# THE DESIGN OF A DOOR LATCH AND HANDLE FOR APPLICATION TO INTERIOR RESIDENTIAL DOORS

T H E S I S  B Y
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## ABSTRACT

THE FACTORS WHICH INFLUENCE THE DESIGN OF A LOCKSET ARE CAREFULLY ANALYZED AND THE DERIVED CONCLUSIONS USED AS A SET OF REQUIREMENTS UPON WHICH TO BASE THE DESIGN.

FIRST, THE ARCHITECTURAL SETTING, DOOR CONSTRUCTION, AND USE OF A DOOR ARE STUDIED TO INDICATE THE FORM WHICH THE LOCK SHOULD TAKE. THEN THE BUYERS' PREFERENCES, SALES CHANNELS, AND VOLUME OF SALES ARE INVESTIGATED TO REVEAL SALES FEATURES WHICH SHOULD BE INCORPORATED IN THE DESIGN TO INSURE ITS SUCCESS ON THE MARKET. THESE RESULTS ARE THEN USED AS A BASIS BY WHICH TO DETERMINE PERFORMANCE REQUIREMENTS, PRODUCTION METHODS, SUITABLE MATERIALS AND CONSTRUCTION.

THE INTEGRATION OF ALL THESE FACTORS RESULTS IN THE FINAL SOLUTION OF THE DESIGN PROBLEM. THE LOCKSET IS DESIGNED TO BE OPERATED BY PUSHING OR PULLING THE HANDLE AND TO BE INSTALLED IN A SMALL V-NOTCH IN THE DOOR. THE SELECTED MATERIALS OF CONSTRUCTION MAKE USE OF COLOR IN THE FORM OF ANODIZED ALUMINUM FINISHES AS WELL AS TINTED PLASTICS.

THE OPERATION AND CONSTRUCTION OF THE FINISHED DESIGN IS DESCRIBED IN DETAIL, AND RECOMMENDATIONS FOR ITS DEVELOPMENT AS A COMMERCIAL PRODUCT ARE MADE.

# ACKNOWLEDGMENTS

THE AUTHOR WISHES TO EXPRESS HIS APPRECIATION OF GUIDANCE AND INVALUABLE CRITICISM RECEIVED FROM THE FACULTY OF THE INDUSTRIAL DESIGN SECTION AND THE MEMBERS OF HIS THESIS COMMITTEE--MR. DAVID F. WELCH, DR. DONALD S. CLARK, AND MR. B. W. MORANT. HE ACKNOWLEDGES HIS INDEBTEDNESS TO DR. GREGG TAYLOR OF THE ENGINEERING DEPARTMENT OF THE UNIVERSITY OF CALIFORNIA AT LOS ANGELES AND OFFICIALS OF THE SCHLAGE LOCK MANUFACTURING COMPANY, WHO GAVE FREELY OF THEIR INTEREST AND TIME.

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## INTRODUCTION

IT IS ESTIMATED THAT ON THE AVERAGE A PERSON OPENS AND CLOSES DOORS DURING THE DAY AS OFTEN AS FIFTY TO ONE HUNDRED TIMES. THE TASK OF TURNING THE KNOB AND SWINGING THE DOOR OPEN AND SHUT IS SUCH AN INTEGRAL PART OF OUR LIVING HABITS THAT ITS COMPLEXITY IS SELDOM QUESTIONED. WHILE CONSIDERABLE PROGRESS HAS BEEN MADE RECENTLY IN THE DESIGN AND CONSTRUCTION OF THE HOME AND MOST OF ITS FURNISHINGS, MANY ARTICLES OF BUILDERS HARDWARE REMAIN ESSENTIALLY UNCHANGED IN FORM SINCE THEIR INTRODUCTION A CENTURY AGO. THIS IS PARTICULARLY TRUE OF THE COMMON DOOR LATCH, WHICH NEED ONLY BE COMPARED TO THE PROGRESSIVE EVOLUTION OF THE LATEST REFRIGERATOR AND AUTOMOBILE DOOR LATCHES. ON MANY RECENTLY DESIGNED APPLIANCES GREAT CARE HAS BEEN GIVEN TO THE SHAPE OF THE HANDLE AND TO SIMPLE MECHANISMS WHICH CAN BE OPERATED BY A NUDGE OF AN ELBOW OR THE PUSH OF A BUTTON. THE OBJECTIVE OF THIS THESIS IS TO APPLY THESE FEATURES TO A LOCKSET FOR INTERIOR RESIDENTIAL DOORS. SUCH A LOCKSET SHOULD BE SIMPLE TO OPERATE, INEXPENSIVE TO MANUFACTURE, AND PLEASING TO THE EYE.

THERE ARE AS MANY CLASSIFICATIONS OF DOOR LATCHES AS THERE ARE TYPES OF DOORS. SPECIAL LOCKSETS MAY BE HAD FOR SLIDING DOORS, SWINGING DOORS, FRENCH DOORS, BATHROOM DOORS, FRONT DOORS, AND MANY MORE. THE MOST COMMON OF THESE IS THE ONE-WAY SWINGING DOOR FOR GENERAL INTERIOR USE AND FOR THIS REASON THE SUBJECT OF THIS THESIS HAS BEEN LIMITED TO THE DESIGN OF A LOCKSET FOR SUCH APPLICATION. THIS LOCKSET IS TO BE OPERATED ON ANY ONE-WAY SWINGING DOOR FOR GENERAL PURPOSES WITHIN THE HOME, AND WILL INCLUDE PROVISION FOR LOCKING THE DOOR FROM ONE SIDE WITHOUT THE USE OF A KEY.

## CONCLUSIONS OF ANALYSIS

THE EXCELLENCE OF A DOOR LOCKSET IS DEPENDENT UPON A VARIETY OF FACTORS EACH OF WHICH MUST BE RECOGNIZED AS INFLUENTIAL TO THE QUALITY OF THE DESIGN. THESE FACTORS ARE BEST ASSEMBLED UNDER FIVE GENERAL HEADINGS:

1. THE NATURE OF ARCHITECTURAL SETTING IN WHICH THE LOCKSET IS TO BE USED
2. THE NATURE OF THE DOOR TO WHICH THE LOCKSET IS TO BE APPLIED
3. THE NATURE OF MAN WHO IS TO USE THE LOCKSET
4. THE NATURE OF THE COMMERCIAL HARDWARE MARKET IN WHICH THE LOCKSET MUST SUCCEED
5. THE NATURE OF THE MATERIALS AND PROCESSES BY WHICH THE LOCKSET IS TO BE PRODUCED MOST ECONOMICALLY.

THOROUGH ANALYSIS OF THESE FIVE FACTORS RESULTED IN THE FOLLOWING CONCLUSIONS:

## ARCHITECTURAL SETTING

THERE IS A DECIDED TENDENCY TOWARD THE USE OF FEWER DOORS IN THE NEWER RESIDENTIAL FLOOR PLANS, MAKING GREATER USE OF CENTRAL OPEN AREAS WITHIN THE HOME WITH THE INTRODUCTION OF BETTER INSULATING MATERIALS AND HEATING EQUIPMENT. THE INTERIOR DOORS ARE USED LESS FOR SECURITY THAN PRIVACY, AND TEND TO BE LIMITED TO A FEW SPECIAL-PURPOSE ROOMS, SUCH AS BEDROOMS, BATHROOMS, CLOSETS, AND SERVICE AREAS, WHICH AT TIMES NEED TO BE CLOSED FROM VIEW.

## DOOR CONSTRUCTION

DOORS ARE USED PRIMARILY AS INSULATION AGAINST THE PASSAGE OF LIGHT AND SOUND BETWEEN ROOMS WHERE SUCH CONTROL IS DESIRED. THE APPEARANCE AND CONSTRUCTION OF DOORS IS UNDERGOING A CHANGE FROM THE CONVENTIONAL ORNAMENTAL PANELING, WHICH SERVED AS A SOUNDING BOARD, TO A SIMPLIFIED SLAB OF INSULATING MATERIAL. THE DESIGN APPEARANCE OF THE DOOR LOCK SHOULD BE IN KEEPING WITH THE STRAIGHTFORWARD CHARACTER OF THE MODERN DOOR, AND SHOULD EMPHASIZE THE FUNCTIONAL ORGANIZATION OF ITS SEVERAL PARTS WITH SPECIAL STRESS ON SIMPLICITY OF CONTOUR. THE SHAPE OF THE HANDLE SHOULD INDICATE AT A GLANCE THE WAY IN WHICH IT IS TO BE GRASPED AND OPERATED.

## THE HUMAN ELEMENT

THERE IS DEFINITE INDICATION OF PUBLIC PREFERENCE FOR A PUSH-PULL TYPE OF DOOR HANDLE SHAPED TO FIT THE HAND. OBJECTION IS FOUND TO USE OF THE TURN-KNOB, ESPECIALLY WHEN THE HANDS ARE FULL OR WHEN LUBRICATED WITH SOAP OR GREASE. OPENING THE DOOR IS PREFERABLY ACCOMPLISHED IN ONE CONTINUOUS MOTION WITH A HANDLE WHICH AFFORDS ADEQUATE CONTROL OVER THE MOVEMENT OF THE DOOR. A RAPID YET SILENT LATCH-ACTION IS DESIRED TO MEET ALL NEEDS, FROM HURRIED EXITS TO CLOSING THE DOOR QUIETLY ON A SLEEPING CHILD. TO FACILITATE THIS, THE HANDLE SHOULD BE SHAPED SO THAT THE FINGERS MAY BE WRAPPED AROUND A PORTION OF IT TO AFFORD A FIRM GRIP. IT WAS FOUND THAT THE MOST NATURAL POSITION FOR THE HUMAN ANATOMY TO USE THE HANDLE WAS IN A VERTICAL AXIS, SLIGHTLY TILTED SO AS TO BE NORMAL TO THE EXTENDED ARM AT A HEIGHT OF 30 INCHES.

## MARKETING CONDITIONS

THE SALES OF LOCKSETS ARE ATTRIBUTED LARGELY TO NEW BUILDING CONSTRUCTION. FUTURE SALES ARE THEREFORE BASED ON THE NUMBER OF BUILDING PERMITS ISSUED, WHICH IS CURRENTLY ESTIMATED AT 950,000 UNITS FOR THE UNITED STATES DURING THE YEAR 1948. THE NUMBER OF DOORS TO BE USED IN THIS BUILDING PROGRAM WILL BE APPROXIMATELY 15,000,000, EACH REQUIRING SOME TYPE OF LOCKSET. IN A FIELD OF OVER

TWENTY-FIVE COMPETING MANUFACTURERS, ONLY 0.5% OF THIS TOTAL MARKET COULD BE CAPTURED BY A NEW HARDWARE PRODUCT. THIS PLACES THE FIRST-YEAR PRODUCTION AT 75,000 LOCKSETS FOR THE INTRODUCTION OF A NEW LOCKSET INTO THE MARKET.

OVER 80% OF BUILDERS HARDWARE IS MARKETED THROUGH WHOLESALE JOBBER OUTLETS, THE REMAINDER BEING DISTRIBUTED THROUGH BUILDING SUPPLY HOUSES AND RETAIL STORES. AN EXTENSIVE SURVEY SHOWED THAT THE OWNER OF THE PROPERTY IS THE ONE WHO ULTIMATELY MAKES THE FINAL SELECTION OF THE FINISH HARDWARE IN 75% OF THE CASES COVERED. THE CONTRACTOR IS THE ULTIMATE PURCHASER OF HARDWARE FOR LARGE BUILDING PROGRAMS, WHICH ACCOUNT FOR 20% OF THE MARKET. THE ARCHITECT IS INFLUENTIAL BUT SELDOM MAKES THE CHOICE. THE FACTORS WHICH PROVE TO BE MOST IMPORTANT IN THE SALE OF A PARTICULAR LOCK ARE THE FOLLOWING: THE CONVENIENCE OF OPERATION, SECURITY, PRESTIGE, PRICE, QUALITY, AND EASE OF INSTALLATION. THESE FACTORS ARE USED AS A BASIS FOR MOST HARDWARE ADVERTISING COPY AND ARE DIRECTED TO THE OWNER, THE CONTRACTOR, AND THE ARCHITECT. THE ONE SALES APPEAL WHICH IS EFFECTIVE WITH ALL THREE GROUPS OF CUSTOMERS IS CONVENIENCE OF OPERATION.

ESTIMATES FOR THE YEAR 1948 ANTICIPATE AN EXPENDITURE OF 6 BILLION DOLLARS FOR BUILDING, 1% OF WHICH, OR $60,000,000,

MAY BE ATTRIBUTED TO FINISH HARDWARE. FOR FIFTEEN MILLION LOCKS THE AVERAGE PRICE WILL THEREFORE BE ROUGHLY $4 PER LOCK. INVESTIGATION OF THE HARDWARE MARKET BEARS THIS OUT, REVEALING THAT THE MOST POPULARLY PRICED LOCKS AVERAGE $3.60. THIS FIGURE SHOULD BE MAINTAINED AS THE PRICE LIMIT FOR A NEW PRODUCT. THE USUAL MARK-UP REALIZED ON HARDWARE SALES IS 40% FOR AN ITEM OF THIS TYPE, INDICATING THAT MANUFACTURING COSTS SHOULD NOT EXCEED $1.20.

## CONSTRUCTION AND OPERATION

THE CONSTRUCTION OF A LOCKSET SHOULD COMPLY WITH THREE DETERMINING ELEMENTS OF ITS DESIGN. THESE ARE: METHOD OF INSTALLATION, OPERATION OF THE MECHANISM, AND THE MATERIALS AND PROCESSES OF CONSTRUCTION.

METHOD OF INSTALLATION. THE LOCKSET SHOULD BE DESIGNED AS A SINGLE, PRE-ASSEMBLED UNIT TO FIT INTO A SMALL, EASILY FORMED CAVITY IN THE DOOR STILE, AND SHOULD REQUIRE MINIMUM SKILL AND EFFORT TO INSTALL. AT THE SAME TIME THE LOCK MUST BE REVERSIBLE ABOUT THE AXIS OF THE BOLT SO AS TO BE APPLICABLE TO A RIGHT OR LEFT HAND DOOR. THIS SERVES TO FACILITATE ORDERING AND INSTALLING AS WELL AS TO REDUCE INVENTORY AND PRODUCTION COSTS. THE UNIT MUST ALSO BE ADJUSTABLE TO VARIATION IN DOOR THICKNESS BY MEANS OF A DIRECT AND SIMPLE ADJUSTMENT.

SCREWS FOR FASTENING AND ADJUSTING THE LOCK TO THE DOOR SHOULD BE CONCEALED WHEN THE DOOR IS CLOSED FOR THE SAKE OF APPEARANCE AND SECURITY. THE DESIGN SHOULD INCLUDE AN ESCUTCHEON PLATE TO PROTECT THE FINISH OF THE DOOR BEHIND THE HANDLE AND TO CONCEAL THE CAVITY IN THE WOOD.

MECHANICAL OPERATION. THE FORCE OF CLOSING THE DOOR SHOULD NOT BE ABSORBED BY THE METAL-TO-METAL CONTACT BETWEEN THE LATCH BOLT AND THE STRIKE PLATE, BUT RATHER CUSHIONED FOR QUIET OPERATION. PROVISION SHOULD BE MADE FOR A KEYLESS LOCK TO BE MOUNTED ON THE HANDLE FOR SIMPLE CONTROL, AND SHOULD BE ADAPTABLE TO EITHER SIDE OF THE LOCK AT THE POINT OF INSTALLATION. THIS LOCK MUST INCLUDE A MEANS FOR TRIPPING IT IN EMERGENCIES BY APPLYING A SIMPLE TOOL FROM THE OUTSIDE.

MATERIALS AND PROCESSES. THE MECHANISM SHOULD BE CONSTRUCTED OF DIE-STAMPED PARTS FORMED FROM COLD ROLLED STEEL AND ZINC-PLATED TO RESIST CORROSION. THE MATERIALS AND CONSTRUCTION OF THE LOCKSET SHOULD BE SUITABLE FOR AN EFFECTIVE CORROSION-FREE LIFE OF TWENTY-FIVE YEARS UNDER CONDITIONS OF NORMAL EXPOSURE AND STRESSES. SPRINGS SHOULD BE OF PHOSPHOR BRONZE FOR LASTING SERVICE. BEARINGS FOR MOVING PARTS ARE BEST PUNCHED INTO THE SHEET

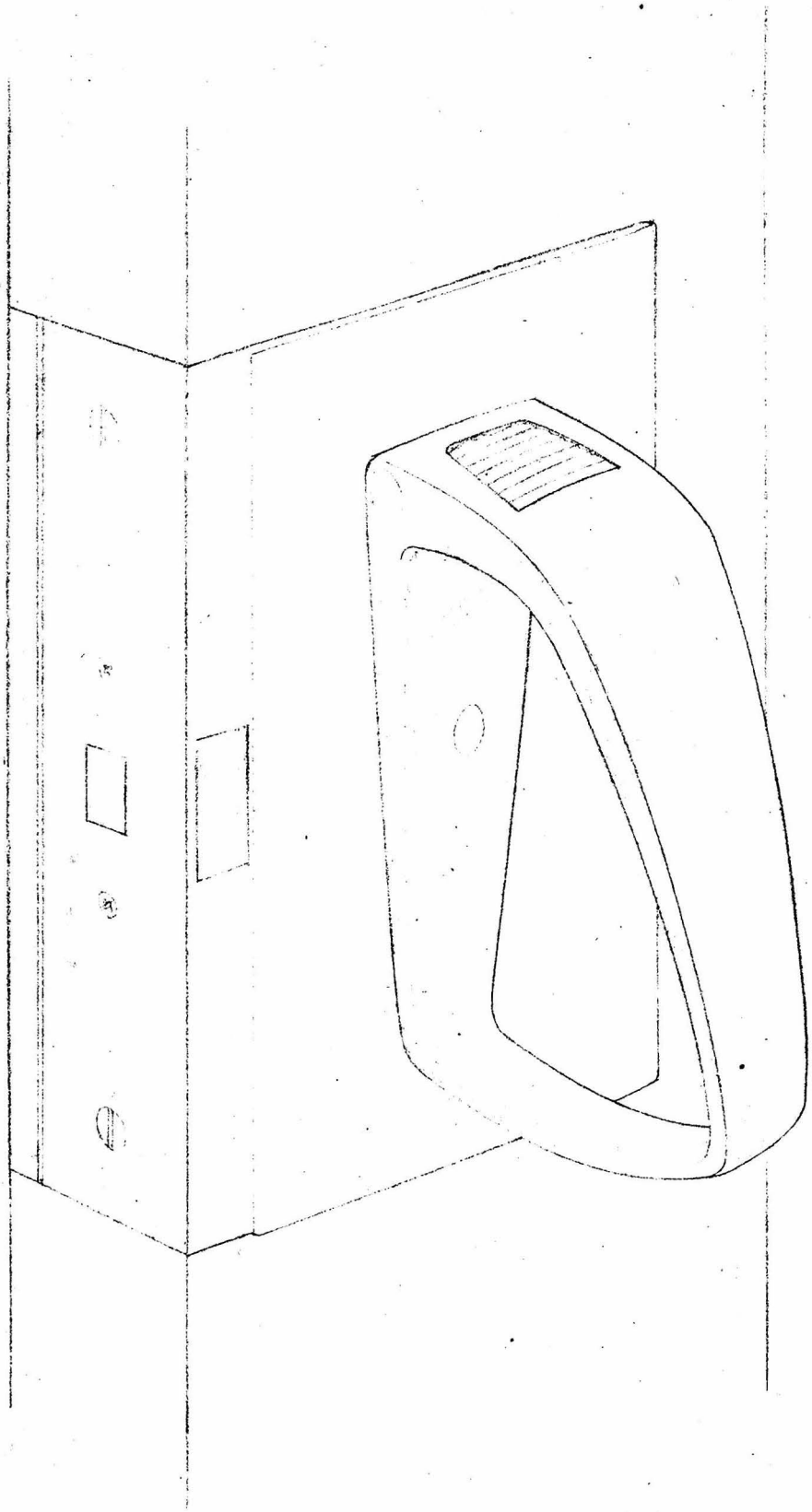


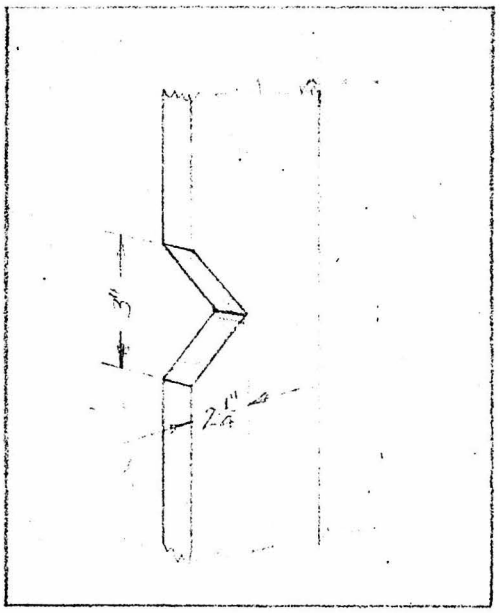
FIGURE 1.

METAL TO ALLOW SMOOTH CONTACT WITH THE HARDENED COLD ROLLED STEEL PINS.

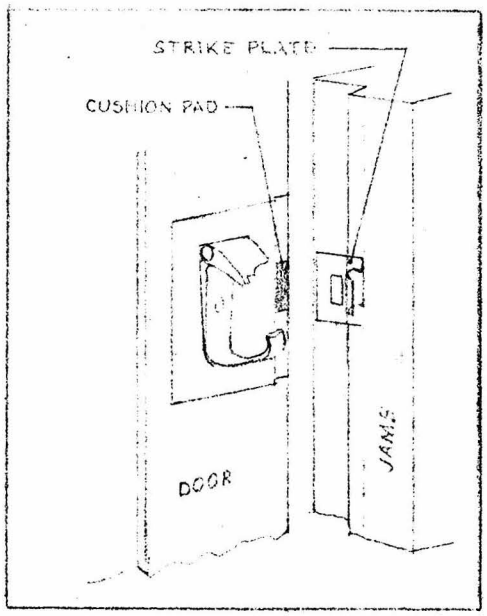
THE ESCUTCHEON AND STRIKE PLATE SHOULD BE FORMED FROM SHEET STOCK, PREFERABLY ALUMINUM BRONZE OR ANODIZED ALUMINUM TO PRESERVE AN ATTRACTIVE AND EFFECTIVE FINISH. TO OBTAIN THE BEST SURFACE, THE HANDLE SHOULD BE FORMED OF PERMANENT MOLDED MATERIALS, SUCH AS ALUMINUM BRONZE, CAST ALUMINUM, OR AS AN OPTION A TRANSFER MOLDED PHENOLIC RESIN OR INJECTION-MOLDED POLYSTYRENE PLASTIC. THESE MATERIALS ARE SELECTED TO PERMIT A WIDE RANGE OF COLORS AND FINISHES TO INSURE MARKET ACCEPTANCE.

## DESCRIPTION OF FINAL DESIGN

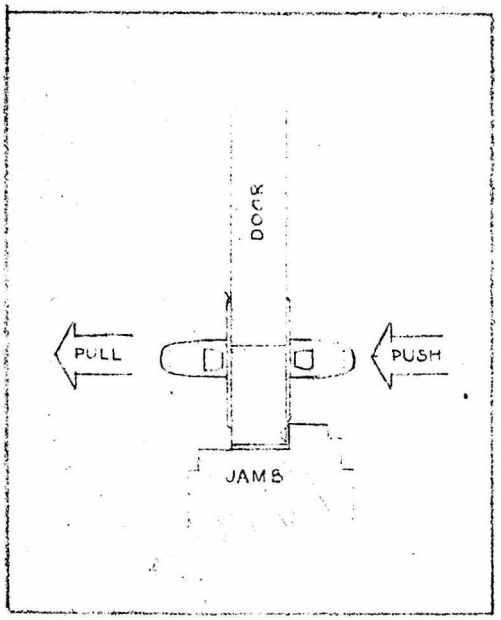
THE CONCLUSIONS ENUMERATED ABOVE SERVE AS A LIST OF REQUIREMENTS WHICH A WELL-DESIGNED LOCKSET SHOULD SATISFY. EACH OF THESE MANY REQUIREMENTS HAS BEEN TREATED AS A SEPARATE PROBLEM, AND THE ANSWERS WERE INTEGRATED TO PRODUCE THE FINISHED DESIGN SOLUTION ILLUSTRATED IN FIG.1. THIS PICTURE SHOWS THE WORKING MODEL AS APPLIED TO A STANDARD PANEL DOOR. THE UNIT LOCK IS MOUNTED IN A SMALL V-NOTCH IN THE DOOR STILE, AND IS SLIPPED INTO PLACE AND FASTENED WITH FOUR SCREWS. THE DRAWINGS IN FIGS.2-A THROUGH 2-D ILLUSTRATE THE OPERATION OF THE LOCKSET AND THE MEANS BY WHICH IT IS INSTALLED IN THE DOOR. A NEOPRENE PAD, SHOWN AS SHADED IN FIG.2-B, CUSHIONS THE FORCE



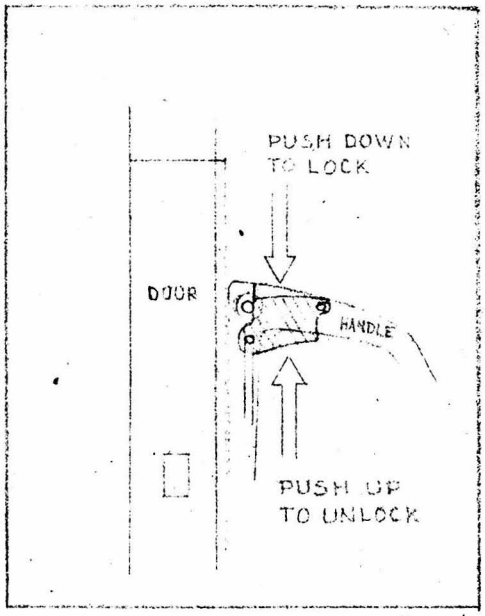
A. SHAPE OF NOTCH IN DOOR




B. VIEW OF CUSHION PAD




C. (PLAN VIEW) HANDLES OPERATE IN ONE DIRECTION




D. ACTION OF LOCKING BUTTON

FIGURE 2

OF THE DOOR AS IT IS SWUNG CLOSED. AS THIS PAD IS DEPRESSED AGAINST SPRING PRESSURE, IT MOVES THE BOLT TO ENGAGE THE STRIKE PLATE. THE BOLT IS SILENTLY RETRACTED BY SLIGHT MOVEMENT OF EITHER HANDLE IN THE DIRECTION THE DOOR SWINGS OPEN. THE DOOR MAY BE LOCKED BY DEPRESSING THE THUMB BUTTON ON THE HANDLE, WHICH RENDERS THE OPPOSITE HANDLE INOPERATIVE. THE LOCKING BUTTON MAY BE MOUNTED ON EITHER SIDE OF THE DOOR AT THE TIME OF INSTALLATION.

THE DESIGN OF THE HANDLE AND OUTER CASE HAS BEEN CAREFULLY REFINED TO EXPRESS AN ARCHITECTURAL SIMPLICITY IN KEEPING WITH THE FUNCTION. THESE PARTS ARE TO BE FINISHED IN A VARIETY OF COLORS IN ANODIZED ALUMINUM OR MOLDED PLASTICS AS WELL AS IN THE CONVENTIONAL BRASS OR BRONZE. IN THIS WAY THE LOCK MAY SERVE AS A PLEASING ACCENT TO BRIGHTEN A PLAIN DOOR PANEL.

# DESIGN ANALYSIS

## INTRODUCTION

THE ANALYSIS OF THIS PROBLEM IS DIVIDED INTO TWO MAIN CATEGORIES. IN THE FIRST ARE INCLUDED THE ENVIRONMENTAL FACTORS, AND IN THE SECOND, THE MECHANICAL FACTORS. UNDER ENVIRONMENTAL FACTORS THE ANALYSIS DEALS WITH THE ARCHITECTURAL SETTING, THE DOOR CONSTRUCTION, HUMAN NEEDS AND HABITS, AND THE COMMERCIAL MARKETING PRACTICES. UNDER MECHANICAL FACTORS A STUDY IS MADE OF INSTALLATION METHODS, MECHANICAL OPERATION, MATERIALS OF CONSTRUCTION AND FINISHES, AND PRODUCTION METHODS AND COSTS.

## ENVIRONMENTAL FACTORS

### ARCHITECTURAL SETTING

THE DOOR LATCH MUST BE RECOGNIZED AS AN ARCHITECTURAL IMPLEMENT AND SHOULD THEREFORE BE DESIGNED ONLY AFTER CAREFUL CONSIDERATION OF THE ARCHITECTURAL SETTING INTO WHICH IT MUST FIT. FOR THIS REASON THE TRENDS OF ARCHITECTURAL DESIGN AND THE PART WHICH THE DOOR PLAYS IN THIS TREND WILL BE CONSIDERED FIRST.

Use of Doors. ANALYSIS OF THE ARCHITECTURAL SETTING IS BASED ON THE STUDY OF TWENTY TYPICAL HOUSE PLANS FROM EACH OF THE YEARS 1927 AND 1947. THESE PLANS WERE SELECTED

# TABLE I

NUMBER OF ROOMS AND DOORS FOR TYPICAL HOUSES - 1927 VS 1947

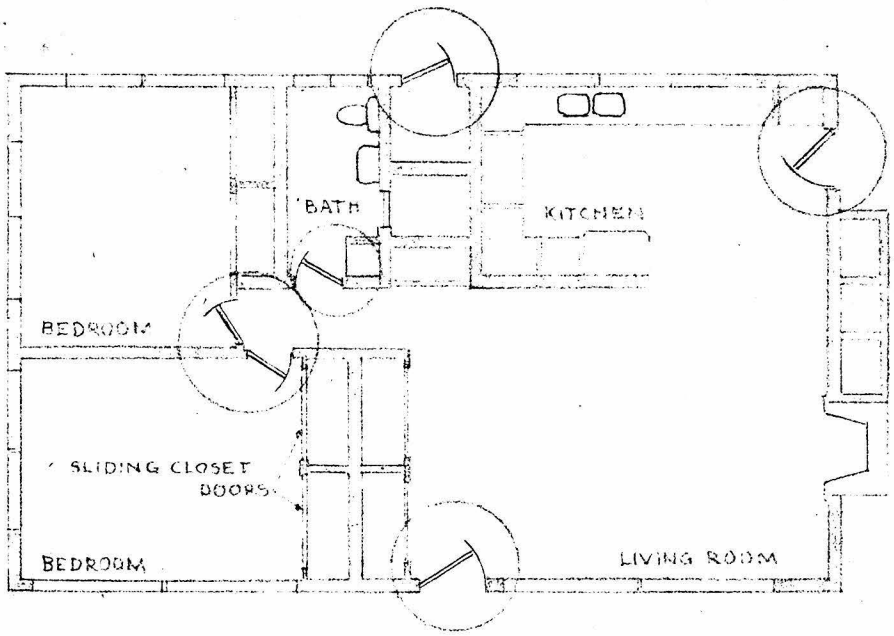
| HOUSE STUDY | | TOTAL ROOMS | TOT EXT DRS/HSE | TOT INT DRS/HSE | TOT DRS PER HSE | EXT DRS PER RM | INT DRS PER RM | TOT DRS PER RM |
|---|---|---|---|---|---|---|---|---|
| 1947 | A | 12 | 8 | 19 | 27 | .66 | 1.60 | 2.25 |
| | B | 7 | 3 | 9 | 12 | .43 | 1.30 | 1.70 |
| | C | 6 | 4 | 5 | 9 | .66 | .83 | 1.50 |
| | D | 5 | 4 | 6 | 10 | .80 | 1.20 | 2.00 |
| | E | 5 | 4 | 5 | 9 | .80 | 1.00 | 1.80 |
| | F | 11 | 6 | 17 | 23 | .55 | 1.55 | 2.10 |
| | G | 8 | 3 | 13 | 16 | .37 | 1.62 | 2.00 |
| | H | 4 | 2 | 6 | 8 | .50 | 1.50 | 2.00 |
| 1947 AVE | | 7 | 4 | 10 | 14 | .57 | 1.40 | 2.00 |
| | | | | | | | | |
| 1927 | J | 12 | 2 | 20 | 22 | .17 | 1.68 | 1.80 |
| | K | 10 | 2 | 20 | 22 | .20 | 2.00 | 2.20 |
| | L | 12 | 3 | 18 | 21 | .17 | 1.50 | 1.75 |
| | M | 9 | 2 | 21 | 23 | .22 | 2.30 | 2.52 |
| | N | 8 | 2 | 18 | 20 | .25 | 2.25 | 2.50 |
| | O | 10 | 3 | 20 | 23 | .30 | 2.00 | 2.30 |
| | P | 9 | 3 | 19 | 22 | .33 | 2.10 | 2.45 |
| 1927 AVE | | 10 | 2 | 20 | 22 | .20 | 2.00 | 2.20 |

EXT - EXTERIOR
INT - INTERIOR
DRS - DOORS
HSE - HOUSE

AT RANDOM FROM A VARIETY OF ARCHITECTURAL PERIODICALS APPEARING IN THOSE YEARS.(1)* IT IS RECOGNIZED THAT SUCH PERIODICALS CATCH THE INNOVATIONS AND MARK THE TRENDS IN DESIGN, AND IN THE PROCESS SERVE TO INFLUENCE ALL ARCHITECTURAL DESIGN IN TIME. FOR THIS REASON THIS SOURCE IS CONSIDERED VALID FOR THIS STUDY. FROM THIS COMPARATIVE SURVEY THE FOLLOWING TRENDS ARE CONCLUSIVELY DERIVED, IN SPITE OF THE LIMITED BASE OF THE STUDY.

