test No. 15 where 827 lbs caused complete "punch through" of a hollow core door.

FIGURE 61

SUMMARY OF FINAL (1973 & 1974) EXTERIOR DOOR TESTS

Test No.	Door*	Frame	Locks/Latches	Reinforcements*	Failure: Load (lbs)** KE (in.lbs)***	Failure: Mode
14	30" wide metal door with paper honeycomb core	Metal	Knoblatch only	None	776 lbs	Latch rotated out of striker plate due to door bending defl.
15	Same door that was used in Test 201	Metal	Knoblatch only	None	1034 lbs	Latch sheared
16	Same type as above	Metal	Knoblatch and deadbolt	None	6265 in.lbs	Deadbolt failed due to internal failure of door at latch
17	36" wide metal door with styrofoam core	Metal	Knoblatch only	None	1137 lbs	Door wood split at latch screws and latch pin fractured
18	Same door as above except damaged lock ass'y replaced and damaged area of door reinforced	Metal	Knoblatch only	Two 3/8" D through-bolts added to damaged area of door at latch	1778 in.lbs	Lock failed

* Description reading "same as above" means same as last above.
** Static test load, applied normal to door on level with, and 1/3 door width inboard of, latch.
*** Maximum KE of impactor, just prior to impact.

-continued-

FIGURE 61

SUMMARY OF FINAL (1973 & 1974) EXTERIOR DOOR TESTS

Test No.	Door*	Frame	Locks/Latches	Reinforcements*	Failure: Load (lbs)** KE (in.lbs)***	Failure: Mode
19	72" wide wood	Metal	Knoblatch only	None	1207 in.lbs	Door split at latch and lock was damaged
20	Same door as above except for reinforcements	Metal	Knoblatch only	Latch areas of movable and fixed doors reinforced with "U" channels	1344 lbs	Lwr flush bolt striker plate attachment to wood jamb sheared
21	Same door as above except flush bolt attachment areas reinforced	Metal	Knoblatch only	Same as above plus reinforcement at flush bolt attachment areas	2476 in.lbs	Latch rolled off striker plate & lock was damaged
22	Same door as above except lock set replaced with new one and separate dead bolt added	Metal	Knoblatch and deadbolt	Same as above	1944 lbs	Locks rolled off striker plate damaging them
23	72" wide wood hollow core double door	Metal	Knoblatch and deadbolt	Latches reinforced with doubler wrapped over edge. Fixed door edge reinforced with "U" channel.	724 lbs ------ 827 lbs	Ram punched through door ------ Deadbolt failed

-continued-

FIGURE 61

SUMMARY OF FINAL (1973 & 1974) EXTERIOR DOOR TESTS

Test No.	Door*	Frame	Locks/Latches	Reinforcements*	Failure: Load (lbs)** KE (in.lbs)***	Failure: Mode
24	72" wide CCTRF reinforced core double doors	Metal	Combination deadlatch and deadbolt ass'y	CCTRF door edge latch stiffeners. Al "T" section on fixed door edge. "U" channels at flush bolts	Max. test KE of 4058 in.lbs	No failure
25	Same door as above	FHA wood	Combination deadlatch and deadbolt ass'y	Same as above	2000 in.lbs ---- 2585 lbs	Local material failure at point of impact. ---- 1st failure in jamb at top & middle hinges. Deadbolt failed & flush bolts deformed
26	72" wide standard solid core, double wood doors	FHA wood	Knoblatch and deadbolt	None	776 lbs	Fixed door fracture at upper & lwr flush bolts
27	Same door as above except channel reinforcements at flush bolt attachments	FHA wood	Knoblatch and deadbolt	"U" channels at flush bolts (in fixed door).	1241 lbs	Movable door split at lock location

-continued-

FIGURE 61

SUMMARY OF FINAL (1973 & 1974) EXTERIOR DOOR TESTS

Test No.	Door*	Frame	Locks/Latches	Reinforcements*	Failure	
					Load (lbs)** KE (in.lbs)***	Mode
28	Same door as above except reinforcement added to door latch area	FHA wood	Knoblatch and deadbolt	Same as above plus door edge latch reinforcements	1034 lbs	Fixed door split along striker plate screw line
29	Same door as above except channel reinforcement added to fixed door latch area	FHA wood	Knoblatch and deadbolt	Same as above except channel reinforcement added to fixed door in latch areas	1768 lbs	Movable door split at wood around latch reinforcement
30	Same type of door system as above	FHA wood	Knoblatch and deadbolt	Same as above	2378 lbs	Fixed door failed in bending tension on inside at latch
31	36" wide metal clad solid core wood door	FHA wood	Knoblatch and deadbolt	None	465 lbs	Door edge failed in tension between deadbolt & deadlatch
32	Same door as above except for reinforcements	FHA wood	Knoblatch and deadbolt	Door edge reinforced at both latches	620 lbs	Door frame (jamb) failed at both latch striker plates simultaenously

-continued-

FIGURE 61

SUMMARY OF FINAL (1973 & 1974) EXTERIOR DOOR TESTS

Test No.	Door*	Frame	Locks/Latches	Reinforcements*	Failure	
					Load (lbs)** KE (in.lbs)***	Mode
33	Same door as above except for reinforcements	FHA wood	Knoblatch and deadbolt	Same as above and CCTRF striker plate used	1965 lbs	Deadbolt failed
34	36" wide solid core wood door	Metal	Knoblatch and deadbolt	None	1220 lbs	Door edge failed in tension between deadbolt and deadlatch
35	Same door as above except for reinforcement	Metal	Knoblatch and deadbolt	"MAG" reinforcement at latches	2533 lbs	Deadbolt failed at 2378 lbs and deadlatch at 2533 lbs.
36	36" wide CCTRF design reinforced core door	Metal	Knoblatch and deadbolt	None	920 lbs	Door edge split at latch
37	Same door as above except for reinforcements	Metal	Knoblatch and deadbolt	"MAG" reinforcement at latches	2378 lbs	Door failed locally at cross beam and stile joint. Deadbolt was damaged.

3. Static Lateral Spreading Load Tests

Static load tests were conducted by applying lateral loads to the standard FHA door framing both with and without wood and metal door frames and exterior and interior sheeting. The tests were conducted both with and without a door on the frame. In a bumperjack spreader threat, the bolt of a conventional door latch cannot provide resistance to the applied load. Only the door frame resists the threat. In the case of the pry-bar threat, the door must be capable of a local resistance to the compressive bar load. In addition, the door and hinges must be capable of transferring the bar load to the frame. Again, the primary resistance factor is the framing system.

In one test the nailing schedule shown in Figure 62 was used in construction of the door frame. An application of a 2,000 lb. static force of a bumperjack on the jambs caused only a deflection of 0.3 inch which would preclude the disengagement of any standard one-inch latch.

4. CCTRF Striker Plate and Exterior Door

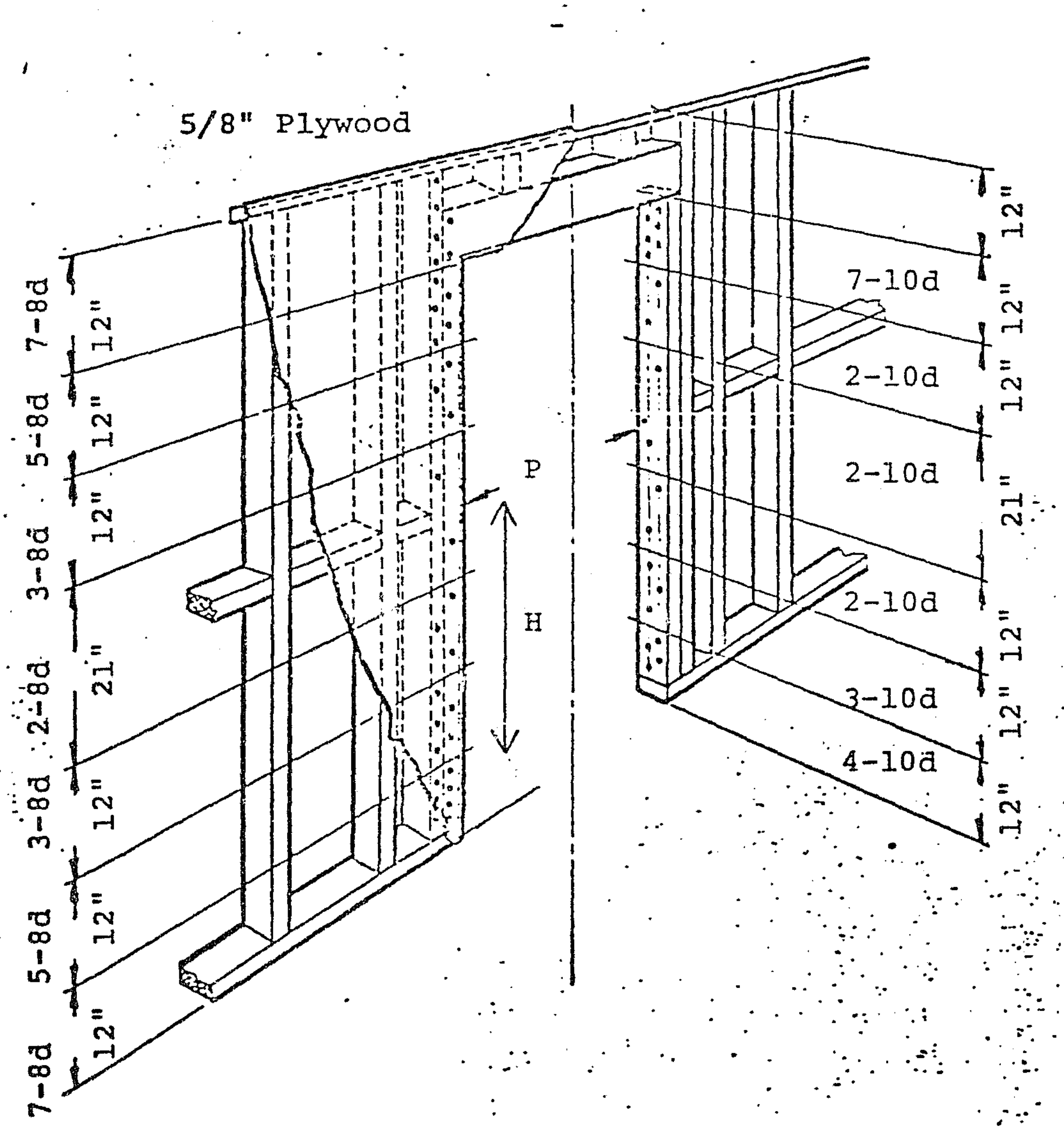
a. CCTRF Striker Plate Design

The initial static load failure tests (Tests No. 1 and No. 3) of the exterior doors determined that the standard lock striker plate installed in the door jamb constituted the weakest area of the system. In each test, the wooden door jamb split at the striker plate screw holes with no damage occurring to the actual striker plate. Failure loads as low as 1/3 of man's impact capability were observed.

At this time, it was necessary to strengthen the striker plate installation before proceeding with the test program to determine the strength of other components in the door system. Various methods were considered and tested, including longer screws and bonding agents between the striker plate and the door jamb. The most effective strengthening modification found was a simple increase in the distance from the screws to the edge of the door jamb. The revised design (Design No. 1) adopted is depicted in Figure 50 and was utilized in the subsequent static door system testing without being failed. The final static strength test incorporated a door edge reinforcement (Design No. 1A) which is shown in Figure 60. A more structurally adequate latch reinforcement,

FIGURE 62

CCTRF NAILING SCHEDULE TO REDUCE SPREADING OF DOOR JAMBS UNDER LATERAL LOADING



H = 1/2 DOOR HEIGHT

P = Applied Load = 2,000 lbs

Design No. 2, was developed for the dynamic load tests and described by Figure 63. In this design the jamb is held between two steel plates with loads being transferred into the framing studs by both tensile and shear loads on the screw attachments. In order to fail this striker plate assembly, the applied load would have to shear the door jamb and fail the attachment screws in the framing studs.

b. CCTRF Exterior Door Design

The results of the static failure test program demonstrated that both the standard hollow and solid core exterior doors had serious weaknesses in construction and ability to transfer loads to the remainder of the door system components. During these tests, the weaker component parts were strengthened in order to increase the overall strength of the door system. The modifications were all incorporated into a hollow door design described by Figure 64. This door design incorporates the following features not normally found in commercially available residence type doors.

1. Expanded steel screen to prevent sawing.
2. "Soft" edges to absorb prybar loads by deformation.
3. Hardened attachment point for hinge screws.
4. Hardened attachment point for knob/lockset.
5. Efficient load-carrying structure connecting hinges and lock; assuring proper load distribution.
6.

A prototype door was constructed to this design and tested under dynamic loading described below. The door successfully resisted all test loadings well in excess of the expected threat loads.

FIGURE 63

CCTRF STRIKER PLATE ASSEMBLY-DESIGN NO. 2

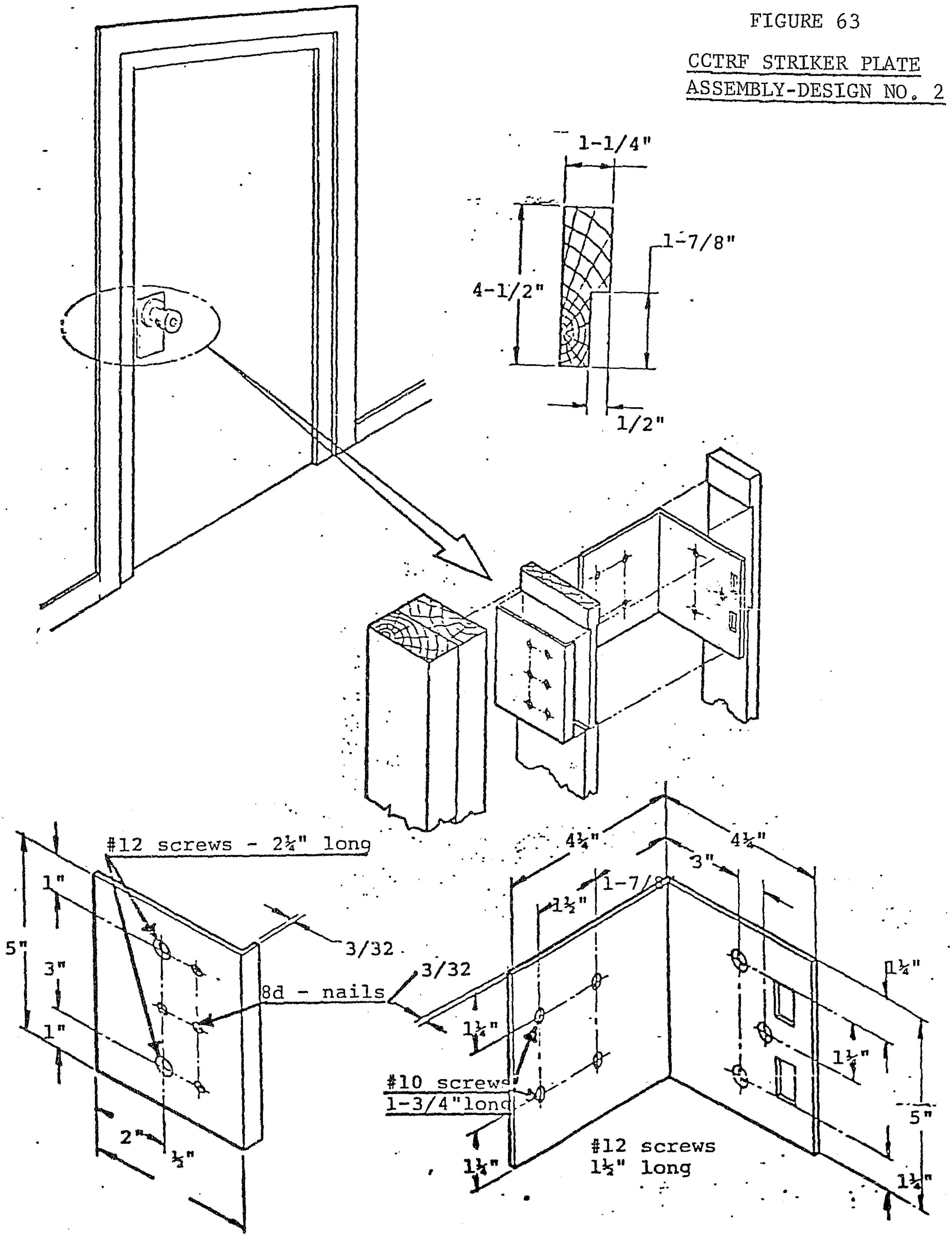
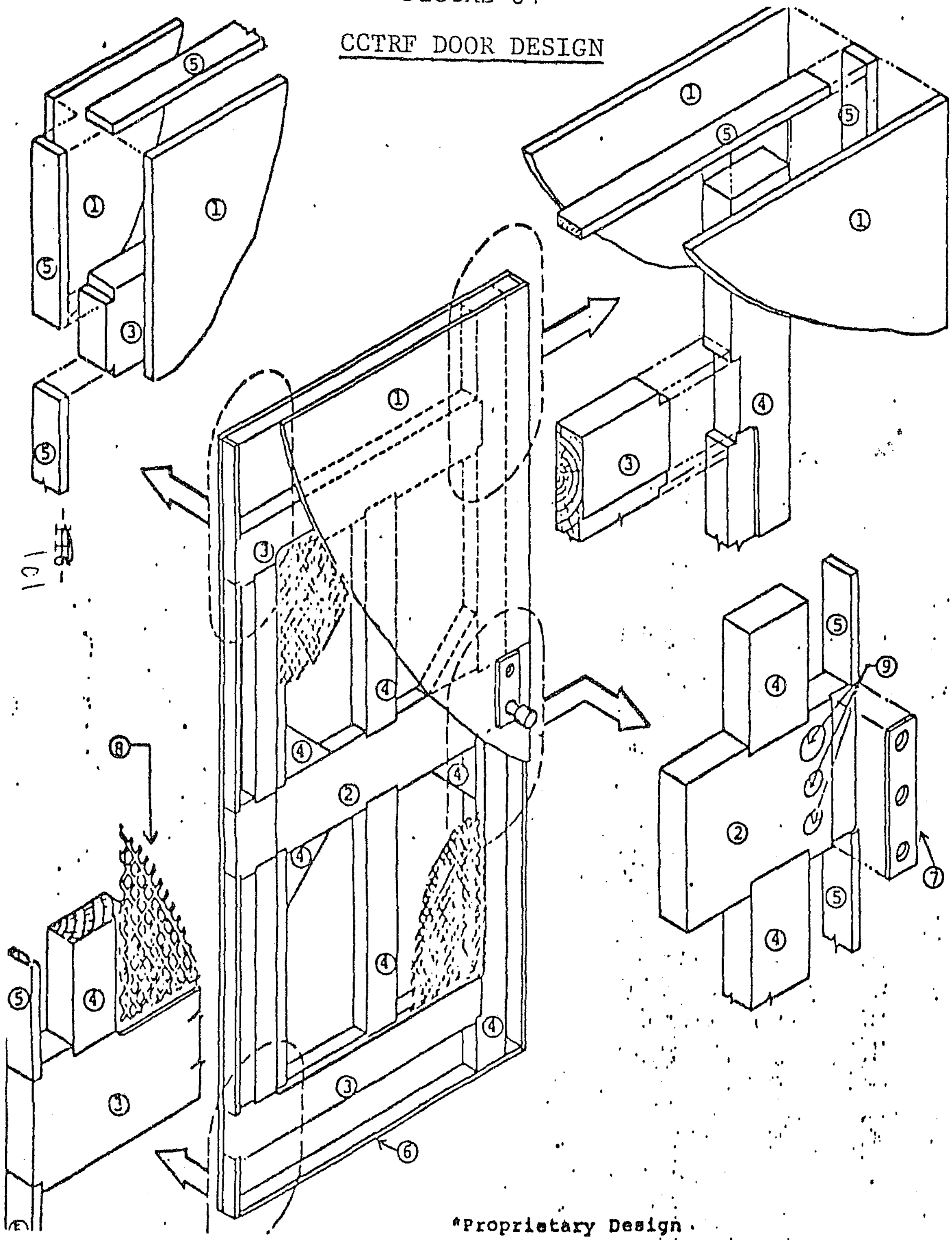


FIGURE 64

CCTRF DOOR DESIGN



Legend

1. 1/4" exterior grade plywood - glued to structure
2. 2x8 Douglas Fir - select structural
3. 2x6 Douglas Fir - select structural
4. 2x4 Douglas Fir - Dense No. 1
5. 1x2 Clear Pine
6. 2x2 Clear Pine
7. Door edge stiffener Plates (2) - 1/16" thick ASTM 1020 or 1025 steel. Outside plate to be blank: The two plates secured by screws installed from inside. These may be incorporated in lock design.
8. Carbon steel expanded metal screen - 1/16" thick ASTM 1010 steel. Secured by staples and epoxy resin glue.
9. Lock installation holes

5. Dynamic Tests

Impact energy was generally applied in gradually increasing steps and ranged from 163 to 6265 in-pounds. Impact failure loads ranged from 1207 to 6265 in-pounds. A summary of the dynamic test results for the various types of doors is presented in Figure 65.

A margin of safety on building security is defined for each test on the basis of the measured strength resistance and input threat load. The applied loads and resistance strengths are given in terms of both energy and equivalent dynamic load. Figure 66 gives typical results of applying other dynamic threats such as a foot-kick impact; a battering ram impact and a hammer impact.

In addition to the quantitative data, there were some very clear and valuable qualitative conclusions derived from the exterior door tests.

First, the tests demonstrated the standard hollow core doors will not readily resist the threat loads. The tests showed the doors to be entirely too susceptible to "punch-through." This type of failure occurred in Test No. 18 at a static load level of 827 pounds, whereas, a similar door in a similar test configuration but with a solid core design resisted 1944 pounds in Test No. 17 before excessive deflection caused the lock latches to roll off the striker plates. It was demonstrated that even paper honeycomb cores can increase the strength and stiffness greatly over that of the hollow core type.

Secondly, these door tests showed that to meet any building security standards, a certain minimal amount of metal reinforcement will be needed at the maximum concentrated load locations. These are all on the latchside edges of door and frame; latch and deadbolt plates, striker plates, and flush bolt attachments in the case of double doors. Wood is an excellent material for many structural applications including doors, but, as anticipated, the tests showed that local failures in wood at the highly concentrated load areas will occur long before the full potential capacity of the bulk of the door is reached. (Splitting of wood along striker or latch plate screw lines was a common occurrence.) The tests demonstrated that this

FIGURE 65

SUMMARY OF SINGLE EXTERIOR DOOR

MAXIMUM DYNAMIC LOAD TESTS

SHOULDER IMPACT THREAT[1]
(FHA FRAMING)

Resistance Parameters	Test Number	1	2	3	4
1.	Door Material	Wood (D.F.)	Wood(D.F.)	Wood(D.F.)	Wood(D.F.)
2.	Door Width	36" Wide	36" Wide	36" Wide	36" Wide
3.	Single or Double Door	Single	Single	Single	Single
4.	Door Thickness	1-3/4"	1-3/4"	1-3/4"	2"
5.	Door Frame Thickness[2]	1-1/2" Wood	1-1/2" Wood	1-1/2" Wood	1-1/2" Wood
6.	Type of Door Construction	Hollow Core	Solid Core	Solid Core	Hollow Core CCTRF
7.	Boundard Fastener	Butt Hinges	Butt Hinges	Butt Hinges	Butt Hinges
8.	Method of Fastener Attachment	#9x3/4 Screws	#9x3/4 Screws	#9x3/4 Screws	#9x3/4 Screws
9.	Type of Support Structure	FHA	FHA	FHA	FHA
10.	Striker Plate Reinforcement	None	None	CCTRF Design[3]	CCTRF Design[3]
11.	Latch Fastener	Dead Latch	Deadbolt & Latch	Deadbolt & Latch	Deadbolt & Latch
12.	Threat Energy Input, U_i	1800 in-lb	1800 in-lb	1800 in-lb	1800 in-lb
13.	Measured Spring Constant, K				
14.	Maximum Applied Test Energy, U_a	1078 in-lb	1332 in-lb	2620 in-lb	4602 in-lb
15.	Maximum Energy Absorption, U_R	800 in-lb	560 in-lb	2296 in-lb	>2019 in-lb
16.	Measured Dynamic Load Capability	914 lbs	1130 lbs	2068 lbs	>2069 lbs
17.	Equivalent Dynamic Test Load for Static Test				
18.	Failure Mode	Jamb at Latch	Jamb at Latch	Door at Latch	No Failure
19.	Failure Load				
20.	Security Safety Margin, E(%)[4]	-40	-26	+45	>+156

Notes:
1. Load Normal to Door
2. Wood Used - White Pine
3. CCTRF - Design No. 2 (Figure)
4. $E = (U_a/U_i = 1)\ 100$

FIGURE 66

SUMMARY OF SINGLE EXTERIOR DOOR

DYNAMIC LOAD TESTS

VARIOUS IMPACT THREATS

(FHA FRAMING)

Door System	Threat No.	Threat Energy Input (In-lb)	Failure Energy (In-lb)	Energy Rec'd By Assembly (In-lb)	Measured Dynamic Load(Lbs)	Security Safety Margin***
Group A - Standard Hollow Core	(1)Shoulder	1800	1078	800	915	-40%
Group B - Standard Solid Core	(1)Shoulder	1800	1332	560	1130	-26%
Group C - Solid Core with CCTRF Reinforced Latch *	(6)Hammer	125		114	461	+HIGH
	(5)Ram	1050		500	965	+150%
	(2)Kick	775		1192	763	+238%
	(1)Shoulder	1800	2620	2296	2068	+ 45%
Group D - CCTRF Door** and Latch	(2)Kick	775		378	895	>+494%
	(1)Shoulder	1800	>4602	2020	2070	>+156%

*Figure
**Figure
***E = (R/M -1)100
Where R = Resistance Failure Energy Applied Input
M = Threat Energy

problem may be greatly alleviated by attaching a light sheet metal channel with screw fasteners to the door edge of the lock or using the door edge stiffeners depicted in Figure 60.

Another important finding from the tests was that the addition of a deadbolt will greatly increase a door system's chances of passing a security standards performance test. Besides increasing locking security, it will greatly decrease the maximum concentrated reactive load (equal to 1/3 of the applied load) and stress by sharing the door latch-side reaction with the knob latch, which would otherwise have to resist it at this single, concentrated location. This is particularly important in view of the fact that most residential and light commercial exterior doors open inward so there is no possibility of help from a stopper strip in distributing the impact load reaction.

The tests demonstrated that only minor differences in installation details of door frames and framing, particularly in nailing and shimming, may make major differences in the strength and stiffness parameters that determine resistance to forced entry. Therefore, it is obvious that the building security performance test standards will need to include a requirement for providing detailed installation instructions with each type of door system qualified.

B. Lock Systems

The test series measured the resistance to burglar attack of various types of locks used on exterior doors and garages for security of residences. The types of locks tested included cylindrical locks, tubular locks (deadbolts), mortise locks, unit locks, interlock bolts, flush bolts and padlocks. The padlocks tested were of both standard and high security types.

In the laboratory investigation of each lock threat, the approach was to first determine the techniques used in gaining entry, e.g., how the burglar tools are used, and then measuring the magnitude of the forces involved in the threat. These forces were then applied to typical lock equipment to evaluate threat resistance capability.

The various threat levels measured for each type of burglar attack method on lock systems are summarized in Figure 67. These data were used to develop the lock performance test requirements.

Figure 68 summarizes the test results of applying static and dynamic loads to simulate a shoulder impact load, to single and double exterior doors, assemblies which were secured with a variety of types of locking equipment. These test data are for the door tests in which a lock failure contributed to or caused the entire assembly to fail.

The results of using a hammer and punch on the end of a lock bolt in four different tests are given in Figure 69, which shows that two of the four locks were susceptible to the threat. However, one lockbolt which failed jammed in a locked position and would not allow the lock to be activated open. All the locks failed above the threat level load.

The results of ten different hammer impact tests on cylindrical knobs deadbolt locks and padlocks are given in Figure 70. These tests showed that typical lock systems were vulnerable to the hammer impact threat.

The threat of using a length of pipe on a door knob was demonstrated on only one lock but it was obvious that the threat would be difficult to resist by typical cylindrical knob locks.

The effect of using twisting tools on cylindrical knob locks and the deadbolts was measured and the results of nineteen tests are given in Figure 71. These tests demonstrated that the only locks that resisted the threat were those with a free rotating lock cylinder guard or knob handle. All other locks failed at a torque level well below the threat level.

FIGURE 67

LOCK THREAT LEVELS

Threat No.	Type Threat	Type Load	Threat Load
1	Shoulder Impact	Lateral Impact	1800 in-lbs. or 2250 lbs.
2	Lockbolt End Impact	Axial Impact	170 in-lbs.
3	Hammer Impact	Vertical and Axial Impact	170 in-lbs.
4	Doorknob Bending	Moment	3300 in-lbs.
5	Wrench Twisting	Torque	3300 in-lbs.
6	Deadbolt Prying	Wedging and Moment	300 lbs. and 625 in-lbs.
7	Lock Cylinder Pulling	Impact and Static Tension	120 in-lbs. and 2350 lbs.
8	Lock Cylinder Twisting	Torque	600 in-lbs.
9	Drilling	Drilling Force	50 lbs. and 5 Minutes
10	Sawing	Sawing Force	26 lbs. and 5 Minutes
11	Shackle Cutting	Shear Force	32,600 lbs.
12	Shackle Prying	Tension and Bending	2500 lbs. and 1600 in-lbs.
13	Padlock Heating	Cutting Torch	6000° F.
14	Padlock Freezing	Liquid N_2 and Impact Force	-320° F. and 170 in-lbs.
15	Jimmying	Spreading Force	2000 lbs.
16	Loiding	Manipulation	5 Minutes
17	Rapping	Manipulation	5 Minutes
18	Picking	Manipulation	5 Minutes

Test No.	Lock	Type Lock	Latch Reinforcement	Type Door	Type Frame	Applied Load	Failure Load (lbs)	Failure Mode
	Kwikset 600DL	Entry Lock	None	Single, wood, hollow core	Wood	Static	530	Striker Plate
	Kwikset 685	Deadbolt	None	Single, wood, hollow core	Wood	Static	1086	Deadbolt Rotation
	Dexter 7266	Knobset						
	Amerock C6271	Knobset	CCTRF	Single, wood, hollow core	Wood	Static	557	Latch Rotation
	Velch 153	Deadlock						
	Kwikset 600DL	Entry Lock	CCTRF Door Edge Stiffner & Striker Plate	Single, wood, solid core	Wood	Static	1788	None
	Schlage D51PP	Entry Lock	None	Single, metal, paper honeycomb	Metal	Static	1164	Lockbolt Rotated
	Kwikset 680	Deadbolt	None	Single, metal, paper honeycomb	Metal	Static	1550	Deadbolt Sheared
	Kwikset 680	Deadbolt	None	Single, metal, paper honeycomb	Metal	Dynamic	1727	Deadbolt Sheared
	Schlage D51PD	Entry Lock	2 Bolts Thru Door Edge	Single, metal, styrofoam core	Metal	Static	1706	Latchbolt Bending
	Schlage D51PD	Entry Lock	2 Bolts Thru Door Edge	Single, metal, styrofoam core	Metal	Dynamic	1787	Latchbolt Bending
	Schlage D51PD	Entry Lock		Double, wood, solid core	Metal	Dynamic	1698	Door Edge Attach.
	Ives 458	Flush Bolt	None					
	Schlage D51PD	Entry Lock	M.A.G. Inactive Door	Double, wood, solid core	Metal	Static	2016	Flushbolt Striker Plate
	Ives 450	Flush Bolt	"U" Channel, Inactive Door					
	Schlage D51PD	Entry Lock	M.A.G. Active Door	Double, wood, solid core	Metal	Dynamic	1748	Latchbolt Rotated
	Ives 458	Flush Bolt	"U" Channel & Flush Attach., Inactive Door					
	P.F.Corbin 830-1451	Entry Lock	"U" Channel & Flush Attach., Inactive Door	Double, wood, solid core	Metal	Static	1944	Striker Plate Defor[illegible]
	Kwikset 680	Deadlock	"U" Channel & Flush Attach., Inactive Door					
	Ives 458	Flush Bolt	"U" Channel & Flush Attach., Inactive Door					
	Arrow 1001-P7	Flush Bolt	"U" Channel & Flush Attach., Inactive Door	Double, wood, hollow core	Metal	Static	1240	Deadlock Bolt Failed
	Weiser D947	Flush Bolt	"U" Channel & Flush Attach., Inactive Door					
	Ives 458	Flush Bolt	"U" Channel & Flush Attach., Inactive Door					
	Schlage G51PD	Deadlatch/ Deadbolt	"U" Channel & Flush Attach., Inactive Door	Double, wood, CCTRF solid core	Metal	Dynamic	2976	None
	Ives 458	Flush Bolt	"U" Channel & Flush Attach., Inactive Door					
	Schlage G51PD	Deadlatch/ Deadbolt	"U" Channel & Flush Attach., Inactive Door	Double, wood, CCTRF solid core	Wood	Static	3878	Deadbolt Sheared
	Ives 458	Flush Bolt	"U" Channel & Flush Attach., Inactive Door					