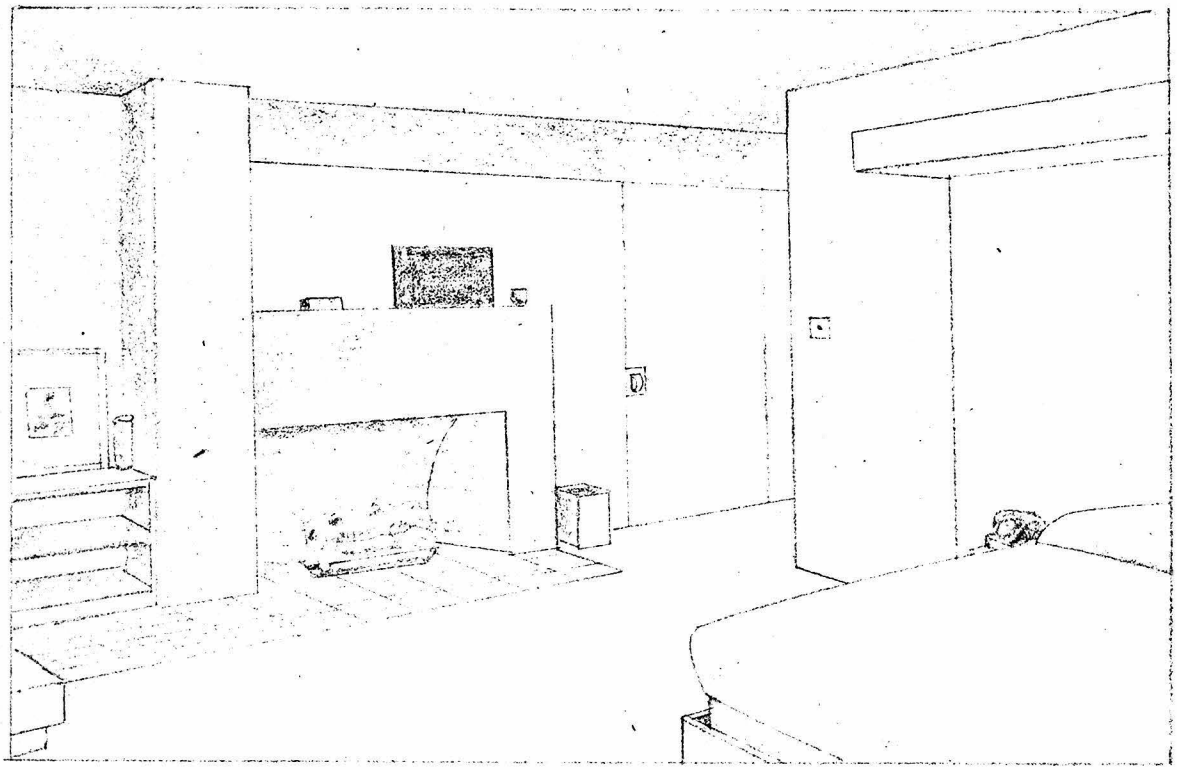
THE AVERAGE NUMBER OF SEPARATED ROOMS PER RESIDENTIAL UNIT WAS COMPUTED, SHOWING A DECLINE FROM 10 ROOMS PER HOUSE IN 1927 TO ONLY 7 IN 1947. THE FINDINGS ARE TABULATED IN TABLE I. THE NUMBER OF EXTERIOR DOORS WAS COMPARED AND FOUND TO HAVE INCREASED FROM 2 PER HOUSE, OR 0.20 PER ROOM IN 1927, TO AN AVERAGE OF 4 PER HOUSE, OR 0.57 PER ROOM IN 1947. THE NUMBER OF INTERIOR DOORS WAS COMPARED LIKEWISE, AND FOUND TO HAVE DECREASED DECIDEDLY, FROM 21 PER HOUSE OR 2.1 PER ROOM IN 1927, TO 10 PER HOUSE OR 1.4 PER ROOM IN 1947. MEANWHILE THE TOTAL FLOOR AREA OF THESE SMALLER HOMES HAS REMAINED RELATIVELY CONSTANT.(2) THESE FIGURES, SUPPORTED BY EXAMINATION OF MANY TYPICAL PLANS, CLEARLY INDICATE A TREND TOWARD LARGE OPEN CENTRAL AREAS AND FEWER ENCLOSED SPACES WITHIN THE HOME. FURTHER EXAMINATION SHOWED THAT WHERE IN 1927 MANY ROOMS HAD ACCESS TO CONNECTING HALLS; NOW THE ROOMS OPEN

*FOR REFERENCES SEE PAGE 80




LOCATION OF DOORS IN USUAL HOUSE

FIGURE 3



MODERN INTERIOR

FIGURE 4

DIRECTLY ONTO THE CENTRAL LIVING AREA. THE EARLIER HOMES OFTEN INCLUDED A SITTING ROOM, A DEN, A LIBRARY, AND OTHER SPECIAL-PURPOSE ROOMS, AND EACH COULD BE CLOSED OFF TO ASSIST IN HEATING AND VENTILATING THE HOUSE. IN CONTRAST TO THIS, THE PRESENT TENDENCY IS TOWARD A MORE COMPACT HOME, WITH FEWER INDIVIDUAL ROOMS BUT WITH LARGER LIVING AREAS. A TYPICAL MODERN PLAN IS SHOWN IN FIG.3, WHERE THE DOORS ARE LARGELY LIMITED TO THREE INTERIOR APPLICATIONS: THE BEDROOMS, BATHROOMS, AND THE STORAGE OR SERVICE AREAS. AN ENCLOSED DINING ROOM IS SELDOM INCLUDED IN THE LATEST PLANS, BUT IS AN INTEGRAL PORTION OF THE LIVING ROOM. CLOSETS ARE OFTEN EQUIPPED WITH SLIDING DOORS TO CONSERVE FLOOR SPACE, AND KITCHENS ARE MANY TIMES LEFT OPEN TO THE DINING AREA. THIS OPEN KITCHEN IS FEASIBLE WHEN ADEQUATE FORCED-DRAFT VENTILATION IS INCLUDED OVER THE STOVE TO CARRY OUT THE COOKING ODORS.

IT IS THOUGHT THAT THIS INCLINATION TOWARD A CENTRAL LIVING AREA COMES IN RECOGNITION OF THE FACT THAT THE KITCHEN IN THE 1927 HOUSE SERVED AS THE COMMUNITY ROOM, WHILE THE PARLOR WAS RESERVED FOR COMPANY. THE PRESENT TREND FAVORS THE FAMILY MORE THAN THE GUESTS. THIS CHANGE HAS BEEN MADE POSSIBLE THROUGH THE INTRODUCTION OF NEW BUILDING MATERIALS AND INSULATING BOARDS AS WELL AS

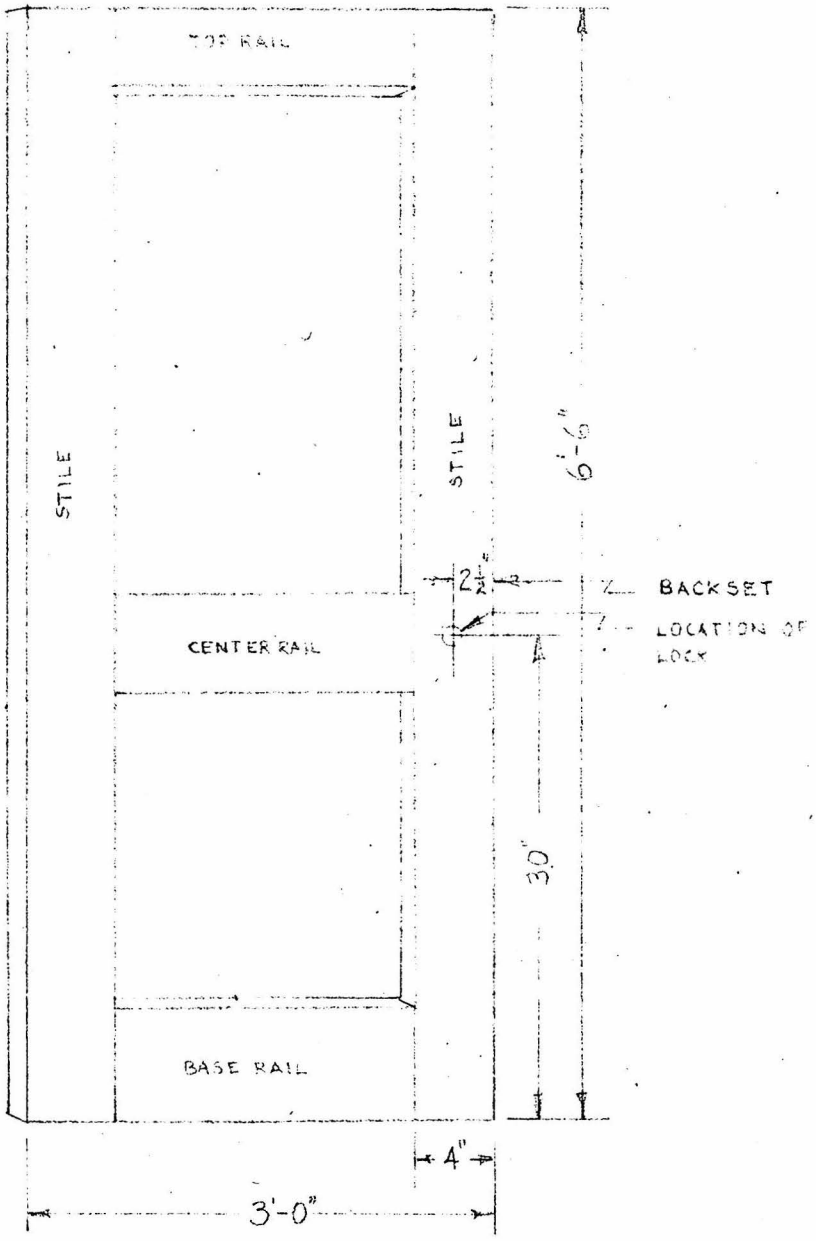
HEATING AND LIGHTING IMPROVEMENTS.

ARCHITECTURAL DESIGN TRENDS. IT IS FELT THAT THE SPIRIT OF CURRENT ARCHITECTURAL DESIGN SHOULD STRONGLY INFLUENCE THE FORM AND APPEARANCE OF A MODERN DOOR LOCK. THOUGH THE GENERAL PUBLIC HAS BEEN RELUCTANT TO ACCEPT THE NEW OPEN-VISTA GLASS-WALLED HOUSE WITHOUT RESERVATION, THIS MODE HAS TOUCHED THE SIMPLEST CAPE COD STYLE HOUSE, RESULTING IN A BETTER ORGANIZATION OF WINDOW TREATMENT AND ELIMINATION OF JUMBLED FORMS. THIS DEFINITE TREND TOWARD CLEAN FORM AND SIMPLICITY OF LINE IS RECOGNIZED AS THE DOMINANT INFLUENCE WHICH THE LOCK DESIGN SHOULD FOLLOW. A MODERN INTERIOR IS SHOWN IN FIG.4, ILLUSTRATING THE NEED FOR DISTINCTIVE TREATMENT OF THE DOOR LOCK.

CONCLUSIONS. THERE IS A GROWING TENDENCY TO LIMIT THE USE OF DOORS WITHIN A HOME TO A FEW ROOMS IN WHICH PRIVACY IS MANDATORY. THE LATCHING MECHANISM MUST BE DESIGNED TO GIVE THE TYPE OF SERVICE REQUIRED FOR BEDROOM, BATHROOM, AND CLOSET DOORS. TO HARMONIZE WITH THE MORE FUNCTIONAL ARCHITECTURAL DESIGNS, DOOR HARDWARE SHOULD EXPRESS SIMPLICITY OF CONTOUR AND ORGANIZATION OF FORM.

## DOOR CONSTRUCTION

JUST AS THE DESIGN OF AN AUTOMOBILE JACK IS GOVERNED BY THE WEIGHT OF THE CAR AND THE STRENGTH OF A MAN, SO IS THE

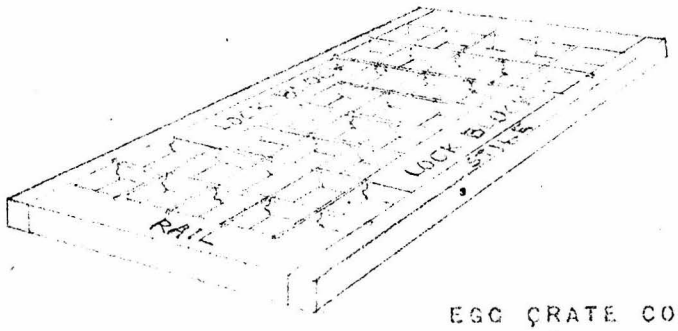



CONSTRUCTION OF PANEL DOOR

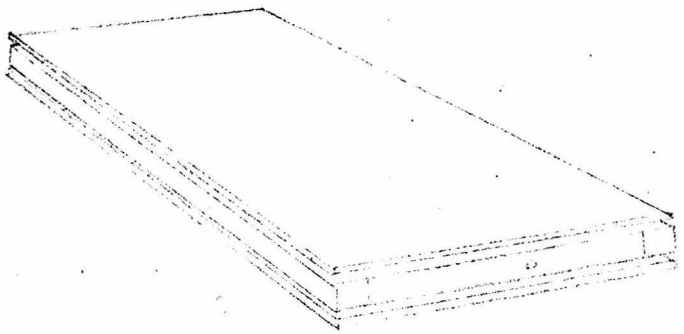
FIGURE 5

DESIGN OF A DOOR LOCKSET GOVERNED LARGELY BY THE SIZE AND CONSTRUCTION OF THE DOOR AND THE STRENGTH AND SHAPE OF MAN. IN THIS WAY, A DOOR LATCH CAN BE THOUGHT OF AS A TOOL FOR OPERATING A DOOR.

NATURE AND CONSTRUCTION OF DOORS. A WOODEN DOOR CONSISTS ESSENTIALLY OF A RELATIVELY RIGID FRAME MADE UP OF TWO VERTICAL STILES AND A TOP AND BOTTOM HORIZONTAL RAIL. THIS FRAME USUALLY INCLUDES CENTER RAILS FOR ADDITIONAL BRACING. THESE PARTS ARE JOINED BY DOWELS, AND SERVE TO SUPPORT THE WOOD PANELS OR OTHER COVERNING VENEER. THE STILES ON PANEL DOORS VARY IN WIDTH FROM 3 INCHES TO $5\frac{1}{2}$ INCHES, AND IN THICKNESS FROM $1\frac{1}{4}$ INCHES TO 3 INCHES. THE STANDARD STILES FOR INTERIOR USE ARE $4\frac{1}{2}$ INCHES WIDE BY 1-3/8 INCHES THICK. THE DOOR FRAMES RANGE IN SIZE FROM 6 TO 8 FEET HIGH AND 2 TO 4 FEET WIDE. THE STANDARD DIMENSIONS ARE $6\frac{1}{2}$ FEET HIGH BY 3 FEET WIDE.[3] THE WIDTH OF THE STILE IS IMPORTANT TO THE DESIGN OF A LOCKSET IN SO FAR AS IT LIMITS THE BACKSET FROM THE EDGE OF THE DOOR. THE BACKSET IS THE TERM APPLIED TO THE DISTANCE FROM THE AXIS OF THE TURNING KNOB TO THE EDGE OF THE DOOR. THE ACCEPTED BACKSET IS $2\frac{1}{2}$ INCHES, WHICH REQUIRES THAT THE DOOR STILE BE CUT TO A DEPTH OF 3 INCHES OR MORE FOR MOST LOCKS. AN AMPLE BACKSET IS NECESSARY SO THAT THE KNUCKLES WILL CLEAR THE CORNER OF THE DOOR JAMB WHEN TURNING THE




EGG CRATE CORE



VENEER ENCLOSURE

CONSTRUCTION OF FLUSH DOOR

FIGURE 6

KNOB. IT HAS BEEN DETERMINED BY A LARGE DOOR LOCK MANUFACTURER THAT A BACKSET OF FIVE INCHES IS THE MOST DESIRABLE. FIG.5 ILLUSTRATES THE CONSTRUCTION OF THE TYPICAL DOOR, AND INDICATES THE BACKSET DIMENSION.

OTHER TYPES OF DOORS ARE CLASSIFIED AS FLUSH, SLAB, HOLLOW, OR SOLID CORE. SUCH DOORS ARE CONSTRUCTED SO THAT THE STILES EMBRACE SOME CENTER CORE, AND THE WHOLE FRAME IS SANDWICHED BETWEEN TWO VENEER SHEETS AS SHOWN IN FIG.6.

WHERE A WOOD OR GLASS PANEL DOOR HAS LITTLE INSULATING VALUE BETWEEN ROOMS, THE FLUSH OR SLAB DOORS PERMIT A RELATIVELY HIGH DEGREE OF EFFICIENT SOUND AND HEAT INSULATION.(4) THE HOLLOW FLUSH DOORS CONSIST OF A BUILT-UP CORE OF INTERLOCKING EGG-CRATE WOOD CONSTRUCTION FACED WITH A SELECTED PLY OR VENEER WOOD. THE DEAD AIR SPACES THUS FORMED ARE EFFECTIVE INSULATORS, AND THE DOOR HAS EXCEPTIONAL RIGIDITY AND STRENGTH. THE STILES ON THESE FLUSH DOORS ARE REDUCED TO $1\frac{1}{4}$ INCHES IN WIDTH, AND THE RAILS TO $2\frac{1}{2}$ INCHES. TO ACCOMMODATE THE DOOR LOCKSET, A LOCK-BLOCK IS BUILT INTO THE CORE AT THE PROPER 30 INCH HEIGHT, AND IS USUALLY 4 INCHES WIDE AND 12 INCHES HIGH TO PERMIT A FULL CHOICE OF INSTALLATIONS. THE LOCK-BLOCKS ARE INDICATED IN FIG.6, OPPOSITE PAGE 15.

Doors vary in weight from 35 pounds for the usual panel door for interior use, to 90 pounds for the 2 inch solid-core flush exterior doors. The forces involved in moving a 90 pound door on its hinges will depend on the nature of the hings bearings and their vertical spacing. For purposes of designing a lock, this force is negligible.

It is the practice to provide a slight bevel of 1/8th inch in 2 inches of door thickness at the edge of doors over $1\frac{1}{2}$ inches thick.(5) This bevel permits a tighter closed fit in the jamb. However, for interior use the standard 1-3/8 inch door thikness is seldom exceeded, and the bevel need not be incorporated in a lock designed for this application.

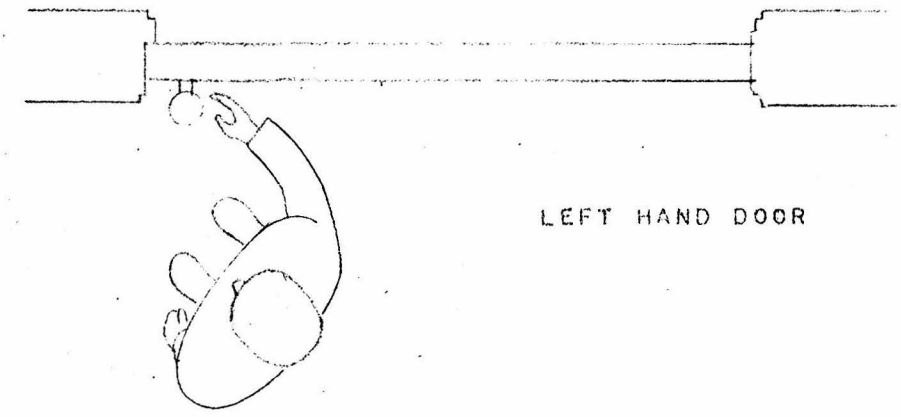
Design Trends. Interviews with a number of architects and contractors revealed a definite trend toward exclusive use of the slab or flush doors, though during the current materials shortage any door is acceptable. Complete acceptance of the flush door is anticipated within the next decade, as evidenced by the listings in architectural materials catalogues. The appearance of the flush door is more in keeping with the simplified architectural forms in its smooth and uninterrupted surface. It is certainly more functional for both insulating and structural purposes.

Conclusions. It is concluded that the design of a door lock is limited by the width of the door stile, but not by the weight of the door. The lock must occupy a volume small enough so as not to affect materially the strength of the door at the stile. The increased use of the flush doors with their clean, unbroken planes suggests that the lock design should be equally clean and direct in appearance. The lock should harmonize with the rectangular character of the door, and should serve to enhance it by supplying a simple accent at the point of control.

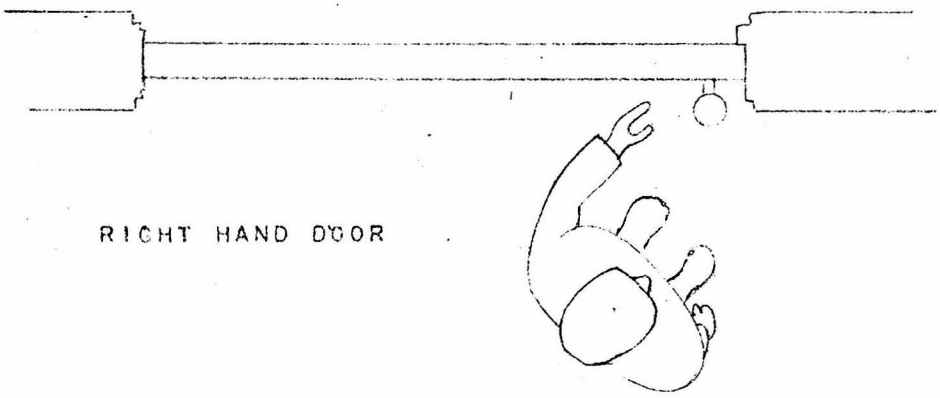
## HUMAN REQUIREMENTS

Since the door lock is to be regarded as a tool used by man to control the door, a successful design must meet the specific human requirements. These requirements involve both cultural and physiological considerations.

Cultural Considerations. Data on the manners and habits involved in the use of a door has been gathered by direct observation of many people in the act of opening and closing doors. It was found that man acquires an automatic skill in operating a door at an early age. The only difficulty experienced by six-year-old children is in applying their weight against the door at the handle height, for which they prefer to use both hands. Mankind



LEFT HAND DOOR



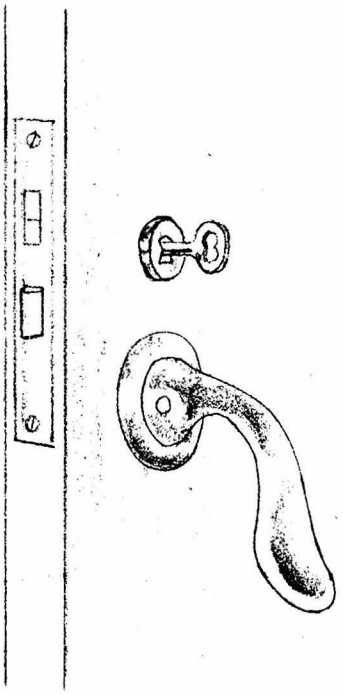
RIGHT HAND DOOR

USE OF RIGHT OR LEFT HAND OPENING DOOR

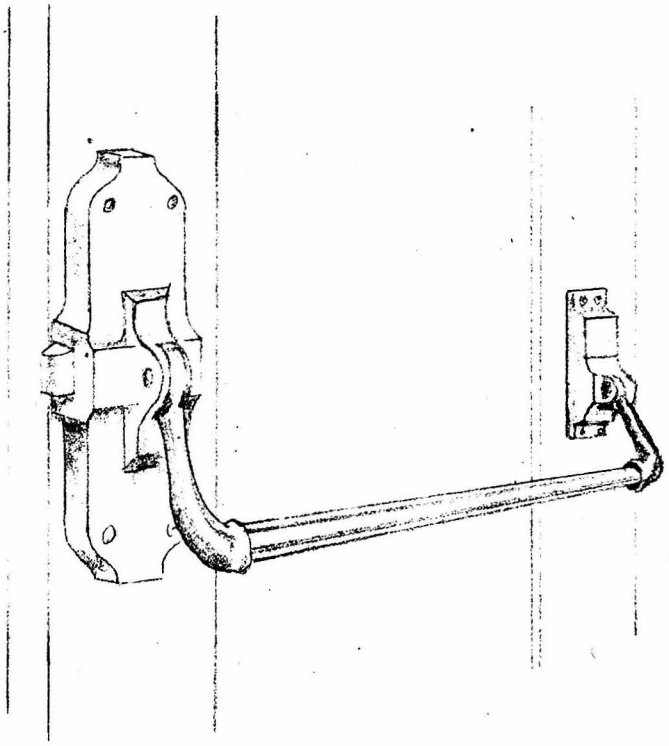
FIGURE 7

IN GENERAL CAN ADAPT EASILY TO THE USE OF ANY PROJECTION ON A DOOR WHICH CAN BE GRIPPED TO OPERATE. AT THE SAME TIME IT IS RECOGNIZED THAT AN AWKWARD OR UNCOMFORTABLE HANDLE SUBCONSCIOUSLY ANNOYS THE MAN WHO USES IT.

USE OF THE DOOR FOLLOWS A BASIC PATTERN WHEREIN THE PERSON APPROACHES THE DOOR AT THE OPENING EDGE AND USES THE HAND NEAREST THE DOOR KNOB AS HE FACES THIS EDGE. (SEE FIG.7) THUS THERE IS NO PROBLEM OF HAVING TO SATISFY LEFT OR RIGHT-HANDED PEOPLE, THE USE OF THE HAND BEING DETERMINED BY WHETHER THE DOOR SWINGS LEFT OR RIGHT.(6) IT IS OBSERVED THAT PEOPLE PREFER TO SWING THE DOOR BY SHIFTING THEIR WEIGHT FROM THE FOOT NEAREST THE DOOR TO THE OTHER FOOT RATHER THAN USE THE MUSCLES OF THE ARM OR SHOULDERS ALONE. IT IS FURTHER OBSERVED THAT AS A PERSON STEPS THROUGH THE DOORWAY, HE WILL NORMALLY RELEASE THE HANDLE HE USED FOR OPENING THE DOOR AND CATCH THE HANDLE ON THE OTHER SIDE, USING EITHER HAND TO CONTROL THE DOOR IN CLOSING IT AGAIN. THIS IS USUALLY DONE WITHOUT LOOKING AT THE HANDLES. IN THIS THROWING AND CATCHING ACTION THE HAND MUST FIND SOMETHING AROUND WHICH OR THROUGH WHICH IT MAY PASS THE FINGERS. THEREFORE A SIMPLE BUTTON OR PLATE, WHICH MIGHT BE SUFFICIENT FOR OPERATING THE LATCH, IS NOT ADEQUATE AS A HANDLE FOR CONTROLLING THE MOVEMENT OF THE DOOR.



PUSH-PULL HOSPITAL DOOR LATCH



PANIC BAR DOOR LATCH

FIGURE 8

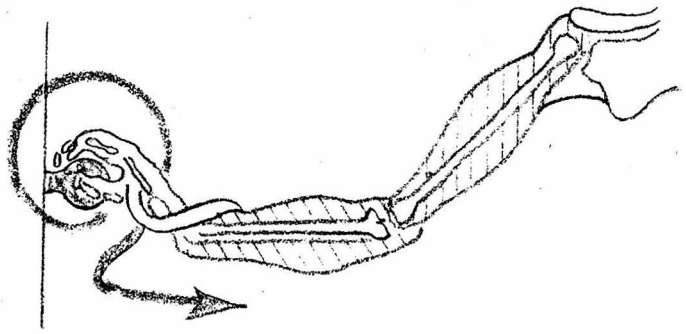
A WELL-DESIGNED LOCKSET SHOULD FULFILL THE MANY PERSONAL NEEDS INVOLVED IN ITS USE. THESE NEEDS INCLUDE SILENT OPERATION OF THE LATCH SO THAT THE DOOR MAY BE OPENED AND CLOSED WITHOUT AN AUDIBLE CLICK WHEN LOOKING IN ON A SLEEPING CHILD OR SICK PERSON. THE EXCEPTIONAL NEEDS MUST BE MET ALSO, AS WHEN THE ARMS ARE FULL OR IN CASE OF FIRE OR ACCIDENT. FOR USE IN HOSPITALS, WHERE ATTENDANTS AND NURSES MUST OPEN AND CLOSE DOORS WHILE CARRYING TRAYS OR BEDDING, A LATCH SUCH AS SHOWN IN FIG.8 WAS DEVELOPED TO BE OPERATED BY A NUDGE OF THE ELBOW. THIS OPERATING PRINCIPLE WOULD BE WELL APPLIED IN THE HOME. AS A PRECAUTION AGAINST ACCIDENT IN CASE OF FIRE OR PANIC, MOST PUBLIC SCHOOLS AND FACTORY BUILDINGS ARE EQUIPPED WITH SAFETY-BAR EXIT DOORS. HERE THE LATCH IS SO DESIGNED THAT BY PUSHING AGAINST THE OPERATING BAR AT ANY POINT THE BOLT RETRACTS AND RELEASES THE DOOR. AGAIN, THE APPLICATION OF THIS SAFETY PRECAUTION IS DESIRABLE WITHIN THE HOME.

REPORTS GATHERED BY INTERVIEWING RETAIL HARDWARE SALESMEN AND BUILDING CONTRACTORS REVEALED THAT THE NECESSITY TO INCORPORATE A BIT-KEY LOCK ON ALL DOORS WITHIN THE HOME IS NO LONGER RECOGNIZED. THE REPORTS SHOW FURTHER THAT IN MANY OF THE HOUSES SO EQUIPPED, SUCH LOCKS ARE SELDOM IF EVER USED AND THE BIT KEYS ARE DISCARDED OR MISLAID

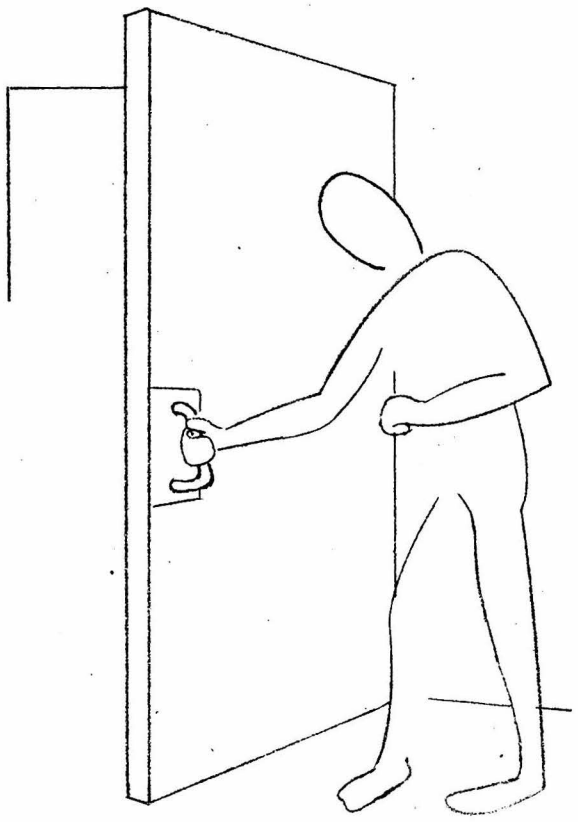
SHORTLY AFTER OCCUPANCY. THE FACT THAT PASS KEYS WERE SO EASILY OBTAINABLE DISCLOSED THE MYTH OF SECURITY. IT IS REPORTED THAT IN MANY CASES MEMBERS OF A HOUSEHOLD DO NOT FEEL IT NECESSARY TO LOCK EVEN THE BATHROOM DOOR. THE DOOR IS NORMALLY LEFT OPEN BUT WHEN CLOSED SERVES TO INDICATE TO OTHER MEMBERS OF THE FAMILY THAT THE ROOM IS OCCUPIED. HOWEVER, THE NEED FOR A SIMPLE LOCKING DEVICE IS APPARENT TO MEET ALL PREFERENCES. THE LOCK NEED BE CONTROLLED FROM THE INSIDE OF THE DOOR ONLY AND IS BEST OPERATED BY A LEVER INTEGRAL WITH THE LOCKSET TO ELIMINATE THE NECESSITY FOR A SEPARATE KEY. SPECIAL TUMBLER LOCKS MAY BE INSTALLED ON DOORS AS A SEPARATE UNIT WHERE GREATER SECURITY IS REQUIRED.

PHYSIOLOGICAL CONSIDERATIONS. NOT ONLY MUST THE HABITS IN USING THE DOOR BE OBSERVED, BUT THE ACTION OF THE LIMBS AND MUSCLES INVOLVED SHOULD BE CONSIDERED.

THROUGH SCIENTIFIC STUDY OF HUMAN MOTION, KINESIOLOGY, IT HAS BEEN FOUND THAT IN ORDER TO PERFORM A TASK MOST NATURALLY AND WITH GREATEST EASE, THE MOTIONS SHOULD BE CONTROLLED BY THE LARGEST MUSCLES WITH THE HIGHEST PERFORMANCE CAPACITY.(7) IT IS OBVIOUS THAT LIFTING IS EASIER WITH THE BACK THAN WITH THE WRIST MUSCLE, WHERE ONLY A $\frac{1}{2}$-INCH LEVER ARM IS BROUGHT TO BEAR.



TRIPLE COMPLEX MOTION
IN USING DOOR KNOB



SIMPLE MOTION OF
PULLING VERTICAL
BAR HANDLE

COMPARISON OF MUSCULAR ACTIVITY

FIGURE 9

ANALYSIS SHOWS THAT TO OPERATE THE USUAL TURN-KNOB DOOR LATCH, THE KNOB MUST FIRST BE GRIPPED WITH SUFFICIENT FORCE BY THE FINGERS AND PALM TO OVERCOME RESISTANCE OF THE SPRING BY FRICTION. THIS IS ACCOMPLISHED THROUGH THE FLEXOR MUSCLES OF THE FOREARM. WHILE THESE MUSCLES ARE THUS TENSE, THE KNOB IS TURNED $60^{\circ}$ BY RADIAL EXTENSION OF THE CARPI MUSCLES OF THE FOREARM. IN THE PRESENCE OF ANY LUBRICANT SUCH AS SOAP OR GREASE ON THE HANDS, LARGE PRESSURE IS REQUIRED TO TURN THE KNOB. WITH THE MAJORITY OF THE ARM AND HAND MUSCLES IN TENSION AND AWKWARDLY TWISTED, THE DOOR IS THEN PULLED OR PUSHED BY USING THE MORE BASIC BRACHII MUSCLES OF THE UPPER ARM AND THE DELTIODEUS SHOULDER MUSCLE. THE THREE STEPS INVOLVED IN THIS OPERATION ARE ILLUSTRATED IN FIG.9. BY KINESIOLOGIC STANDARDS, SUCH A PERFORMANCE IS CLASSIFIED AS A TRIPLE COMPLEX MUSCULAR MOVEMENT,(8) AND THOUGH IN THIS CASE FATIGUE IS NOT A LIMITING FACTOR, ITS AWKWARDNESS SHOULD BE AVOIDED.

IN CONSULTATION WITH AN AUTHORITY ON MUSCULAR ACTIVITY OF THE ARM,(9) IT WAS POINTED OUT THAT FEWER AND MORE BASIC MUSCLES ARE BROUGHT INTO ACTION WHEN THE HAND IS USED IN A PLANE PARALLEL WITH THE SIDES OF THE BODY AND WITH THE KNUCKLES PERPENDICULAR TO THE AXIS OF THE FOREARM. FOR INSTANCE, IT IS FAR EASIER TO CARRY A SUITCASE OR CHIN

TABLE II

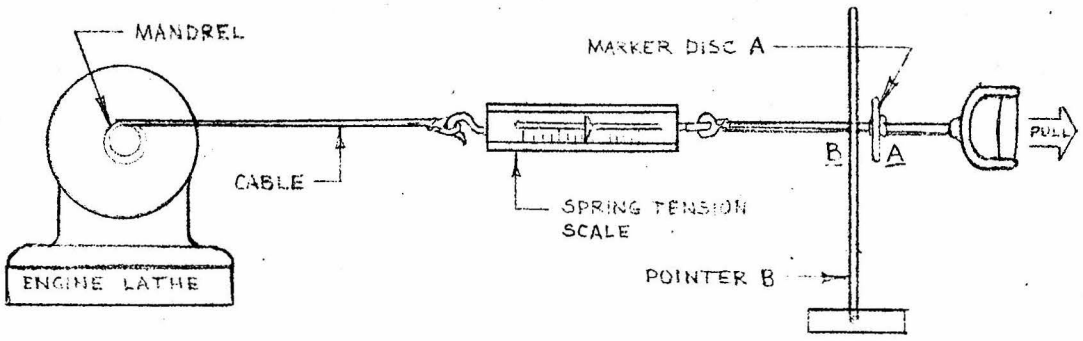
RESULTS OF TESTS ON HUMAN STRENGTH

| TEST NUMBER | ISOMETRIC PULL TEST LBS. PULL | HORIZONTAL PUSH TEST LBS. PULL | TORQUE STRENGTH TEST | |
|---|---|---|---|---|
| | | | RT. TURN | LFT. TURN |
| 1 | 46 | 50 | 35 | 26 |
| 2 | 45 | 50 | 30 | 18 |
| 3 | 38 | 46 | 30 | 22 |
| 4 | 44 | 48 | 33 | 23 |
| 5 | 50 | 51 | 40 | 28 |
| 6 | 49 | 52 | 36 | 26 |
| 7 | 50 | 50 | 31 | 25 |
| 8 | 45 | 49 | 30 | 22 |
| 9 | 47 | 49 | 30 | 24 |
| 10 | 46 | 50 | 32 | 24 |
| AVE | 46.0 | 49.5 | 32.7 | 21.8 |
| | IN. LBS. TORQUE | | 164 | 109 |

ONESELF WITH THE HANDS PARALLEL TO THE SIDES THAN WHEN TURNED TO A PERPENDICULAR POSITION. APPLIED TO THE DOOR, THIS PRINCIPLE SUGGESTS A VERTICAL HANDLE SET AT A SLIGHT ANGLE (ABOUT $20^{0}$) TO THE PLANE OF THE DOOR. THIS PERMITS A COMFORTABLE AND NATURAL GRIP NORMAL TO THE EXTENDED ARM, AS ILLUSTRATED IN FIG.9-B.

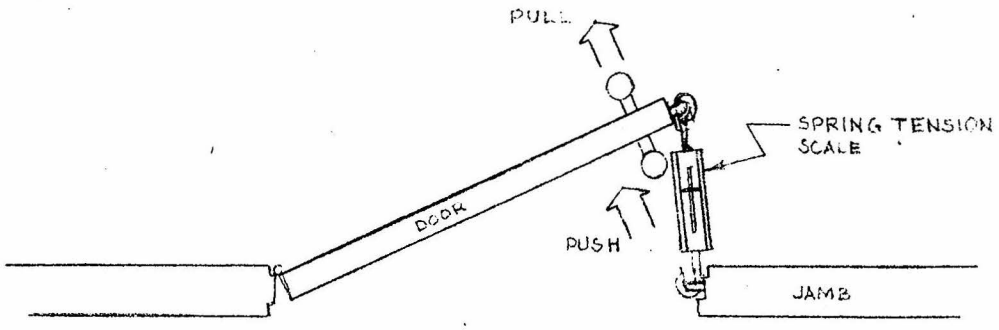
THE STANDARD HEIGHT AT WHICH MOST DOOR LOCKS ARE SET IS 30 INCHES FROM THE FLOOR. THIS LOCATION HAS EVOLVED THROUGH MANY CENTURIES AS THE MOST EQUITABLE HEIGHT FOR PEOPLE OF ALL SIZES. IN PUBLIC BUILDINGS INTENDED PRIMARILY FOR ADULT TRAFFIC AND EQUIPPED WITH HEAVIER DOORS, THE HANDLES ARE CUSTOMARILY INSTALLED AT A HEIGHT OF THREE OR FOUR FEET TO PERMIT A MORE DIRECT PULL AT ELBOW HEIGHT. FOR THE HOME, SPECIAL THOUGHT SHOULD BE GIVEN TO THE PLIGHT OF SMALLER CHILDREN, WHO HAVE BEEN OBSERVED TO GRIP THE KNOB WITH TWO HANDS TO EXERT SUFFICIENT FORCE TO TURN IT. TO MEET THE NEEDS OF CHILDREN, THE LOWER PORTION OF THE VERTICAL HANDLE SHOULD AFFORD AN ADEQUATE GRIP NORMAL TO THE UPSTRETCHED ARM.

A SERIES OF TESTS WERE SET UP TO DETERMINE THE MAXIMUM FORCES WHICH AN AVERAGE MAN COULD GENERATE THROUGH HIS HANDS. FIRST, A SET-UP WAS MADE AS SHOWN IN FIG.10 TO TEST THE ISOMETRIC STRENGTH OF THE HAND, ARM, AND



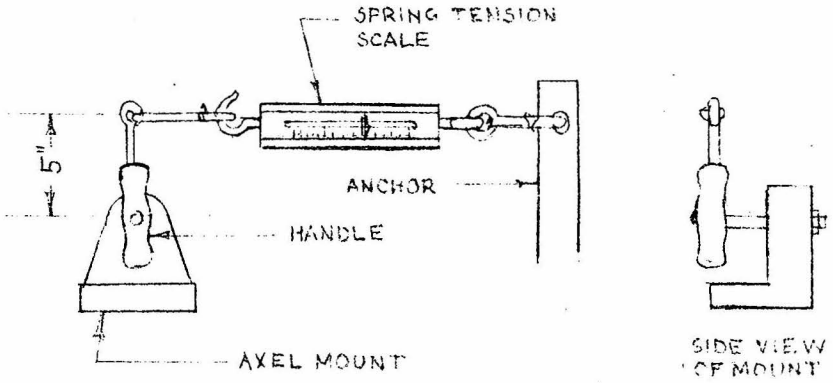

ISOMETRIC PULL STRENGTH TEST

FIGURE 10




HORIZONTAL FORCE TEST

FIGURE 11

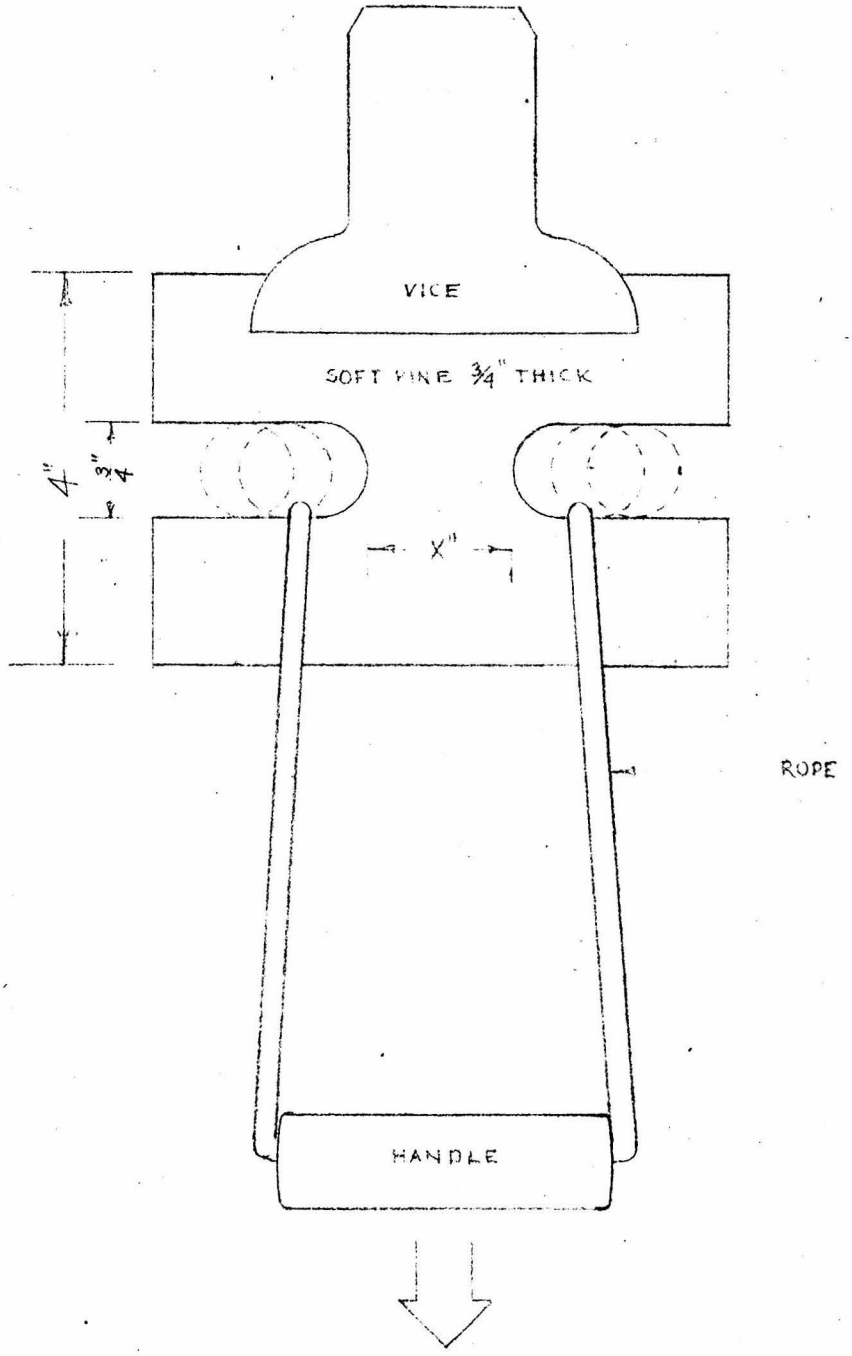



TORQUE STRENGTH TEST

FIGURE 12

SHOULDER MUSCLES. THE ISOMETRIC OR STATIC TYPE OF TEST ELIMINATES SOME OF THE VARIABLES INVOLVED BY MEASURING THE STRENGTH WITH WHICH MOVEMENT OF THE LIMBS IS RESISTED. THE TESTS WERE MADE ON A SERIES OF TEN MEN OF AVERAGE 150 POUND BUILD, WHO ATTEMPTED TO PREVENT THE MARKER A FROM BEING PULLED PAST THE POINTER B. WHEN THE MARKER PASSED THE POINTER, A READING WAS TAKEN ON THE TENSION SCALE. IN THESE TEN CASES THE PULL VARIED BETWEEN 45 AND 50 POUNDS FORCE. (SEE TABLE III OPPOSITE PAGE 24.) IT WAS CONCLUDED THAT A 50-POUND PULL IS THE LIMIT WHICH AN AVERAGE MAN CAN EXERT HORIZONTALLY.

THE SECOND TEST WAS SET UP AS SHOWN IN FIG.11, AND THE TEN MEN ASKED TO PUSH TO THEIR LIMIT AGAINST THE DOOR HELD BY THE SPRING TENSION SCALE. THE FORCES RECORDED HERE AVERAGED 50 POUNDS AGAIN, BOTH FOR PUSHING AND PULLING. (TABLE III.) IT WAS FURTHER NOTICED THAT A LIGHTER OR HEAVIER PERSON COULD GENERATE A FORCE ROUGHLY EQUAL TO ONE-THIRD OF HIS WEIGHT. A THIRD TEST, ILLUSTRATED IN FIG.12, MEASURED THE MAXIMUM TORQUE WHICH THE AVERAGE MAN COULD GENERATE THROUGH HIS HAND. THE DATA RECORDED IN TABLE III SHOWS THAT USING HIS STRONGEST HAND, THE AVERAGE MAN WAS ABLE TO DEVELOP A TORQUE OF 12 FOOT POUNDS TURNING AWAY FROM THE BODY, AND 15 FOOT POUNDS TOWARD THE BODY.




EMPIRICAL IMPACT TEST

FIGURE 13

To determine the relative impact force which a man could exert through his hand, an empirical test was made using samples of wood. The tensile strength across the grain of the selected specimens of wood was carefully measured by testing and found to be 80 pounds per square inch. The selected wood was chosen for its uniform grain. Specimens were prepared in blocks and two holes drilled a measured distance apart and then cut away to the outer edge of the wood, as shown in Fig.13. A looped wire was attached at these holes and the samples clamped in a vice. A handle was attached to the wire loop and pulled upon with a load of 50 pounds. The distance between the holes was reduced in small increments until the remaining section failed under tension. A tabulation of the results of this test shows a range of forces between 150 and 160 pounds per square inch. (See Table II.) It was therefore deduced that on the average a man could exert a maximum impact force through his hand of 175 pounds.

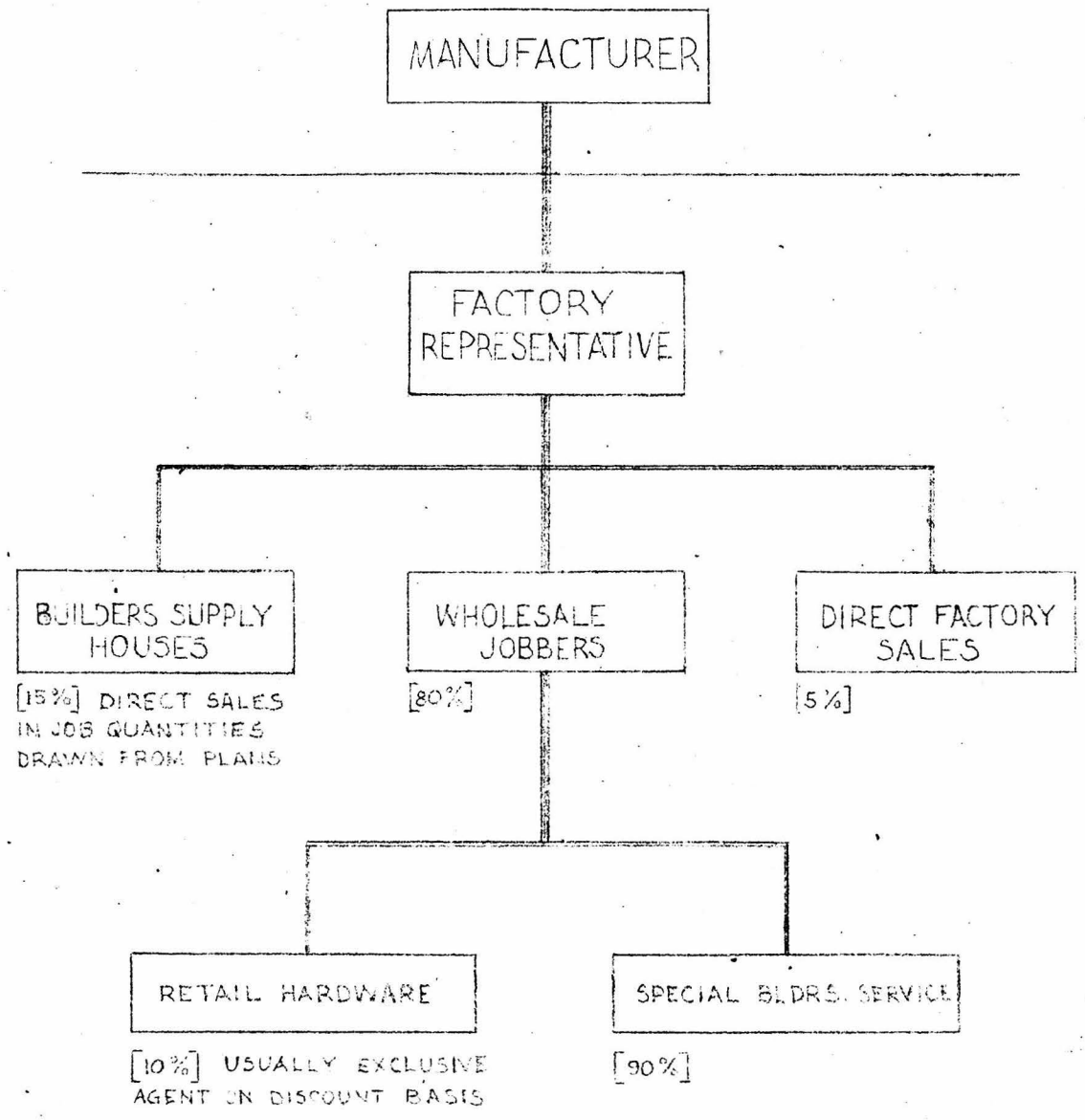
Conclusions. The conclusions of this study of the human elements indicate that a lockset should operate with a push-pull action. The handle should be vertical and inclined upward toward the hand, and shaped so that the fingers may be wrapped around it. The push-pull operation is not only desirable from a physiological point of view

BUT IS ALSO PRACTICAL FOR SAFETY AND EFFICIENCY IN THE HOME. THE MAXIMUM FORCES FOR WHICH THE LOCK MUST BE DESIGNED ARE IN THE MAGNITUDE OF 200 POUNDS PERPENDICULAR TO THE PLANE OF THE DOOR.

## MARKETING PRACTICES

THIS SECTION DEALS WITH THE OVERALL MARKETING PICTURE FOR BUILDERS HARDWARE, AND ANSWERS THE QUESTIONS AS TO WHO MAKES LOCKS, WHERE AND HOW THEY ARE SOLD, AS WELL AS WHO BUYS THEM AND WHY. THE ANSWERS TO THESE QUESTIONS FALL UNDER THE FOLLOWING HEADINGS: MANUFACTURING COMPETITORS, DISTRIBUTION CHANNELS, LOCATION AND NATURE OF MARKET, FACTORS INFLUENCING SALES, AND ANTICIPATED SALES FOR THE YEAR 1948.

MANUFACTURING COMPETITORS. BY CHECKING LISTS OF MANUFACTURERS AND EXAMINING HARDWARE ADVERTISEMENTS, THERE WERE OBSERVED TO BE TWENTY-FIVE FORMIDABLE COMPETITORS, AND THERE ARE PRESUMABLY THAT MANY MORE UNPUBLICIZED. OF THE TWENTY-FIVE MAJOR COMPANIES INCLUDED IN THIS SURVEY, TEN ARE LOCATED IN NEW YORK OR NEW ENGLAND, FIVE IN THE MIDDLE WEST AROUND MICHIGAN AND ILLINOIS, AND THE REMAINING TEN ON THE WEST COAST.(10) HOWEVER, IT IS SIGNIFICANT TO NOTE THAT OF THE "BIG FOUR" MANUFACTURERS ONLY ONE IS LOCATED ON THE WEST COAST, BUT 65% OF THE INDUSTRY, BY DOLLAR VOLUME OF SALES, REMAINS IN NEW ENGLAND.(11)




DISTRIBUTION CHANNEL FOR BUILDERS HARDWARE

FIGURE 14

Distribution Channels. After conference with several lock manufacturers and a number of distributors, the chart illustrated in Fig.14 was drawn up showing the network of agents and dealers through which the distribution of these hardware products takes place. A greater bulk of sales, some 80% of the total, is made through wholesale jobbers directly to contractors. Another 10% is sold through specialists in builders hardware called builders supply houses, and the remaining 10% through retail hardware store outlets. These latter sales outlets for the most part fill small orders for replacements and remodeling.

Location and Nature of Market. It is roughly estimated by the finish-hardware industry that 95% of their product goes into new building construction. Of the remainder, 4% goes into building alterations and additions, while less than 1% replaces outworn or damaged hardware. The largest centers of new building construction are the New York and Los Angeles areas, the latter accounting for approximately one-tenth of the total for the nation.(12)

The purchasers of builders hardware fall into three groups: owners, building contractors, and architects. In the planning of large commercial buildings it is

USUALLY THE ARCHITECT WHO SELECTS THE FINISH-HARDWARE, THOUGH THE OWNER OFTEN SHARES THE RESPONSIBILITY. FOR LARGE RESIDENCES, THE ARCHITECT CUSTOMARILY SPECIFIES A GRADE OF HARDWARE, BUT THE OWNER MAKES THE FINAL CHOICE OF MODEL. IN THE CASE OF SMALL HOMES, THE OWNER PICKS OUT THE DOOR LOCK, OFTEN IN THE COMPANY OF THE ARCHITECT. WHERE A CONTRACTOR IS PUTTING UP A HOUSING PROJECT, HE IS THE PURCHASER OF THE HARDWARE. IT IS ROUGHLY ESTIMATED THAT BY PROPORTION 75% OF THE DOOR LOCKS ARE SELECTED BY THE OWNER OF THE BUILDING, 20% BY THE CONTRACTOR, AND PERHAPS 5% BY THE ARCHITECT. IT IS THEREFORE OBVIOUS THAT THE DESIGN OF THE LOCK MUST APPEAL PRIMARILY TO THE NEEDS AND TASTES OF THE OWNER.

Factors Influencing Sales. IN ORDER TO COMPLETE THE SALES ANALYSIS IT IS NECESSARY TO CONSIDER THE BASIS ON WHICH THE DECISION TO PURCHASE A PARTICULAR LOCK IS MADE. AFTER QUESTIONING RETAIL SALES PERSONNEL AND MANAGERS OF BUILDERS SUPPLY HOUSES, A LIST WAS COMPILED OF FIVE FACTORS WHICH ARE JUDGED TO DETERMINE THE SUCCESS OF HARDWARE SALES. THESE ARE: TYPE OF SERVICE FEATURED, OPERATION OF MECHANISM, QUALITY OF CONSTRUCTION, PRICE, AND INSTALLATION COSTS.

THE TYPE OF SERVICE FEATURED BY THE LOCK IS CONSIDERED THE MAIN BASIS FOR SELECTING A LOCKSET. THE BUYER IS MOST INTERESTED IN THE WAY THE LOCK WILL SERVE HIM AND THE DEGREE OF SECURITY PROVIDED. THE OPERATION OF THE MECHANISM IS ALSO IMPORTANT AS THE PURCHASER SELDOM BUYS A MODEL OF LOCK WITHOUT FIRST TRYING THE BOLT ACTION. PEOPLE ARE INTERESTED IN HAVING A SMOOTHLY WORKING MECHANISM, AND TO AID THE CUSTOMER IN TESTING HIS PRODUCT THE MANUFACTURERS PROVIDE THEIR SALES OUTLETS WITH MOCK-UP INSTALLATIONS. AT THE SAME TIME THE BUYERS CAREFULLY JUDGE THE QUALITY OF THE MATERIALS, THE HARDNESS OF THE FINISH, AND THE OVERALL APPEARANCE OF THE LOCKSET. A DECIDED PREFERENCE EXISTS FOR LOCKS OF BRASS OR BRONZE, PARTLY DUE TO TRADITION, BUT ALSO DUE TO A REPUTATION FOR TOUGHNESS AND RESISTANCE TO CORROSION. THERE IS APPARENT RESISTANCE TO BUYING A LOCK OF DIE-CAST ZINC, BOTH ON THE PART OF DEALERS AND OF HIS CUSTOMERS. PAST EXPERIENCE WITH INFERIOR GRADES OF ZINC ALLOYS HAS LEFT LOCK REPAIRMEN AND HOUSE OWNERS WITH A SUSPICIOUS ATTITUDE TOWARD THIS MATERIAL. EFFORT IS BEING MADE TO OVERCOME THIS STIGMA BY MANUFACTURERS WHO USE THE HIGH-GRADE ZAMAC ALLOYS.

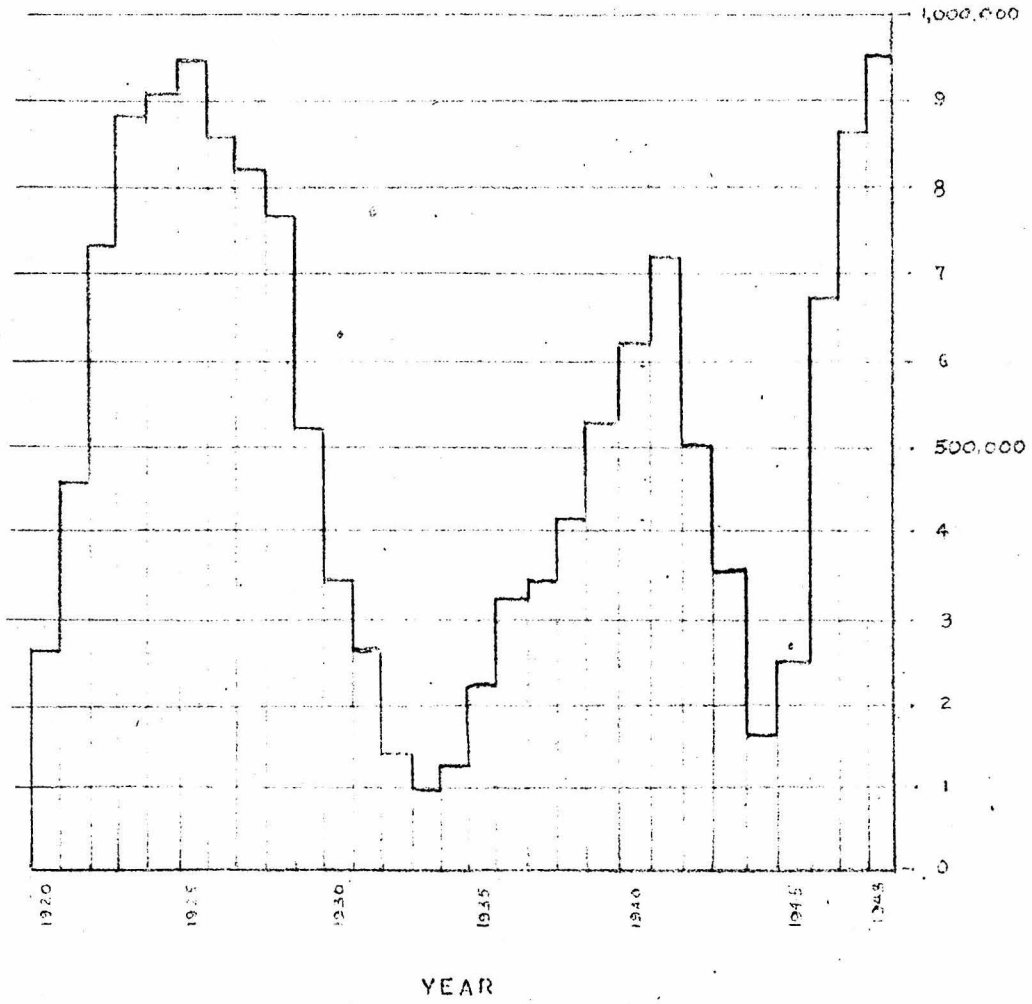
THE PRICE OF THE LOCK IS THE DECIDING FACTOR ONLY WHERE A CHOICE EXISTS BETWEEN COMPETITIVE MODELS OF EQUAL QUALITY AND SERVICE, OR WHERE A BUILDING CONTRACTOR IS INTENT ON MINIMUM EXPENDITURE. OTHERWISE, IT IS EVIDENT THAT MOST OWNERS WHO HAVE THE MEANS TO BUILD EVEN THE SMALLEST HOUSE ARE INTERESTED IN EQUIPPING IT WITH SUBSTANTIAL HARDWARE. MANUFACTURERS OF DOOR LOCKS GENERALLY SET A LIST PRICE AND ALLOW DISCOUNTS ON THE BASE PRICE TO THEIR SALES OUTLETS. THESE PRICES RANGE FROM $1.85 FOR THE VERY SIMPLEST DIE-CAST TUBULAR LOCKS TO $11.00 FOR THE STRONG UNIT MORTISE LOCKS FOR FRONT-DOOR OR COMMERCIAL USE. HOWEVER, SOME SPECIALLY DESIGNED HARDWARE FOR LARGER ESTABLISHMENTS AND PUBLIC BUILDINGS MAY RUN TO OVER A HUNDRED DOLLARS PER UNIT. THE PRICE OF LOCKS FOR INTERIOR RESIDENTIAL USE MAY BE GROUPED INTO THREE PRICE RANGES. THE LOWEST GROUP RUNS FROM $1.85 TO $3.25, THE MIDDLE GROUP FROM $3.25 TO $4.60, AND THE HIGHEST GROUP FROM $4.60 TO $10.00.(13) THESE PRICES APPLY TO THE NON-LOCKING STANDARD DOOR LATCH. THE ADDITION OF SPECIAL FINISHES OR LOCKING DEVICES INCREASES THE PRICE SOME 75 CENTS.