SHOULDER IMPACT THREAT
EXTERIOR DOOR LOCK BOLT
FIGURE 68

Test No.	Lock	Type Lock	Latch Reinforcement	Type Door	Type Frame	Applied Load	Failure Load (lbs)	Failure Mode
	Arrow 151 P7X	Lockset	None	Double, wood, solid core	Wood	Static	1164	Flushbolt Attach.
	Arrow 921K	Deadbolt						
	Ives 458	Flush Bolt						
	Arrow 151 P7X	Lockset	Flush Attach.	Double, wood, solid core	Wood	Static	1862	Door Edge Attach.
	Arrow 921 K	Deadbolt						
	Ives 458	Flush Bolt						
	Arrow 151 P7X	Lockset	CCTRF Door Edge Stiffner	Double, wood, solid core	Wood	Static	1551	Inactive Door Striker Plate
	Arrow 921K	Deadbolt	Flush Attach.					
	Ives 458	Flush Bolt						
	Arrow 151P7X	Lockset	CCTRF Door Edge Stiffner	Double, wood, solid core	Wood	Static	2632	Door Edge Attach.
	Arrow 921K	Deadbolt	Steel channel, inactive door					
	Ives 458	Flush Bolt	Flush attach.					
	Arrow 1001PTX	Entrance Lock	M.A.G., CCTRF Door Edge Stiffner	Double, wood, solid core	Wood	Static	3567	Inactive Door Striker Plate
	Arrow 921K	Deadbolt	Steel channel inactive door					
	Ives 458	Flush Bolt	Flush attach.					
	Arrow 1001P7X	Entrance Lock	None	Single, metal clad wood	Wood	Static	608	Door Failed
	Schlage B360P	Deadbolt						
	Arrow 1001P7X	Entrance Lock	CCTRF door edge stiffners	Single, metal clad wood	Wood	Static	930	Striker Plate Atta
	Schlage B360	Deadbolt						
	Arrow 1001P7X	Entrance Lock	CCTRF door edge & striker	Single, metal clad wood	Wood	Static	2948	Deadbolt Sheared
	Schlage B360P	Deadbolt	Plate stiffner					
	Arrow 1001P7X	Entrance Lock	None	Single, solid core	Metal	Static	1830	Door Edge Attach.
	Schlage B360P	Deadbolt						
	Arrow 1001P7X	Entrance Lock	M.A.G. on both locks	Single, solid core	Metal	Static	3800	Deadbolt Sheared
	Schlage B360P	Deadbolt						
	P.F. Corbin 830-1451	Entry Lock	None	Single, wood, CCTRF solid core	Metal	Static	1380	Door Edge Attach.
	Schlage B360P	Deadbolt						
	P.F. Corbin 830-1451	Entry Lock	M.A.G. on both locks	Single, wood, CCTRF solid core	Metal	Static	3567	Door Failed
	Schlage B360P	Deadbolt						

SHOULDER IMPACT THREAT
EXTERIOR DOOR LOCK BOLT
FIGURE 68

FIGURE 69

LOCK BOLT IMPACT TESTS

Test No.	Lock	Type Lock	Failure Applied Load	Failure Mode	*Security Safety Margin
A	Weiser 4371	Deadbolt	>784 in.lbs.	Lockbolt bent	+360%
b	Kwikset 485	Deadlock	182 in.ldb.	Door edge bent	+7%
c	Amerock c6275	Deadlock	431 in.lbs.	Mechanism bent	153%
c	Dexter 4209	Deadbolt	170 in.lbs.	Deadbolt bent	70%

*Security Margin = [(Failure Load/170 in.lbs.)-1] 100

FIGURE 70

HAMMER IMPACT TESTS

Test No.	Lock	Type Lock	Failure Applied Load	Failure Mode	* Security Safety Margin
a	P.F. Corbin 830-1451	Entry Lock	300 in lbs.	Knob bent off spindle	76%
b	Falcon 4371	Deadlock	600 in.lbs.	Door failed	253%
c	P.F. Corbin 830-1451	Entry lock	170 in.lbs.	Knob failed at lock rose	0%
d	P.F. Corbin 226DBL	Vert. Rim lock	<340 in.lbs.	None	<100%
e	WPLSCO 840	Padlock	170 in.lbs.	Shackle lock bolt	0%
f	Dynation 211	Padlock	170 in.lbs.	Shackle failed	0%
g	American 300	Padlock	170 in.ldbs.	Internal mechanism	0%
h	American P6	Padlock	170 in.lbs.	Internal mechanism	0%
i	American 260	Padlock	170 in.lbs.	Shackle	0%
j	American 600	Padlock	340 in.lbs.	Shackle	100%

*Security Margin = [(Failure load/170 in.lbs.)] -1   100

FIGURE 71

PIPE WRENCH THREAT

Test No.	Lock	Type Lock	Failure Applied Load	Failure Mode	Security Safety Margin
a	Welch 207 1/2	Mortise	200 in.lbs.	Lock cylinder	-94%
b	Welch 72TUS10	Mortise deadlock	400 in.lbs.	Attach bolt	-99%
c	Weiser 5000L-7	Entry lock	200 in.lbs.	Knob twisted off	-94%
d	Weiser 500DL-B	Entry lock	200 in.lbs.	Locking dog	-94%
e	Weiser K927	Mortise deadbolt	600 in.lbs.	Lock cylinder cover	-82%
f	Amerock C9076	Deadlock	240 in.lbs.	Attach bolts	-93%
g	Amerock C-6271	Entry lock	Knob turned	None	0%
h	Adams Rite 1871	Cylinder flushbolt	144 in.lbs.	Attach screw	-96%
i	Adams Rite 1891	Cylinder deadlock	Guard turned	None	0%
j	Dexter 7362	Hotel-motel lock	200 in.lbs.	Lock assembly	-94%
k	Kwikset 400B	Entry lockset	120 in.lbs. Turned knob cover	None	0%
l	Kwikset 500L	Entry lockset	120 in.lbs.	Internal mechanism	-96%
m	Kwikset 485	Deadlock	240 in.lbs.	Lock body rotated	-93%
n	Kwikset 60006	Entry lockset	Knob turned at 240 in lbs.	None	0%
o	Russwin 1403	Deadbolt	600 in.lbs.	Lock collar	-82%
p	Schlage B360P	Deadbolt	1500 in.lbs.	Attach screws	-55%
p	Schlage B360P	Deadbolt	1500 in.lbs.	Attach screws	-55%
q	Schlage B362P	Deadbolt	1500 in.lbs.	Attach screws	-55%
r	Schlage 651PD	Entry lockset	Knob rotation	None	0%
s	Welch 163	Deadbolt	750 in.lbs.	Locking pin	-77%

The three threat tests with a hoof nipper and a prying k-tool are summarized in Figure 72. Figure 73 is a summary of twenty-nine lock cylinder pulling tests in which 45% of the lock cylinders that resisted the threat generally were either of hard enough material to prevent inserting the puller screw or soft enough material to allow the puller screw to strip out.

The results of the lock cylinder twisting tests are presented in Figure 74. These tests demonstrate that in those cases where a screwdriver or a screwdriver type wrench bit can be driven into the keyway, the torque applied to the lock plug was great enough to fail the lock cylinder retaining devices or even shear the lock pins; however, in some cases the keyway material would yield and release the tool.

The lock cylinder drilling tests in Figure 75 showed that the locks tested were highly susceptible to drilling. The drilling threat measurements determined that lock cylinders made of material Rockwell C 48 or harder will resist drilling.

The lock deadbolt sawing tests summarized in Figure 76 show that the use of a hardened center pin in the bolt will effectively deter sawing. The sawing threat measurements determined that lock bolts made of material harder than Rockwell C 48 will resist the sawing threat.

Figure 77 summarizes the results of the padlock shackle cutting tests. These data show that only three out of eleven lock shackles tested resisted this cutting threat. The threat measurements determined that padlock shackles heat treated to Rockwell C 56 will preclude cutting by bolt cutters.

The high temperature tests were conducted with oxygen-propane and oxygen-acetylene torches applying heat to padlock shackle. These tests showed that some padlocks could resist the oxygen propane torch but none were able to withstand the oxygen-acetylene flame.

Low temperature tests using liquid Freon, propane and nitrogen measured the brittle fracture resistance of padlocks under hammer impact. Test results showed that embrittlement with liquid nitrogen made all the locks tested susceptible to hammer impact loads.

Lock manipulation tests covered techniques such as jimmying, loiding, shoveknife type tools and lock picking. In general, these tests demonstrated that each burglar technique was feasible and could be done in a reasonable period of time.

Lock picking tests were conducted using 180 lock cylinders manufactured by 10 different companies. These tests showed that some locks could be picked as quickly as 2 seconds and that they could be picked quickly both by hand or with picking guns. Insufficient tests have been conducted to date to apply a statistical analysis to the results to determine the influence of the various variables investigated.

FIGURE 72

HOOF NIPPER THREAT

Test No.	Lock	Type Lock	Failure Level	Failure Mode	* Security Safety Margin
a	Falcon 4371	Deadlock	300 lbs. nipper	None	0%
b	Parker 2184	Deadlock	300 in-lbs. Prying K-tool	Mounting Screws	-52%
c	Falcon 437	Deadlock	K-tool would not fit	None	0%

*Security Margin = [(Failure Load/625 in-lbs. or 300 lbs. -1] 100

FIGURE 73
LOCK CYLINDER PULLING

Test No.	Lock	Type Lock	Failure Load	Failure Mode
a	Amerock C-627	Entry Lockset	None	Puller Screw Stripped
b	Adams Rite 1891	Cylinder Deadlock	None	Impactor Couldn't Pull
c	P.F. Corbin 2266	Vert. Rim	None	Puller Screw Stripped
d	P.F. Corbin 5283	Lock Cylinder	120 in-lbs.	Rotating Side Bar Failed
e	Dexter 7362	Knobset	120 in-lbs.	Lock Plug Released
f	Dynation KD230	Padlock	None	Puller Screw Wouldn't Enter
g	General G4341	Mortise Door Lock and Deadbolt	None	Screw stripped out
h	Kwikset 500L	Entry Lock	120 in-lbs.	Mech. Failed Internally
i	Kwikset 485	Deadlock	120 in-lbs.	Lock Body Failed
j	Kwickset 680	Deadlock	None	Puller Screw Failed
k	Medeco 10-3001 J526D	Lock Cylinder	None	Puller Screw Stripped Out
l	Russwin 1403	Deadbolt	None	Puller Screw Wouldn't Enter
m	Russwin 2863	Padlock	None	Puller Screw Failed
n	Schlage 45-101	Padlock	None	Puller Screw Couldn't Enter
o	Schlage B362P	Deadbolt	None	Puller Screw Failed
p	Schlage A51PD	Entrance Lock	120 in-lbs.	Entire Knob & Lock Cylinder Assy. Failed
q	Schlage G51PD	Entry Lockset	None	Puller Screw Failed
r	Welch 207 1/2	Mortise Lock	None	Puller Screw Wouldn't Enter
s	Weiser 500DS	Entrance Lock	120 in-lbs.	Lock Cylinder Case Split
t	Weiser 500DL	Entrance Lock	120 in-lbs.	Lock Cylinder Housing
u	Weiser 955	Padlock	120 in-lbs.	Lock Cylinder Retaining Pin
v	Weiser 1175B	Padlock	120 in-lbs.	Shackle Failed
w	American H-10	Padlock	120 in-lbs.	Lock Wafers Failed
x	Falcon 437	Deadlock	None	Impactor Couldn't Pull
y	American 600	Padlock	120 in-lbs.	Key Cylinder Released
z	American P6	Padlock	120 in-lbs.	Key Cylinder Released
za	American 260	Padlock	120 in-lbs.	Key Cylinder Released
zb	Sargent & Greenleaf 0931	Padlock	None	Cover Plate Prevented Pulling
zc	Schlage B360P	Deadbolt	None	Puller Screw Failed

FIGURE 74

LOCK CYLINDER TWISTING

Test No.	Lock	Type Lock	Failure Load	Failure Mode	Security Safety Margin*
a	Adams Rite 1891	Deadbolt & Latch	60 in-lbs	Set screw failed	-90%
b	Welch 207½	Mortise Lock	> 325 in-lbs	None	> -46%
c	Falcon 4371	Deadlock	> 325 in-lbs	None	> -46%
d	General G4341B	Mortise	> 325 in-lbs	None	> -46%
e	Kwikset 400B	Entry Lock Set	120 in-lbs	Retaining Device Sheared	-80%
f	Kwikset 485	Deadlock	120 in-lbs	Lock housing failed	-80%
g	Kwikset 600DL	Entry Lock Set	180 in-lbs	Lock pins sheared	-70%
h	Medeco 10-300 US26D	Lock Cylinder	None	Could not drive screw-driver in keyway	0%
i	Russwin 1403	Deadbolt	None	Keyway yielded & released screwdriver	0%
j	Russwin 2863	Padlock	> 325 in-lbs	None	> -46%
k	Schlage 45-101	Padlock	> 325 in-lbs	None	> -46%

* Security Safety Margin = [(Failure Load/600 in.-lbs. -1)]100

FIGURE 75

LOCK CYLINDER DRILLING

Test No.	Lock	Type Lock	Type of Attack	Drilling Time	Manipulate Lock
a	Parker 2184	Deadlock	Drill Lock Plug & pins	65 sec.	Yes
b	Welch 76TU53	Mortise Deadlock	Drill upper pins	34 sec.	Yes

FIGURE 76

LOCK SAWING

Test No.	Lock	Type Lock	Type of Attack	Sawing Time	Failed
a	Dexter 4209	Deadbolt	Saw bolt	24 sec. to hardened center bolt	No
b	Falcon 437	Deadlock	Saw bolt	26 sec. to hardened center bolt	No
c	Kwikset 485	Deadlock	Saw bolt	92 seconds	Yes
d	Weiser 4371	Deadbolt	Saw bolt	10 sec. to hardened center bolt	No

FIGURE 77

PADLOCK SHACKLE CUTTING

Test No.	Lock	Bolt Cutter Size*	Shackle Diameter (in.)	Handle Cutting Load(lbs)	Blade Cutting Load(lbs)	Maximum Threat Load #5 Cutter(lbs)	Security Safety Margin**
a	American 600	No. 5	7/16	258	28,608	20,000	+43%
b	American 300	No. 5	1/4	60	8,087	24,200	-67%
c	American 260	No. 5	3/8	181	21,290	21,300	0%
d	American H10	No. 3	7/16	180	15,900	20,000	-21%
e	Dynation KD230	No. 3	7/16	200	17,700	20,000	-12%
f	Russwin 286	No. 3	.345	100	9,800	22,000	-55%
g	Schlage 45-101	No. 3	.341	75	7,400	22,000	-66%
h	Walsco F370	No. 5	.4725	192	20,432	18,600	+10%
i	Weiser 1175B	No. 1	1/4	50	4,100	24,200	-83%
j	Weiser 1175B	No. 5	1/4	40	3,300	24,200	-86%
k	Weiser 955	No. 3	.341	100	9,800	22,000	-55%

* H.K. Porter Bolt Cutters
** Security Safety Margin = [(Blade Cutting Load/Max. Threat Load) -1]100

C. Sliding Glass Door Systems

Figure 78 presents an overall summary of the test results for sliding glass door systems. A tabulation and plot of load vs. deflection are given for each test run. The number of deflectometers used per test ranged from two to four. Depending upon the particular test, the points for which deflections were measured were located at or near the latch centerline; near the top and bottom of the latch-edge stile; at the frame head near the latch edge; and near the centerline of the top and bottom rails, frame head, and wood sill. The positions of the deflectometers in each test are illustrated by a sketch on the load/deflection graph for each test. These load deflection curves provided an evaluation of the structural rigidity of the door system, and the load distributions between the wood framing, metal frame and glazing panels.

Various failure modes were observed in the different tests for sliding glass doors and the magnitude of failure load ranged from 214 pounds to 1276 pounds for the horizontal (in-plane) load tests. Generally, before each load test, reinforcement or other improvement to the structural design was incorporated based on the failure mode of the last preceding test. In the final horizontal load, Test No. 7, a load of 3085 pounds was sustained, i.e., 85 pounds in excess of the maximum anticipated threat.

No structural failure was experienced in the vertical load test at values less than the maximum threat. However, the deflection of the bottom rail, to which the load was applied, was so great that the panel could quite easily have been removed from the frame by pulling outward on the bottom rail. In Test No. 5, which sustained a load of 3826 pounds before failure, deflections were measured up to a load level of 1276 pounds.