THESE THREE PRICE CATEGORIES REFLECT SUBSTANTIAL DIFFERENCES IN OVERALL QUALITY OF THE PRODUCT. THERE ARE FOUR

MAJOR VARIABLES WHICH INFLUENCE THESE PRICE DIFFERENTIALS: THE MATERIALS OF CONSTRUCTION, THE FINISHES, THE REPUTATION OF THE TRADE NAME, AND PATENTED OPERATING FEATURES. MATERIALS OF CONSTRUCTION VARY FROM THE LESS EXPENSIVE DIE-CASTING TO SOLID BRONZE AND BRASS IN THE HIGHER-PRICED CLASS. THE CHEAPEST FINISH IS A SPRAYED LACQUER COAT, WHILE THE COSTLIER FINISHES CONSIST OF A HEAVY PLATING OF CHROMIUM OR BRASS. THE TRADE NAMES OF THE OLDER COMPANIES SUCH AS YALE, CORBIN, RUSSWIN, AND SCHLAGE OBVIOUSLY CARRY WEIGHT OVER THE NEWCOMERS INTO THE FIELD. AS FOR PATENTED FEATURES, THE OUTDATED MORTISE LOCKS ARE OF COURSE IN THE LOWER PRICE BRACKET WHILE THE NEWEST PATENTED PUSH-PULL MODEL FALLS IN THE MOST EXPENSIVE GROUP.

THE QUESTION OF COST OF INSTALLATION WEIGHS SIGNIFICANTLY IN THE SALES OF LOCKSETS, PARTICULARLY WITH CONTRACTORS WHO MUST PAY THEIR CARPENTERS FOR THE TIME SPENT IN INSTALLING THE LOCKS. A SAVING OF AS LITTLE AS TEN MINUTES PER DOOR AMOUNTS TO TWO AND A HALF HOURS, OR ROUGHLY $5, FOR A HOUSE WITH FIFTEEN DOORS. IN A LARGE BUILDING OF SEVERAL HUNDRED DOORS SUCH A SAVING IS OBVIOUSLY CONSIDERABLE.

<u>ANTICIPATED SALES FOR 1948</u>. BUILDERS HARDWARE MANUFACTURERS LOOK PRIMARILY TO THE VOLUME OF PRESENT AND FUTURE




NEW DWELLING UNITS

STARTED IN NON-FARM AREAS

FROM 1920 TO DATE

SOURCE: STATISTICAL ABSTRACT OF UNITED STATES
DEPARTMENT OF INTERIOR BULLETIN

FIGURE 15

BUILDING CONSTRUCTION FOR RELIABLE INDICATION OF THE POTENTIAL MARKET. SUCH REPORTS ARE AVAILABLE FROM FEDERAL GOVERNMENT AND LOCAL SOURCES. FIGURES PUBLISHED BY THE BUREAU OF LABOR STATISTICS AND THE BUREAU OF CENSUS INDICATE THAT THE DOLLAR VOLUME OF BUILDING AND CONSTRUCTION FOR 1948 WILL BE 15.2 BILLION, 20% OVER THE 12.6 BILLION FOR 1947. OF THIS TOTAL, 6 BILLION DOLLARS WILL BE SPENT FOR RESIDENTIAL BUILDING ALONE, AMOUNTING TO 950,000 HOUSING UNITS. THIS REPRESENTS AN INCREASE OF 25% OVER THE 4.8 BILLION DOLLARS FOR RESIDENTIAL BUILDING IN 1947, WHEN 850,000 BUILDING STARTS WERE MADE. OF THE TOTAL 6 BILLION, ONE FIFTH WILL BE FOR APARTMENT HOUSE DWELLINGS.(14) THIS INCREASE APPEARS ON THE CHART OF THE RECURRING BUILDING CYCLE, SHOWN IN FIG.15. THE FACT THAT THERE IS A CURRENT SHORTAGE OF OVER TWO AND A HALF MILLION HOUSING UNITS INDICATES THAT A CONTINUED RISE IN THE RATE OF BUILDINGS STARTED PER YEAR WILL PERSIST FOR SEVERAL YEARS TO COME.

THE AVERAGE COST OF BUILDERS HARDWARE FOR RESIDENTIAL CONSTRUCTION IS 2% OF THE TOTAL CONTRACT PRICE.(15) ONE-HALF OF THIS, OR 1% OF THE TOTAL, IS SPENT FOR DOOR HARDWARE ALONE. IT MAY THEREFORE BE CALCULATED THAT AN EXPANDING HARDWARE MARKET OF SOME 60 MILLION DOLLARS IS TO

BE EXPECTED FOR 1948. THE NUMBER OF LOCKS REPRESENTED BY THIS FIGURE MAY BE ROUGHLY CALCULATED BY ASSUMING THAT IN EACH OF THE 950,000 DWELLING UNITS TO BE BUILT AN AVERAGE OF FIFTEEN DOORS (SEE PAGE 11) WILL BE INSTALLED, REQUIRING 14,250,000 LOCKSETS. FURTHERMORE, SINCE IT IS ESTIMATED THAT ONLY 95% OF THE TOTAL PRODUCTION GOES INTO NEW BUILDINGS, A TOTAL OF 14,500,000 LOCKS MAY BE SOLD IN 1948. ON THE BASIS OF A TOTAL EXPENDITURE OF 60 MILLION DOLLARS, AN AVERAGE OF $4.20 PER LOCK IS CALCULATED. THIS IS CLOSELY BORNE OUT BY ESTIMATES OF SALES OUTLETS, WHICH SET THE AVERAGE PRICE NEAR $4.65 PER LOCKSET.

Conclusions. THE MANUFACTURE AND SALES OF DOOR HARDWARE IS CONCLUDED TO BE A HIGHLY COMPETITIVE FIELD, THE MANUFACTURING PROCESSES BEING JEALOUSLY GUARDED. SELLING THE PRODUCT IS A SPECIALIZED JOB OF APPEALING TO BUILDERS GENERALLY THROUGH OUTLETS OF A WHOLESALE NATURE. THE APPEALS ARE MADE ON THE BASIS OF EASE OF OPERATION, QUALITY, PRICE, AND METHOD OF INSTALLATION. ONLY RECENTLY HAS EMPHASIS BEEN PLACED ON THE DESIGN APPEARANCE. IN THE FACE OF AN EXPANDING PERMANENT MARKET, A NEW PRODUCT IN THIS LINE WOULD STAND A GOOD CHANCE OF SUCCEEDING. THIS IS ESPECIALLY TRUE FOR THE WEST COAST, WHERE BUILDING IS

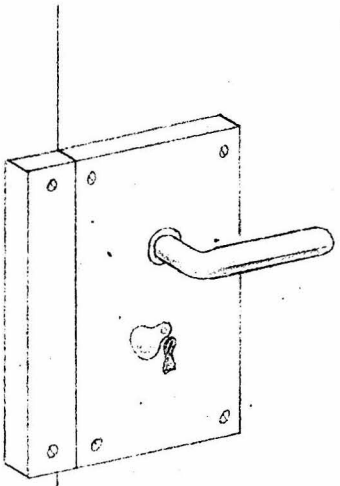
FLOURISHING, ASSUMING AN ESTABLISHED DISTRIBUTION OUTLET. IN A FIELD OF TWENTY-FIVE MAJOR COMPETITORS, FOUR OF WHICH CONTROL SOME 65% OF THE TOTAL MARKET, A NEW PRODUCT COULD NOT BE EXPECTED TO ACQUIRE MORE THAN HALF OF ONE PER CENT OF THE TOTAL 15 MILLION SALES, OR 75,000. GREAT EFFORT WOULD NECESSARILY BE SPENT ON OVERCOMING PUBLIC AND DEALER SKEPTICISM REGARDING A "NEW THING," AS WELL AS ON INTRODUCING THE PRODUCT TO BUYERS WHO HAVE ESTABLISHED PURCHASING CHANNELS IN A WIDE MARKET. SALES WOULD FARE BEST IF THE NEW LOCK WERE PRICED AT THE LOWER LIMIT OF THE MOST EXPENSIVE GROUP, OR AROUND $4.50.

## MECHANICAL FACTORS

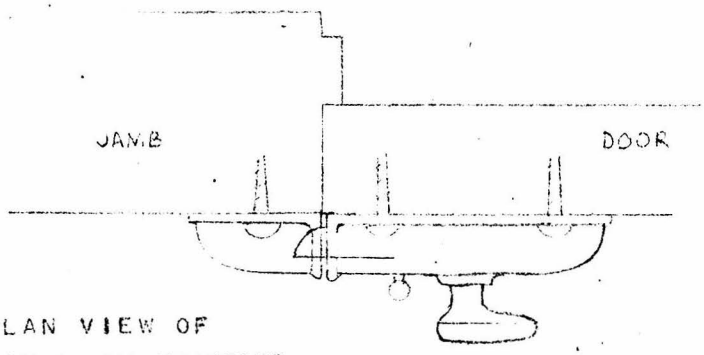
TOPICS UNDER THIS HEADING ARE DIVIDED INTO THREE MAIN SUBJECTS. THEY ARE: INSTALLATION, MECHANICAL OPERATION, AND MATERIALS AND PROCESSES.

### INSTALLATION

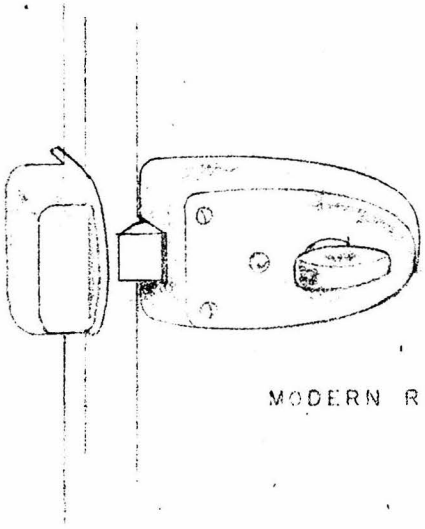
INVESTIGATION SHOWED THAT THERE ARE FOUR PRINCIPAL METHODS OF INSTALLING A LOCK ON A DOOR. THESE METHODS CHARACTERIZE THE BASIC TYPES OF LOCKS, FIRST, THE RIM LOCK, SECOND, THE MORTISE LOCK, THIRD, THE UNIT LOCK, AND NOW THE TUBULAR LOCK.



COLONIAL DESIGN
OF RIM LOCK




PLAN VIEW OF
RIM LOCK MOUNTED

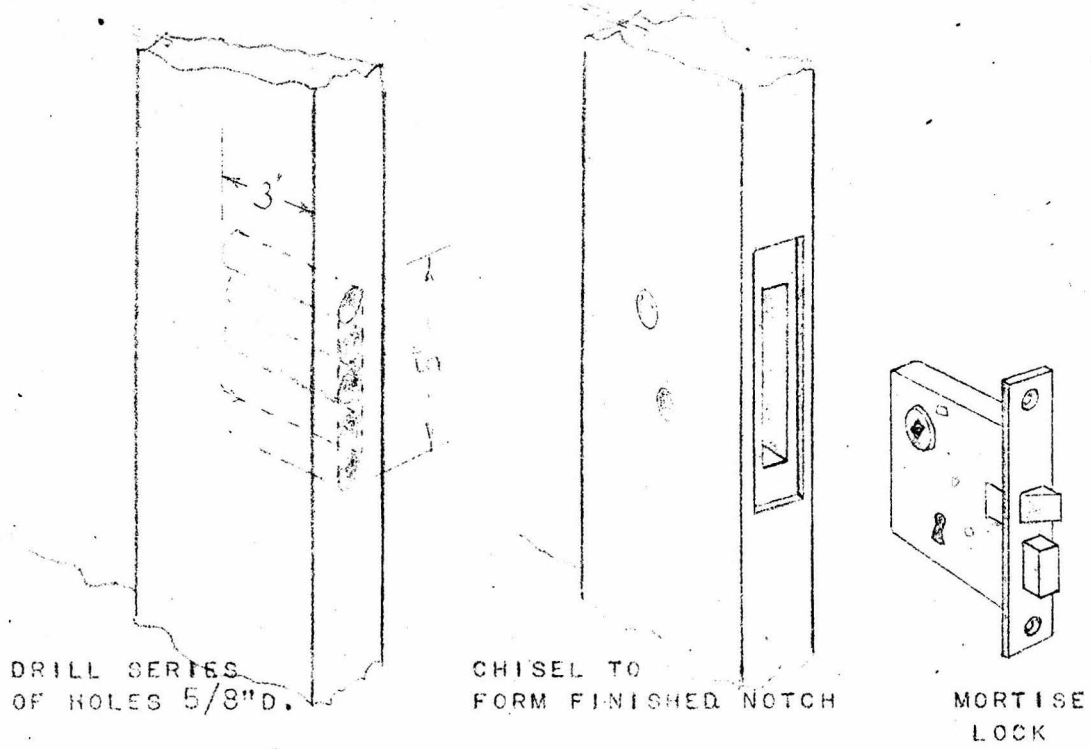


MODERN RIM LOCK

FIGURE 16

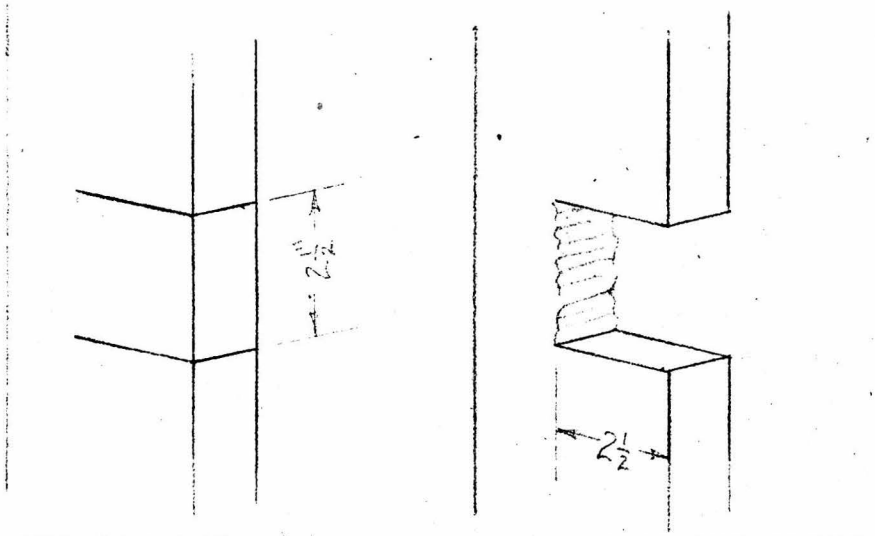
Current Methods. The first and simplest method is to attach the lock to the side of the door stile by means of screws, in which case it is referred to as a rim lock. (See illustration in Fig.16.) Having its origin in the early Roman period, these rim locks were still widely used on early American Colonial doors, and are yet regarded as an indication of authentic antiquity in New England. This type of installation is used now for doors too thin to take the usual lock (less than 1 inch thick). These rim locks took the form of rectangular brass cases originally, but have been modified to the streamlined shapes shown in the illustration.

During the architectural Renaissance, when many refinements were developed in building details, the use of the rim lock was largely replaced by the mortised lock. For mounting this type, a deep mortise is formed in the edge of the stile to take the lock. The mortise is cut by drilling a series of holes into the edge of the door some three inches deep. The wood connecting these holes is then chiseled. Most mortise locks are 4 inches to 6 inches high, 3 inches to 4 inches deep, and 3/4 inch wide, and require a recess which comes close to cutting the stile in two. (See Fig.17.) The strike plate must also be




MORTISE LOCK

FIGURE 17

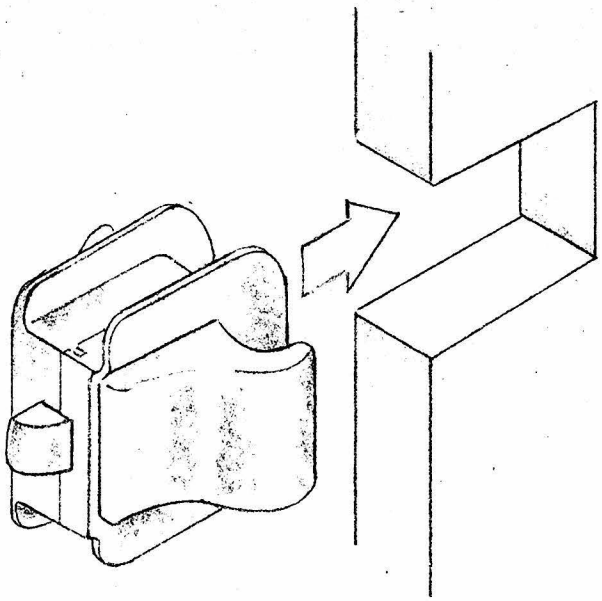



NOTCH FOR UNIT LOCK

FIGURE 18

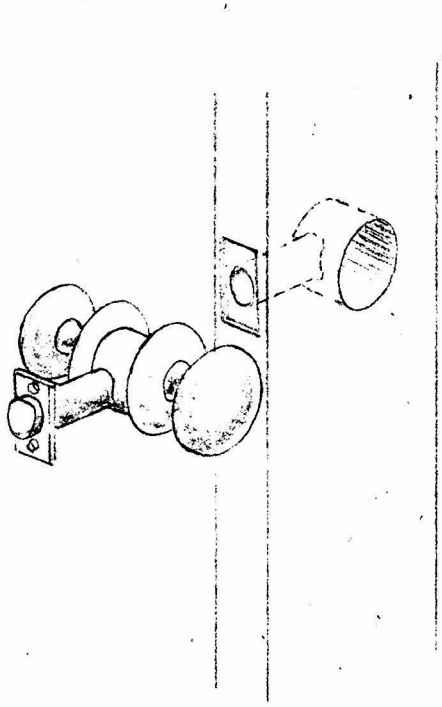
MORTISED INTO THE JAMB TO MATCH THE LOCK. INSTALLING A MORTISE LOCK IS A JOB FOR A SKILLED CRAFTSMAN AND IT TAKES AS LONG AS 30 MINUTES JUST TO CUT THE MORTISE. A FULL HOUR IS ALLOWED BY BUILDING FOREMEN TO COMPLETE THE INSTALLATION OF THIS TYPE OF LOCK, THOUGH IN THE PAST TEN YEARS A NUMBER OF JIG-BORING DEVICES HAVE BEEN DEVELOPED TO REDUCE THIS TIME.(16) IT IS GENERALLY AGREED THAT SIMPLER METHODS ARE PREFERABLE FOR MOST HARDWARE APPLICATION, YET THE MORTISE LOCK IS STILL USED IN MANY NEW BUILDINGS AND THE PRODUCTION OF THESE LOCKS CONTINUES TO FLOURISH.

THE THIRD TYPE IS KNOWN AS THE UNIT LOCK BECAUSE IT IS SOLD AS AN ASSEMBLED UNIT WHICH NEED MERELY BE SLIPPED INTO PLACE IN THE DOOR AND FASTENED. A RECTANGULAR NOTCH IS REQUIRED IN THE EDGE OF THE STILE TO TAKE THE LOCK CASE WHICH IS USUALLY $2\frac{1}{2}$ INCHES SQUARE OR MORE. THE NOTCH IS FORMED BY MAKING TWO SAW CUTS $2\frac{1}{2}$ INCHES DEEP ACROSS THE STILE, AND $2\frac{1}{2}$ INCHES APART, AS SHOWN IN FIG.18. THE WOOD BLOCK BETWEEN IS THEN CHIPPED OUT WITH A CHISEL. THE TWO MAIN OBJECTIONS TO THIS TYPE OF INSTALLATION ARE FIRST, THAT CUTTING THROUGH THE STILE TENDS TO WEAKEN THE DOOR, AND SECOND, THAT TO FORM THE NOTCH WITH THE ACCURACY REQUIRED TO MAKE A SNUG FIT WITH

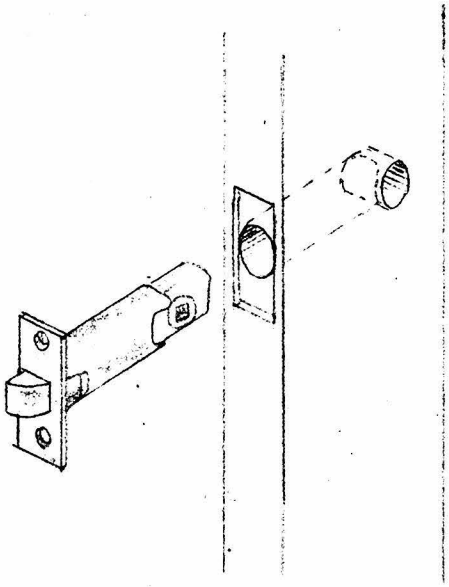


PARLYN PUSH-PULL UNIT LOCK

FIGURE 19



SCHLAGE TUBULAR LOCK
INSTALLATION.



ALLIED TUBULAR LOCK
INSTALLATION.

FIGURE 20

THE CASE INVOLVES EXCESSIVE CARE AND TIME. THE UNIT LOCK IS USED PRIMARILY ON LARGER FRONT DOORS AND IN PUBLIC BUILDINGS WHERE THE NEED FOR SECURITY DICTATES THE USE OF THE BIGGER CASE AND MECHANISM. HOWEVER, A NEWLY DESIGNED UNIT LOCK IS NOW AVAILABLE FOR SMALLER DOORS. (SEE FIG.19.)

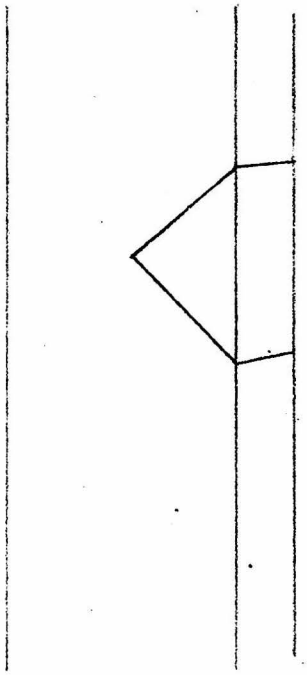
THE FOURTH CATEGORY INCLUDES THE SEVERAL TYPES OF TUBULAR LOCKS, THE MECHANISMS OF WHICH ARE CONTAINED IN CYLINDRICAL TUBES, AS THE NAME IMPLIES. THE TUBULAR LOCK WAS INTRODUCED SOME TWENTY YEARS AGO AND HAS RAPIDLY BECOME ONE OF THE MOST POPULAR TYPES. THE INSTALLATION OF A TUBULAR LOCK INVOLVES DRILLING TWO HOLES, ONE THROUGH THE SIDE OF THE STILE, AND THE OTHER INTERSECTING IT THROUGH THE EDGE OF THE DOOR, AS SHOWN IN FIG.20. FOR THE LARGER LOCKS, A HOLE $2\frac{1}{4}$ INCHES IN DIAMETER IS DRILLED FOR THE CYLINDRICAL KNOB MECHANISM, AND THE BARREL CONTAINING THE BOLT IS ASSEMBLED TO IT THROUGH A 3/4 INCH DIAMETER HOLE IN THE EDGE OF THE STILE. FOR THE SMALLER LOCKS, THE BARREL CONTAINING THE MECHANISM AND BOLT IS INTERSECTED BY THE SQUARE SHAFT ON WHICH THE HANDLES ARE MOUNTED. A 3/4 INCH HOLE IN THE EDGE OF THE DOOR AND A HOLE AS SMALL AS 1/2 INCH IN DIAMETER IS ALL THAT IS REQUIRED FOR INSTALLING THIS SIMPLER TYPE OF LOCK.

Basis for Selection. Three major factors must be considered in selecting the method of installation for which to design a lockset. One factor is the intricacy of carpentry involved, with special attention to the length of time it takes. Another factor is the provision for concealing the mounting and adjusting screws so as not to betray the security nor the appearance of the lock. A third factor is the effect which the selected shape and size of the recess has on the strength of the door stile.

The intricacy and time required to form the cut in the door is in turn a function of the accuracy demanded, the type of tools to be used, and the depth of cut or volume of wood to be removed. The degree of accuracy involved depends on whether the cut will be concealed by a flange on the lock case or by an escutcheon plate. It is a definite advantage to provide a cover over the cut portion of the door since to shave the edges down to accurate size is estimated to add 6 or 8 minutes to the preparation of the notch. The three most commonly used tools for cutting wood are the saw, chisel, and drill bit. Of these, the saw is the fastest acting and most easily used, but the least accurate. The drill is neither accurate

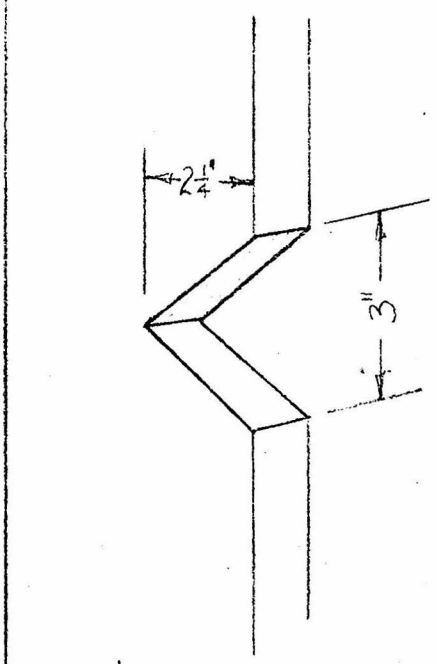
NOR FAST, WHILE THE CHISEL IS THE SLOWEST BUT MOST ACCURATE. TIME MAY BE SAVED BY DESIGNING THE CUT FOR THE USE OF ONE TOOL ONLY, AS THIS WILL INVOLVE LESS HANDLING AND LESS TO CARRY FROM DOOR TO DOOR. THE POSSIBILITY OF USING POWER TOOLS SHOULD BE CONSIDERED IN DESIGNING THE NOTCH. ON SOME CONSTRUCTION JOBS THE DOORS ARE ALL CUT AT ONE TIME ON A JIG WHERE A POWER SAW OR A POWER DRILL IS MOUNTED ON A BENCH. THIS PRE-CUTTING HAS ONE SERIOUS DRAWBACK, HOWEVER, IN THAT MOST DOORS ARE MADE SLIGHTLY OVERSIZE SO THAT THE EDGE MUST BE SHAVED DOWN TO FIT THE PARTICULAR JAMB WHEN THE DOOR IS HUNG. SHAVING THE DOOR EDGE WOULD AFFECT THE DIMENSIONS OF THE NOTCH BY THE AMOUNT REMOVED.

SIGNIFICANT SAVINGS IN INSTALLATION TIME ARE REALIZED WHEN THE VOLUME OF WOOD TO BE REMOVED AND THE DEPTH OF CUT ARE KEPT TO A MINIMUM. THE USUAL MORTISE LOCKS ARE 5x3x7/8 INCHES, REQUIRING A TOTAL OF 14 CUBIC INCHES OF WOOD TO BE REMOVED. THE MORE POPULAR CYLINDER LOCK OF $2\frac{1}{4}$ INCHES DIAMETER REQUIRES THE REMOVAL OF $6\frac{1}{2}$ CUBIC INCHES, WHILE FOR THE $2\frac{1}{2}$ INCH SQUARE UNIT LOCK, 8 CUBIC INCHES MUST BE REMOVED. FOR THE SMALLEST TUBULAR LOCK ONLY 3 CUBIC INCHES ARE REMOVED. CONSIDERATION MUST ALSO BE GIVEN TO THE SHAPE AND THE NATURE OF THE HOLE. IT IS



TWO SAW CUTS

SIZE OF NOTCH




V-NOTCH

FIGURE 21

OBVIOUSLY MORE DIFFICULT TO REMOVE THE WOOD FROM A MORTISED CAVITY USING A DRILL, CHISEL AND HAMMER, THAN SIMPLY TO DRILL TWO HOLES FOR THE LOCK.

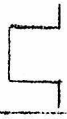
TO FORM A RECTANGULAR NOTCH FOR THE UNIT LOCK REQUIRES THE USE OF A SAW AND CHISEL, THOUGH WHERE THERE IS A TENDENCY FOR THE WOOD TO CRACK OR THE VENEER TO SPLIT IT IS NECESSARY TO DRILL THE CORNERS OF THE RECTANGLE. TIME STUDIES REVEAL THAT THE RATE FOR SAWING WOOD (SOFT PINE) $1\frac{1}{4}$ INCHES THICK, UNDER NORMAL CONDITIONS, IS 6 SECONDS PER INCH. THE TIME REQUIRED TO SAW THE TWO CUTS FOR A UNIT LOCK TO A DEPTH OF $2\frac{1}{2}$ INCHES IS 15 SECONDS EACH, OR 30 SECONDS. BY TIME STUDY IT IS RECORDED THAT AN ADDITIONAL 40 SECONDS IS REQUIRED TO CHIP OUT AND TRIM THE RECTANGLE.(17) IF THE NECESSITY FOR THIS LAST OPERATION WERE ELIMINATED, THE SAWED NOTCH COULD BE THE QUICKEST METHOD OF INSTALLATION. BY DESIGNING THE LOCK TO FIT INTO A NOTCH THE SHAPE OF A V, WHICH COULD BE MADE BY TWO SIMPLE CUTS OF THE SAW, THIS OBJECTIVE CAN BEST BE REALIZED. (SEE FIG.21.) A V-NOTCH, 3 INCHES ON THE BASE AND $2\frac{1}{4}$ INCHES DEEP, WOULD REQUIRE THE REMOVAL OF ONLY 3.4 CUBIC INCHES AS COMPARED TO 7.8 CUBIC INCHES FOR THE RECTANGULAR NOTCH. SUCH A NOTCH COULD BE FORMED IN ONLY 40 SECONDS, ACCORDING TO THE TIME STUDY.

THE IMPORTANCE OF CONSIDERING THE TIME ELEMENT CANNOT BE OVEREMPHASIZED. IN EVERY CASE THE BUILDERS AND CONTRACTORS INTERVIEWED EXPRESSED CONCERN WITH THE RATE AT WHICH DOORS COULD BE HUNG AND THE LOCK SET. WHERE COSTS COUNT, THIS SOURCE OF ADDITIONAL SAVING IS SIGNIFICANT.

THE SECOND BASIC PROBLEM IS ONE CONCERNING THE PROVISION TO CONCEAL ALL MOUNTING SCREWS AND ADJUSTMENTS FROM THE OUTSIDE OF THE DOOR SO THAT THEY CANNOT BE TAMPERED WITH WHILE THE DOOR IS LOCKED. IN THE OLDER MORTISE-TYPE LOCK THE CASE WAS FASTENED IN PLACE BY TWO SCREWS DRIVEN INTO THE EDGE OF THE DOOR. (SEE FIG.17.) HOWEVER, FOUR SCREWS WERE NEEDED TO HOLD THE ESCUTCHEON IN PLACE. THE KNOBS WERE FASTENED TO A SQUARE SHAFT BY MEANS OF SET SCREWS, WHICH TENDED TO WORK LOOSE OVER A PERIOD OF TIME, SO THAT THE KNOBS WERE EASILY REMOVED. MOST UNIT-TYPE LOCKS ARE MOUNTED BY SCREWS THROUGH THE EXPOSED SURFACE OF THE CASE, THOUGH ON SOME THE SCREWS ARE CONCEALED BENEATH THE HANDLE. (SEE FIG.19.) THE BETTER CYLINDER AND TUBULAR LOCKSETS ARE FASTENED TO THE DOOR BY TWO SCREWS THROUGH THE FACE PLATE, AND THE KNOBS ARE SNAPPED INTO PLACE FROM THE CONTROL-SIDE OF THE DOOR BY MEANS OF A SPRING CATCH. (SEE FIG.20.) A SMALL RELEASE BUTTON IS DEPRESSED WITH A TOOL FOR DISASSEMBLING, THERE BEING

TABLE III

RESULTS OF BENDING TESTS ON WOOD SPECIMENS

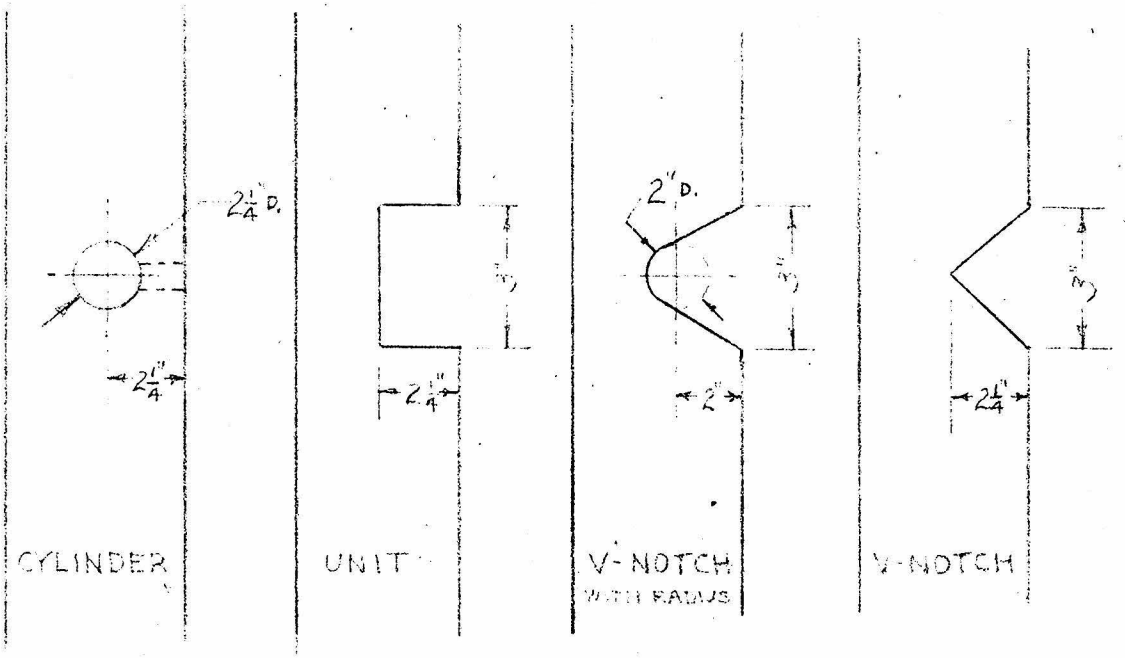
| SPECIMEN | POUNDS FORCE AT FIRST CRACK | POUNDS FORCE AT FAIL-URE | TYPE OF BREAK | AREA SECT. AT NOTCH SQ.IN. | LBS. PER SQ. IN. |
|---|---|---|---|---|---|
| CONTROL | 5860 | 6100 | SPLIT & SHEAR | 6.4 | 950 |
|  CYLINDER | 1510 | 2150 | SPLIT & SHEAR | 2.6 | 826 |
|  UNIT | | 3140 | SPLIT | 3.5 | 896 |
|  V-NOTCH WITH RADIUS | | 3010 | SPLIT | 3.5 | 860 |
|  SIMPLE V-NOTCH | 2170 | 3500 | SPLIT | 3.5 | 1000 |

NOTHING TO WORK LOOSE AS IN THE CASE OF A SET SCREW. THUS, NO ACCESS MAY BE HAD TO ANY SCREWS FROM THE OUTSIDE OF THE DOOR WHEN IT IS CLOSED, WHICH IS AN IMPORTANT CONSIDERATION REGARDING SECURITY.

THE THIRD IMPORTANT FACTOR IS CONCERNED WITH THE EFFECT WHICH THE NOTCH HAS UPON THE STRENGTH OF THE DOOR STILE. BY EXPERIMENT IT WAS FOUND THAT THE STRENGTH DEPENDS ON THREE ELEMENTS.

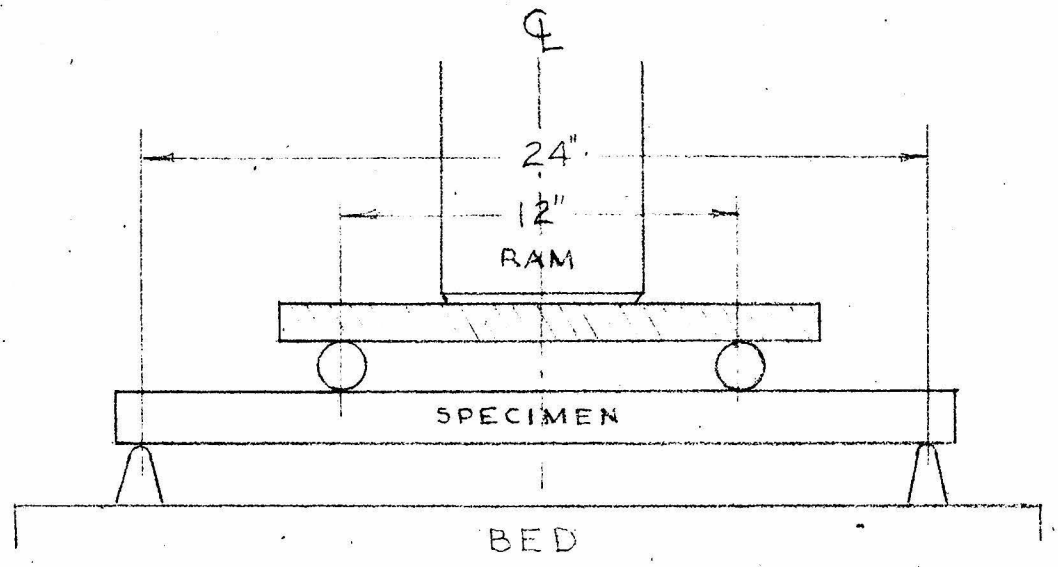
1. THE DEPTH TO WHICH THE WOOD FIBERS OF THE STILE ARE CUT.
2. THE CONDITION OF THE TERMINAL OF THE CUT.
3. THE TOTAL VOLUME OF WOOD FIBER REMOVED AT THE CUT.

A SIMPLE BENDING TEST WAS MADE ON FIVE CAREFULLY SELECTED SPECIMENS OF WOOD, EACH WITH A DIFFERENT TYPE OF NOTCH CUT INTO IT. THE OBJECTIVE OF THE TEST WAS TO DISCLOSE ANY EXTREME WEAKENING EFFECTS WHICH THE VARIOUS TYPES OF NOTCHES MIGHT HAVE ON THE WOOD AS A BEAM, AND TO SHOW THE EFFECT WHICH THE SHAPE OF THE CUT MIGHT HAVE ON THE NATURE OF THE FAILURE. THESE SPECIMENS WERE OF SEASONED YELLOW PINE, AND WERE ALL CUT FROM THE SAME PORTION OF A 6x6 INCH TIMBER, THUS INSURING RELATIVE UNIFORMITY OF CONDITIONS. EACH BOARD MEASURED 25 INCHES LONG, 5 INCHES WIDE, AND 1.25 INCHES THICK, AND WAS SANDED TO REMOVE ANY SURFACE DEFECTS. ONE BOARD WAS MAINTAINED AS A CONTROL, AND




TEST SPECIMENS

FIGURE 22

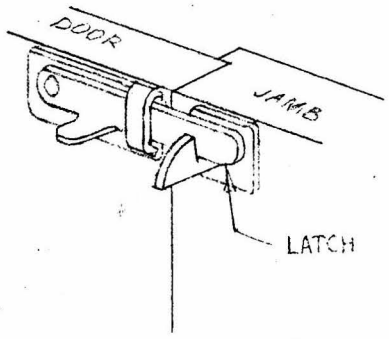



TEST SET-UP

FIGURE 23

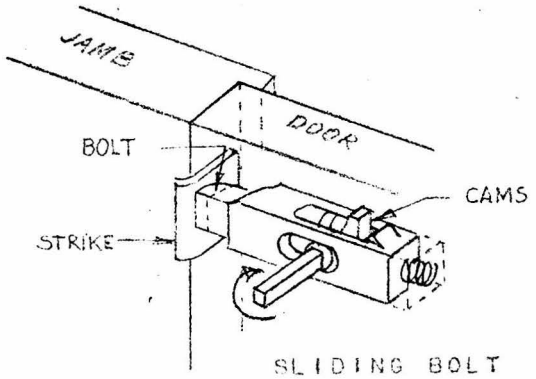
EACH OF THE OTHERS WAS CUT IN A DIFFERENT MANNER TO SIMULATE EXISTING OR PROPOSED INSTALLATION NOTCHES, ILLUSTRATED IN FIG.22. ALL PIECES WERE SUBJECTED TO BENDING STRESS ON A UNIVERSAL TESTING MACHINE AT A UNIFORM SPEED, AND WERE MOUNTED AS SHOWN IN FIG.23. THE RESULTS OF THE TEST ARE TABULATED IN TABLE III OPPOSITE PAGE 41. THE CONCLUSIONS ARE TWO. FIRST, THAT IN SPITE OF THE SHAPE OR THE LOCATION OF THE CUT THE STRENGTH OF THE BOARD REMAINED PROPORTIONAL TO THE CROSS-SECTION AREA OF THE UNCUT FIBERS. SECOND, THAT THE SPLIT BETWEEN FIBERS TENDED TO OCCUR AT THE POINT WHERE THE PITCH OF THE CUT APPROACHED $45^{\circ}$ TO THE DIRECTION OF THE GRAIN. THESE WERE THE ANTICIPATED RESULTS AND INDICATED THAT THE MOST DESIRABLE INSTALLATION WAS THAT WHICH SEVERED THE MINIMUM NUMBER OF FIBERS.

THE SHAPE OF INSTALLATION NOTCH SHOULD PROVIDE FOR A MINIMUM BACKSET OF 2 INCHES, THE DISTANCE FROM THE AXIS OF THE HANDLE TO THE EDGE OF THE DOOR. (SEE PAGE 14.) THE BACKSET SHOULD BE GREAT ENOUGH TO AFFORD AMPLE CLEARANCE FOR THE HAND, BUT THIS DISTANCE IS LIMITED BY THE WIDTH OF THE STILE. WITH THE ADVENT OF THE FLUSH-TYPE DOOR, WHICH INCORPORATES A GENEROUS LOCKBLOCK, A GREATER BACKSET IS POSSIBLE.



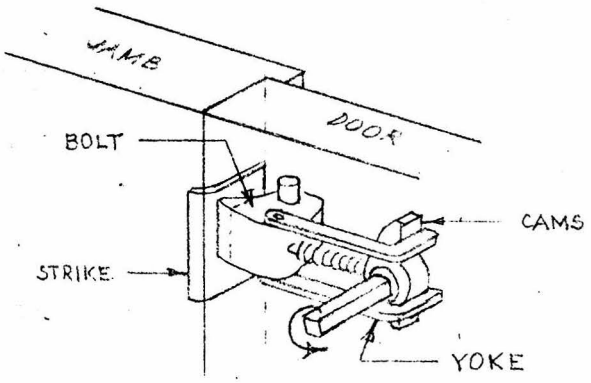

SIMPLE LATCH

DIAGRAM A



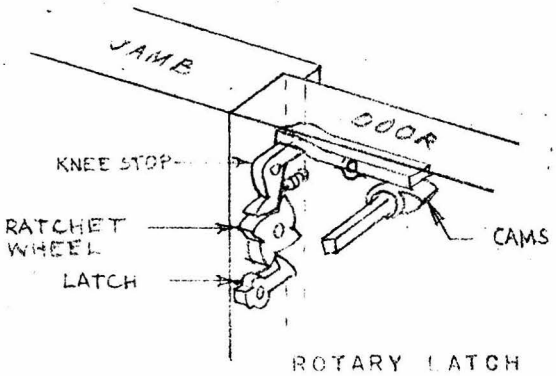

SLIDING BOLT

DIAGRAM B



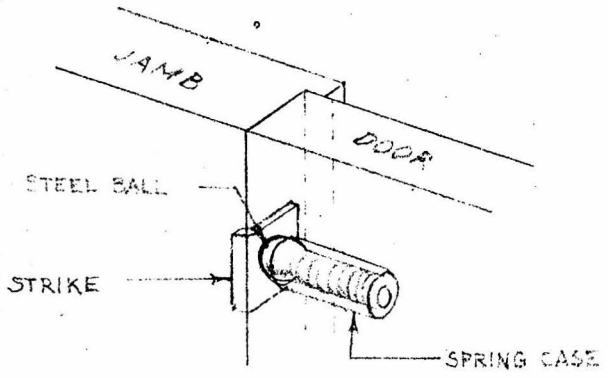

PIVOTED BOLT

DIAGRAM C




ROTARY LATCH

DIAGRAM D




BULLET STOP

DIAGRAM E

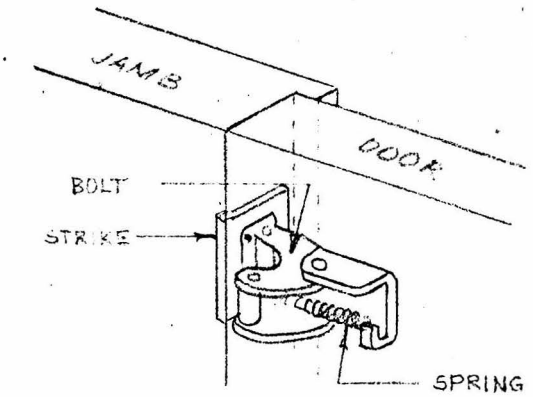



DIAGRAM F SPRING STOP

FIGURE 24

Conclusions. It is concluded that a V-notch 2¼ inches deep, formed with two cuts of the saw, is the simplest answer to the problem of selecting a method of installation. Tests showed that this shape of cut will not weaken the stile more than one of any other shape provided the number of fibers cut is not greater. This type of notch would save time in cutting and in attaching the lock, and would necessarily require that the mechanism take the form of a unit lock.(18)

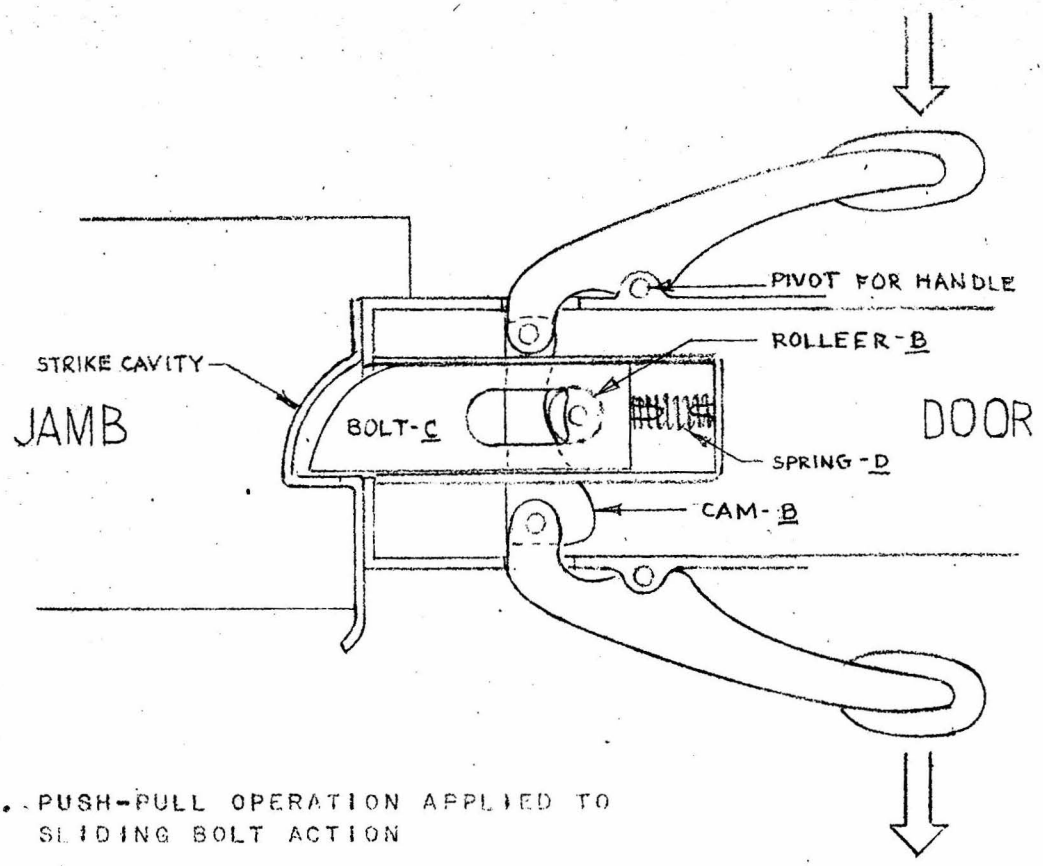
## MECHANICAL OPERATION

The function of the door lock is to fasten the door temporarily to the jamb. The fastening is made by means of a retractible bolt or some other form of latch. Examination of the United States patent files shows that each year several new latching methods are devised. The majority of these are variations on a few basic mechanical principles.

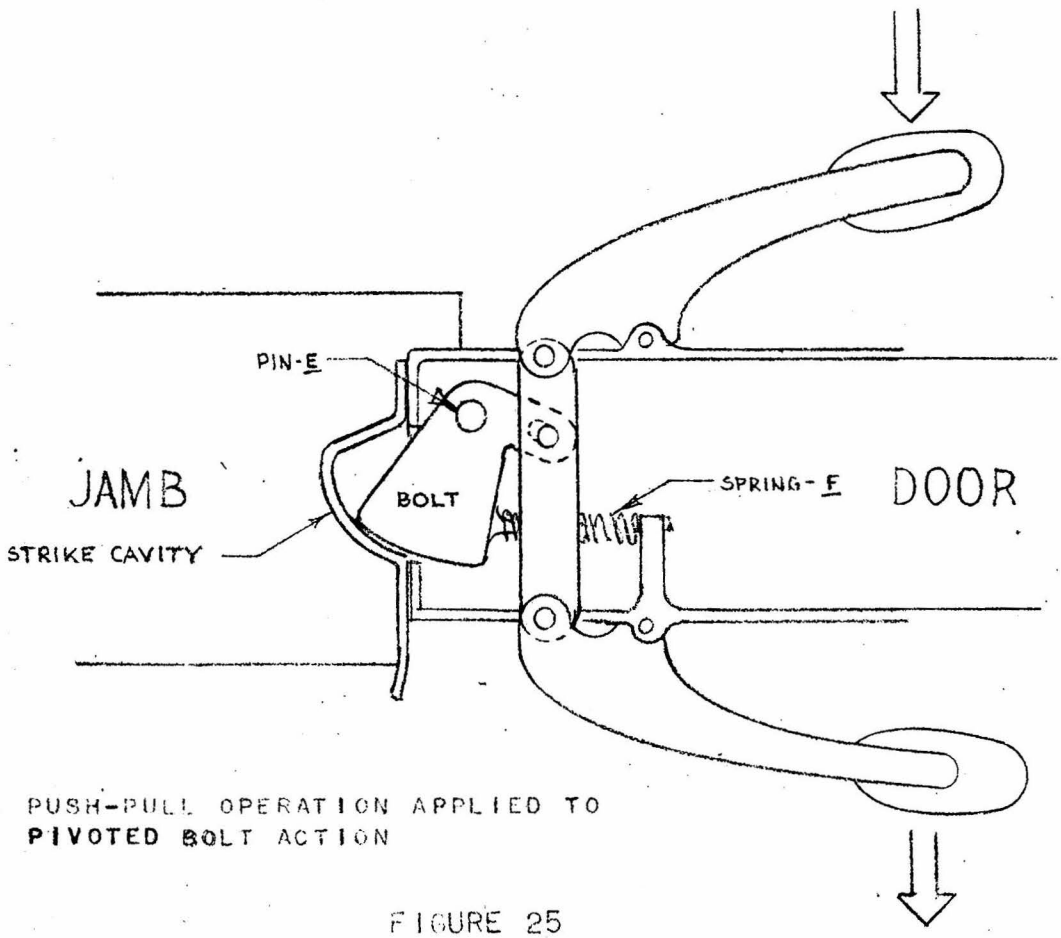
Types of Mechanisms. The operating principles of the most common latch systems are shown schematically in Fig.24. The simple latch bar type is shown in Diagram A. In B is shown the sliding-bolt system used in most door locks. Here the rotary action of the handle is converted into horizontal movement of the bolt through the cams.

DIAGRAM C SHOWS THE PIVOTED-BOLT ACTION OFTEN USED IN AUTOMOBILE AND REFRIGERATOR DOORS. IN D IS SHOWN THE ROTARY DOOR LATCH RECENTLY ADAPTED TO USE ON AUTOMOBILES. IT IS BASED ON THE RATCHET PRINCIPLE. THERE IS ALSO THE BULLET-STOP SHOWN IN DIAGRAM E, WHICH IS WIDELY USED ON CABINET DOORS, BUT WHICH RELIES ON SPRING PRESSURE ALONE FOR SECURITY. IN DIAGRAM F IS SHOWN THE SPRING STOP NORMALLY APPLIED TO SCREEN DOORS, BUT WHICH IS INCORPORATED IN PRINCIPLE ON MANY REFRIGERATOR DOORS. HERE STRONG SPRING TENSION SECURES THE DOOR.

BASIS FOR SELECTION. CONCLUSIONS ARRIVED AT FROM THE ENVIRONMENTAL STUDIES DISCUSSED IN THE PREVIOUS SECTION POINTED TO THE NEED FOR A LATCH WHICH WOULD OPERATE SILENTLY AND BY PUSH-PULL ACTION OF THE HANDLE. THE LATCHING PRINCIPLES ILLUSTRATED WERE ANALYZED AND THEIR APPLICATION TO AUTOMOBILES AND REFRIGERATORS WAS STUDIED TO DETERMINE HOW THE DESIRED ACTION COULD BE OBTAINED. THE SYSTEMS WHICH RELIED ON SPRING PRESSURE ALONE WERE ELIMINATED FOR THEIR LACK OF POSITIVE SECURITY. THE SIMPLE LATCH SHOWN IN DIAGRAM A AND THE ROTARY LATCH SHOWN IN DIAGRAM D, (FIG.24) WERE ELIMINATED BECAUSE THE PARTS MUST PROJECT BEYOND THE EDGE OF THE DOOR AND REQUIRE AN OVERLAPPING FLANGE TO COVER THE OPENING BETWEEN THE




A. PUSH-PULL OPERATION APPLIED TO SLIDING BOLT ACTION

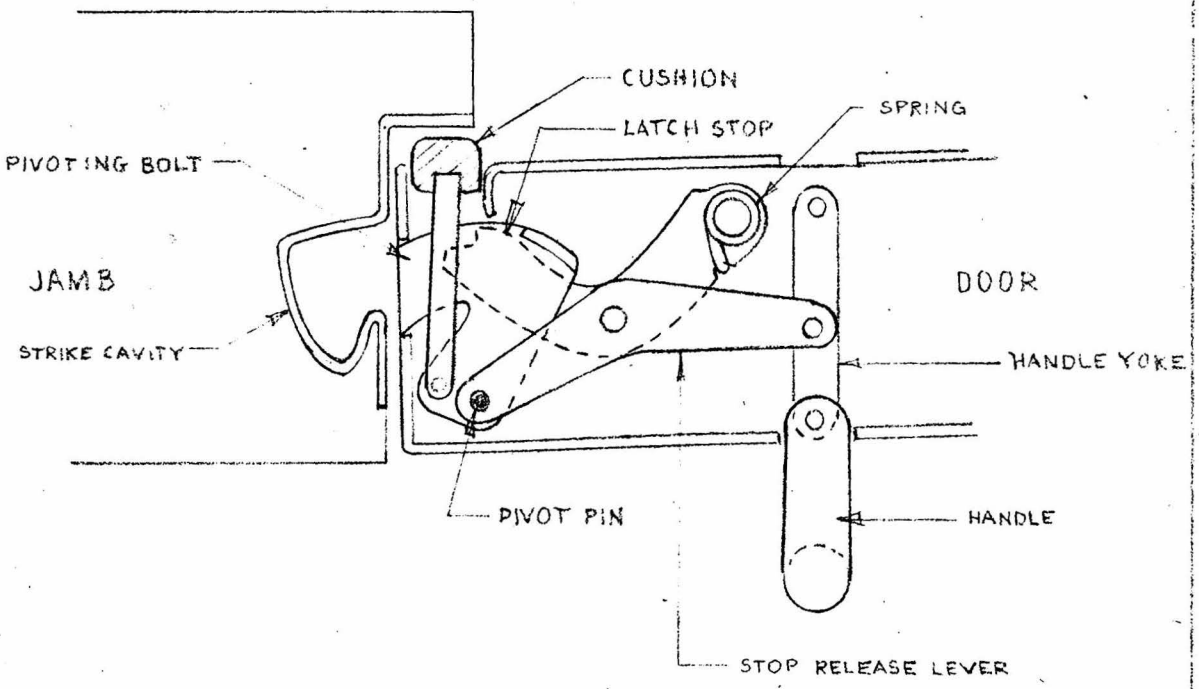


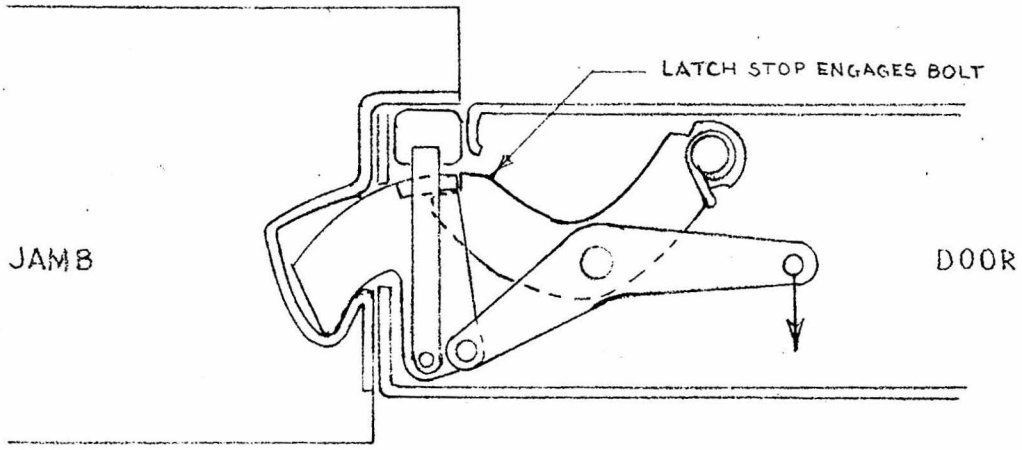

B. PUSH-PULL OPERATION APPLIED TO PIVOTED BOLT ACTION

FIGURE 25

DOOR AND THE JAMB. THE SLIDING BOLT AND THE PIVOTING BOLT ARE THE TWO SYSTEMS WHICH LEND THEMSELVES MOST DIRECTLY TO THE DESIRED PUSH-PULL ACTION. THE COMBINATION OF THESE TWO PRINCIPLES WITH PUSH-PULL CONTROL IS ILLUSTRATED BY THE SCHEMATIC DRAWINGS IN FIG.25. IN FIG. 25A THE SLIDING BOLT ACTION IS DEVELOPED THROUGH THE ACTION OF THE CAM (A) AGAINST THE ROLLER (B), CAUSING THE BOLT (C) TO RETRACT AND COMPRESS THE COIL SPRING (D). THIS MECHANISM IS SIMILAR TO A UNIT LOCK EXISTING ON THE MARKET. FIG. 25B ILLUSTRATES HOW THE PUSH-PULL PRINCIPLE MAY BE OBTAINED WITH THE PIVOTING BOLT, WHERE LEVER ACTION OF THE HANDLE CAUSES THE BOLT TO PIVOT ABOUT THE PIN (E) AGAINST THE PRESSURE OF THE COIL SPRING (F).

CONCLUSIONS. IT IS CONCLUDED THAT OF THE MANY LATCHING PRINCIPLES AVAILABLE, EITHER THE SLIDING OR PIVOTING BOLT ACTION IS MOST DIRECTLY APPLICABLE TO THE OBJECTIVES OF THIS DESIGN. FURTHER, SINCE THE PIVOTING-BOLT ACTION BEST LENDS ITSELF TO THE CONFINING SHAPE OF THE SMALL V-NOTCH, THIS ACTION SHOULD BE APPLIED IN SOME FORM TO THE FINAL MECHANISM. TO OBTAIN THE DESIRED QUIET OPERATION, A SHOCK ABSORBER SHOULD BE INCORPORATED SO AS TO INTERCEPT THE DOOR-JAMB AS THE DOOR CLOSES. THE PLUNGER ACTION DEVELOPED BY THE SHOCK ABSORBER SHOULD BE USED TO PIVOT THE BOLT, AS SHOWN SCHEMATICALLY IN FIG.26.




SHOCK ABSORBER WITH PLUNGER ACTION
TO PIVOT BOLT AND DAMPEN SLAMMING

FIGURE 26

## MATERIALS AND PROCESSES

THE MATERIALS OF WHICH A LOCKSET ARE CONSTRUCTED AND THE PROCESSES BY WHICH THE PARTS ARE FABRICATED AND FINISHED SHOULD MEET THE FOLLOWING CONDITIONS: THE MATERIALS SHOULD BE READILY FORMED BY THE PROCESSES SELECTED AND SHOULD HAVE THE NECESSARY STRENGTH, RESISTANCE TO WEAR AND TO CORROSION, AND DESIRABLE SURFACE APPEARANCE--ALL AT A LOW COST. THE PROCESSES SHOULD ENTAIL LOW OPERATING COSTS AND SHOULD PERMIT THE DESIRED DEGREE OF ACCURACY AND CONTROL. AT THE SAME TIME, THE PROCESSES SHOULD BE SUITABLE FOR PRODUCTION IN LARGE QUANTITIES WITH A FAST OPERATING CYCLE. TO FACILITATE THIS STUDY, A SEPARATE ANALYSIS IS MADE FOR EACH OF THE FOUR DISTINCT PARTS OF THE LOCKSET: THE HANDLE, THE STRIKE-PLATE, AND THE MECHANISM, AND THE CASE.

THE HANDLE. THE MATERIAL FOR THE HANDLE OF A DOOR LOCK SHOULD COMPLY WITH THE FOLLOWING CHARACTERISTICS.

1. IT MUST BE CAPABLE OF TAKING A SHAPE COMFORTABLE TO THE HAND, WITH SOFT CURVES AND VARYING SECTIONS.
2. IT MUST PRESENT A SMOOTH SURFACE, READILY FINISHED BY PLATING OR POLISHING.
3. THE MATERIAL MUST BE RELATIVELY CORROSION-RESISTANT OR CAPABLE OF BEING COATED FOR PROTECTION. THIS

INCLUDES RESISTANCE TO OILS, FATS, WEAK ACIDS, SUN, WATER, AND OTHER MATERIALS WHICH MAY BE PRESENT IN THE HAND.

4. IT MUST BE OF SUFFICIENT STRENGTH AND HARDNESS TO PERFORM ITS FUNCTION WITHOUT BECOMING MARRED OR MISSHAPEN.
5. IT MUST HAVE A PLEASING AND APPROPRIATE APPEARANCE FOR ARCHITECTURAL ORNAMENT, OR BE A GOOD BASE FOR A SUITABLE PLATED FINISH.
6. IT MUST BE A DURABLE AND INEXPENSIVE MATERIAL SUITED TO LOW-COST PROCESSING.