Assuming linear behavior to the maximum threat load, the vertical translation was determined to be 1.11 inches. Even with the 1/4-inch spacer bar added to the top of the sliding panel, there was some "free play" in the vertical direction before beginning the loading which produced this value of deflection. The net result of this free movement plus structural deflection was sufficient to permit easy access through the bottom so that a force could have been applied for easy outward removal.

There was only one test (No. 3) in the lateral load threat, i.e., with the applied force perpendicular to the plane of the door and applied just above the latch. Failure occurred at a load of 545 pounds with frame attach screws pulling through the jamb in the latch area.

Two tests were conducted to evaluate the application of combined lateral, vertical and normal shock loads to the door handle. In one test the latch failed at 660 lbs. and in the other test the handle fasteners failed at 870 lbs.

The results of the test using a prybar attack on a standard door system with no reinforcement showed the door to have a very low resistance. A force less than 50 pounds on a 12-inch lever arm or 600 in-lbs. broke the latch and removed the rollers from the guide rail. The input threat is 6,000 in-lbs. In two other tests the spring loaded centerpunch attack on a tempered glass door severely damaged the glass and only a light touch was required to push out the glazing and gain access to the latch.

In addition to the seven instrumented tests and one prybar test described above, there were three other actual prybar tests on reinforced glass doors in which the only parameter measured was the time required for the "intruder" to cause sufficient damage to permit entry.

The series of sliding glass door tests revealed that, with some fairly simple changes to the accessories hardware, the basic structure of a typical commercial door is adequate to resist the maximum anticipated break-in threat of 3000 pounds. Specifically, the changes made in the test series to accomplish this result consisted of:

> Replacement of the deadbolt provided with the door (at the top) by one having better load path and material qualities.
>
> Addition of an identical improved deadbolt at the bottom.
>
> Improvement of the structural anchoring of deadbolts to framing.
>
> Replacement of the latch provided with the door by one having more engagement length.
>
> Addition of a specer strip along the top rail to prevent excessive vertical lift.
>
> Improvement of jamb attachment to wall framing.

It was obvious from the sping loaded punch tests on the tempered glass door glazing panels which are typical glazing in California, forced entry can be accomplished easily; however, this type of entry by attack on glazing panel could be thwarted by use of some fracture resistant glazing material, i.e., certain acrylic and poly-carbonate plastics. (See section III.E.)

As mentioned above, the tempered glass used in the doors of this test series was easily broken by a stress concentration impact; however, it resisted the types of external loading with surprisingly large glazing panel deflections without breakage. In fact, the glass provided most of the resistance to the test loads since the aluminum stiles and rails by themselves would be able to withstand only a small fraction of the 3000 pound applied force.

Although the overall structural assembly of the sliding glass doors was found capable of resisting the test load which is equivalent to one that can be produced by prybar leverage, the soft aluminum stiles and rails are vulnerable to local tearing by the sharply concentrated forces of an actual prybar. To achieve adequate resistance to this type of damage in the prybar tests, it was found necessary to add steel angles as barriers to prevent the prybar from contacting the aluminum members in certain likely target areas such as the stile and jamb in the latch area. Also, 1/4" bolts with tensile capacity were added top and bottom to anchor the sliding panel to the fixed panel and frame. The purpose of the latter was to increase resistance to removal by prying between sliding and fixed panels. In commercial practice, this could be accomplished by some device such as providing deadbolt assemblies having "ball-detent" pins.

Although it was not the intent of this project to specify design requirements, these test results clearly indicate that some modifications to present, typical sliding glass door design configurations will be necessary to meet the performance test requirements.

FIGURE 78

SUMMARY OF RESULTS - SLIDING GLASS DOOR TESTS

Test No.	Configuration	Type of Test**	Failure Load Pounds	Failure Mode	Remarks
1	Vendor Standard 6'3-3/4"x27-1/4xXO*	Combined Load on Handle	269 Lateral 269 Vertical 538 Horizontal (In plane)	Latch	Combined resultant Load 660 lbs
2	Same as Test 1	Combined Load on Handle	332 Lateral 712 Vertical 362 Horizontal (In-plane)	Handle Bolt	Combined resultant load 870 lbs
3	Vendor standard 5'x6'8" XO* door except deadbolt added at bottom & 1/4" thick Al spacer strip added along top of sliding panel. Door latch not engaged	Horizontal (In-plane) Load	412	Top deadbolt sheared after door came out of bottom track on latch end (lower L.H. corner viewed from outside)	Failed bolt was Al and grooved.
4	Same as Test 3 except latch was engaged	Lateral Load	545	Frame attach screws pulled thru jamb in latch area	Insufficient quantity of frame (jamb) attachment screws
5	Same as Test 4	Vertical (In-plane) Load	3826	Lower rail failed in beam bending and tempered glass shattered	Failure load exceeded required test load by 826 lb

-continued-

FIGURE 78

SUMMARY OF RESULTS - SLIDING GLASS DOOR TESTS

Test No.	Configuration	Type of Test**	Failure Load Pounds	Failure Mode	Remarks
6	Same type door as above except 6'x6'8" XO. Top deadbolt replaced by one identical to bottom one. Attachment of jamb to framing improved with additional screws in latch area. Latch engaged.	Horizontal (In-plane) Load	1270	Latch failed, then upper deadbolt.	Latch was light Al section with 1-1/2" in engagement with jamb.
7.	Same as Test 6 except sliding panel top spacer strip increased to 3/8"; latch replaced with one having 3" engagement; anchoring of deadbolts to framing improved.	Horizontal (In-plane) Load	No Failure at 3085 lbs		Exceeded required test load without failure.
8	Same as Test 1	Prybar		Latch	Threat is 6000 in-lbs
9	Same as Test 7	Prybar Test	N/A (39 sec. required to fail)	Local tearing of stile channel permitted complete penetration of prybar & sufficient leverage to cause the steel latch to fail mating flange on jamb.	Reaction to 3" steel latch had to be entirely resisted by light Al flange on jamb.

-continued-

FIGURE 78

SUMMARY OF RESULTS - SLIDING GLASS DOOR TESTS

Test No.	Configuration	Type of Test	Failure Load Pounds	Failure Mode	Remarks
10	Same as Prybar Test 1 except 1"x1"x1/4"x12" long steel angles were installed along both sides of jamb in latch area and 1/4"x2"x12" long plates sandwiched sliding panel stile in same area.	Prybar Test	N/A(1 min. & 53 sec. required to fail.	Bottom inboard corner of sliding panel pryed out of track by prying between sliding & fixed panels at bottom.	Addition of latch shieldin prevented entr in latch area. Attack location changed.
11	Same as Prybar Test 2 except 1/4" bolts with tensile capacity were used to anchor sliding panel to fixed panel & frame head & sill.	Prybar Test	N/A (1 min. 32.5 sec. required to fail.	Tempered glass panel shattered due to excessive distortion of assembly at attack location (same as Test 2)	Addition of tensile interconnection of panels prevented any remova of panels by prying.
12	Same as Test 1	Spring loaded Punch	---	Glass crazed into small cubes	Immediate Access
13	Same as Test 3	Spring Loaded Punch	---	Glass crazed into small cubes	Immediate Access

Notes: * All doors had 3/16" tempered glass and 6063-T5 Al extrusion structural members.

D. Window Systems

The results for sliding glass window tests are shown in figure 79. Tabulations of load vs. deflection, both raw and reduced data, are given for each test run. The number of deflectometers used per test ranged from two to six. The center of the outboard stile of the sliding panel was used for loading in the lateral and horizontal in-plane tests.

The instrumentation for the lateral tests was along the length of the aluminum jamb and stud framing on tis side.* For the horizontal in-plane test there was a deflectometer at the load and two in the stud framing on the far side to check for possible "softness" of support for the complete window and frame assembly. In the vertical in-plane tests, the load was applied at the center of the moving panel lower rail, and one deflectometer was located close to this load point on the rail and another directly above in the header beam. The positions of the deflectometers in each test are illustrated by a sketch on the load/deflection tabulation for each test.

In the six lateral load tests, failure loads ranged from 292 to 1950 pounds. After each test, some structural improvement was made, based on the mode of failure of that test. An increase of capacity was realized with each successsive test. The largest increase in capacity was demonstrated in the third test after replacing the ordinary window glass with acrylic plastic glazing and adding a rolled steel section frame bolted to wall framing to completely cover the aluminum frame on the outside. The two vertical in-plane load tests also achieved a level of 1942 pounds before the loading rod slipped off the stile because of excessive lateral deflection of the loaded stile. A planned actual prybar test was not performed at the time of publication of this report.

The sliding glass window tests revealed that, although the burglar threat force is smaller,* it will be more difficult to achieve adequate resistance to window break-in. The main reason for this is the lower breaking strength and smaller thickness of glass in the windows, i.e., 3/32-inch nominal, whereas the door tempered glass nominal was 3/16-inch. Both bending and buckling allowables are proportional to the square of the panel thickness:

$$M_{b_{All.}} = K_1 t \text{ in.-lbs.}$$

$$F_{cr} = K_2 \, t^2 \text{ psi}$$

* Adjacent to outboard stile of sliding panel.
* 2000 pounds as compared to 3000 pounds for windows.

Since the door glass thickness was twice that of the window, the strength of the door panel compared to the window panel, based on thickness ratio alone would be:

$$S_D/S_W = (2t_W/t_W)^2 = 4$$

Furthermore, although it would be difficult at this point to determine the actual breaking strength (stress) of each particular window glass used, industry sources indicate a typical breaking stress of 16,000 psi for single strength glass, as compared to 33,000 psi for tempered glass under the same conditions.

The first window test did, in fact, demonstrate the far smaller capacity of the glass window panel, which broke at a test load of 292 pounds, as contrasted with the tempered glass door lateral load test in which there was no glass failure when the jamb attachment failed at 545 pounds. In a horizontal (in-plane) load test, the complete door assembly, including glass, withstood a load of 3085 pounds without failure.

After the second test, which was made with a panel of insulated glass which also broke, the glazing panels were of polycarbonate plastic, a material which is difficult to break until distortions are far greater than any that could be expected in a break-in attempt.

Several other changes were made sequentially between tests until the assembly finally demonstrated the capability of almost meeting the test load requirement with 1950 pounds maximum sustained in the lateral load tests, and also 1942 pounds in the horizontal (in-plane) load tests. Specifically, the changes made in the test series, besides the change to plastic glazing panel material, to accomplish this result, consisted of:

Addition of a rolled steel* section frame bolted to wall framing and completely covering the perimeter of the window frame on the outside.

Addition of a 1/8 inch thick strip of aluminum along the top of the sliding panel to prevent excessive vertical lift. Also, addition of two toggle bolts through frame head and tangent to top of sliding panel upper rail to prevent lift-out.

Addition of horizontal blocks between sliding panel and wall framing to prevent horizontal sliding

Addition of studs, full length to the wall framing, making a total of three per side.

Addition of a steel* bar to fill the space inside the channel of the load-bearing stile.

*In commercial practice, the same improvement could be achieved with aluminum extrusion if desired, but a considerably larger volume of material would be required. Since the stiffness of the edge members is a direct function of EI, the area moment of inertia required in an aluminum section would be:

$$I_{Al} = \frac{E_{STL}}{E_{AL}} I_{STL} \approx \frac{30(10)^6}{10(10)^6} I_{STL} \approx 3 I_{STL}$$

As an example, to replace the rolled steel section referred to above and pictured in Figure 94, an aluminum extrusion would have to be 3/8 inch thick if the same overall dimensions were maintained.

As with sliding glass doors, the window test series clearly demonstrated the necessity of modifications for currently typical sliding glass windows to withstand the test load equivalent to the maximum anticipated break-in threat. In addition to the above-mentioned changes, these tests have demonstrated the following:

(1) Blocking against vertical and horizontal movement can be accomplished by the use of well-designed deadbolts; one at the top and one at the bottom.

(2) To prevent sliding panel removal by inward pushout, some strong blocks or brackets should be considered for addition to the window frame (jambs, head, and sill) on the inside.

FIGURE 79

SUMMARY OF RESULTS - SLIDING GLASS WINDOWS

Test No.	Configuration*	Type of Test**	Failure Load Pounds	Failure Mode	Remarks
L1	Vendor stock Model A (Single thickness glass)	Lateral Static Load	292	Standard latch failed	Excessive rotation of load bearing stile allowed disengagement & glass broke.
L2	Vendor stock Model B (Insulated Glass)	Lateral Static Load	474	Loaded stile failed and glass broke	Excessive bending deflection caused stile to slip out of jamb
L3	Vendor stock Model A with glass replaced with Lexan; rolled steel section frame bolted to framing covered complete perimeter of window frame on outside; 1/8" thick Al strip bonded along top of sliding panel; two toggle bolts thru frame head & tangent to top of sliding panel upper rail to prevent excessive vertical movement.	Lateral Static Load	1130	Panel pulled out of frame.	Excessive deflection of stud framing allowed separation of frame and panel.
L4	Same as L3 except additional studs added full length each side making total of 3 per side.	Lateral Static Load	1312	Latch failed.	

-continued-

FIGURE 79

SUMMARY OF RESULTS - SLIDING GLASS WINDOWS

Test No.	Configuration*	Type of Test**	Failure Load Pounds	Failure Mode	Remarks
L5	Same as L4 except 3/4" plywood columns added top & bottom between sliding panel & far side jamb to prevent horizontal sliding.	Lateral Static Load	1914	Panel pulled out of frame.	Excessive deflection of loaded stile allowed separation.
L6	Same as L5 except wall framing stiffened with gusseted bracket plate at mid-height of studs on loaded stile.	Lateral Static Load	1950	Panel pulled out of frame.	Same as L5. Stiffener fitting contributed little support.
V1	Same as L6	Vertical (In-plane) Load	1942	No failure	Test stopped at 1942 lbs., essentially = required test load.
V2	Same as L6 (repeat test)	Vertical(In-plane) Load	1850	No failure	Test stopped at 1850 lbs., essentially = required test load.
H1	Same as L6 except .32"x.36" steel bar added to inside of load bearing stile aluminum channel.	Horizontal(In-plane) Load	1942	Loading rod rolled off stile.	Loaded stile deflected laterally till jack slipped off.

-continued-

FIGURE 79

SUMMARY OF RESULTS - SLIDING GLASS WINDOWS

Test No.	Configuration*	Type of Test	Failure Load Pounds	Failure Mode	Remarks
P1	Same as H1 except short steel angles added in several locations inside to brace window frame to wall framing and prevent prybar attack from pushing sliding panel out in the inward direction.	Prybar Test	(Test still to be performed)		

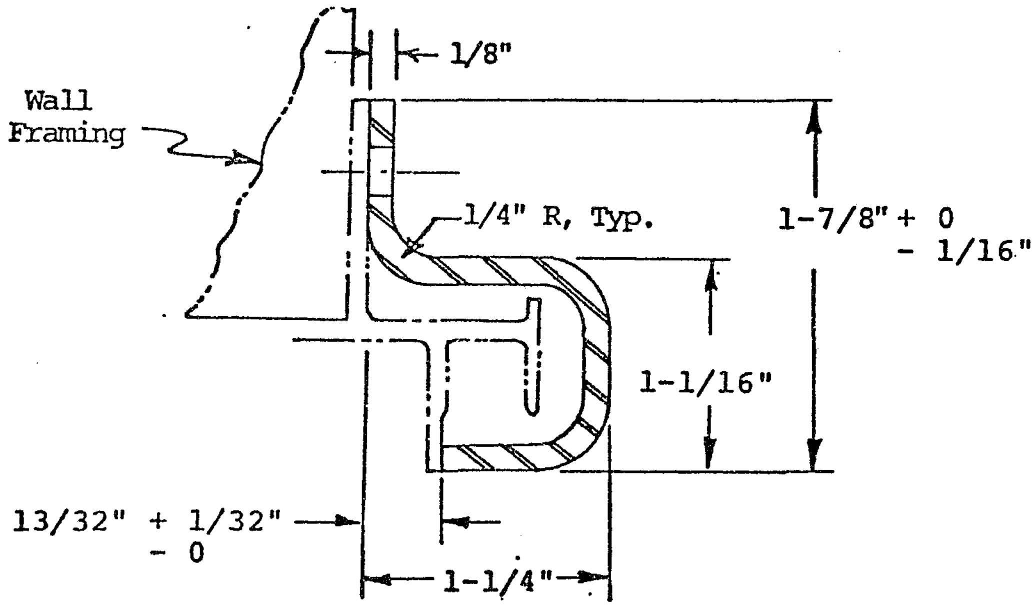
Notes:

* All assemblies tested were type XO, 3' x 4' nominal size. Structural members (glazing panel stiles and rails and frame jambs, head, and sill) are 6063-T5 Al extrusion.
XO arrangement.