TO SATISFY THE SHAPE REQUIREMENT, THE HANDLE WOULD BEST BE FORMED EITHER BY CASTING, MOLDING, OR FORGING. TO SATISFY THE SMOOTH SURFACE REQUIREMENT USING ONE OF THESE THREE BASIC METHODS, THE PROCESSES ARE LIMITED TO THE FOLLOWING:

| | |
|---|---|
| HOT PRESSING | PLASTER MOLD CASTING |
| DIE-CASTING | INJECTION MOLDING |
| PERMANENT MOLD CASTING | COMPRESSION MOLDING |

THIS LIST REPRESENTS THE METHODS OF CASTING, MOLDING, AND FORGING, WHICH PRODUCE A SURFACE SMOOTH TO THE TOUCH WITHOUT EXTENSIVE GRINDING OR SUPPLEMENTARY FINISHES.

TABLE IV

CHARACTERISTICS OF MATERIALS CONSIDERED FOR HANDLE

| MATERIALS BULK FORM | TSL STR (CAST) LB/SQ.IN | % ELONG 2 IN | BR HARD. 3000KG | FABRICAT. METHOD | MELT. PT. F° | COST/ LB. ¢ | SPC. VOL. | COST/ CU.IN. ¢ | COST FINSHG. ¢ | TYPE OF FINISH REQU'D | FINAL COST/ 4 CU.IN. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CAST BRASS | 37,000 | 40 | 75 | PERMANENT MOLD | 1913° | 26.0 | 3.14 | 8.3 | 15.0 | BUFF AND LAQUER | 48.3 |
| ALUMINUM BRONZE (8%) | 70,000 | 55 | 125 | HOT PRESS | 1940° | 32.0 | 5.20 | 6.2 | 12.0 | SAND AND BUFF | 37.0 |
| NICKEL SILVER (18%) | 60,000 | 45 | 160 | HOT PRESS | 1931° | 42.4 | 3.18 | 13.3 | 12.0 | BUFF | 65.0 |
| MONEL METAL | 72,000 | 34 | 125 | PLASTER MOLD | 2460° | 40.0 | 3.14 | 12.7 | 12.0 | SAND OR BUFF | 62.8 |
| EVERDUR #100 | 50,000 | 25 | ROCK B-70 | PERMANENT MOLD | 1832° | 38.6 | 3.35 | 11.5 | 12.0 | BUFF AND LAQUER | 58.0 |
| STAINLESS STEEL (18-8) | 90,000 | 20 | 270 | PLASTER MOLD | 2800° | 35.0 | 3.58 | 10.0 | 12.0 | SAND AND BUFF | 52.0 |
| ZINC DIE-CST (ZAMAC #5) | 44,000 | 3 | 79 | DIE-CAST | 717° | 13.0 | 4.15 | 3.1 | 25.0 | BUFF AND CHROM PLT | 37.5 |
| ALUMINUM ALLOY 4% MG | 27,000 | 7 | 500KG 60 | PERMANENT MOLD | 1150° | 15.0 | 10.0 | 1.5 | 17.0 | BUFF AND ANODIZE | 23.0 |
| PHENOLIC PLASTIC | 7,000 | | ROCK M-120 | COMPRES. MOLD | FLOW POINT 320° | 15.0 | 22.0 | 0.7 | CORE 3.0 | NONE | 5.8 |
| POLYSTYRENE | 6,000 | | ROCK M-90 | INJECTION MOLD | 250° | 26.0 | 26.0 | 1.0 | CORE 3.0 | NONE | 7.0 |
| CELLULOSE ACETATE BUTYRATE. | 4,500 | | ROCK M-70 | INJECTION MOLD | 314° | 56.0 | 22.0 | 2.5 | CORE 3.0 | NONE | 13.0 |

THE MATERIALS WHICH OFFER A SUITABLE SURFACE APPEARANCE AND ARE RELATIVELY RESISTANT TO CORROSION AS WELL AS EASILY FORMED BY THE PRODUCTION METHODS LISTED ABOVE, ARE:

| | |
|---|---|
| BRASS | PLATED DIE-CAST ZINC |
| ALUMINUM BRONZE | PLATED DIE-CAST ALUMINUM |
| NICKEL SILVER | UNFILLED PHENOLIC RESIN |
| MONEL METAL | POLYSTYRENE PLASTIC |
| STAINLESS STEEL | CELLULOSE ACETATE BUTYRATE |

TO SELECT FROM THIS LIST THE MATERIALS WHICH ARE MOST SUITABLE FOR THE DOOR HANDLE, THE CHART IN TABLE IV IS PREPARED TO SHOW THE COMPARATIVE STRENGTH, ELONGATION, AND HARDNESS, TOGETHER WITH THE RELATIVE APPEARANCE, COST, AND FINISHING COSTS.

THE STRENGTH AND HARDNESS CHARACTERISTICS NECESSARY TO SATISFY THE USE TO WHICH THE HANDLE WILL BE PUT ARE EASILY MET. A MINIMUM TENSILE STRENGTH OF 4000 POUNDS PER SQUARE INCH IS ASSUMED AS SUFFICIENT TO CARRY THE FORCES IN THE MAGNITUDE OF 50 POUNDS WHICH WERE ARRIVED AT IN THE STUDY OF HUMAN REQUIREMENTS. (SEE PAGE 23.) THIS FIGURE INCLUDES A SAFETY FACTOR OF 5 AND A MINIMUM SECTION OF 1/16 SQUARE INCH. THE HARDNESS NEED BE ONLY ENOUGH TO RESIST SCRATCHING BY FINGER NAILS OR RINGS, AND THE EQUIVALENT OF BRINELL 60, OR ROCKWELL B 10 FOR THE METALS AND ROCKWELL M 90 FOR THE PLASTICS, IS SUFFICIENT

FOR NORMAL USE. SINCE A TOUGH RATHER THAN A BRITTLE MATERIAL IS REQUIRED FOR THIS PURPOSE, THE MATERIALS WITH THE HIGHER PER CENT ELONGATION VALUES (HIGHER THAN 10% IN 2 INCHES) ARE TO BE PREFERRED.

AS A MATERIAL FOR THE HANDLE, THE DIE-CAST ZINC IS ELIMINATED BECAUSE OF THREE OBJECTIONS. FIRST, THE MATERIAL IS RELATIVELY BRITTLE FOR THIS APPLICATION, ITS IMPACT RESISTANCE BEING ONLY 12 FOOT POUNDS BY CHARPY IMPACT TEST. SECOND, MARKET RESISTANCE TO A PRODUCT CONSTRUCTED OF EVEN THE BETTER DIE-CAST ALLOYS MUST BE CONTENDED WITH. THIRD, THOUGH THE COST OF THE BASE METAL IS LOWER THAN THE COPPER OR FERROUS ALLOYS, THE NECESSITY FOR FINISHING BY PLATING MAKES THE ZINC ALLOY ONE OF THE MORE COSTLY MATERIALS FOR THIS USE. THE COMMERCIAL COST ESTIMATE FOR PLATING A PART THE SIZE OF THE HANDLE IS 25 CENTS EACH, WHICH INCLUDES THE BASE COPPER PLATE, THE NICKEL UNDERPLATE, AND THE FINAL CHROMIUM PLATE (0.00003 INCHES), AS WELL AS THE FINISH BUFFING. OF THIS PRICE, ONLY 10 CENTS IS ATTRIBUTED TO THE BUFFING OPERATION. THE COST DIFFERENTIAL IS THEREFORE 15 CENTS OVER THE OTHER METALS WHICH NEED ONLY BE BUFFED. BY AVOIDING THE DIRECT COST OF PLATING THE HANDLE, MANY EXTENDED SAVINGS MAY BE REALIZED, SUCH AS

SHORTER PRODUCTION TIME, LESS CAPITAL EQUIPMENT IN THE FORM OF DIP-TANKS AND POWER GENERATORS, AND SMALLER PLANT AREA AND UPKEEP.

COMPARISON OF THE REMAINING MATERIALS CONSIDERED ON THE CHART POINT TO FOUR WHICH SATISFY ALL THE REQUIREMENTS AND HAVE PARTICULARLY GOOD SURFACE APPEARANCE. TWO OF THESE ARE METALS AND THE OTHER TWO ARE PLASTICS. OF THE METALS, THE ALUMINUM BRONZE WAS SELECTED FOR USE ON THE DE LUXE MODEL TO APPEAL TO THOSE CUSTOMERS WHO PREFER THE TRADITIONAL YELLOW BRASS FINISH AT A QUALITY PRICE. A HANDLE OF THIS METAL WOULD BE FORMED BY HOT-PRESSING OR BY PERMANENT-MOLD CASTING, AND WOULD BE FINISHED BY SANDING AND BUFFING TO A SATIN OR POLISHED SURFACE. A LESS EXPENSIVE HANDLE COULD BE MADE FROM AN ALUMINUM CASTING ALLOY BY PERMANENT-MOLD CASTING, AND BE FINISHED IN A CLEAR OR TINTED ANODIZED SURFACE. THIS WOULD PERMIT SOME VARIETY FOR CHOICE OF COLORS AND TEXTURE. INVESTIGATION PROVED THAT THE COST OF ANODIZING IS LESS THAN HALF THE COST OF ELECTROPLATING. THE COST TO ANODIZE AN ALUMINUM CASTING THE SIZE OF THE HANDLE IS QUOTED AT 10 CENTS PER PIECE.

THE USE OF PLASTICS FOR STRUCTURAL ELEMENTS WHICH COME IN CONTACT WITH THE BODY HAS LONG BEEN ACCEPTED IN

PREFERENCE TO METALS, WHICH FEEL HARD AND CHILLING TO THE TOUCH. THE ADAPTATION OF PLASTICS TO DOOR HARDWARE HAS BEEN LIMITED, HOWEVER, DUE PARTLY TO THE INERTIA OF THE MANUFACTURERS AND PARTLY TO PUBLIC SKEPTICISM ARISING FROM THE ORIGINAL MISAPPLICATION OF THESE MATERIALS. A SURVEY CONDUCTED BY THE EDITORIAL STAFF OF ARCHITECTURAL FORUM MAGAZINE IN 1941, FOR WHICH MORE THAN 3,000 ARCHITECTS AND CONTRACTORS WERE POLLED, SHOWED CONCLUSIVELY A MAJORITY (78% THEN) WHO FAVORED THE USE OF PLASTICS ON DOOR HANDLES.(19) IN THEIR NEW DURABLE FORM, SOME OF THE PLASTICS ARE PARTICULARLY ADAPTED TO USE FOR THE CONSTRUCTION OF HARDWARE. ONE OF THESE IS CLEAR PHENOLIC RESIN, AVAILABLE IN POLISHED BLACK, GREY, OR TRANSLUCENT DARK COLORS. FOR ADDED STRENGTH AND RIGIDITY, IT IS RECOMMENDED THAT A METAL INSERT OR CORE BE INCORPORATED IN THE MOLDED FORM, THROUGH WHICH CONNECTION TO THE DOOR MAY BE MADE. BEST PRACTICE MAKES USE OF ALUMINUM FOR INSERTS BECAUSE OF ITS RELATIVE FLEXIBILITY AND A COEFFICIENT OF EXPANSION NEAR THAT OF THE PLASTICS ($24 \times 10^{-6}$).(20) THE OTHER PLASTIC, SELECTED FOR ITS LOW COST AND ATTRACTIVE APPEARANCE, IS POLYSTYRENE. THIS MATERIAL HAS EXCELLENT MECHANICAL PROPERTIES, AND IF MOLDED SO AS TO ENCLOSE COMPLETELY A METAL CORE, THE TENDENCY FOR IT TO PART FROM THE METAL WILL OFFER NO PROBLEM.(21) IN THE FORM OF A

CLEAR TRANSPARENT OR TRANSLUCENT PLASTIC, POLYSTYRENE IS AVAILABLE IN A WIDE RANGE OF COLOR TINTS, FROM CLEAR TO DARK OPAQUE. IT IS ANTICIPATED THAT THE AESTHETIC EFFECT OF A BRUSHED ALUMINUM CORE VISIBLE THROUGH THE TRANSPARENT PLASTIC WOULD BE MOST PLEASING. SUCH A HANDLE WOULD AFFORD A CLEAN AND COLORFUL ACCENT AGAINST THE FLAT WALL FINISHES, AND WOULD BE WELL SUITED TO THE MOST MODERN INTERIORS.

IN CONCLUSION, IT WILL BE SEEN THAT THE SELECTION OF THE FOUR MATERIALS NOTED ABOVE PROVIDES A VARIETY OF FINISHES AT A MINIMUM COST. THE CUSTOMER IS THEREBY GIVEN AN OPTION AS TO MATERIAL, COLOR, AND PRICE.

THE CASE. ON A UNIT LOCK, THE CASE ITSELF IS VISIBLE AT THE SURFACE OF THE DOOR AND SERVES ALSO AS AN ESCUTCHEON. AS SUCH, IT MUST SATISFY MANY FUNCTIONS: SUPPORT THE MECHANISM, FASTEN THE LOCK TO THE DOOR, CONCEAL THE NOTCH IN THE WOOD AS AN ESCUTCHEON, AND SET OFF THE HANDLE WITH AN ATTRACTIVE SURFACE. THE MATERIAL SELECTED FOR THE CASE MUST THEREFORE INCLUDE THE FOLLOWING PROPERTIES:

1. SUFFICIENT RIGIDITY TO MAINTAIN ITS SHAPE.
2. A HARD SURFACE TO RESIST SCRATCHING.
3. CORROSION RESISTANCE.
4. EASILY WORKED WITH LOW DIE COST.

5. THE SURFACE APPEARANCE SHOULD HARMONIZE WITH THE MATERIALS OF THE DOOR AS WELL AS THE HANDLE.

SINCE THE CASE MUST BE ADJUSTABLE TO VARIATIONS IN DOOR THICKNESS, IT IS BEST CONSTRUCTED OF TWO PARTS FITTED TOGETHER TO FORM THE TWO SIDES AND FACE OF THE LOCK CASE. THE NATURE OF THE CASE IS ESSENTIALLY A THIN, FLAT SECTION WITH A RIGHT-ANGLE FLANGE TO FORM THE FACE OF THE LOCK, AND FOR THIS REASON WOULD BE MOST SIMPLY MADE FROM FLAT SHEET STOCK. TO OBTAIN THE DESIRED RIGIDITY WITH THE MINIMUM GAUGE OF SHEET, THE SIDES SHOULD BE STAMPED WITH A SLIGHTLY CONVEX SHAPE.

SERVING AS THE BACKBONE OF THE ENTIRE LOCK AND THE BASIS FOR THE SECURITY REQUIRED, THE CASE MUST EXHIBIT STRENGTH QUALITIES NORMALLY NOT AVAILABLE IN MATERIALS OTHER THAN METAL. FOR THIS REASON, THE LIST OF POSSIBLE MATERIALS HAS BEEN LIMITED TO THOSE METALS AVAILABLE IN SHEET FORM AND ARE KNOWN TO HAVE SUITABLE STRENGTH AND CORROSION-RESISTANT PROPERTIES. THIS LIST INCLUDES:

PLATED COLD ROLLED STEEL
STAINLESS STEEL (18-8)
MONEL METAL
NICKEL SILVER
BRASS (70-30)
ALUMINUM BRONZE
ALUMINUM ALLOY (61S-T4)

TABLE V

CHARACTERISTICS OF MATERIALS CONSIDERED FOR CASE

| MATERIALS SHEET STOCK | TENSILE STRENGTH LB/SQ.IN | % ELONG 2IN | BR HARD 3000K | SURFACE APPEAR. | COST PER LB ¢ | SPC VOL | COST PER CU IN. ¢ | COST FINSHG ¢ | TYPE OF FINISH REQU'D | FINAL COST/ 2CU. IN. |
|---|---|---|---|---|---|---|---|---|---|---|
| COLD ROLLED STEEL (½ HRD) | 50,000 | 15 | 110 | HIGH LUSTR CHROM PLT | 4.00 | 3.53 | 1.13 | 50.0 | CHROM PLT AND BUFF | 52.26 |
| STAINLESS STEEL (18-8) | 150,000 | 12 | 140 | HIGH LUSTRE | 38.00 | 3.58 | 10.60 | 25.0 | SAND AND BUFF | 46.20 |
| MONEL METAL | 72,000 | 30 | 100 | MATT OR LUSTRE | 49.00 | 3.14 | 15.60 | 25.0 | SAND AND BUFF | 56.20 |
| NICKEL SILVER | 65,000 | 30 | 90 | LUSTRE | 42.42 | 3.18 | 13.30 | 25.0 | SAND AND BUFF | 51.60 |
| BRASS (70-30) | 45,000 | 40 | 75 | YELLOW LUSTRE | 30.16 | 3.14 | 10.40 | 30.0 | BUFF AND LAQUER | 50.80 |
| ALUMINUM BRONZE | 105,000 | 50 | 120 | WHITE GLD LUSTRE | 42.00 | 5.20 | 8.06 | 25.0 | BUFF | 41.12 |
| ALUMINUM ALLOY (61S-T4) | 35,000 | 25 | 500KG 65 | ANODIZED SHEEN | 25.00 | 10.00 | 2.50 | 40.0 | BUFF AND ANODIZE | 45.00 |
| | | | | | | | | | | |

COMPARISON OF THE PRICE PER POUND FOR THESE METALS IN SHEET FORM SHOWS A RANGE FROM THE LOW OF 4 CENTS PER POUND FOR COLD ROLLED STEEL TO A HIGH OF 49 CENTS PER POUND FOR MONEL METAL. HOWEVER, THE LOW PRICE PER POUND OF COLD ROLLED STEEL DOES NOT REFLECT THE HIGHER COST INVOLVED IN ELECTROPLATING TO ACHIEVE A SUITABLE FINISH. REFERENCE TO THE COMPARATIVE TOTAL COSTS TABULATED IN TABLE V SHOWS THAT PLATED CR STEEL IS EXCEEDED IN COST ONLY BY MONEL METAL. CONSIDERATION OF PRICE THEREFORE FAVORS THE USE OF ALUMINUM ALLOY SHEET.

THE CONTROLLING FACTOR IN THE SELECTION OF THE MATERIAL FOR THE CASE IS THE FINAL APPEARANCE OF THE FINISHED METAL IN COMBINATION WITH THE HANDLE MATERIAL AND THE DOOR. IT IS CONCEDED AS AN AESTHETIC PRINCIPLE THAT THE MOST PLEASING EFFECTS ARE REALIZED EITHER THROUGH DECIDED SIMILARITY OR THROUGH STRIKING CONTRAST BETWEEN THE ELEMENTS OF A FORM.(22) A WEAK MATCHING OF COLORS AND FINISHES SHOULD BE AVOIDED AT ALL COSTS. APPLIED TO THE DOOR LOCKSET, THIS WOULD IMPLY THAT THE HANDLE AND CASE SHOULD BE CONSTRUCTED OF THE SAME MATERIAL TO EMPHASIZE THE UNITY IN DESIGN, OR THERE SHOULD BE SHARP CONTRAST WITH THE INTENT TO EMPHASIZE THE SEPARATE FUNCTIONS OF THE PARTS. FOR THIS REASON IT IS RECOMMENDED THAT WITH THE ALUMINUM BRONZE HANDLE, THE ALUMINUM BRONZE

CASE BE USED. IN THE SAME WAY, THE ANODIZED SURFACE ON THE HANDLE OF THE ALUMINUM ALLOY MODEL SHOULD BE CARRIED THROUGH TO THE FINISH OF THE CASE OF THE SAME MATERIAL. IN THE INSTANCE OF SELECTING A MATERIAL AND FINISH TO BE COMBINED HARMONIOUSLY WITH THE VARIOUS COLORS OF PLASTIC HANDLES, IT IS RECOMMENDED THAT EITHER ONE OF THE ALUMINUM ALLOY CASES COULD BE USED WITH A LIMITED NUMBER OF COLORED PLASTICS. TO EXTEND THE POSSIBILITIES OF COMBINATIONS, IT IS FURTHER SUGGESTED THAT A THIRD MATERIAL, SUCH AS MONEL METAL BE USED TO SET OFF THE BLACK OR CLEAR PLASTICS AGAINST A POLISHED WHITE METAL BACKGROUND. MONEL METAL IS SUITED TO COLD FORMING AND DOES NOT HAVE THE DESTRUCTIVE EFFECT ON DIES WHICH IS ATTRIBUTED TO STAINLESS STEEL. IT IS EASILY BUFFED OR BRUSHED TO AN ATTRACTIVE FINISH AND HAS EXCELLENT CORROSION-RESISTANT PROPERTIES.

THESE THREE MATERIALS, ALUMINUM ALLOY, ALUMINUM BRONZE, AND MONEL METAL, SATISFY THE REQUIREMENTS FOR THE CASE. THEY ARE PLEASING IN APPEARANCE AND STRUCTURALLY SOUND, AND AFFORD A RANGE OF FINISHES TO APPEAL TO THE PARTICULAR CUSTOMER.

STRIKE PLATE. THE MATERIAL FROM WHICH THE STRIKE PLATE IS MADE SHOULD MATCH THE MATERIAL OF THE CASE. THE APPARENT AESTHETIC REASON FOR THIS SIMILARITY OF MATERIALS IS SUPPORTED PRACTICALLY BY THE EVIDENT EXPEDIENCY OF INCLUDING THE STRIKE PLATE DIES SO THAT THEY CAN BE FORMED IN PARALLEL OPERATIONS. IN THIS MANNER SAVINGS MAY BE REALIZED BY ELIMINATING ADDED HANDLING AND PURCHASING OF MATERIALS. THE FACT THAT THE STRIKE PLATE CARRIES NO CRITICAL LOAD IN BENDING AND AMOUNTS TO LESS THAN A TENTH OF A CUBIC INCH IN VOLUME, JUSTIFIES THIS BASIS FOR THE SELECTION OF MATERIAL FOR THIS PART.

MECHANISM. THE PARTS OF THE MECHANISM OF A DOOR LOCK FALL INTO THREE GROUPS:

1. MOVING PARTS
2. BEARINGS
3. SPRINGS

ALL OF THESE PARTS ARE NECESSARILY SMALL AND YET ARE SUBJECTED TO CONSIDERABLY HIGH STRESSES, AS WHEN THE DOOR IS TRIED WHILE THE BOLT IS LOCKED OR WHEN THE DOOR IS SLAMMED. THE PRODUCTION OF SMALL PARTS FOR THIS PURPOSE WOULD BE ACCOMPLISHED MOST ECONOMICALLY BY DIE-STAMPING OR BY DIE-CASTING. COMPARISON OF THESE TWO PRODUCTION PROCESSES REVEALS THAT FOR LARGE QUANTITY RUNS WHERE THE PART IS A SIMPLE FLAT SHAPE AND REQUIRES LITTLE ADDITIONAL MACHINING,

FORMATION BY DIE-STAMPING AND PUNCHING IS BY FAR THE LESS COSTLY OF THE TWO.(23)

THE MATERIALS TO BE FORMED BY DIE-STAMPING WOULD LOGICALLY BE LIMITED TO THOSE AVAILABLE IN THE FORM OF STRIP STOCK. THESE MATERIALS SHOULD BE RELATIVELY CORROSION-RESISTANT, TOUGH, AND RESILIENT, AND REQUIRE A MINIMUM OF DIE PRESSURE AND DIE MAINTENANCE. IT IS NOTED THAT THE MECHANISMS OF THE NEWER REFRIGERATOR DOOR LOCKS ARE CONSTRUCTED OF STAMPED STEEL PARTS, ZINC-PLATED TO PREVENT THE FORMATION OF RUST. THESE LATCHES ARE DESIGNED TO TAKE THE FULL IMPACT OF THE HEAVY DOORS AS THEY ARE CLOSED. MANY OF THE BETTER GRADES OF BUILDERS HARDWARE ARE ALSO CONSTRUCTED OF STAMPED STEEL PARTS, THOUGH THE FINEST LOCKS ARE OF STAMPED BRASS OR BRONZE. WITH THESE APPLICATIONS AS JUSTIFICATION AND BECAUSE OF THE GOOD COLD-FORMING CHARACTERISTICS, IT IS RECOMMENDED THAT THE PARTS OF THE LEVER MECHANISM FOR THIS LOCKSET BE MADE OF ZINC-PLATED COLD ROLLED STEEL (MEDIUM HARD). FOR SPECIAL APPLICATION IN HUMID SEA ATMOSPHERE, HARD ROLLED WROUGHT BRASS PARTS SHOULD BE MADE AVAILABLE.

TO INSURE ADEQUATE STRENGTH AND SUFFICIENT BEARING SURFACE, CARE SHOULD BE GIVEN TO SELECTING THE MOST APPROPRIATE GAUGE THICKNESS. IN THE BETTER LOCKS ON THE MARKET MAXIMUM

BEARING SURFACE IS ACHIEVED BY DESIGNING THE MOVING PARTS AS CONCENTRIC SLEEVES. ADEQUATE BEARINGS MAY BE FORMED BY DRAWING AND PUNCHING THE SHEET TO FORM A SMOOTH SLEEVE AS SHOWN BY DIAGRAM IN FIG.27.

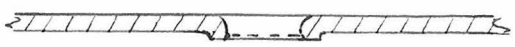


FIG.27

THE PARTS OF A LOCK MOVE AT LOW SPEEDS AND NORMALLY LESS THAN ONE REVOLUTION, SO THE PROBLEM OF LUBRICATION DOES NOT ENTER. IT IS RECOMMENDED THAT THE BEARINGS BETWEEN MOVING LEVERS AND PINS BE OF A LOOSE CLASS I FIT, AND THAT THE PINS BE OF HARD COLD ROLLED STAINLESS STEEL (18-8) TO PROVIDE A LASTING CORROSION-RESISTANT BEARING SURFACE. THE SPRING MATERIAL SHOULD BE OF A SHOCK-RESISTANT, CORROSION-RESISTANT PHOSPHOR BRONZE FOR LASTING SERVICE. A PHOSPHOR BRONZE ALLOY CONTAINING 10% TIN IS NOTED FOR ITS FINE SPRING QUALITIES. THE ADDITIONAL COST OF THIS MATERIAL BY THE POUND IS INSIGNIFICANT HERE FOR THE WEIGHT OF THE SPRING IS NEGLIGIBLE. THE USE OF NON-FERROUS SPRING MATERIAL IS REQUIRED BY FEDERAL SPECIFICATIONS FOR HARDWARE APPLIED TO GOVERNMENT PROJECTS.(24) THE FRAME IN WHICH THE MECHANISM IS MOUNTED SHOULD BE FORMED FROM THE SAME COLD ROLLED STEEL STRIP FROM WHICH

THE VARIOUS PARTS ARE STAMPED. THIS WOULD PROVIDE A STRONG, RIGID FRAME, EASILY FORMED AND PIERCED, AT THE LOWEST COST. THIS STEEL FRAME SHOULD BE ZINC-PLATED AS ARE THE OTHER STEEL PARTS.

THE SHOCK-ABSORBING CUSHION SHOULD BE MADE OF NEOPRENE, A POLYCHLOROPRENE, WHICH HAS THE GENERAL CHARACTERISTICS OF HIGH-GRADE RUBBER. HOWEVER, THIS MATERIAL IS NOT SIGNIFICANTLY AFFECTED BY OILS OR SUNLIGHT, AS IS THE CASE WITH RUBBER. IT IS READILY BONDED TO METAL BY THE USE OF NEOPRENE SOLVENT CEMENTS, AND HAS EXCELLENT ABRASION-RESISTANT QUALITIES.(25)

Conclusions. THE IMPORTANCE OF SELECTING THE APPROPRIATE MATERIALS FOR THE CONSTRUCTION OF THE PARTS OF THIS LOCKSET CANNOT BE OVEREMPHASIZED. BY QUESTIONING LOCK REPAIRMEN AND HARDWARE SALESMEN AS TO THE QUALITY THEY CONSIDERED MOST IMPORTANT TO THE SUCCESS OR FAILURE OF A LOCKSET, IT IS FOUND THAT THE MAJORITY OF REPAIRS, AS WELL AS THE LOSS OF MANY SALES, IS ATTRIBUTED TO USE OF INFERIOR MATERIALS.

# DESIGN SPECIFICATIONS

## INTRODUCTION

THE FOREGOING ANALYSIS HAS LED TO A SET OF CONCLUSIONS WHICH IN TURN DEFINE THE OPERATION AND FORM OF THE LOCK-SET AS THE SOLUTION TO THIS PROBLEM. IN THIS SECTION THIS SOLUTION IS DESCRIBED IN DETAIL AND THE WORKING SPECIFICATIONS ESTABLISHED.

## STRUCTURAL DETAILS

EACH OF THE FOUR MAJOR PARTS OF THE LOCKSET IS HERE CONSIDERED IN TURN: THE MECHANISM, THE CASE, THE HANDLE, AND THE STRIKE PLATE. THE FUNCTION AND CONSTRUCTION OF THESE PARTS ARE DESCRIBED AND THE MATERIALS AND FINISHES SPECIFIED. DETAILED WORKING DRAWINGS ARE INCLUDED TO ILLUSTRATE THE TEXT.

### MECHANISM

THE MECHANISM MUST SATISFY THE REQUIREMENTS FOR SILENT OPERATION, PUSH-PULL CONTROL, CORROSION-RESISTANCE, AND STRONG CONSTRUCTION FOR SECURITY. THESE REQUIREMENTS ARE MET AS DESCRIBED.

OPERATION. TO ACCOMPLISH SILENT OPENING AND CLOSING, THE USUAL METAL-TO-METAL CONTACT BETWEEN THE BOLT AND STRIKE

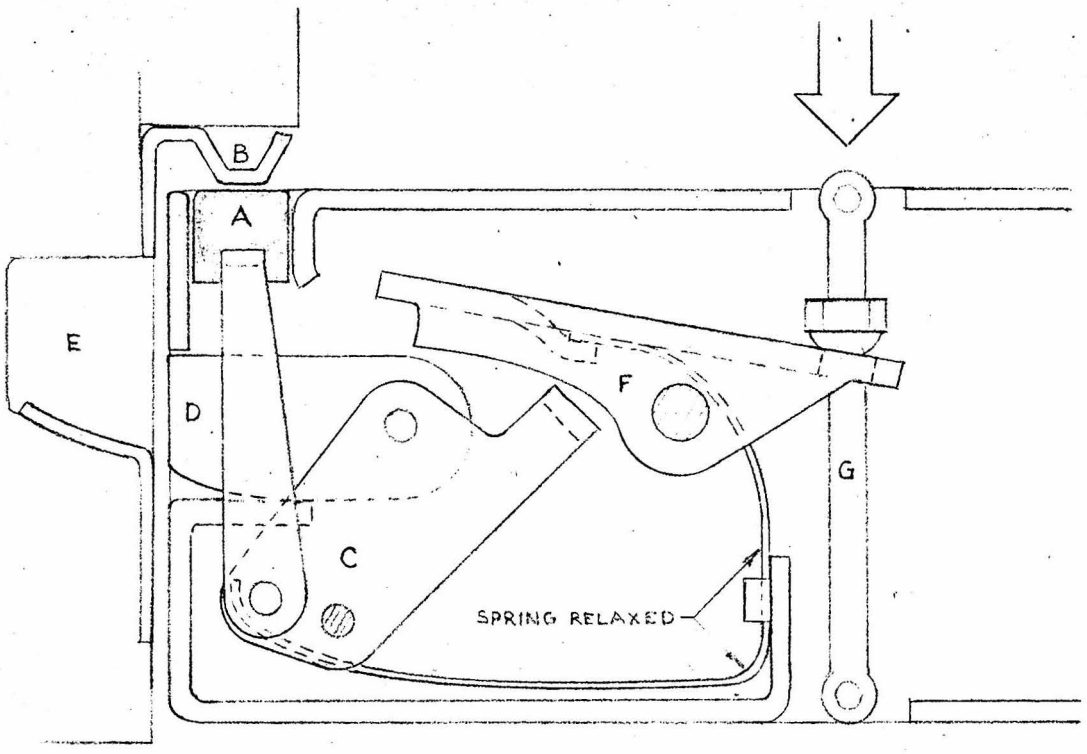
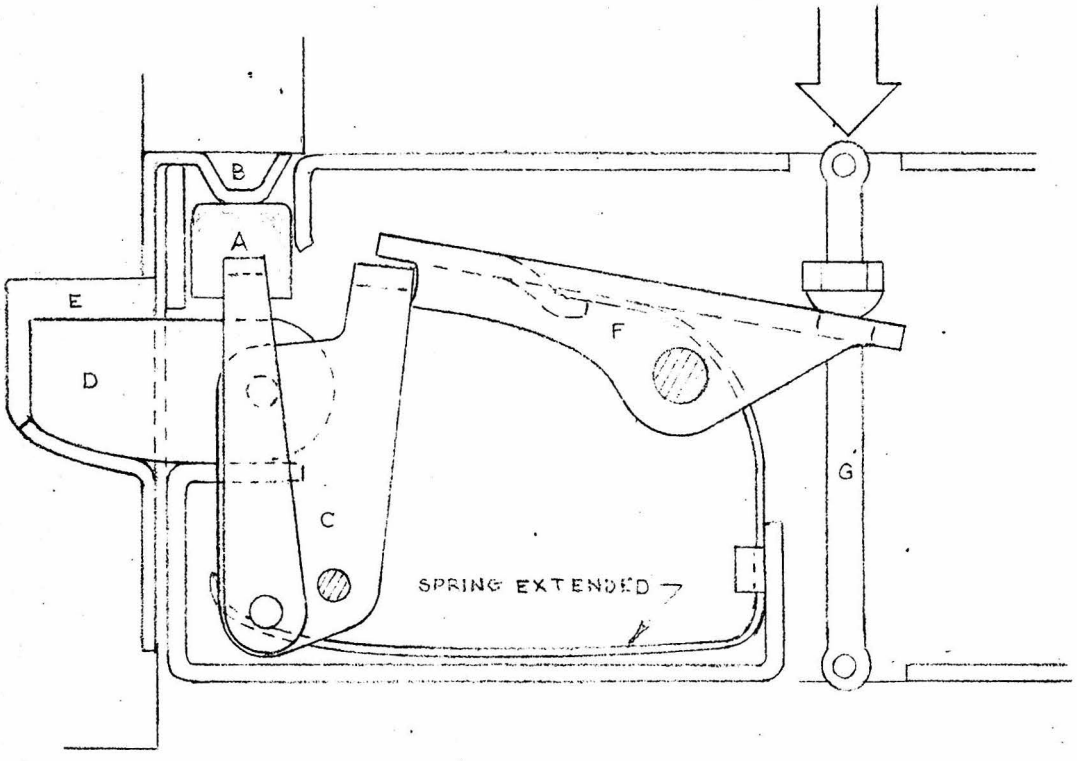



FIGURE 28

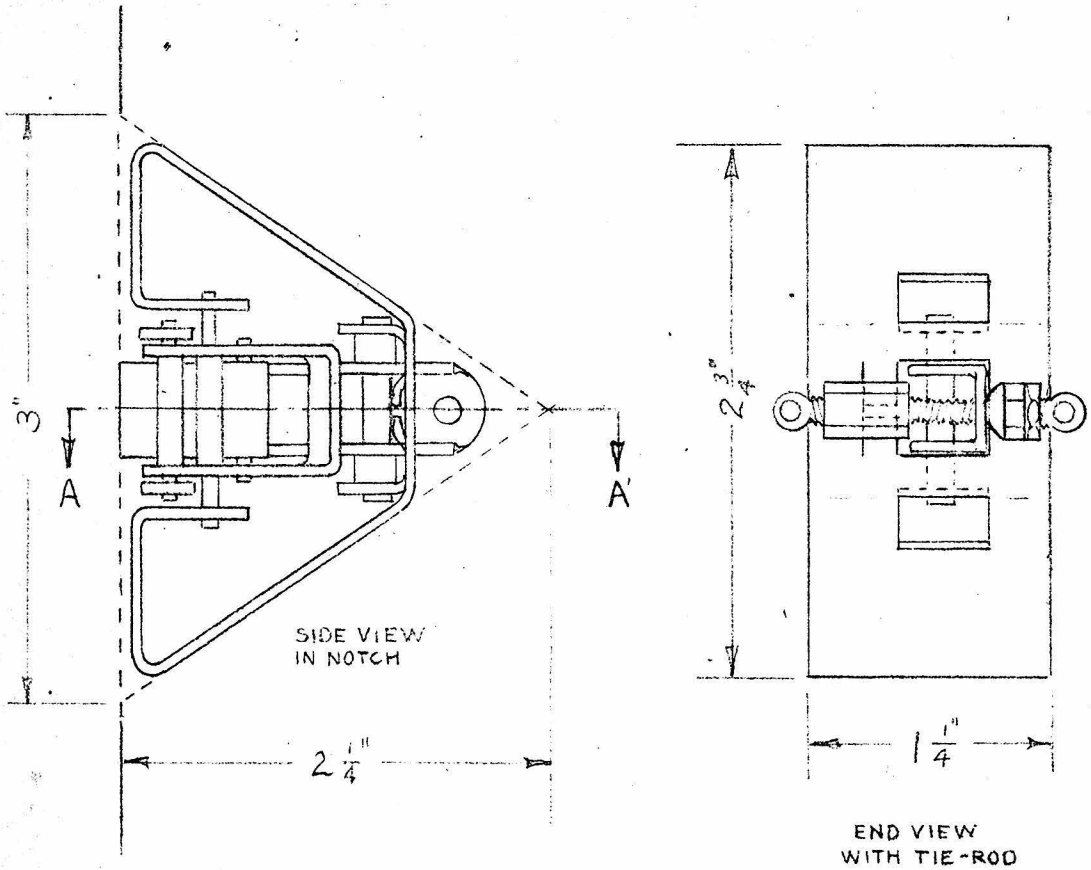


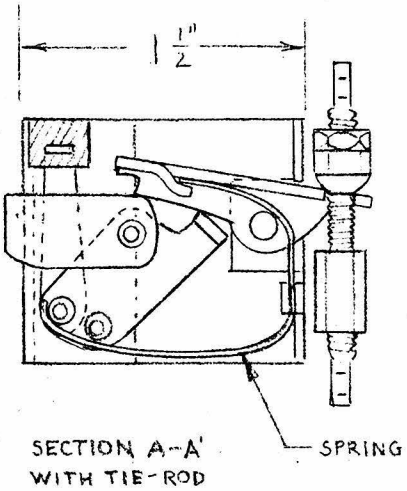

OPERATION OF LOCK MECHANISM.

FIGURE 29

LIP HAS BEEN ELIMINATED, AND REPLACED BY CUSHIONED CONTACT WITH THE DOOR STOP. THE ENERGY ABSORBED BY THIS CUSHION IS UTILIZED IN ACTUATING THE BOLT MOVEMENT. THIS OPERATING MECHANISM IS ILLUSTRATED IN FIG.28. IN PUSHING THE DOOR CLOSED, THE RUBBERIZED CUSHIONED PAD (A) IS DEPRESSED AGAINST THE STRIKE STOP (B) SO THAT IT ROTATES THE CENTER CAM (C). THIS MOVES THE BOLT (D) INTO THE STRIKE PLATE AT (E), HOLDING THE DOOR IN THE LOCKED POSITION UNTIL THE LATCH STOP (F) IS RELEASED BY MOVING THE HANDLE YOKE (G) IN THE DIRECTION OF THE ARROW. THUS AN AUTOMATIC DEAD-LOCKING FEATURE IS INCORPORATED WHICH INSURES AGAINST THE BOLT BEING PRIED BACK WHILE THE DOOR IS LOCKED. WHEN THE DOOR IS IN THE CLOSED POSITION AS IN FIG.29, MOVEMENT OF THE HANDLE AS INDICATED RELEASES THE LATCH STOP, ALLOWING THE SPRING TO RETURN THE BOLT TO THE NEUTRAL POSITION SO THAT THE FACE IS FLUSH WITH THE CASE. (FIG.28.) AS THE BOLT RETRACTS, THE YOKE WITH THE CUSHIONED PAD IS DRIVEN AGAINST THE DOOR STOP SO AS TO PUSH THE DOOR SLIGHTLY AJAR. THUS, WHEN APPROACHING THE DOOR WITH THE ARMS FULL, IT IS ONLY NECESSARY TO MOVE THE DOOR HANDLE TO CAUSE THE DOOR TO OPEN SUFFICIENTLY FOR IT TO BE PUSHED WITH THE FOOT.

IN ORDER TO LOCK THE DOOR FROM THE INSIDE, IT IS REQUIRED THAT THE OPPOSITE HANDLE BE PREVENTED FROM MOVEMENT. THIS




DETAILS OF MECHANISM
MOUNTED IN FRAME

FIGURE 30

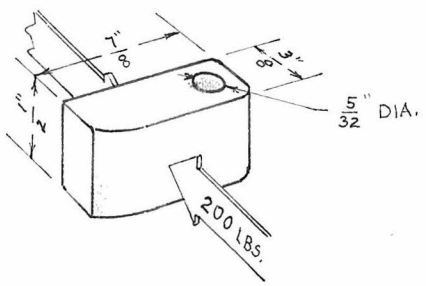
IS ACCOMPLISHED BY DEPRESSING THE BUTTON MOUNTED ON THE HANDLE WHICH IN TURN LOCKS THE HANDLE YOKE (G) TO THE CASE BY THE ACTION OF THE LOCKING LEVER (H). THE LOCKING ACTION IS THEREBY ACHIEVED AT THE SOURCE OF THE FORCE, RELIEVING THE SMALLER PARTS IN THE MECHANISM FROM THIS STRAIN. THE DOOR IS UNLOCKED AGAIN BY MOVING THE HANDLE ON THE CONTROL BUTTON INSIDE. THIS LOCK-CONTROL HANDLE MAY BE MOUNTED ON EITHER SIDE OF THE MECHANISM.

DETAILS OF DESIGN. EACH PART OF THE MECHANISM IS DESIGNED TO PERFORM ITS FUNCTION IN THE MINIMUM SPACE ESTABLISHED BY THE SHAPE OF THE NOTCH. SINCE THE INDIVIDUAL PARTS OF THIS LOCK ARE FEW AND SMALL, THERE EXISTS NO PROBLEM OF WEIGHT SUPPORT. THEREFORE THE CROSS-SECTIONAL AREA OF MOST OF THE PARTS IS AMPLE TO CARRY THE MOST EXTREME FORCES WHICH MIGHT BE ENCOUNTERED IN THE USE OF THE LOCK.

THE STRUCTURAL STRENGTH OF THE PARTS OF THIS MECHANISM IS TO BE EXAMINED AT SIX CRITICAL POINTS. THESE PARTS ARE DESIGNATED BY THE NUMBERS 1 THROUGH 6 IN THE WORKING DRAWINGS OF THE MECHANISM SHOWN IN FIG.30. EACH OF THESE IS CONSIDERED IN TURN AND THE MINIMUM SAFE SECTION IS CALCULATED USING A MAXIMUM LOAD OF 200 POUNDS AS THE ASSUMED FORCE.

PART I. THE PRIMARY PURPOSE OF THE DOOR LATCH IS TO RESIST MOVEMENT OF THE DOOR ON ITS HINGES BY THE SHEAR STRENGTH OF THE BOLT. THE BOLT IS MADE FROM SOLID BRASS BAR STOCK (MANGANESE BRONZE - 39% ZN, 1% SN). THE ULTIMATE SHEAR STRENGTH OF THIS MATERIAL IS 36,000 POUNDS PER SQUARE INCH. THE MINIMUM SECTION IS FOUND BY SUBSTITUTING THE VALUES IN THE EQUATION:

$$A_S = \frac{P_S}{S_S}$$




PART I - BOLT

WHERE $A_S$ = SECTIONAL AREA IN SQ. IN.
$P_S$ = FORCE ON SECTION IN LBS. = 200 LBS.
$S_S$ = SHEAR STRENGTH OF MATERIAL IN LBS./SQ.IN.= 8,000 LBS./SQ.IN. INCLUDING SAFETY FACTOR OF 3.

$$A_S = \frac{200}{8000} = \frac{1}{40} \text{ SQ. IN. OR } 0.025 \text{ SQ. IN.}$$

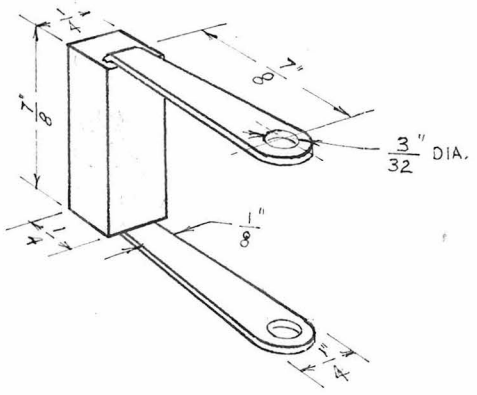
HOWEVER, FOR PURPOSES OF PROPORTION AND SCALE, THE BOLT IS MADE $\frac{1}{2}$X3/8 INCHES, SUFFICIENT TO CARRY A LOAD OF 6750 POUNDS IN SHEAR. TO PRODUCE THE BOLT IN QUANTITIES, THE BRASS BAR STOCK WOULD BEST BE CHUCKED IN A MULTIPLE SPINDLE AUTOMATIC LATHE, DRILLED, GROUND TO CONTOUR, AND CUT OFF IN SUCCESSIVE OPERATIONS.

PART 2. THE LEGS OF THE SHOCK-ABSORBER YOKE ACT ONLY IN COMPRESSION AS COLUMNS. THIS YOKE IS TO BE MADE OF COLD ROLLED STEEL WITH A COMPRESSION YIELD STRENGTH OF 45,000 POUNDS PER SQUARE INCH. EACH LEG SUPPORTS HALF THE LOAD, OR 100 POUNDS. THE SECTION REQUIRED TO SUPPORT THIS LOAD IS FOUND BY SUBSTITUTING IN THE EQUATION: $A_c = \frac{P_c}{S_c}$

WHERE: $A_c$ = SECTIONAL AREA IN SQ.IN.
$P_c$ = FORCE IN LBS./SQ.IN. = 100 LBS.
$S_c$ = COMPRESSIVE STRENGTH OF MATERIAL IN LBS./SQ.IN.= 15,000 LBS./SQ.IN. INCLUDING A SAFETY FACTOR OF 3

$$A_c = \frac{100}{15000} = 0.0066 \text{ SQ.IN.}$$

THEREFORE A MINIMUM SECTION OF 1/8x1/16 INCHES IS SUFFICIENT. THIS PIECE IS BLANKED AND PIERCED, THEN ZINC-PLATED. AT THIS POINT IT IS INSERTED INTO THE SLOT OF THE NEOPRENE EXTRUSION IN THE PRESENCE OF A NEOPRENE SOLVENT CEMENT. THEN THE LEGS ARE BENT IN A DIE TO FORM THE YOKE AS ILLUSTRATED.



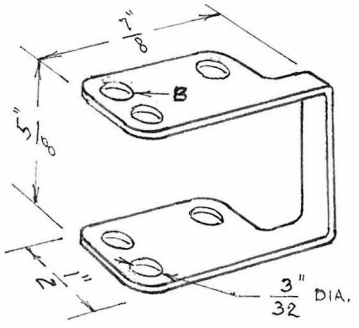

PART 2 - YOKE

PART 3. NO EXCEPTIONALLY CONCENTRATED FORCES OCCUR AT THE HOLES IN THE CENTER PIVOTING PIECE EXCEPT AT THE HOLE LABELED (B). THIS PART SERVES TO TRANSMIT THE MOTION OF THE CUSHIONED YOKE TO THE SLIDING BOLT, AND ALSO TO ENGAGE THE LATCH STOP, AND MUST RESIST ONLY A SLIGHT SPRING PRESSURE. THE MATERIAL FOR THIS PART IS ZINC-PLATED COLD ROLLED STEEL WITH AN ULTIMATE SHEAR STRENGTH OF 30,000 POUNDS PER SQUARE INCH. SUBSTITUTING AGAIN IN THE EQUATION: $A_s = \frac{P_s}{S_s}$

WHERE $A_s$ = SECTIONAL AREA IN SQ.IN.
$P_s$ = FORCE IN LBS./SQ.IN. = 100 LBS. AT EACH HOLE
$S_s$ = ULTIMATE SHEAR STRENGTH OF MATERIAL IN LBS./SQ.IN. = 10,000 LBS./SQ.IN. INCLUDING A SAFETY FACTOR OF 3.

$$A_s = \frac{100}{10000} = 0.010 \text{ SQ.IN.}$$

DIVIDING THIS MINIMUM AREA BETWEEN THE TWO SHEAR SECTIONS SURROUNDING EACH HOLE, IT IS FOUND THAT FOR 1/16 INCH SHEET STOCK, A MINIMUM OF 3/32 INCH OF MATERIAL MUST BE LEFT AROUND THE HOLES. THIS PART IS FABRICATED BY BLANKING AND PIERCING THE HOLES, THEN BENDING THE SIDES TO THE 90° ANGLE.




PART 3 - PIVOT

THE PINS CONNECTING THESE THREE PARTS ARE CHECKED TO DETERMINE THE MINIMUM DIAMETER NECESSARY TO SUPPORT THE LOAD. FOR THE SAKE OF EXPEDIENCY, THE PIN WHICH IS SUBJECT TO THE MOST CRITICAL LOADING IS SELECTED FOR ANALYSIS, WHICH ON OBSERVATION IS FOUND TO BE AT (B). BY DESIGNING FOR THIS PIN AND USING ONE STANDARD ROD SIZE FOR ALL THREE PINS, DUPLICATE PURCHASING AND HANDLING IN PRODUCTION IS ELIMINATED. THE GREATEST STRESS ON PIN (B) IS IN SHEAR, AND EACH OF THE OTHER PINS CARRIES A LOAD DIMINISHED BY THE LEVERAGE OF PART 3. THESE PINS ARE MADE FROM COLD ROLLED STAINLESS STEEL (18-8) ROD WHICH HAS AN ULTIMATE SHEAR STRENGTH OF 90,000 POUNDS PER SQUARE INCH. THE SECTIONAL AREA OF THE PIN REQUIRED TO CARRY THE FULL 200 POUND LOAD IS FOUND BY SUBSTITUTING IN THE EQUATION: $A_s = \frac{P_s}{S_s}$

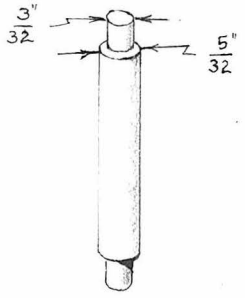
WHERE $A_s$ = AREA OF PIN IN SQ.IN.
$P_s$ = SHEAR FORCE IN LBS. = 100 LBS. AT EACH END
$S_s$ = ULTIMATE SHEAR STRENGTH OF MATERIAL IN LBS./SQ.IN. = 30,000 LBS./SQ.IN. INCLUDING A SAFETY FACTOR OF 3.

$$A_s = \frac{100}{30000} = 0.0033 \text{ SQ.IN.}$$

$$A = \frac{\pi D^2}{4} \qquad D = \sqrt{\frac{4A}{\pi}} = \sqrt{\frac{0.013}{\pi}} = 0.064 \text{ IN.}$$

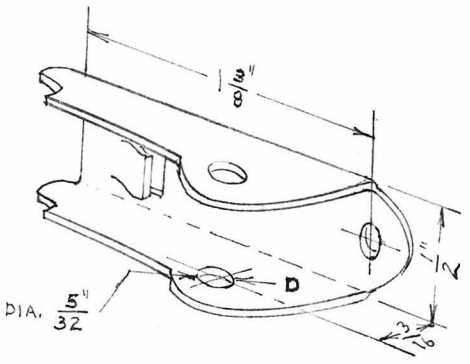
THEREFORE A 1/16 INCH DIAMETER PIN IS ADEQUATE FOR THE MAXIMUM LOADS INVOLVED. HOWEVER, AS AN ADDED PRECAUTION

AND ALSO FOR CHEAPER DIE COSTS, A DIAMETER OF 3/32 INCH IS USED. SINCE A SHOULDER ON THE PINS IS REQUIRED FOR SPACING THE PARTS IN ASSEMBLY, A 5/32 INCH ROD IS SELECTED TO BE TURNED DOWN AT THE ENDS TO THE 3/32 INCH DIMENSION. THESE PINS ARE MADE IN A MULTIPLE SPINDLE AUTOMATIC LATHE.



PIN

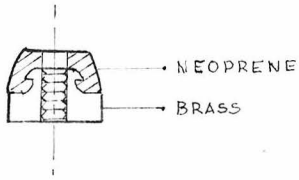
PART 4. THIS PART IS FORMED OF 1/16 INCH COLD ROLLED STEEL SHEET STOCK, BLANKED, PIERCED, THEN BENT TO THE CHANNEL SHAPE IN A DIE. SINCE THIS PIECE IS THEREFORE REINFORCED BY THE CHANNEL FLANGES, IT WILL RESIST BENDING UNDER THE MOST EXTREME LOADS APPLIED DIRECTLY THROUGH THE HANDLE, ESPECIALLY SINCE THE BENDING MOMENT ARM IS LESS THAN 1/4 INCH. THE PIN SUPPORTING THIS PIECE AT (D) IS USED IN THE FULL 5/32 INCH DIAMETER SINCE THIS PART OF THE LOCK IS SUBJECT TO IMPACT LOADING. THE PIECE IS



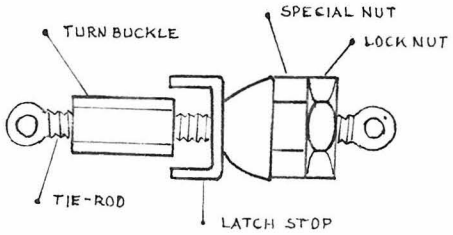
PART 4 - LATCH STOP

LOCATED BY SPACING WASHERS AND THE PIN HELD IN PLACE BY SWAGING THE ENDS. AS WITH THE OTHER PINS, 3/32 INCH MATERIAL IS LEFT AROUND THE HOLE.

PART 5. THE LATCH STOP, PART 4, IS RELEASED THROUGH THE ACTION OF THE SPECIAL NUT, PART 5. THIS NUT IS MADE OF HEXAGONAL BRASS BAR DRILLED AND TAPPED TO TAKE THE TIE-ROD AS SHOWN IN THE ACCOMPANYING ILLUSTRATION. THIS NUT INCLUDES A SPECIAL NEOPRENE FORM TO CUSHION THE CONTACT OF THE NUT AND THE END OF THE LATCH STOP THROUGH WHICH THE TIE-ROD PASSES. THIS NUT IS ADJUSTED TO THE PROPER OPERATING POSITION FOR EACH LOCK AS IT IS ASSEMBLED, AND IS SECURED BY A SIMPLE BRASS LOCK-NUT AS SHOWN IN THE ILLUSTRATION.



PART 5 - ACTUATING NUT



TIE-ROD ASSEMBLY

PART 6. THE TIE-ROD CONSISTS OF TWO SECTIONS OF THREADED BRASS ROD, ONE WITH THE CONVENTIONAL RIGHT-HAND THREAD, AND THE OTHER WITH THE LEFT-HAND THREAD. THIS IS FOR THE APPLICATION OF A TURN-BUCKLE AS SHOWN IN THE ILLUSTRATION ABOVE, TO PERMIT ADJUSTMENTS TO BE MADE ON THE POSITION

OF THE HANDLE FOR VARYING THICKNESSES OF DOORS. THE THREADS OF THIS NUT AND TIE-ROD MUST BE SUFFICIENT TO CARRY THE FULL IMPACT LOADS. SUBSTITUTING THE APPROPRIATE VALUES IN THE EQUATION: $A_s = \frac{P_s}{S_s}$

WHERE $A_s$ = AREA OF SECTION IN SQ.IN.
$P_s$ = FORCE IN LBS.
$S_s$ = ULTIMATE SHEAR STRENGTH OF BRASS ROD = 8,000 LBS./SQ.IN.

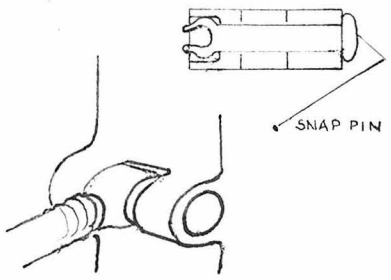
$$A_s = \frac{200}{8000} = 0.025 \text{ SQ.IN.}$$

$A = \pi CH$ WHERE C IS THE ROOT DIAMETER OF THE THREADS
H IS THE HEIGHT OF THE NUT

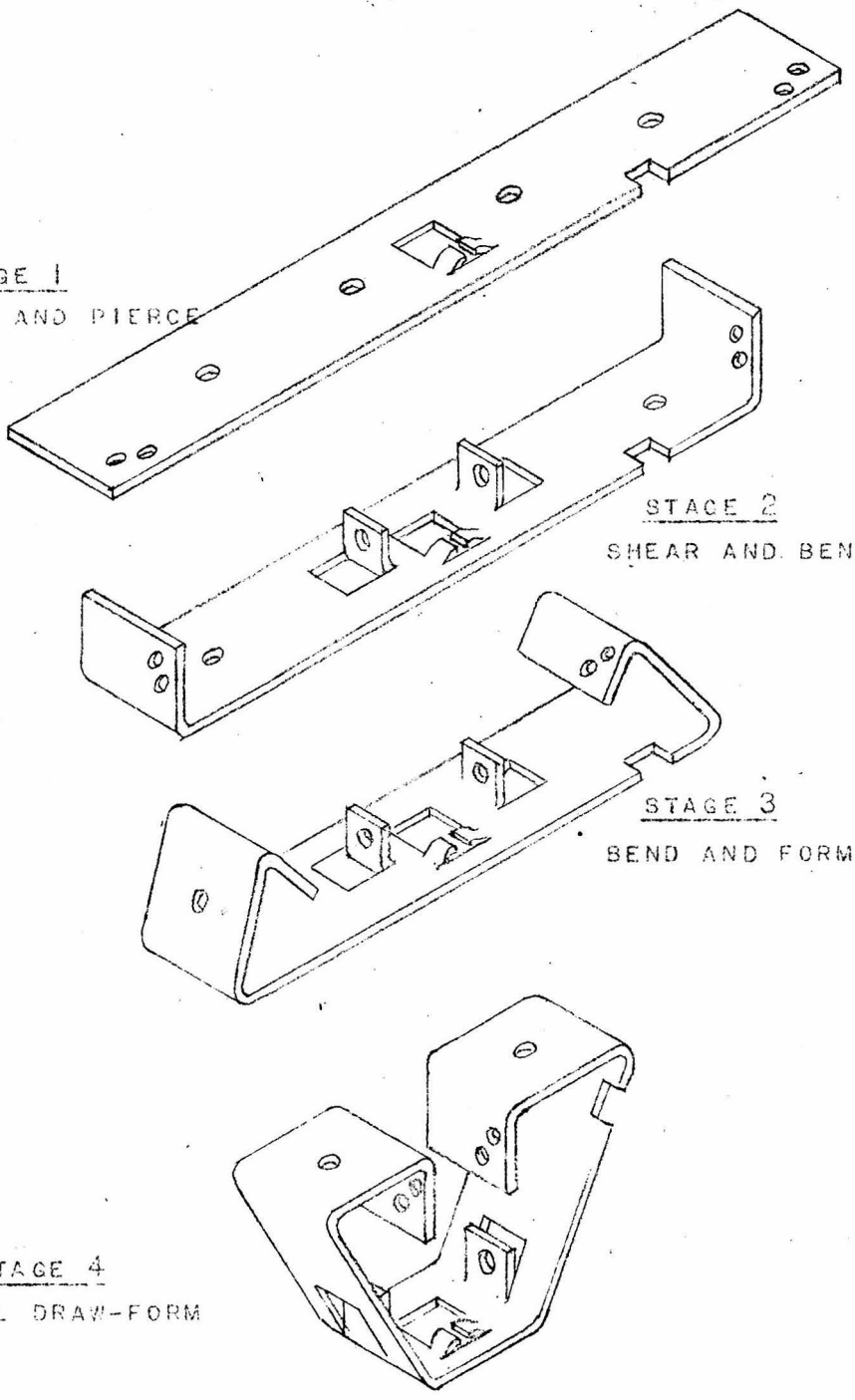
$$H = \frac{0.025}{\pi 5/32} = 0.050 \text{ IN.}$$

THEREFORE A 1/16 INCH NUT IS SUFFICIENT. THE SPECIAL ACTUATING NUT IS 1/8 INCH HIGH. THE TURN-BUCKLE IS $\frac{1}{2}$ INCH LONG AND ALLOWS FOR ADJUSTMENTS UP TO 3/8 INCH. FOR SPECIAL INSTALLATION ON DOORS OVER $1\frac{1}{2}$ INCHES THICK, A LONGER TURN-BUCKLE WILL BE SUPPLIED.

CONNECTION BETWEEN THE TIE-ROD AND THE HANDLE IS MADE AS SHOWN IN THE ACCOMPANYING ILLUSTRATION. THE END OF THIS THREADED ROD IS COLD-FORGED TO FORM A FLAT EAR $\frac{1}{4}$ INCH IN DIAMETER. THE EAR IS DRILLED TO TAKE A 5/32 INCH PIN WHICH PASSES THROUGH THE LUGS ON THE HANDLE. THIS PIN IS CALCULATED



HANDLE CONNECTION



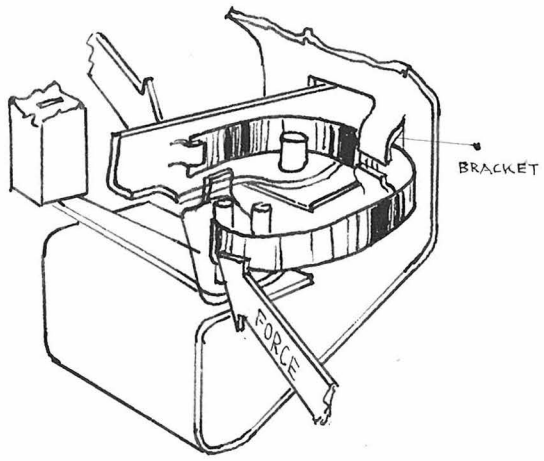

BREAKDOWN OF STAGES FOR FORMING FRAME

FIGURE 31

TO CARRY A LOAD OF 150 POUNDS IN SHEAR, OR 300 POUNDS FOR THE CONNECTION, THUS SERVING AS A SHEAR PIN FOR THE MECHANISM. WHERE EXCESSIVE LOADS MIGHT OTHERWISE DAMAGE THE PARTS WITHIN THE FRAME, THIS PIN WILL FAIL FIRST AND IS READILY REPLACED.

MECHANISM FRAME. THE FRAME TO WHICH THE PARTS OF THE MECHANISM ARE ASSEMBLED IS FORMED BY BLANKING AND PIERCING COLD ROLLED STRIP STEEL, $1\frac{1}{4}$ INCHES WIDE. IT IS THEN BENT TO THE REQUIRED SHAPE IN SUCCESSIVE STAGES OF A PROGRESSIVE DIE. THE FOUR STAGES ARE ILLUSTRATED IN FIG.31. THIS STRIP IS 0.051 INCH THICK, A STANDARD GAUGE WHICH IS STRONG AND RIGID, AND YET EASILY FORMED IN LOW PRESSURE DIES.

SPRING. A LIGHT SPRING PRESSURE IS REQUIRED IN TWO PLACES FOR THE OPERATION OF THIS MECHANISM. A SINGLE SPRING CAN ACCOMPLISH THE PRESSURE AT BOTH POINTS AS ILLUSTRATED. THIS SPRING IS MOUNTED TO THE CASE BY INSERTING THE STRAIGHT END THROUGH THE BRACKET STAMPED INTO THE FRAME AS SHOWN IN THE




SPRING

DRAWING. THE SPRING IS TO BE MADE OF PHOSPHOR BRONZE, SAE STD. NO. 77, GRADE B HARD TEMPER,[26] WHICH HAS A TENSILE STRENGTH OF 85,000 POUNDS PER SQUARE INCH. BY SUBSTITUTING IN THE EQUATION FOR STRIP SPRINGS[27]

$$W=\frac{SBT^2}{6P}$$

WHERE W= SAFE LOAD
S= TENSILE STRENGTH OF MATERIAL IN LBS./SQ.IN.= 85,000 LBS./SQ.IN.
B= WIDTH OF THE STRIP = $\frac{1}{4}$ IN.
T= THICKNESS OF STRIP
P= DEPTH OF FLEXURE = 1 IN.