FIGURE 80

ROLLED STEEL SECTION FRAME

SLIDING GLASS WINDOW TESTS



E. Glass Systems

1. Static Tests

The results of the static tests to failure of the eight different types of glazing panels are summarized in Figure 81.

The range of failure loads as shown in Figure 81 was from 110 lbs. to 3960 lbs. The Lexan panel could not be fractured in this test arrangement. The loads listed for the three Lexan tests represent the values at which the glazing panel slipped, or began to slip, from the supporting frame.

The load deflection curves generally showed a curvature, especially in the higher load reanges, opposite to that plotted from data of static tests on most commonly used engineering materials, i.e., steel or aluminum, on simple supports. This different behavior for the glass panels tested in this series is ascribed to the neoprene molding infolding the panel edges and socketed in a recess in the supporting fixture. At lower load levels most of the measured deflection is from compression of the rubber-like neoprene. Because of the unique properties of the molding and the fact that it becomes more nearly completely confined at higher load levels, the panel behavior then corresponds more closely to that of a panel on rigid supports. Thus, instead of decreasing spring constant at higher loads, i.e., more deflection for a given load increment, the spring constant increases in this regime with less deflection for the same load increment. Part of this effect is also due to the increasing stiffness experienced upon transition into the plate large deflection regime. In the case of the two plastic glazing panels, the change in the molding resistance plus increased stiffness in the large deflection regime, combined with the change in the glazing material behavior from elastic to elastoplastic, results in the upper portion of their load/deflection curves being nearly straight although the shape of the curve for Test 8A is undoubtedly influenced by slippage of some of the panel edging from the retaining fixture.

Re-tests of three of the materials on rigid, simple supports, i.e., without molding between panel and support, were performed on three of the materials: double strength glass, Watchguard, and Plexiglass. The results confirm the foregoing explanation of the structural behavior of the original test setups, except in the case of Plexiglas. The latter material is

FIGURE 81

SUMMARY OF STATIC "A" LOAD TESTS* OF EIGHT COMMERCIAL

GLAZING SPECIMENS (25" x 25") WITH EDGES SIMPLY SUPPORTED

Test		Commercial Glazing Material	Nominal Thickness (In)	Measured Thickness (In.)	Load			Deflection			Loading Time (Sec.)	Energy at Fracture (In.-Lbs)
No.	1975 Date				Calibrated Constant (Lbs/In.)	Galvo. (Volt/In.)	Max. (lbs)	Calibrated Constant In. Trace / In. Actual	Galvo. (Volt/In.)	Max. (In.)		
1	2/21	Double Strength	1/8	0.134	160	1	336.0	1.37	1	0.394	8.44	66.2
2	2/24	Tempered	1/4	0.242	160	1	667.2	1.35	1	0.407	6.93	135.8
3	2/25	Safety Laminated	1/4	0.275	160	1	675.2	2.58	0.5	0.504	12.94	170.2
4	2/25	Wire Reinforced	1/4	0.260	160	1	110.4 99.2	3.10	0.5	0.065 0.287	1.53 4.0	Glass Frac. 14.2 wire fail.
5	2/26	Vigil Pane	5/16	0.312	160	1	524.8	2.72	0.5	0.456	6.23	119.7
6	2/26	Watchguard	5/16	0.314	160	1	513.6	2.83	0.5	0.282	4.25	72.4
7	3/6	Plexiglas	5/16	0.388	0.931 In./Volt	1	3960	0.48	5	3.50	30.0	6930
8 8A 8B	3/6 3/6 3/13	Lexan	5/16	0.348	0.92 In./Volt	1	2756 3268 2910	0.50 0.50 0.50	5	2.96 2.48 2.78	25.7 20.52 26.05	4079** 4052** 4045**

* Static "A" tests are those tests made using the support fixture shown in Figure

** No fracture; panel slipped from frame.

CONTINUED

2 OF 3

so flexible relative to glass $\left(\frac{E_{glass}}{E_{Plex.}} = \frac{9.7(10)^6}{.45(10)^6} > 25.5\right)$, that apparently meaningful comparison of support effects cannot be obtained in the small load regime. The comparative results are important for correla- of test data with theoretical calculations required for determination of required thicknesses and qualification test loads.

2. Impact Tests

The results of the impact tests to failure of the eight different glazing panels are summarized in Figure 82.

Two specimens of each glazing material were tested. There is an "A" test and a "B"* test for each of the eight different materials. In all these tests except for the tempered glass, Lexan and one part of the Plexiglas tests, the panel failed on the first impact. The kinetic energy at impact on these first drop failures was such a small portion of the specified threat energy that further tests were not warranted. The maximum energy sustained by any one of the panels was the 1534 inch-pounds applied to the Lexan panel. The panel was not fractured by this load but some of the panel edging had slipped from the retaining fixture, so this should be considered a failure load in that the results would permit entry by access to the latching/locking mechanism without fracture of the glazing.

It should be noted that although all tests were stopped as soon as any glazing lamina fractured, there may still have been considerable break-in resistance remaining except for the single lamina double strength glass, tempered glass, and Plexiglas plastic panels - and possibly the wire reinforced glass panel. Due to the very non-uniform nature of the structure after initial failure, it would be very difficult to quantitatively evaluate the remaining resistance in terms of force and/or time to effect complete penetration; however, this aspect should be kept in mind in the development of performance test specification requirements.

3. Special Tests

The degrees of resistance of the various panels to the various threats other than static force and thrown missile simulation are summarized in the Special Test Summary, Figure 83.

*Except for Test No. 1 which has only one part.

FIGURE 82

SUMMARY OF IMPACT LOAD TESTS OF EIGHT COMMERCIAL

GLAZING SPECIMENS (25" x 25") WITH EDGES SIMPLY SUPPORTED

Test No.	Test 1975 Date	Commercial Glazing Material	Nominal Thickness (In.)	Measured Thickness (In.)	Load: Calibrated Constant (Lbs/In.)	Load: Galvo. (Volt/In.)	Load: Max. (Lbs)	Deflection: Calibrated Constant In. Trace / In. Actual	Deflection: Galvo. (Volt/In.)	Deflection: Max. (On.)	Applied Kinetic Energy at Impact (In.-Lbs)
1A	5/5	Double Strength	1/8	0.134	160	1	64.2	0.987	1	0.188	21.5
2A	5/6	Tempered	1/4	0.265	160	1	664.7	0.987	1	0.424	247.0
2B	5/8			0.235			664.7			0.438	264.0
3A	5/9	Safety Laminated	1/4	0.255	160	1	345.2	0.987	1	0.563	198.0
3B	5/12			0.260			577.7			0.395	158.0
4A	5/13	Wire Reinforced	1/4	0.270	160	1	480.7	0.987	1	0.370	105.0
4B	5/13			0.255			405.1			0.286	62.0
5A	5/14	VigilPane	5/16	0.303	160	1	592.0	0.987	1	0.276	110.0
5B	5/14			0.301			459.0			0.308	682.0
6A	5/15	Watchguard	5/16	0.302	160	1	285.3	0.987	1	0.424	66.0
6B	5/16			0.304			510.7			0.513	682.0
7A	5/16	Plexiglas	5/16	0.300	0.931 In./Volt	1	328.0	0.987	1	0.711	550.0
7B	5/16			0.305			665.0			1.167	440.0
8A3	5/19	Lexan	5/16	0.348	0.92 In./Volt	1	1825.0	0.987	1	1.933	1300.0
8B	5/30			0.348			5650.0			3.30	1534.0

* Maximum loads and corresponding deflections at which failure occurred.

FIGURE 83

RESULTS OF SPECIAL TESTS: SPRING PUNCH, HAMMER, HOLE-CUTTING, THERMAL SHOCK, COMBINATIONS

Type	No.*	Panel	Results
Spring Punch**	1c	1/8" Double Strength Glass	Panel fractured.
	2c	1/4" Tempered Glass	Panel fractured.
	3c	1/4" Safety Laminated Glass	First layer of panel slightly fractured.
	4c	1/4" Wire Reinforced Glass	Panel fractured.
	5c	5/16" Vigil Pane Laminate	First layer of panel fractured.
	6c	5/16" Watchguard Laminate	First layer of panel fractured.
	7c	5/16" Plexiglas	Panel not fractured.
	8c	5/16" Lexan	Panel not fractured.
Hammer	4d	Wire Reinforced Glass	Two moderate or one heavy blow fractured.
	5d	Vigil Pane Laminate	Six moderate blows caused failure.
	8d	Lexan	Five heavy blows did not cause failure.
LN_2	3e	Safety Laminated Glass	Surface marred & laminate "popped" after 4 min. 30 sec. LN_2 but caused no penetration.
	4e	Wire Reinforced Glass	Panel fractured after 1 min. 25 sec. LN_2 cooling.
	5e	Vigil Pane Laminate	One specimen failed after 1 min. 55 sec. Other specimen not failed after 4 min. 30 sec.
Torch	1f	Double Strength Glass	Panel fractured at T = 982°C, ΔT = 792°C at 395 sec.
	2f	Tempered Glass	No failure at T = 821°C. ΔT = 632°C at 276 sec.
	3f	Safety Laminated Glass	Failure of 1 glass layer only at T =1123°C, ΔT = 921°C at 224 sec.
	4f	Wire Reinforced Glass	Fracture in glass at T = 790°C, ΔT = 634°C at 158 sec. but apparently no penetration.
	5f	Vigil Pane Laminate	Failed at T = 945°C, ΔT = 750°C at 348 sec.

FIGURE 83

RESULTS OF SPECIAL TESTS: SPRING PUNCH, HAMMER, HOLE-CUTTING, THERMAL SHOCK, COMBINATIONS

Type	No.*	Panel	Results
Torch Cont'd	6f	Watchguard Laminate	Heated side only of panel fractured after 3 min. 2 sec. heating.
	7f	Plexiglas	Panel failed at T = 843°C, ΔT = 670°C at 2 min. 52 sec.
	8f	Lexan	Panel failed at T =1065°C, ΔT = 968°C at 3 min. 36 sec.
Hole-Sawing	8g	Lexan	14 seconds required to saw through with hole saw on power drill.
LN_2 & Torch	1h	Double Strength Glass	Panel was cracked but not penetrated.
	2h	Tempered Glass	Panel apparently not damaged after 4 min. LN_2, then torch.
	5h	Vigil Pane Laminate	LN_2 applied for 1 min. then torch. Lamina "popped."
	7h	Plexiglas	LN_2 applied for 3 min. then torch for 1. No effect.
	8h	Lexan	LN_2 applied for 4 min. then torch. No fracture.
Torch & Hammer	4i	Wire Reinforced Glass	Fractured at ΔT = 404°C at 49 sec. Three light blows punched through.
	5i	Vigil Pane Laminate	Fractured at ΔT = 636°C at 2 min. 56 sec. Three moderate blows punched through.
	6i	Watchguard Laminate	Failed with one moderate blow after 2 min. heating.
	8i	Lexan	No failure at T = 1004°C, ΔT = 917°C at 3 min. Three moderate blows required for penetration.

FIGURE 83

RESULTS OF SPECIAL TESTS: SPRING PUNCH, HAMMER, HOLE-CUTTING, THERMAL SHOCK, COMBINATIONS

Type	No.*	Panel	Results
LN_2 & Hammer	4j	Wire Reinforced Glass	Fracture after 1 min. 25 sec. LN_2. Then larger hole caused by hammer but no shatter.
	5j	Vigil Pane Laminate	Penetration effected by LN_2 followed by hammer.
	7j	Plexiglas	After 3 min. 5 sec. LN_2, shattered with very heavy blow.
	8j	Lexan	After 2 min. 50 sec. LN_2, no failure caused by hammer.
LN_2, Torch & Hammer	4k	Wire Reinforced Glass	Panel penetrated after LN_2, heat, & hammer.
	8k	Lexan	After heat for 1 min. 30 sec., then LN_2 & hammer, no failure.

* No's. from Test Matrix Table 1-1.
** Each test in this series was "go-no-go" check; i.e., determination of whether the given spring punch impact would break the panel or not.

The results indicate that the single lamina panels (double strength, tempered, and wire reinforced glass) will not withstand the impact type threats (spring punch and hammer) whereas the plastics and the laminated types will, at least up to the point of preventing complete penetration.

The low and high temperature thermal shock and/or soak threats proved generally ineffective for achieving access, except that fracture of the single lamina double strength glass panel may be considered essentially a break-through. An interesting exception is in the case of tempered glass which almost always experiences shattering disintegration of the complete panel when a crack (stress concentration) is formed at any point. It was found that by moving a torch flame over the same circular path on tempered glass surface, a sufficient number of times, the inscribed circle of glass could be pushed out quietly without breaking the rest of the panel. A combination of thermal shock and impact (hammer) was often effective or more effective, in achieving penetration as compared with the use of either type of threat alone. For example, Plexiglas, which is very strong and was not affected by a sequence of LN_2 shock/soak followed by torching, was shattered with a hammer impact after 3+ minutes of LN_2 exposure.

4. Threat Resistance

The series of tests on glazing panels has revealed that currently marketed glazing materials for residential doors and windows are incapable of resisting burglary break-in threats for which realistic values have been determined by the threat analysis. Whereas the critical break-in threat is a dynamic load of 4200 inch-pounds total impact, the maximum energy at impact resisted prior to fracture in this test series was between 396 and 400 inch-pounds. This was achieved with a 5/16-inch (nominal) acrylic plastic panel. A similar polycarbonate panel resisted a 1534 inch-pounds impact without fracture; however, the bowing deflection of the panel was so great that part of the panel edging had pulled away from the retaining fixture and the impact would have to be considered a failure load.

The above conclusion regarding inadequacy applies even in the case of commercially designated "burglar resistant" panels. The latter are considerably more resistant than ordinary window double strength (1/8-inch nominal) sheet glass or 1/4-inch nominal tempered, safety, and wire-reinforced glass, although one of the 5/16-inch laminated glasses advertised as "burglar resistant" broke at a lower impact energy than the 1/4-inch safety laminated. It should be noted again that, although each test was stopped as soon as any lamina fractured, there may still have been considerable break-in resistance remaining in the case of the glass/plastic laminates. It was not within the scope of this project to evaluate this additional resistance quantitatively. Strength of a square simply supported panel to resist a concentrated static central load is,

$$P_{All.} = C_1 \ F_b \ t^2$$

where C_1 is a constant for a panel of given size and material, F_b is the bending breaking strength, and t is the thickness.

Assuming the same relation exists for dynamic loads, the required thickness of acrylic to resist the specified threat may be determined.

$$\frac{{t_2}^2}{{t_1}^2} = \frac{4200}{400}$$

$$t_2 = \frac{t_1}{20} \sqrt{4200} = \frac{.305}{20} \sqrt{4200} = .99 \text{ in.}$$

Assuming that the 1534 inch-pound impact achieved with the polycarbonate panel was close to the breaking load, the required thickness for a panel of this material would be

$$t_2 = t_1 \sqrt{\frac{4200}{1534}} = (.348) \sqrt{\frac{4200}{1534}} = .576 \text{ in.}$$

providing this thickness would reduce the deflection to an amount that would not result in panel edge disengagement. The square panel center displacement for a central concentrated load is

$$\delta = C_2 \frac{P}{t^3}$$

Assuming the same relation holds for dynamic loads, the deflection for the new, thicker panel would be

$$\delta_2 = \left[\frac{t_1}{t_2}\right]^3 \delta_1 = \left[\frac{.348}{.576}\right]^3 (3.09) = .68 \text{ in.}$$

This center deflection should correspond to a small enough retraction of the panel edges so the assembly could be designed to prevent panel disengagement due to excessive bowing.

All of the panels tested demonstrated considerable improvement over the ordinary double strength sheet glass, except perhaps for the wire reinforced. It exhibits peculiar, unpredictable behavior probably because of stress concentrations set up in the glass by the imbedded wire mesh. This is not to say that it does not have advantages over ordinary sheet glass. Even though it may break at a low load level, it is safer from the fragment cut injury standpoint. With regard to burglar resistance, there is some retention of barrier represented by the wire mesh after the glass is broken.

In conclusion, all of the panels tested may be considered "burglar retardant," if not "burglar resistant" as compared to ordinary window glass. At this point, however, it appears that only one currently used homogenous material, the polycarbonate plastic, is a practical consideration to meet the maximum anticipated break-in threat and then only with a significant increase in thickness. Another possibility for accomplishing sufficient resistance with reasonable thickness values is to build up the existing safety laminated and "burglary resistant" types with a greater number of (more than two) glass lamina. Thinner layers of glass could be used with the total plastic and overall panel thicknesses somewhat greater. The outer layer(s) of glass would obviously fracture with the specified threat impact, but the remaining composite might be sufficient to prevent access. There was not enough testing possible in this limited program to provide data to determine what combination of lay-ups would be required.