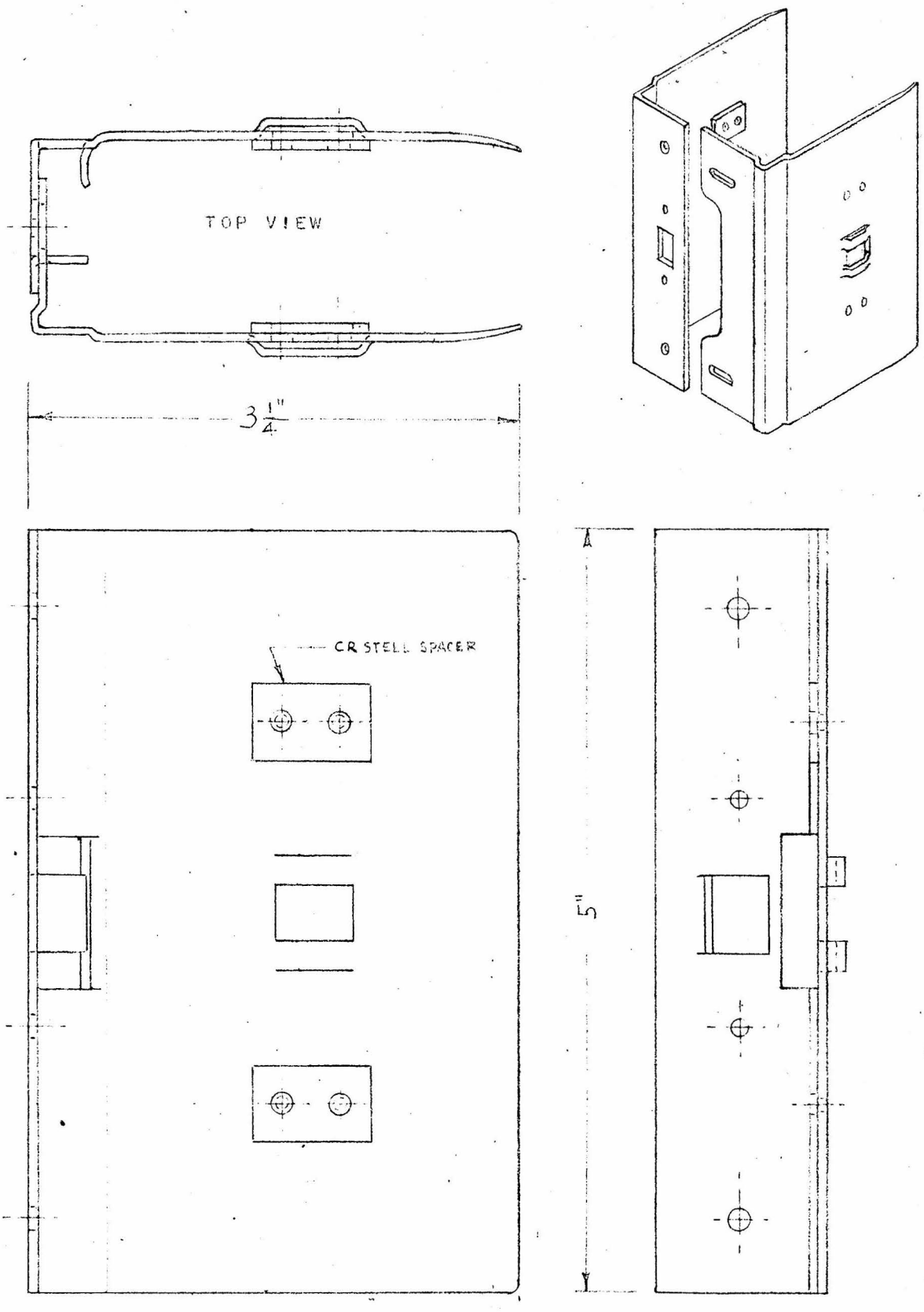
SINCE THE SPRING IS TO RESIST NO GREAT WEIGHT, BUT MERELY TO PIVOT THE PARTS ON THEIR PINS, A WEIGHT OF 1 POUND IS CONSIDERED SUFFICIENT. THEREFORE THE EQUATION IS SET UP TO SOLVE FOR THE THICKNESS OF THE SPRING:

$$T = \frac{W6P}{SB} = \frac{1(6)1}{85,000(\frac{1}{4})} = \frac{6}{21,250} = 0.017 \text{ IN.}$$

A THICKNESS OF 0.020 INCHES (B&S GAUGE 24) WILL GIVE THE DESIRED RESULTS. TO CHECK THE MAXIMUM ALLOWABLE FLEXURE, VALUES ARE SUBSTITUTED IN THE FOLLOWING EQUATION: $F=\frac{3SP^2}{ET}$

WHERE F= FLEXURE IN INCHES
S= TENSILE STRENGTH OF MATERIAL IN LBS./SQ.IN. OR 85,000 LBS./SQ.IN.
P= DEPTH OF LENGTH OF COIL IN INCHES
E= MODULUS OF ELASTICITY IN LBS./SQ.IN. OR 20,000,000 LBS./SQ.IN.
T= THICKNESS OF SPRING IN INCHES.

$$F = \frac{3(85,000)1}{20,000,000(0.030)} = \frac{255,000}{600,000} \text{ OR } 7/16 \text{ IN.}$$




DETAILS OF CASE

FIGURE 32

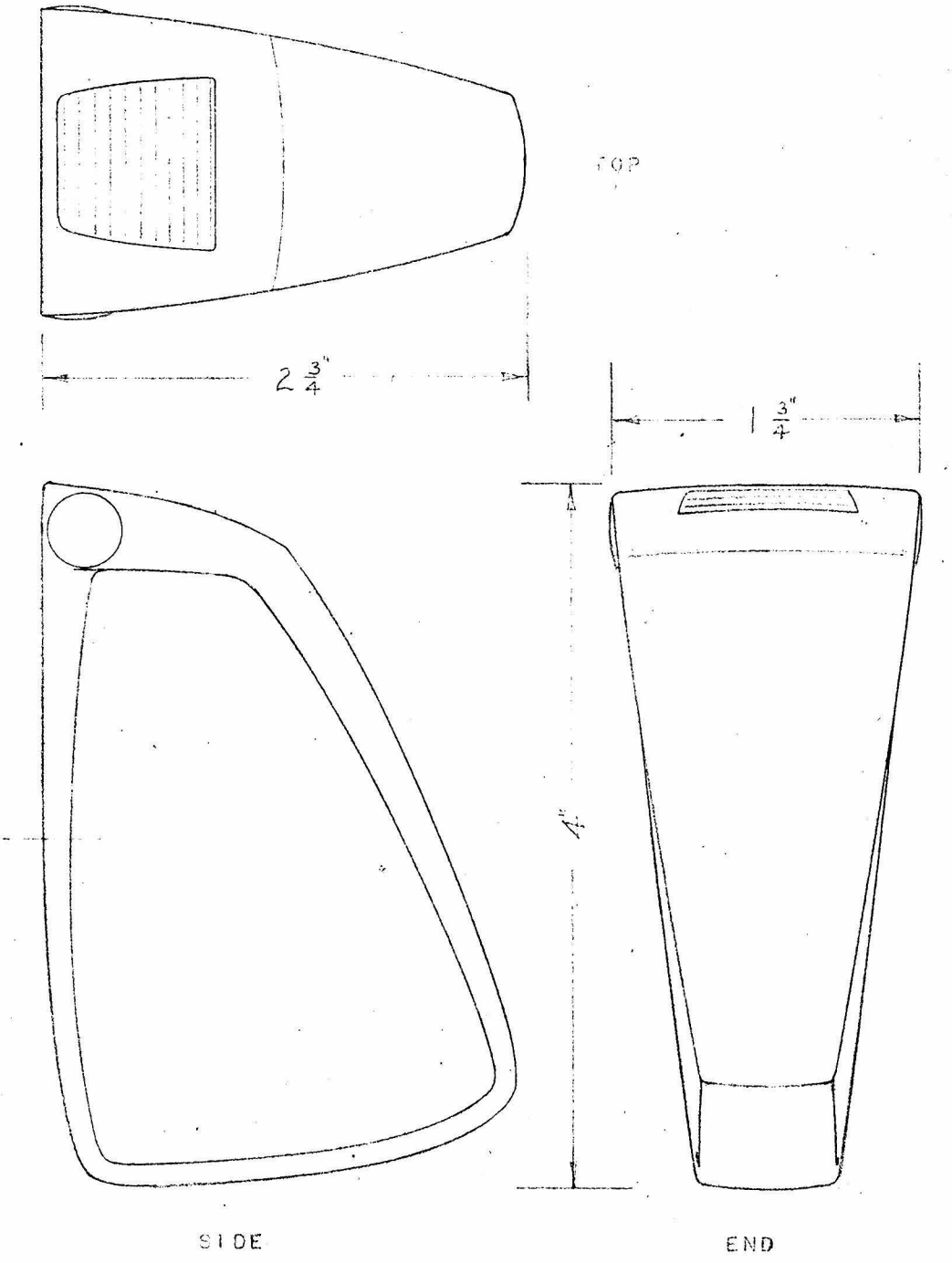
SINCE THE COMBINED MOVEMENT OF THE TWO PARTS ON WHICH THIS SPRING BEARS IS LESS THAN 3/8 INCH, THE SIZE SELECTED FOR THIS SPRING ANSWERS THE NEED.

FOR ASSEMBLY, THESE PARTS ARE PUT IN A JIG AND THE FRAME PRESSED INTO THE FINAL V-SHAPE TO INCLUDE THEM. THEN THE ENDS OF THE PINS ARE SWAGED.

CASE

THE CASE IS FORMED OF TWO ANGLE PLATES WHICH ARE JOINED AT THE FACE BY SCREWS THROUGH THE EDGE OF THE DOOR. THE SIDES OF THE CASE ARE HELD IN PLACE BY THE HANDLE HINGE BUTT WHICH IS SCREWED TO THE DOOR. THE FRAME CONTAINING THE MECHANISM IS FASTENED TO THE NON-ADJUSTING HALF OF THE CASE WITH TWO PHILLIPS HEAD SCREWS SO THAT THE PARTS MAY BE REMOVED IN THE EVENT OF REPAIRS. THE OTHER HALF OF THE CASE IS ADJUSTABLE TO VARIABLE DOOR THICKNESS BY THE INCORPORATION OF A SLOTTED, OVERLAPPING FLANGE. DETAILED DRAWINGS OF THE CASE ARE SHOWN IN FIG.32, INCLUDING THE PHANTOM OUTLINE OF THE MECHANISM.

DETAILS OF DESIGN. THE CASE IS TO BE FORMED BY BLANKING, PIERCING, AND BENDING IN SUCCESSIVE OPERATIONS THE 0.051 INCH SHEET METAL. THE FINAL OPERATION IS TO DIE-STAMP THE SIDES TO FORM A SLIGHT CONTOUR FOR STIFFNESS, AND TO ROUND AND TRIM THE EDGES FOR A MORE FINISHED APPEARANCE.




DETAILS OF HANDLE

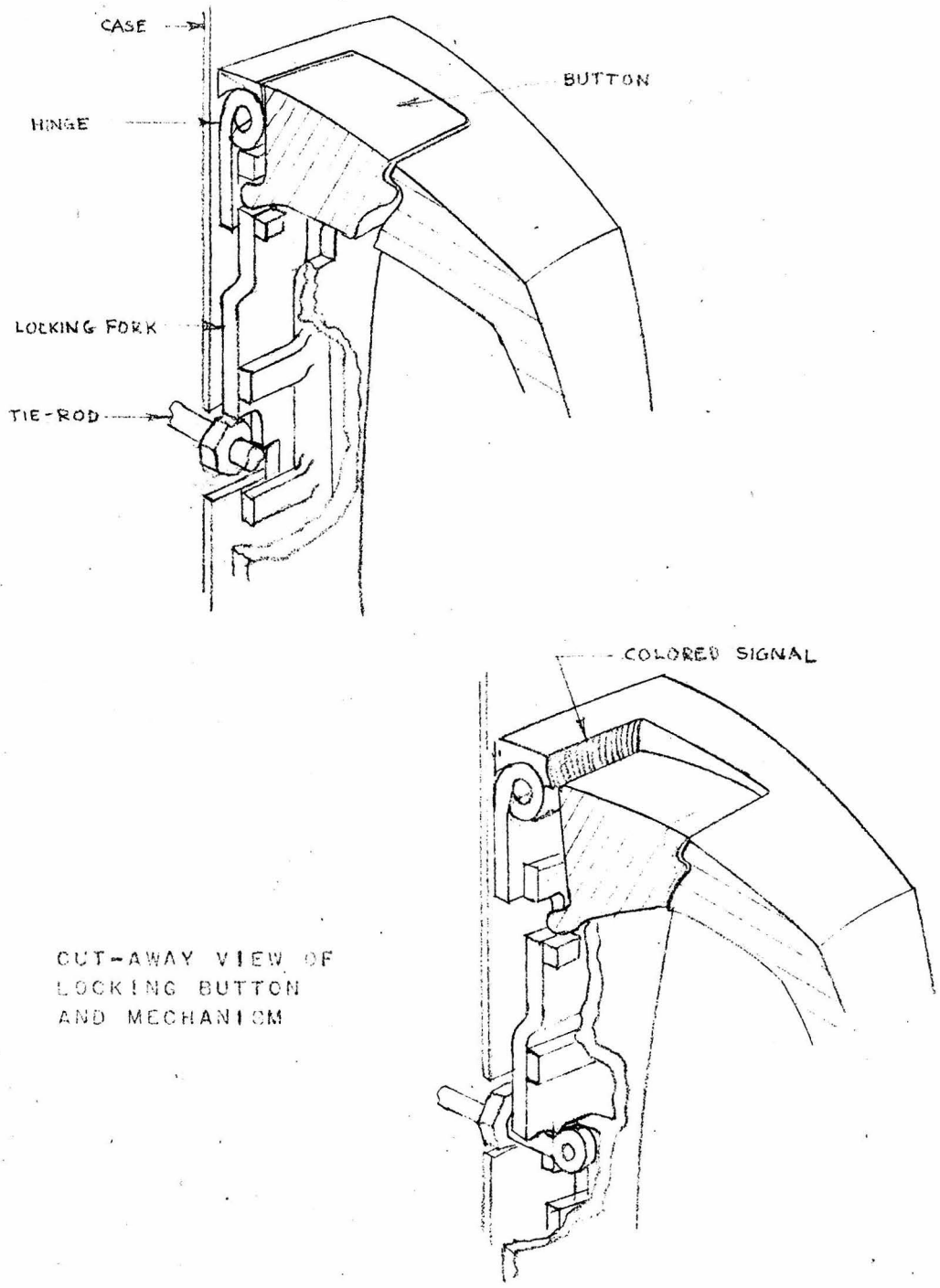
FIGURE 33

THE MATERIAL FROM WHICH THE CASE IS MADE IS ONE OF A CHOICE OF THREE: MONEL METAL, ALUMINUM BRONZE, AND ALUMINUM ALLOY 61S-T4, WHICH IS PARTICULARLY SUITABLE FOR ANODIZED FINISH. THE STRENGTH AND MACHINABILITY OF EACH OF THESE METALS IS DETERMINED UNDER THE DISCUSSION OF MATERIALS AND PROCESSES (PAGE 53).

HANDLE

OPERATION. TO ACHIEVE THE PUSH-PULL OPERATION REQUIRED, THE HANDLE IS SHAPED AS ILLUSTRATED IN FIG.33, AND IS HINGED TO THE CASE AT THE TOP. THIS PERMITS COMPLETE CONTROL OVER THE MOVEMENT OF THE DOOR AND THE MECHANISM. THE SEPARATE HINGE BUTT IS SCREWED INTO THE DOOR SO AS TO AFFORD A FIRM CONNECTION FOR THE HANDLE, WHICH IS FASTENED TO THE BUTT WITH A SNAP-SPRING PIN AS SHOWN IN FIG.33. ONE OF THE TWO HANDLES IS EQUIPPED WITH A LOCKING BUTTON AND FORK (SEE FIG.34) WHICH LOCKS THE TIE-ROD TO THE CASE. BY DEPRESSING THE BUTTON, THE FORK SLIDES DOWN TO BLOCK THE MOVEMENT OF THE HANDLES. THE LOCK IS RELEASED BY LIFTING THE BUTTON FROM THE UNDERSIDE OF THE HANDLE GRIP. THE BUTTON IS NORMALLY HELD IN THE UP POSITION BY THE FRICTION LEAF-SPRING LOCATED AT THE HINGE.

FOUR MATERIALS ARE SUGGESTED FOR THE CONSTRUCTION OF THE HANDLE. TWO OF THESE ARE CLEAR PHENOLIC AND POLYSTYRENE




CUT-AWAY VIEW OF LOCKING BUTTON AND MECHANISM

FIGURE 34

PLASTICS. THESE MATERIALS ARE SUBJECT TO CAREFUL COLOR CONTROL THROUGH THE ADDITION OF APPROPRIATE DIES. THE DETERMINATION OF THE PRECISE COLORS IS BEYOND THE SCOPE OF THIS THESIS, SINCE SUCH CONTROL DEPENDS ON THE COLOR TASTES OF THE COMMUNITY IN WHICH THE LOCKS ARE TO BE MARKETED. THE COLORS WOULD NECESSARILY BE ARRIVED AT THROUGH EXTENSIVE EXPERIMENT IN THE LABORATORY. THE FUNCTION OF THE PLASTIC IN THE HANDLE IS NOT TO BEAR ANY CONCENTRATED STRESS, BUT RATHER TO ADD A COMFORTABLE AND SMOOTH TEXTURE TO THE GRIP AS WELL AS A TOUCH OF COLOR. THE PLASTIC MATERIAL IS INJECTION-MOLDED AROUND A CAST ALUMINUM CORE WHICH IS DESIGNED TO CARRY THE LOAD.

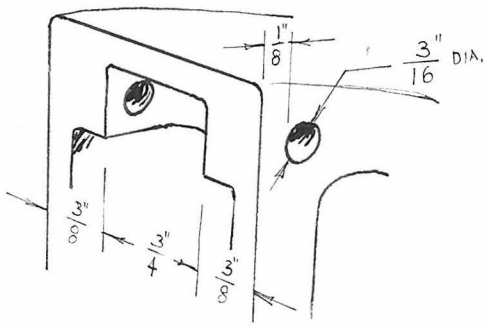
A CAST ALUMINUM ALLOY WITH 3.8% MAGNESIUM (SAE STD. NO. 320, TYPE I - ALCOA A 214) IS DESIGNATED FOR THE CONSTRUCTION OF THE HANDLE SINCE THIS ALLOY IS PARTICULARLY SUITABLE FOR ANODIZED FINISH. THE TENSILE STRENGTH OF THIS MATERIAL IS 22,000 POUNDS PER SQUARE INCH AND THE ULTIMATE SHEAR STRENGTH IS 18,000 POUNDS PER SQUARE INCH. THE ALTERNATE MATERIAL, CAST ALUMINUM BRONZE (SAE STD. NO. 68, GRADE A), HAS A TENSILE STRENGTH OF 76,000 POUNDS PER SQUARE INCH, WHICH IS FAR IN EXCESS OF THE STRUCTURAL NEEDS, BUT THIS MATERIAL IS SELECTED FOR ITS APPEARANCE AND LOW COST.

DETAILS OF DESIGN. SINCE THE CAST ALUMINUM ALLOY HAS THE LOWER STRENGTH VALUES OF THE TWO METALS SPECIFIED, THE CALCULATIONS ARE BASED ON THE STRENGTH OF THIS MATERIAL. TO BE MOST COMFORTABLE, A WELL-DESIGNED HANDLE INVOLVES MINIMUM SECTIONS LARGER THAN IS REQUIRED FOR STRUCTURAL PURPOSES. HOWEVER, THE SECTIONS OF THIS HANDLE ARE CHECKED AT THREE CRITICAL POINTS. THESE ARE AT THE TOP HINGE CONNECTION, AT THE CENTRAL OPERATION LUG CONNECTION, AND AT THE MINIMUM SECTION OF THE HAND GRIP. AT THE TWO PIN CONNECTIONS, THE MOST SEVERE STRESS OCCURS IN SHEAR, AND THE MINIMUM ALLOWABLE SECTION AT THESE TWO POINTS IS FOUND BY SUBSTITUTING THE VALUES IN THE EQUATION: $A_s = \frac{P_s}{S_s}$

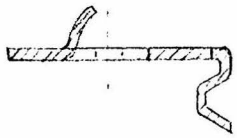
WHERE $A_s$ = AREA IN SQ.IN.
$P_s$ = FORCE IN LBS./SQ.IN. = 200 LBS./SQ.IN.
$S_s$ = ULTIMATE SHEAR STRENGTH OF THE MATERIAL IN LBS./SQ.IN. = 6000 LBS./SQ.IN. INCLUDING A SAFETY FACTOR OF 3.

$$A_s = \frac{200}{6000} = 0.033 \text{ SQ.IN.}$$

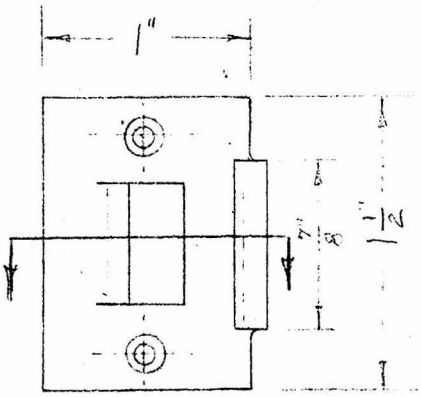
THEREFORE THE MINIMUM SECTION AT EITHER POINT SHOULD BE NOT LESS THAN 1/32 SQUARE INCH. THIS MINIMUM IS EASILY MET IN THE DESIGN OF THE CONNECTIONS AS SHOWN IN THE ACCOMPANYING



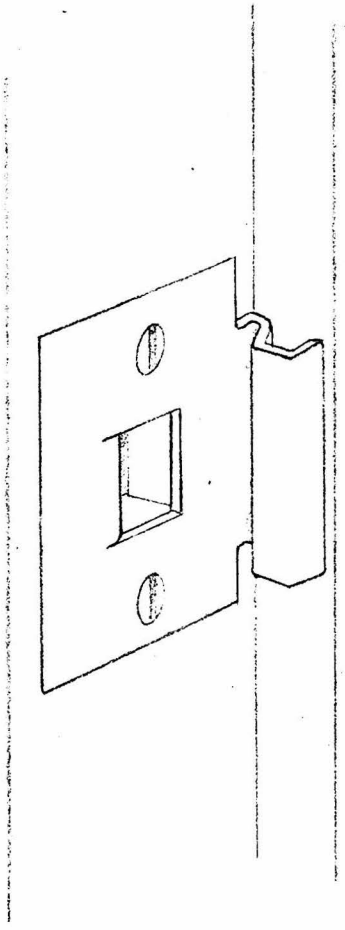

PIN CONNECTION



SECTION FROM TOP




ELEVATION



MOUNTED ON JAMB-POST

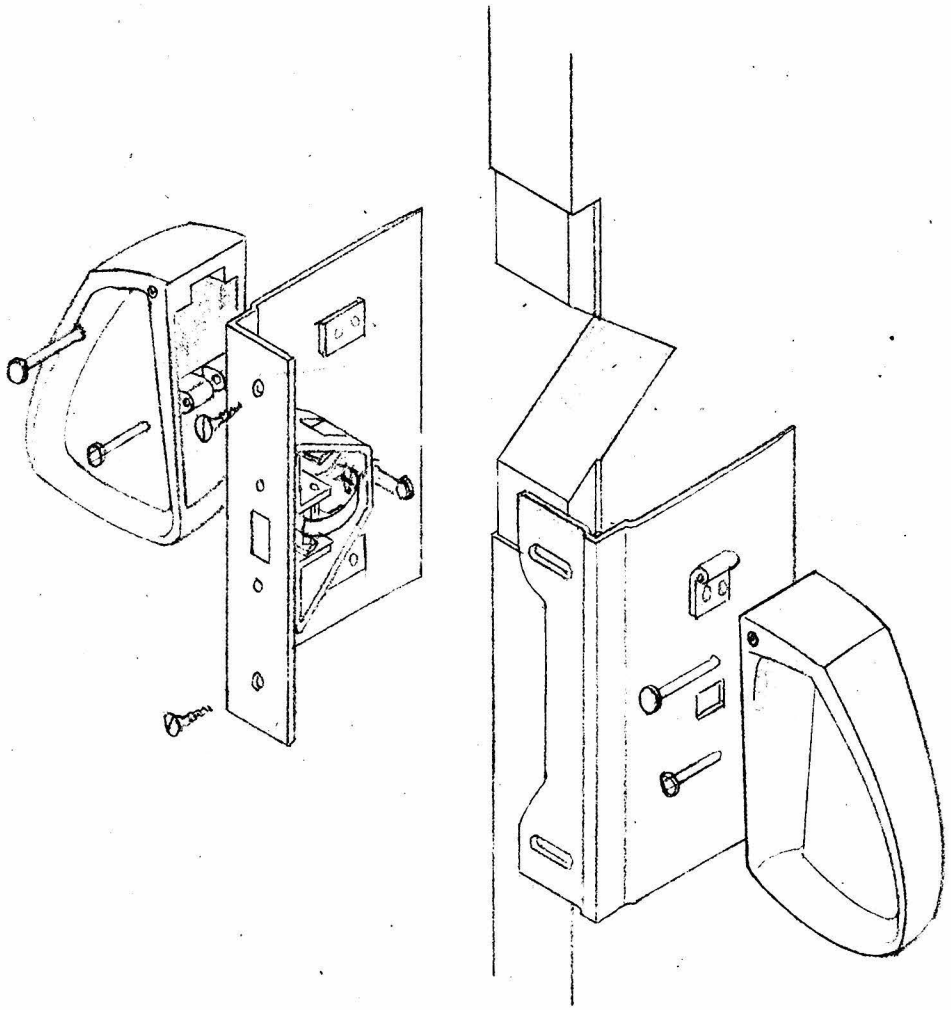
DETAILS OF STRIKE-PLATE

FIGURE 35

ILLUSTRATION. FOR USE WITH THE PLASTIC-COVERED HANDLES, THE CAST ALUMINUM CORE HAS THE IDENTICAL PIN CONNECTIONS AS THE SOLID METAL HANDLE. THE CORE TAKES THE FORM OF A STRAP WITH A MINIMUM SECTION 1/8 INCH THICK BY 3/8 INCH WIDE, WHICH WILL SAFELY RESIST A FORCE IN TENSION OF 328 POUNDS (SAFETY FACTOR 3). THIS FIGURE DOES NOT INCLUDE THE SUPPORT RENDERED BY THE PLASTIC MOLDING, SO THAT THE TENSILE STRENGTH OF THE HANDLE AT THIS MINIMUM SECTION IS SUFFICIENT TO CARRY THE GREATEST FORCES ANTICIPATED.

## STRIKE PLATE

THE STRIKE PLATE IS FORMED OF STAMPED SHEET METAL WHICH TAKES THE SHAPE SHOWN IN FIG.35. THE MATERIAL FOR THIS PART IS THE SAME AS FOR THE LOCK CASE, FOR UNIFORMITY AS WELL AS ECONOMY IN PRODUCTION. THIS PIECE IS NOT SUBJECT TO THE IMPACT AND WEAR FROM CONTACT WITH THE BOLT, FOR THE BOLT ONLY ENGAGES THE EDGE OF THE STRIKE BOX. THEREFORE NO PROTRUDING LIP IS REQUIRED. THE METAL THICKNESS IS 0.051 INCH AND THE SECTIONS SUBJECT TO SHEAR STRESSES ARE AMPLE FOR THE FORCES INVOLVED. THIS PIECE IS MADE BY BLANKING AND PIERCING, THEN FORMING THE ANGLE STOP IN A DIE PRESS. THE SCREW HOLES ARE COUNTERSUNK FOR A FLUSH FASTENING. THE METAL AT THE EDGE OF THE STRIKE BOX IS TURNED BACK TO SERVE AS ADDED SUPPORT FOR THE BOLT.



BLOW-UP OF OVER-ALL ASSEMBLY AS IT IS INSTALLED IN THE DOOR

FIGURE 36

INSTALLATION

IN FIG.36 A BLOWN-UP VIEW OF THE PARTS OF THE LOCKSET ARE SHOWN IN THEIR PROPER RELATIONSHIP. THE STEPS BY WHICH THE FINISHED LOCK IS PROPERLY INSTALLED IN THE DOOR ARE TWELVE IN NUMBER. THIS INCLUDES ALL THE MARKING OFF, ADJUSTING, AND ASSEMBLING, AS FOLLOWS:

1. V-NOTCH IS LAID OUT ON DOOR AND CUT WITH A SAW.
2. LOCK IS PLACED IN POSITION IN THE V-NOTCH AND THE OUTLINE OF THE CASE IS MARKED OFF.
3. RECESS IS CUT 1/16 INCH DEEP WITH A CHISEL.
4. OPERATING TIE-ROD IS ADJUSTED TO THE THICKNESS OF THE DOOR BY MEANS OF THE TURN-BUCKLE.
5. CASE IS SLIPPED INTO PLACE IN THE DOOR, THE TWO SIDES DRAWN TOGETHER AND SCREWED TO THE EDGE OF THE DOOR.
6. HINGE BUTTS ARE SCREWED THROUGH THE CASE INTO THE DOOR.
7. HANDLES ARE MOUNTED ON THE HINGES WITH THE SNAP PINS.
8. LOCK FORK IS SLIPPED INTO ITS BRACKET AND THE BUTTON SNAPPED INTO PLACE IN THE HANDLE.
9. PINS CONNECTING THE HANDLES TO THE OPERATING TIE-RODS ARE SNAPPED INTO PLACE.
10. POSITION OF THE BOLT IS MARKED IN THE JAMB AND THE SHAPE OF THE STRIKE PLATE SCRIBED.

11. The recess is cut out with a chisel for the strike plate.

12. The strike plate is screwed into place.

## CONCLUSION

Each part of the lockset has been described as to its function and construction. The detailed structural analysis has been limited to those few parts which are considered to involve critical stress concentrations. It is anticipated that in the course of setting up this lockset for mass production, many materials and processes specified would be subject to changes in order to conform to particular plant practices.

## EVALUATION OF DESIGN

THE PROCEDURE OF THIS THESIS WAS TO CONSIDER AND ANALYZE ALL THE FACTORS WHICH ENTER INTO THE DESIGN OF A DOOR LOCK, AND FROM THESE CONCLUSIONS DEVISE A PRODUCT WHICH WOULD MEET ALL THE REQUIREMENTS INVOLVED. IN THE COURSE OF THIS PROBLEM IT HAS BEEN FOUND NECESSARY TO DEVIATE CONSIDERABLY FROM THE CONCEIVED IDEAL. FOR INSTANCE, THE SIMPLE V-NOTCH IS MODIFIED TO INCLUDE A CHISELED RECESS IN ORDER THAT THE CASE BE FLUSH WITH THE DOOR, AND TO ACHIEVE FULL REVERSIBILITY OF THE ENTIRE LOCK IT IS NECESSARY TO INVERT THE POSITION OF THE HANDLE ON THE CASE. IT IS FELT, HOWEVER, THAT THE DESIGN AS IT HAS EVOLVED WILL SERVE AS A CREDITABLE NUCLEUS FOR FURTHER DEVELOPMENT. EVERY PRODUCT ON THE MARKET TODAY WAS ORIGINALLY LAUNCHED AS A NEW AND IMPERFECT IDEA, AND YEAR AFTER YEAR ALTERATIONS AND IMPROVEMENTS HAVE BEEN MADE ON THE SUGGESTIONS OF CUSTOMERS, SALESMEN, PRODUCTION WORKERS AND ENGINEERS ALIKE. THE DESIGN OF THIS LOCKSET IS LEFT IN ITS PRESENT FORM WITH THE ASSURANCE THAT CONTEMPLATION BY OTHER MINDS OF THE PRINCIPLES OF OPERATION SET FORTH MAY RESULT EVENTUALLY IN A PERFECTED ARTICLE.

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