With regard to threats other than static force and missile simulation, the general conclusions are that all are real threats for one or more of the glazing materials tested but that none is as critical as the thrown missile threat. (See the Summary of Results, Figure 98 for the resistance of the various panels to all of the various threats imposed.)

5. Additional Research

Inasmuch as all of the glazing materials tested fell far short of meeting the thrown missile threat, research is needed to determine panel designs (primarily composits of the "safety laminated" type and certain plastics) that would be capable of passing a security qualification test. This work would involve additional testing to provide a basis for quantitative evaluations, analysis of test data, and coordination with vendors on fabrication of experimental panels. Since square panels only one size were tested, additional test work is also needed for providing a quantitative evaluation basis for extra-polation to capacity of any size not tested. This is particularly important since most of the panels failed on the first drop impact and because of the wide scatter in strength test results inherent with glass materials.

FOOTNOTES

1. Bureau of Criminal Statistics Report, Crime Specific Program (6 and 12 Agency Studies), April 1972 through March 1973.

2. Roark, R. J., Formulas for Stress and Strain, 4th Edition, McGraw-Hill Book Co., Inc., 1965.

3. Conover, D. W., Woodson, W. E., Human Engineering Guide, 2nd Edition, University of California Press, Berkeley, California 1964.

4. Thompson, W.T., Mechanical Vibrations, 2nd Edition, Prentice-Hall, Inc., 1964.

5. Johnstone, T. H., "Locks and Locking Mechanisms," Industrial Security, July, 1963.

6. U. S. Department of Housing and Urban Development, FHA, Minimum Property Standards for One and Two Living Units, FHA Report No. 300, Rev. No. 5, January 1965.

7. Fir & Hemlock Door Association, "Industry Standard" FH DA/4-72, Product Standard for Douglas Fir, Western Hemlock and Sitka Spruce Doors and Blinds, Yeon Bldg., Portland, Oregon.

APPENDIX

CALIFORNIA MODEL BUILDING

SECURITY ORDINANCE

developed by

The California Crime

Prevention Officers Association

January, 1978

CALIFORNIA MODEL BUILDING SECURITY ORDINANCE

TABLE OF CONTENTS

PREFACE

This model building security ordinance has been developed through the efforts of the California Crime Prevention Officers Association, the California Attorney General's Office and with the assistance of manufacturers, construction and industry personnel, building and fire officials and many others too numerous to list. We do not wish to lead the reader to believe this document is a panacea for building security problems but we do feel it is a reasonable approach. The intent is to provide a viable product which realistically addresses current problems and which can be readily molded to fit the needs of any jurisdiction desirous of implementing such an ordinance. We feel the need for uniformity in building standards can be met by relying on this model.

The California Model Ordinance cannot be considered a final product and, as with most ordinances, probably will never be considered "complete". However, the committee responsible for developing this will sit as a continuing committee on this matter. The objective is to eventually incorporate performance standards throughout the ordinance rather than design standards but the state of the art is such that this is not possible at this point in time. As progress is made, the CCPOA will update it's members and any others interested in the document.

Any agency or jurisdiction interested in implementing this ordinance should be aware that alternatives are available to the various sections included. Although an attempt has been made to provide the broadest possible approach, you may wish to explore other standards and methods due to your own needs, resources or political environment.

A document of this nature is obviously not readily assimilated by those having little exposure to the field or minimal knowledge of security ordinances. For that reason the reader is urged to scrutinize and research this model to become sufficiently familiar with it. In doing so you will gain an understanding of the necessity and logic behind the individual standards. Those responsible for implementing such an ordinance will undoubtedly be faced with responding to questions from building and planning officials, fire department personnel, political figures, manufacturers and construction firms. Because of their individual concerns they may address only a particular portion of the ordinance, not realizing it must be properly cross referenced to other sections for a full understanding. If this is not done, confusion will certainly arise.

The California Crime Prevention Officers Association is also putting together supplemental materials to assist individual agencies in their efforts to document the need for a building security ordinance. Those materials, as well as technical assistance, will be made available to agencies desiring it. For further information please contact the California Crime Prevention Officers Association.

Those individuals who spent many long and arduous hours on this project should not go unrecognized. The CCPOA certainly appreciates the time and expertise they have devoted to this project as well as the cooperation provided by the various agencies they represent. They have also all indicated a willingness to continue their work on this document and the committee will become a standing committee in the association.

Those individuals are as follows:

Robert Bledsoe, San Carlos Police Department
Joe Brann, Santa Ana Police Department
Mike Franchetti, California Attorney General's Office
George Harris, Los Angeles Police Department
Bob Helton, Santa Ana Police Department
Jerry Hillman, Los Angeles County Sheriff's Office
Don Hughes, Pasadena Police Department
Bruce Ramm, Orange Police Department
Pat Rodgers, Irvine Police Department
George Schrader, Anaheim Police Department
John Slough, San Diego Police Department

CALIFORNIA MODEL BUILDING SECURITY ORDINANCE

ORDINANCE NO.________

An ordinance adding (Article/Chapter)[1]____ of the (Municipal/County/Etc.) Code to require security devices in certain buildings as burglary prevention measures and providing for the enforcement thereof by ________________________. (Examples would be citation, fine, or incarceration).

The (City Council of this City/Board of Supervisors of this County) does ordain as follows:

SECTION I — PURPOSE

The purpose of this (Article/Chapter) is to provide minimum standards to safeguard property and public welfare by regulating and controlling the design, construction, quality of materials, use and occupancy, location and maintenance of all buildings and structures within the (City/County) of _____________________ as required in Section 14051 of the California Penal Code relating to Building Security.

SECTION II — SCOPE

(A) The provisions of this (Article/Chapter) shall apply to new construction and to buildings or structures to which additions or alterations are made except as specifically provided by this (Article/Chapter). When additions or alterations made within any 12 month period exceed 25 percent of the value of the existing buildings or structures, such buildings or structures shall be made to conform to the security requirements for new buildings and structures.[2]

(B) Existing multiple family dwelling units which are converted to privately owned family units (condominiums) shall comply with the provisions of Section XIV (Special Residential Building Provisions) of this (Article/Chapter).

(C) Any existing structure which converts from its original occupancy group as designated in the Uniform Building Code, shall comply with the provisions of this (Article/Chapter).

(D) Any building as defined in UBC and Title 19 - California Administrative Code, requiring special type releasing, latching, or locking devices, other than described herein, shall be exempt from the provisions hereof relating to locking devices of interior and/or exterior doors.[3]

SECTION III GLOSSARY

For the purpose of this (Article/Chapter) certain terms are defined as follows:

"Approved" means certified as meeting the requirements of this (Article/Chapter) by the enforcing authority or its authorized agents, or by other officials designated by law to give approval on a particular matter dealt with by the provisions of this (Article/Chapter) with regard to a given material, mode of construction, piece of equipment or device.

"Auxiliary Locking Device" means a secondary locking system added to the primary locking system to provide additional security.

"Bolt" is a metal bar which, when actuated, is projected (or thrown) either horizontally or vertically into a retaining member, such as a strike plate, to prevent a door or window from moving or opening.

"Bolt Projection or Bolt Throw" is the distance from the edge of the door, at the bolt center line, to the farthest point on the bolt in the projected position.

"Burglary Resistant Glazing" means those materials as defined in U.L. Bulletin 972.

"Commercial Building" means a building, or portion thereof used for a purpose other than dwelling.

"Component", as distinguished from a part, is a subassembly which combines with other components to make up a total door or window assembly. For example, the primary components of a door assembly include: door, lock, hinges, jamb/wall, jamb/strike and wall.

"Cylinder" means the subassembly of a lock containing the cylinder core, tumbler mechanism and the keyway. A double cylinder lock is one which has a key-actuated cylinder on both the exterior and interior of the door.

"Cylinder Core or Cylinder Plug" is the central part of a cylinder containing the keyway, which is rotated by the key to operate the lock mechanism.

"Cylinder Guard" means a tapered or flush metal ring or plate surrounding the otherwise exposed portion of a cylinder lock to resist cutting, drilling, prying, pulling, or wrenching with common tools.

"Deadbolt" is a lock bolt which does not have a spring action as opposed to a latch bolt, which does. The bolt must be actuated by a key or a key and a knob or thumb turn and when projected becomes locked against return by end pressure.

"Dead Latch or Deadlocking Latch Bolt" means a spring actuated latch bolt having a beveled end and incorporating a plunger which, when depressed, automatically locks the projected latch bolt against return by end pressure.

"Door assembly" is a unit composed of a group of parts or components which make up a closure for an opening to control passageway through a wall. For the purposes of this (Article/Chapter), a door assembly consists of the following parts: door; hinges; locking device or devices; operation contacts (such as handles, knobs, push plates); miscellaneous hardware and closures; the frame, including the head, threshold and jambs plus the anchorage devices to the surrounding wall and a portion of the surrounding wall extending 36 inches from each side of the jambs and 16 inches above the head.

"Door Stop" means that projection along the top and sides of a door jamb which checks the door's swinging action.

"Double Cylinder Deadbolt" means a deadbolt lock which can be activated only by a key on both the interior and the exterior.

"Dwelling" means a building or portion thereof designed exclusively for residential occupancy, including single family and multiple family dwellings.

"Enforcing Authority" is the agency or person having the responsibility for enforcing the provisions of this (Article/Chapter). (The enforcing authority shall be determined at the time this Ordinance is adopted. Examples of an enforcing authority may be, but not limited to, the Chief Building Official, Chief of Police, Sheriff, and the Planning Director.)

"Flushbolt" is a manual, key or turn operated metal bolt normally used on inactive door(s) and is attached to the top and bottom of the door and engages in the head and threshold of the frame.

"Fully Tempered Glass" means those materials meeting or exceeding ANSI standard Z 97.1 - Safety Glazing.

"Jamb" means the vertical members of a door frame to which the door is secured.

"Jamb/Wall" is that component of a door assembly to which a door is attached and secured; the wall and jamb used together are considered a unit.

"Key-In-Knob" means a lockset having the key cylinder and other lock mechanisms contained in the knob.

"Latch or Latch Bolt" is a beveled, spring-actuated bolt which may or may not have a deadlocking device.

"Lock (or Lockset)" is a keyed device (complete with cylinder, latch or deadbolt mechanism, and trim such as knobs, levers, thumb turns, escutcheons, etc.) for securing a door in a closed position against forced entry. For the purposes of this (Article/Chapter), a lock does not include the strike plate.

"Locking Device" is a part of a window assembly which is intended to prevent movement of the movable sash, which may be the sash lock or sash operator.

"Multiple Family Dwelling" means a building or portion thereof designed for occupancy by two or more families living independently of each other, including hotels, motels, apartments, duplexes and townhomes.

"Panic Hardware" means a latching device on a door assembly for use when emergency egress is required due to fire or other threat to life safety. Devices designed so that they will facilitate the safe egress of people in case of an emergency when a pressure not to exceed 15 lbs. is applied to the releasing device in the direction of exit travel. Such releasing devices are bars or panels extending not less than two-thirds of the width of the door and placed at heights suitable for the service required, not less than 30, not more than 44 inches above the floor.

"Part", as distinguished from component, is a unit (or subassembly) which combines with other units to make up a component.

"Primary Locking Device" means the single locking system on a door or window unit whose primary function is to prevent unauthorized intrusion.

"Private or Single Family Dwelling" means a building designed exclusively for occupancy by one family.

"Rail" means the horizontal member of a window or door. A meeting rail is one which mates with a rail of another sash or a framing member of the door or window frame when the sash is in the closed position.

"Sash" is an assembly of stiles, rails, and sometimes, mullions assembled into a single frame which supports the glazing material. A fixed sash is one which is not intended to be opened. A movable sash is intended to be opened.

"Sill" is the lowest horizontal member of a window frame.

"Single Cylinder Deadbolt" means a deadbolt lock which is activated from the outside by a key and from the inside by a knob, thumb-turn, lever, or similar mechanism.

"Solid Core Door" means a door composed of solid wood or composed of compressed wood equal in strength to solid wood construction.

"Stile" is a vertical framing member of a window or door.

"Strike" is a metal plate attached to or mortised into a door or door jamb to receive and to hold a projected latch bolt and/or deadbolt in order to secure the door to the jamb.

"Swinging Door" means a door hinged at the stile or at the head and threshold.

"U. L. Listed" means tested and listed by Underwriters Laboratory, Inc.

"Window Assembly" is a unit which includes a window and the anchorage between the window and the wall.

"Window Frame" is that part of a window which surrounds and supports the sashes and is attached to the surrounding wall. The members include side jambs (vertical), head jamb (upper, horizontal), sill and mullions.

SECTION IV ENFORCEMENT PROVISIONS

The enforcing authority is directed to adminster and enforce the provisions of this (Article/Chapter). The enforcing authority shall be the _______________. (Examples would be the Building Department, Planning Department, Police Department, Fire Department, etc.)[4]

SECTION V RIGHT OF ENTRY

The enforcing authority shall have the right, and is hereby authorized and empowered, to enter or go on or about any building or premises between 8:00 a.m. and 5:00 p.m. for the purpose of inspecting the physical security of such buildings or premises, or for any other purposes consistent herewith. The enforcing authority shall be given prompt access to any area of the building or premises upon oral notification to the responsible person, and upon exhibiting suitable evidence of their identity and authority; provided however, that except in an emergency situation, an inspection warrant issued pursuant to Title 13, Part 3 of the Code of Civil Procedures (Sections 1822.50 to 1822.57 inclusive) shall first be secured when entry or access thereto is refused. Refusal to admit such members when an inspection warrant is not required shall be a misdemeanor.

SECTION VI VIOLATIONS AND PENALTIES

It shall be unlawful for any person, firm or corporation to erect, construct, enlarge, alter, move, improve, convert, or demolish, equip, use, occupy or maintain any building or structure in the (City/County), or cause same to be done, contrary to or in violation of any of the provisions of this (Article/Chapter).

Any person, firm, or corporation violating any of the provisions of this (Article/Chapter) is guilty of a misdemeanor and shall be punishable for each offense, by a fine of not more than $500, or by confinement in jail for not more than six months, or by both fine and confinement in jail.5

SECTION VII APPEALS

In order to prevent or lessen the unnecessary hardship or practical difficulties in exceptional cases where it is difficult or impossible to comply with the strict letter of this (Article/Chapter), the owner or his designated agent shall have the option to apply for an exemption from any provision of this (Article/Chapter) to the (City Council/Board of Supervisors). The (City Council/Board of Supervisors) shall exercise its powers on these matters in such a way that the public welfare is secured, and substantial justice done most nearly in accord with the intent and purpose of this (Article/Chapter).

SECTION VIII CONSTITUTIONALITY

If any subsection, subdivision, sentence, clause, phrase, or portion of this (Article/Chapter), or the application thereof to any person, is for any reason held to be invalid or unconstitutional by the decision of any court of competent jurisdiction, such decision shall not affect the validity of the remaining portion of the (Article/Chapter) or its application to other persons. The (City Council/Board of Supervisors) hereby declares that it would have adopted this (Article/Chapter) and each subsection, subdivision, sentence, clause, phrase or portion thereof, irrespective of the fact that any one or more subsections, subdivisions, sentences, clauses, phrases, or portions of the application thereof to any person, be declared invalid or unconstitutional.

No portion of this (Article/Chapter) shall supersede any local, state, or federal law, regulation, or codes dealing with life safety factors.

SECTION IX ALTERNATE MATERIALS AND METHODS OF CONSTRUCTION

The provisions of this (Article/Chapter) are not intended to prevent the use of any material or method of construction not specifically prescribed by this (Article/Chapter) provided any such alternate has been approved by the enforcing authority, nor is it the intention of this (Article/Chapter) to exclude any sound method of structural design or analysis not specifically provided for in this (Article/Chapter). Materials, methods of construction, or structural design limitations provided for in this (Article/Chapter) are to be used unless an exception is granted by the enforcing authority.

The enforcing authority may approve any such alternate provided they find the proposed design to be satisfactory and the material and method of work is, for the purpose intended, at least equivalent to that prescribed in this (Article/Chapter) in quality, strength, effectiveness, burglary resistance, durability and safety. [6]

SECTION X KEYING REQUIREMENTS

Upon occupancy by the owner or proprietor, each single unit in a tract or commercial development, constructed under the same general plan, shall have locks using combinations which are interchange free from locks used in all other separate dwellings, proprietorships or similar distinct occupancies.[7]

SECTION XI FRAMES/JAMBS/STRIKES/HINGES

Installation and construction of frames, jambs, strikes and hinges shall be as follows:

(A) Door jambs shall be installed with solid backing in such a manner that no voids exist between the strike side of the jamb and the frame opening for a vertical distance of six (6) inches each side of the strike.[8]

(B) In wood framing, horizontal blocking shall be placed between studs at door lock height for three (3) stud spaces each side of the door openings. Trimmers shall be full length from the header to the floor with solid backing against sole plates.[8]

(C) Door stops on wooden jambs for in-swinging doors shall be of one piece construction with the jamb. Jambs for all doors shall be constructed or protected so as to prevent violation of the strike.

(D) The strike plate for deadbolts on all wood framed doors shall be constructed of minimum sixteen (16) U.S. gauge steel, bronze, or brass and secured to the jamb by a minimum of two screws, which must penetrate at least two (2) inches into solid backing beyond the surface to which the strike is attached.

(E) Hinges for out-swinging doors shall be equipped with nonremovable hinge pins or a mechanical interlock to preclude removal of the door from the exterior by removing the hinge pins.

SECTION XII WINDOWS/SLIDING GLASS DOORS

The following requirements must be met for windows and sliding glass doors:

(A) Except as otherwise specified in Section XIV (Special Residential Building Provisions), and Section XV (Special Commercial Building Provisions) all openable exterior windows and sliding glass doors shall comply with the tests as set forth in Section XVI (Tests).

(B) Louvered windows shall not be used when any portion of the window is less than 12 feet vertically or 6 feet horizontally from an accessible surface or any adjoining roof, balcony, landing, stair tread, platform, or similar structure.

SECTION XIII GARAGE TYPE DOORS -- ROLLING OVERHEAD, SOLID OVERHEAD, SWING, SLIDING OR ACCORDIAN

The above described doors shall conform to the following standards:

(A) Wood doors shall have panels a minimum of five-sixteenths (5/16) inch in thickness with the locking hardware being attached to the support framing.

(B) Aluminum doors shall be a minimum thickness of .0215 inches and riveted together a minimum of eighteen (18) inches on center along the outside seams. There shall be a full width horizontal beam attached to the main door structure which shall meet the pilot, or pedestrian access, door framing within three (3) inches of the strike area of the pilot or pedestrian access door.

(C) Fiberglass doors shall have panels a minimum density of six (6) ounces per square foot from the bottom of the door to a height of seven (7) feet. Panels above seven (7) feet and panels in residential structures shall have a density not less than five (5) ounces per square foot.

(D) Doors utilizing a cylinder lock shall have a minimum five (5) pin tumber operation with the locking bar or bolt extending into the receiving guide a minimum of one (1) inch.

(E) Doors that exceed sixteen (16) feet in width shall have two lock receiving points; or, if the door does not exceed nineteen (19) feet, a single bolt may be used if placed in the center of the door with the locking point located either at the floor or door frame header; or, torsion spring counter balance type hardware may be used.[9]

(F) Except in a residential building, doors secured by electrical operation shall have a keyed-switch to open the door when in a closed position, or by a signal locking device.

(G) Doors with slide bolt assemblies shall have frames a minimum of .120 inches in thickness, with a minimum bolt diameter of one-half (1/2) inch and protrude at least one and one-half (1 1/2) inches into the receiving guide. A bolt diameter of three-eighths (3/8) inch may be used in a residential building. The slide bolt shall be attached to the door with non-removable bolts from the outside. Rivets shall not be used to attach slide bolt assemblies.

(H) Except in a residential building, padlock(s) used with exterior mounted slide bolt(s) shall have a hardened steel shackle locking both at heel and toe and a minimum five pin tumbler operation with non-removable key when in an unlocked position. Padlock(s) used with interior mounted slide bolt(s) shall have a hardened steel shackle with a minimum four pin tumbler operation.

SECTION XIV SPECIAL RESIDENTIAL BUILDING PROVISIONS

(A) Except for vehicular access doors, all exterior swinging doors of any residential building and attached garages, including the door leading from the garage area into the dwelling unit shall be equipped as follows:

(1) All wood doors shall be of solid core construction with a minimum thickness of one and three-fourths (1 3/4) inches, or with panels not less than nine-sixteenths (9/16) inch thick.

(2) A single or double door shall be equipped with a double or single cylinder deadbolt lock. The bolt shall have a minimum projection of one (1) inch and be constructed so as to repel cutting tool attack. The deadbolt shall have an embedment of at least three-fourths (3/4) inch into the strike receiving the projected bolt. The cylinder shall have a cylinder guard, a minimum of five pin tumblers, and shall be connected to the inner portion of the lock by connecting screws of at least one-fourth (1/4) inch in diameter. All installation shall be done so that the performance of the locking device will meet the intended anti-burglary requirements. (It may be desired to have deadbolt locks constructed so as to prevent the key from being removed from the interior cylinder when the bolt is projected.)[10] A dual locking mechanism constructed so that both deadbolt and latch can be retracted by a single action of the inside door knob, or lever, may be substituted provided it meets all other specifications for locking devices.

(3) The inactive leaf of double door(s) shall be equipped with metal flush bolts having a minimum embedment of five-eighths (5/8) inch into the head and threshold or the door frame.

(4) Glazing in exterior doors or within forty (40) inches of any locking mechanism shall be of fully tempered glass or rated burglary resistant glazing, except when double cylinder deadbolt locks are installed.

(5) Except where clear vision panels are installed, all front exterior doors shall be equipped with a wide angle (180°) door viewer.[11]

(B) Street numbers and other identifying data shall be displayed as follows:

(1) All residential dwellings shall display a street number in a prominent location on the street side of the residence in such a position that the number is easily visible to approaching emergency vehicles. The numerals shall be no less than four (4) inches in height and shall be of a contrasting color to the background to which they are attached.[12]

(2) There shall be positioned at each entrance of a multiple family dwelling complex an illuminated diagramatic representation of the complex which shows the location of the viewer and the unit designations within the complex. In addition, each individual unit within the complex shall display a prominent identification number, not less than four (4) inches in height, which is easily visible to approaching vehicular and/or pedestrian traffic.

(C) Lighting in multiple family dwellings shall be as follows:[13]

(1) Aisles, passageways, and recesses related to and within the building complex shall be illuminated with an intensity of at least twenty-five one hundredths (.25) footcandles at the ground level during the hours of darkness. Lighting devices shall be protected by weather and vandalism resistant covers.

(2) Open parking lots and car ports shall be provided with a maintained minimum of one (1) footcandle of light on the parking surface during the hours of darkness. Lighting devices shall be protected by weather and vandalism resistant covers.

SECTION XV SPECIAL COMMERCIAL BUILDING PROVISIONS

(A) Swinging exterior glass doors, wood or metal doors with glass panels, solid wood or metal doors shall be constructed or protected as follows:

(1) Wood doors shall be of solid core construction with a minimum thickness of one and three-fourths (1 3/4) inches. Wood panel doors with panels less than one (1) inch thick shall be covered on the inside with a minimum sixteen (16) U.S. gauge sheet steel, or its equivalent, which is to be attached with screws on minimum six (6) inch centers. Hollow steel doors shall be of a minimum sixteen (16) U.S. gauge and have sufficient reinforcement to maintain the designed thickness of the door when any locking device is installed; such reinforcement being able to restrict collapsing of the door around any locking device.

(2) Except when double cylinder deadbolts are utilized, any glazing utilized within 40 inches of any door locking mechanism shall be constructed or protected as follows:

(a) Fully tempered glass or rated burglary resistant glazing; or

(b) Iron or steel grills of at least one-eighth (1/8) inch material with a minimum two (2) inch mesh secured on the inside of the glazing may be utilized; or

(c) The glazing shall be covered with iron bars of at least one-half (1/2) inch round or one inch by one-fourth inch (1"x1/4") flat steel material, spaced not more than five (5) inches apart, secured on the inside of the glazing.

(d) Items (b) and (c) above shall not interfere with the operation of opening windows if such windows are required to be openable by the Uniform Building Code.

(B) All swinging exterior wood and steel doors shall be equipped as follows:

(1) A single or double door shall be equipped with a double or single cylinder deadbolt. The bolt shall have a minimum projection of one (1) inch and be constructed so as to repel cutting tool attack. The deadbolt shall have an embedment of at least three-fourths (3/4) inch into the strike receiving the projected bolt. The cylinder shall have a cylinder guard, a minimum of five pin tumblers, and shall be connected to the inner portion of the lock by connecting screws of at least one-fourth (1/4) inch in diameter. The provisions of the preceding paragraph do not apply where (1) panic hardware is required, or (2) an equivalent device is approved by the enforcing authority.

(2) Double doors shall be equipped as follows:

(a) The inactive leaf of double door(s) shall be equipped with metal flush bolts having a minimum embedment of five-eighths (5/8) inch into the head and threshold of the door frame.

(b) Double doors shall have an astragal constructed of steel a minimum of .125 inch thick which will cover the opening between the doors. The astragal shall be a minimum of two (2) inches wide, and extend a minimum of one (1) inch beyond the edge of the door to which it is attached. The astragal shall be attached to the outside of the active door by means of welding or with non-removable bolts spaced apart on not more than ten (10) inch centers. (The door to which such an astragal is attached must be determined by the fire-safety codes adopted by the enforcing authority.)

(C) Aluminum frame swinging doors shall be equipped as follows:

(1) The jamb on all aluminum frame swinging doors shall be so constructed or protected to withstand 1600 pounds of pressure in both a vertical distance of three (3) inches and a horizontal distance of one (1) inch each side of the strike, so as to prevent violation of the strike.

(2) A single or double door shall be equipped with a double cylinder deadbolt with a bolt projection exceeding one (1) inch, or a hook shaped or expanding dog bolt that engages the strike sufficiently to prevent spreading. The deadbolt lock shall have a minimum of five pin tumblers and a cylinder guard.

(D) Panic Hardware, whenever required by the Uniform Building Code or Title 19, California Administrative Code, shall be installed as follows:

(1) Panic hardware shall contain a minimum of two (2) locking points on each door; or

(2) On single doors, panic hardware may have one locking point which is not to be located at either the top or bottom rails of the door frame. The door shall have an astragal constructed of steel .125 thick which shall be attached with non-removable bolts to the outside of the door. The astragal shall extend a minimum of six (6) inches vertically above and below the latch of the panic hardware. The astragal shall be a minimum of two (2) inches wide and extend a minimum of one (1) inch beyond the edge of the door to which it is attached.

(3) Double doors containing panic hardware shall have an astragal attached to the doors at their meeting point which will close the opening between them, but not interfere with the operation of either door. (Fire Department approval may be desired here.)

(E) Horizontal sliding doors shall be equipped with a metal guide track at top and bottom and a cylinder lock and/or padlock with a hardened steel shackle which locks at both heel and toe, and a minimum five pin tumbler operation with non-removable key when in an unlocked position. The bottom track shall be so designed that the door cannot be lifted from the track when the door is in a locked position.

(F) In office buildings (multiple occupancy), all entrance doors to individual office suites shall meet the construction and locking requirements for exterior doors.

(G) Windows shall be deemed accessible if less than twelve (12) feet above ground. Accessible windows having a pane exceeding ninety-six (96) square inches in an area with the smallest dimension exceeding six (6) inches and not visible from a public or private throughfare shall be protected in the following manner:

(1) Fully tempered glass or burglary resistant glazing (Fire Department approval may be desired here); or

(2) The following window barriers may be used but shall be secured with non-removable bolts:

(a) Inside or outside iron bars of at least one-half (1/2) inch round or one by one-quarter (1 x 1/4) inch flat steel material, spaced not more than five (5) inches apart and securely fastened; or

(b) Inside or outside iron or steel grills of at least one-eighth (1/8) inch material with not more than a two (2) inch mesh and securely fastened.

(3) If a side or rear window is of the type that can be opened, it shall, where applicable, be secured on the inside with either a slide bar, bolt, crossbar, auxiliary locking device, and/or padlock with hardened steel shackle, a minimum four pin tumbler operation.

(4) The protective bars or grills shall not interfere with the operation of opening windows if such windows are required to be openable by the Uniform Building Code.

(H) All exterior transoms exceeding ninety-six (96) square inches on the side and rear of any building or premises used for business purposes shall be protected by one of the following:

(1) Fully tempered glass or rated burglary resistant glazing (Fire Department approval may be desired here); or

(2) The following barriers may be used but shall be secured with non-removable bolts:

(a) Outside iron bars of at least one-half (1/2) inch round or one by one-quarter (1 x 1/4) inch flat steel material, spaced no more than five (5) inches apart and securely fastened; or

(b) Outside iron or steel grills of at least one-eighth (1/8) inch with not more than a two (2) inch mesh and securely fastened.

(3) The protective bars or grills shall not interfere with the operation of opening the transoms if such transoms are required to be openable by the Uniform Building Code or Title 19, California Administrative Code.

(I) Roof openings shall be equipped as follows:

(1) All skylights on the roof of any building or premises used for business purposes shall be provided with:

(a) Rated burglary resistant glazing; or

(b) Iron bars of at least one-half (1/2) inch round or one by one-fourth (1 x 1/4) inch flat steel material under the skylight and securely fastened; or

(c) A steel grill of at least one-eighth (1/8) inch material with a maximum two (2) inch mesh under the skylight and securely fastened.

(2) All hatchway openings on the roof of any building or premises used for business purposes shall be secured as follows:

(a) If the hatchway is of wooden material, it shall be covered on the inside with at least sixteen (16) U.S. gauge sheet metal, or its equivalent, attached with screws.

(b) The hatchway shall be secured from the inside with a slide bar or slide bolts. (Fire Department approval may be desired here.)

(c) Outside hinges on all hatchway openings shall be provided with non-removable pins when using pin-type hinges.

(3) All air duct or air vent openings exceeding ninety-six (96) square inches on the roof or exterior walls of any building or premises used for business purposes shall be secured by covering the same with either of the following:

(a) Iron bars of at least one-half (1/2) inch round or one by one-fourth (1 x 1/4) inch flat steel material spaced no more than five (5) inches apart and securely fastened; or

(b) Iron or steel grills of at least one-eighth (1/8) inch material with a maximum two (2) inch mesh and securely fastened.

(c) If the barrier is on the outside, it shall be secured with bolts which are non-removable from the exterior.

(d) The above (a and b) must not interfere with venting requirements creating a potentially hazardous condition to health and safety or conflict with the provisions of the Uniform Building Code or Title 19, California Administrative Code.

(J) Permanently affixed ladders leading to roofs shall be fully enclosed with sheet metal to a height of ten feet. This covering shall be locked against the ladder with a case hardened hasp, secured with non-removable screws or bolts. Hinges on the cover will be provided with non-removable pins when using pin-type hinges. If a padlock is used, it shall have a hardened steel shackle, locking at both heel and toe, and a minimum five pin tumbler operation with non-removable key when in an unlocked position.

(K) A building located within eight (8) feet of utility poles or similar structures which can be used to gain access to the building's roof, windows or other openings shall have such access area barricaded or fenced with materials to deter human climbing.

(L) The following standards shall apply to lighting, address identification and parking areas:

(1) The address number of every commercial building shall be illuminated during the hours of darkness so that it shall be easily visible from the street. The numerals in these numbers shall be no less than six (6) inches in height and be of a color contrasting to the background. In addition, any business which affords vehicular access to the rear through any driveway, alleyway or parking lot shall also display the same numbers on the rear of the building.

(2) All exterior commercial doors, during the hours of darkness, shall be illuminated with a minimum of one (1) footcandle of light. All exterior bulbs shall be protected by weather and vandalism resistant cover(s).

(3) Open parking lots, and access thereto, providing more than ten parking spaces and for use by the general public, shall be provided with a maintained minimum of one (1) footcandle of light on the parking surface from dusk until the termination of business every operating day.

SECTION XVI

TESTS[14]

A. It shall be the responsibility of the owner, or his designated agent, of a building or structure falling within the provisions of this (Article/Chapter) to provide the enforcing authority with a written specification performance test report indicating that the materials utilized meet the minimum requirements.

B. Whenever there is insufficient evidence of compliance with the provisions of this (Article/Chapter) or evidence that any material or any construction does not conform to the requirements of this (Article/Chapter), or in order to substantiate claims for alternate materials or methods of construction, the enforcing authority may require tests as proof of compliance to be made at the expense of the owner or his agent by any agency which is approved by the enforcing authority.

C. Specimens shall be representative, and the construction shall be verified by assembly drawings and bill of materials. Two complete sets of manufacturer or fabricator installation instructions and full-size or accurate scale templates for all items and hardware shall be included.

D. Tests for sliding glass doors shall be conducted as follows:

(1) The construction and size of the test door assemblies, jambs and headers, and all hardware components shall be representative of that for which acceptance is desired. The door assembly and mounting in the support fixture shall simulate the rigidity normally provided to a door assembly in a building by the ceiling, floor and walls.

(2) Sample doors submitted for testing shall be glazed. Panels shall be closed and locked with the primary locking device only.

(3) Tests shall be performed on the samples in the following order:

TEST A. With the panels in the test position, a concentrated load of 800 pounds shall be applied to the vertical pull stile incorporating a locking device, at a point on the stile within 6 inches of the locking device, in the direction parallel to the plane of the glass that would tend to open the door. With the load removed, determine if the primary locking device can be unlocked by manipulation as described in Test H.

TEST B (1) With panels in the test position, a concentrated load of 50 pounds shall be applied to the vertical pull stile incorporating a locking device, at a point on the stile within 6 inches of the locking device, in the direction parellel to the plane of the glass that would tend to open the door while, simultaneously, an additional concentrated load of 200 pounds is applied to the same area of the same stile in a direction perpendicular to the plane of glass toward the interior side of the building. With the load applied, determine if the primary locking device can be unlocked by manipulation as directed in Test H.

TEST B (2) Repeat Test B (1) substituting 800 pounds for the indicated 50 pounds. Perform the manipulation tests with the load removed.

TEST C (1) With the panels in the test position, a concentrated load of 50 pounds shall be applied to the vertical pull stile incorporating a locking device, at a point on the stile within 6 inches of the locking device, in the direction parallel to the plane of the glass that would tend to open the door while simultaneously, an additional concentrated load of 200 pounds is applied to the same stile in the direction perpendicular to the plane of the glass toward the exterior side of the door. With the load applied, determine if the primary locking device can be unlocked by manipulation as described in Test H.

TEST C (2) Repeat Test C (1) substituting 800 pounds for the indicated 50 pounds. Perform the manipulation tests with the load removed.

TEST D With the movable panel lifted upward to its full limit within the confines of the door frame, a concentrated load of 800 pounds shall be applied separately to each vertical pull stile incorporating a locking device, at a point on the stile within 6 inches of the locking device, in the direction parallel to the plane of the glass that would tend to open the door. With the load removed, determine if the primary locking device can be unlocked by manipulation as described in Test H.

TEST E (1) With the movable panel lifted upward to its full limit within the confines of the door frames, a concentrated load of 50 pounds shall be applied to the vertical pull stile incorporating a locking device, at a point on the stile within 6 inches of the locking device, in the direction parallel to the plane of the glass that would tend to open the door while, simultaneously, an additional concentrated load of 200 pounds is applied to the same area of the same stile in the direction perpendicular to the plane of the glass toward the interior side of the door. With load applied, determine if the primary locking device can be unlocked by manipulation as described in Test H.

TEST E (2) Repeat Test E (1) substituting 800 pounds for the indicated 50 pounds. Perform the manipulation tests with the load removed.

TEST F (1) With the movable panel lifted upward to its full limit within the confines of the door panel, a concentrated load of 50 pounds shall be applied to the vertical stile incorporating a locking device, at a point on the stile within 6 inches of the locking device, in the direction parallel to the plane of glass that would tend to open the door while, simultaneously, an additional concentrated load of 200 pounds is applied to the same area of the same stile in the direction perpendicular to the plane of the glass toward the exterior side of the door. With the load applied, determine if the primary locking device can be unlocked by manipulation as described in Test H.

TEST F (2) Repeat Test F (1) substituting 800 pounds for the indicated 50 pounds. Perform the manipulation tests with the load removed.

TEST G For inside sliding doors, repeat Test D, while simultaneously applying a concentrated load of 50 pounds at the end of the movable bottom rail near the meeting stiles inward. For outside sliding doors, repeat Test D while simultaneously applying a concentrated load of 50 pounds at the end of the movable bottom rail near the meeting stiles and outward.

TEST H Lift, push, pull, or otherwise manipulate by hand the door relative to the clearances within the frame while attempting to open the door. This test shall be conducted continuously for five (5) minutes.

Examine the assembly and determine a method and position for inserting a tool through the assembly from the outside so as to contact the primary locking device or the latch. Two different tools shall be used: a knife or spatula with a thin blade approximately 1/32 inch thick, not more than one (1) inch wide and no longer than six (6) inches; and a piece of stiff steel wire with a diameter of approximately 1/16 inch. Determine whether it is possible to insert the wire or manipulate with either of these tools so as to unlock the door within a five (5) minute time period.

TEST I With the following tools:

(1) A knife or spatula with a thin blade approximately 1/32 inch thick, not more than one (1) inch wide, and no longer than six (6) inches; and

(2) A straight or Phillips screwdriver with a maximum six (6) inch shaft

Remove from the door assembly all screws, glazing beads, or other mechanical fastners which can be removed readily from the exterior within a time limit of five (5) minutes. Determine if the primary locking device can be unlocked or entry gained by manipulation as described in Test H.

(4) Fixed Panels. Fixed panels shall be fastened in accordance with the manufacturer's instructions. Tests shall be performed in the following order:

TEST A. With the panels in the normal position, a concentrated load of 300 pounds shall be applied at midspan of the fixed jambstile in the direction parallel to the plane of the glass that would tend to remove the fixed panel from the frame jamb pocket. With the load applied, determine if entry can be gained by manipulation as described in Subsection (D), Paragraph (3), Test H, above.

TEST B. With the panels in the normal position, a concentrated load of 300 pounds shall be applied at midspan of the fixed jambstile in the direction parallel to the plane of the glass that would tend to remove the fixed panel from the frame jamb pocket while, simultaneously, an additional concentrated load of 150 pounds is applied at midspan of the fixed panel interlock stile in the direction perpendicular to the plane of the glass which would tend to disengage the meeting stiles. With this load applied, determine if entry can be gained by manipulation as described in Subsection (d), Paragraph (3), Test H, above.

TEST C. Repeat Test A with the fixed panel lifted upward to its full limit within the confines of the door frame. The lifting force need not exceed 150 pounds at the bottom of the exterior face of the meeting stile. With this load applied, determine if entry can be gained by manipulation as described in Subsection (D), Paragraph (3), Test H, above.

(5) A sliding door assembly shall fail these tests if at any time during or after the test, the sliding door assembly does not remain engaged, intact, and in the closed and locked position or by manipulating an exposed component; or if one can enter through displaced or damaged portions.

(6) The report shall include the following: Identification of the samples tested; type, size, location, and number of locking devices; type, location, and number of anchors; type and thickness of glazing material and an indication of whether or not the subject passed the test. The report shall also indicate at what point the assembly fails. The report shall be certified to be a true copy by the testing laboratory and shall be forwarded direct from the laboratory to the enforcing authority.

E. For the purpose of this ordinance, windows are classified as follows:

Type A Window assemblies incorporate one or more sashes that open by sliding in the plane of the wall in which the window is installed.

Type B Window assemblies incorporate one or more framed sashes which are hinged at or near two corners of the individual sash and open toward the exterior of the wall.

Type C Window assemblies incorporate one or more sashes which open toward the interior and are hinged at or near two corners of the sash.

Type D Window assemblies incorporate one or more sashes which are hinged or pivot near the center so that part of the sash opens into the interior wall and part opens toward the exterior.

(1) Window assemblies shall be mounted following the manufacturer's installation instructions. Install the window assembly in a test fixture which simulates the wall construction required by Chapter 25 of the Uniform Building Code. The unit shall be fully glazed. The sash shall be closed and locked with the primary locking device only.

(a) Tests for Type A window assemblies shall be performed in the following order:

TEST A With the sliding sash in the normal position, a concentrated load of 200 pounds shall be applied separately to each member incorporating a locking device, at a point on the sash member within 6 inches of the locking device, in the direction parallel to the plane of the glass that would tend to open the window. With the load removed, apply the manipulation test described in Subsection (D), Paragraph (3), Test H, above.

TEST B With the sliding sash in the normal position, a concentrated load of 200 pounds shall be applied separately to each sash member incorporating a locking device, at a point on the sash member within 6 inches of the locking device in the direction parallel to the plane of the glass that would tend to open the window while, simultaneously, an additional concentrated load of 75 pounds is applied in the same area of the same sash member in the direction perpendicular to the plane of the glass toward the interior side of the window. With the load removed, apply the manipulation test described in Subsection (D), Paragraph (3), Test H, above.

TEST C With the sliding sash in the normal position, a concentrated load of 200 pounds shall be applied separately to each sash member incorporating a locking device, at a point on the sash member within 6 inches of the locking device, in the direction parallel to the plane of the glass that would tend to open the window while, simultaneously, an additional concentrated load of 75 pounds is applied to the same area of the same sash member in the direction perpendicular to the plane of the glass toward the exterior side of the window. With the load removed, apply the manipulation test described in Subsection (D), Paragraph (3), Test H, above.

TEST D With the sliding sash lifted upward to the full limit within the confines of the window frame, a concentrated load of 200 pounds shall be applied separately to each sash member incorporating a locking device, at a point on the sash within 6 inches of the locking device, in the direction parallel to the plane of glass that would tend to open the window. With the load removed, apply the manipulation test described in Subsection (D), Paragraph (3), Test H, above.

TEST E With the sliding sash lifted upward to the full limit within the confines of the window frame, a concentrated load of 200 pounds shall be applied separately to each sash member incorporating a locking device, at a point on the sash within 6 inches of the locking device, in the direction parallel to the plane of the glass that would tend to open the window, while, simultaneously, an additional concentrated load of 75 pounds is applied to the same area of the same sash member in the direction perpendicular to the plane of the glass towards the interior side of the window. With the load removed, apply the manipulation test described in Subsection (D), Paragraph (3), Test H, above.

TEST F With the sliding sash lifted upward to the full limit within the confines of the window frame, a concentrated load of 200 pounds shall be applied separately to each sash member incorporating a locking device, at a point on the sash member within 6 inches of the locking device, in the direction parallel to the plane of the glass that would tend to open the window while, simultaneously, an additional concentrated load of 75 pounds is applied to the same area of the same sash member in the direction perpendicular to the plane of the glass toward the exterior side of the window. With the load removed, apply the manipulation test described in Subsection (D), Paragraph (3), Test H, above.

TEST G For inside sliding windows, repeat Test F while simultaneously applying a concentrated load of 25 pounds inward at the end of the movable bottom rail near the meeting stile opposite the lock stile. For outside sliding windows, repeat Test F while simultaneously applying a concentrated load of 25 pounds in the same direction as the perpendicular load inward at the end of the movable bottom rail near the meeting stile opposite the lock stile outward.

TEST H Perform the disassembly and manipulation test as described in Subsection (D), Paragraph (3), Test I above.

(b) The tests for Type B and C window assemblies shall be performed in the following order:

TEST A With the swinging sash in the normal position, apply a concentrated load of 100 pounds within 3 inches of each end of the rail or stile which is opposite the hinged side, in the direction perpendicular to the plane of the glass that would tend to open the window.

TEST B Repeat Test A and simultaneously apply a concentrated load of 100 pounds on the outside within 1 inch of the end of the stile or rail which is opposite the hinged side, in a direction parallel to the plane of the glazing which would tend to disengage the lock.

TEST C With the swinging sash in the normal position, apply a concentrated load of 200 pounds on the rail or stile containing the locking device within 6 inches of the lock.

TEST D Repeat Test B while simultaneously applying Test C. The manipulation test described in Subsection (D), Paragraph (3), Test H, above, shall be applied in Tests A, B, and D to the sash with the load removed.

TEST E Perform the disassembly and manipulation test as described in Subsection (D), Paragraph (3), Test I, above.

(c) Tests for Type D window assemblies shall be performed in the following order:

TEST A With the sash in the normal position, simultaneously apply a concentrated load of 100 pounds within 3 inches of the ends of each rail or stile which is perpendicular to the pivot sides in the direction that would tend to open the sash.

TEST B With the sash in the normal position, apply a concentrated load of 100 pounds on the rail or stile containing the pivot within 1 inch of the pivot in a direction parallel to the pivots.

TEST C Repeat Test B, applying the load to the opposite rail or stile.

TEST D With the sash in the normal position, apply a concentrated load of 200 pounds on the rail or stile containing the locking device within 6 inches of the lock.

TEST E Repeat Test D while simultaneously applying the load specified in Test B. Repeat Test D while simultaneously applying the load specified in Test C above. The manipulation test described in Subsection (D), Paragraph (3), Test H, above, shall be applied in Tests A, B, C, and D above to the sash with the load removed.

TEST F Perform the disassembly and manipulation test as described in Subsection (D), Paragraph (3), Test I, above.

(d) A window assembly shall fail these tests if at any time during or after the tests, the assembly does not remain engaged, intact, and in the closed and locked position, or by manipulating exposed component; or if one can enter through displaced or damaged portions.

(e) The report shall contain a description of the results of the test performed in accordance with the test methods above. The report shall include the following: Identification of the samples tested; type, location, and number of anchors; type and thickness of glazing material and an indication of whether or not the subject passed the test. The report shall also indicate at what point the assembly fails. The test report shall be certified to be a true copy by the testing laboratory and shall be forwarded direct from the laboratory to the enforcing authority.

FOOTNOTES

1. This model ordinance has been written in such a fashion as to allow it to be easily inserted into most existing municipal codes, county codes or similar legislation. The reader will have to determine whether the document will fall in the category of an article, chapter, etc. An attempt has been made to identify where possible choices exist and must be made by indicating possible choices in parenthesis.

2. It is recommended that 25 percent be the value utilized here when determining whether an entire existing structure should or should not be made to conform to the standards for new construction. The purpose of this section is to provide a method of bringing existing structures up to new standards by requiring compliance throughout the building only if extensive remodeling or renovation is done. If this construction amounts to less than 25% of the existing value of the building, then only the new construction would have to meet the standards.

   NOTE: The method for determining the existing value of the building must be worked out with the local building department. It is also possible that building officials may want to use a higher or lower value than 25%. This should be determined by meeting with building officials.

3. This section is intended to prevent confusion as to requirements for what is known as panic hardware. It is well recognized that certain life safety devices are necessary when constructing public buildings. There are many methods for providing security when utilizing panic hardware and some of those methods are discussed in other sections of this model ordinance.

4. The method of enforcement will also have a bearing upon who is selected as the enforcing authority. If a fine, citation or similar process is used, it will be necessary for the enforcing authority to possess certain police powers.

5. Other alternatives are possible, but should be discussed in depth with the appropriate legal advisor.

6. It is recognized that the new materials and devices will be manufactured as technology develops. Further research may reveal important findings concerning existing requirements as well. This section allows the enforcing authority to grant necessary exceptions without having to restructure the ordinance each and every time a significant development occurs.

7. Due to current practices in the construction industry problems have been encountered with respect to master keying systems used for residential and commercial tract developments. Such systems frequently allow a duplication of individual keys for several separate structures. This has invited burglaries and the new keying requirements can reduce this opportunity.

8. Subsections (a) and (b) substantially reduce the possibility of attacks by prying or "jamb spreading" by providing more strength in the door frame and surrounding wall area. For door openings which have adjacent full length glazing panels, an alternate method to ensure proper blocking of the framing may be of concern. A building official could assist in developing an alternate method for adding strength to the framing.

9. Residential garage doors which exceed 16 feet may be secured in an alternate manner which will accomplish the intended purpose of this section -- that is to restrict entry by lifting a corner of the garage door. Such an alternative is to restrict the height if only one locking device is used (i.e., 24 inches from the bottom of the door).

10. Although no lock manufacturer is marketing such a lock at the time of the publication of this ordinance, many of the lock companies have indicated this can be done. The advantage of such a device is that it would meet the needs for life safety as well as crime prevention and property protection. For further information on such locks contact the California Crime Prevention Officers Association.

11. The mounting height of a door viewer may be of concern for if placed too high this may discourage regular use of the viewer. A suggested guide would be to restrict it from being mounted higher than 58 inches from the bottom of the door.

12. Consideration for requiring lighted house numbers may be advantageous for such numbers aid not only law enforcement, but especially paramedics or rescue personnel responding to a medical call for assistance. That extra minute "hunting" for the house number could result in serious complications for the person needing assistance of the safety services.

13. As with some other sections of this ordinance, more research is needed in this area but these standards have been judged by the Building Security Committee to be adequate. The committee will continue in its attempts to further develop such standards.

14. The current test standards have been found to be among the best available at this point in time. These standards are largely based upon the work done to date by the International Conference of Building Officials. As the committee continues its evaluation of such performance standards modifications are bound to occur. Any such modifications or revisions will be published and disseminated through the CCPOA as soon as possible after approval by the Building Security Committee.

END