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RESULTS OF A SURVEY OF ELEVATOR INTERLOCKS AND AN ANALYSIS OF ELEVATOR ACCIDENT STATISTICS

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RESULTS OF A SURVEY OF ELEVATOR INTERLOCKS AND AN ANALYSIS OF ELEVATOR ACCIDENT STATISTICS

By C. E. Oakes and J. A. Dickinson

ABSTRACT

This report gives the results of a field survey of several thousand elevator landings equipped with various types of mechanical and electromechanical interlocks and contact devices. The survey was conducted in connection with the preparation of an elevator safety code, in which work the Bureau of Standards engineers have cooperated with engineers of the American Society of Mechanical Engineers. The elevators are classified: A, Elevators in buildings having heavy service and where maintenance service is provided; B, elevators located in buildings where the service is heavy but without maintenance; and C, elevators on which the service is light and for which no maintenance service is provided. The statistics show that 73.8 per cent of all fatal accidents might be prevented by well-designed interlocks.

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I. INTRODUCTION

During the European War the Bureau of Standards cooperated with the Federal safety engineers in preparing elevator rules, intended primarily for the use of Government navy yards, arse-

nals, and explosive plants. The code was based on existing regulations as prepared by various States and municipalities, together with suggestions from elevator manufacturers and safety engineers. This work was completed in the spring of 1918. Following the completion of this code the Bureau was requested to revise the Federal code to render it suitable for general application.

The American Society of Mechanical Engineers published an elevator code in 1917, which was prepared by the subcommittee on the protection of industrial workers. A complete revision of this code was undertaken a few months after its publication. In order to avoid duplication of effort, the Bureau in 1918, at the invitation of the American Society of Mechanical Engineers, began to cooperate in the further development of this code. The Bureau placed the data it had collected at the disposal of the American Society of Mechanical Engineers' committee and later, in 1919, abandoned all idea of separate development and publication of an elevator safety code, but continued to cooperate with the A. S. M. E. committee with the idea of developing a single national code.

Early in the work it became evident that the point of greatest controversy was the question of proper hoistway-door protection. The Bureau of Standards decided to make a field survey of the various types of interlocks and contacts in use and did so in 1918 and 1919. The results were submitted to the committee for its use in drafting the portion of the code dealing with such devices.

This paper gives the final results of the survey and a collection of statistics from other sources which have been classified and arranged to show the relation of accidents to hoistway-door protection.

II. REPORT ON A FIELD SURVEY OF ELEVATOR INTERLOCKS AND CONTACTS

In the preparation of a safety code of any kind the need for reliable data upon which to base the various requirements is self-evident.

There are certain hazards which are obviously apparent. It may be, however, that hazards of a far graver nature exist which are not apparent to a person making a casual survey of the industry. Ofttimes these less apparent hazards prove to be more serious than those readily apparent. A careful study of accident statistics taken from as large a number of sources as possi-

ble will indicate in a general way the particular parts or types of machines responsible for the more serious accidents.

A summary of the accidents given in the appended tables will show that by far the larger portion of elevator accidents occur at the hoistway door. The question, therefore, of the best method of reducing this hazard is one to which considerable study has been given.

1. HOISTWAY-DOOR PROTECTIVE DEVICES

All forms of hoistway-door protective devices may be broadly classified in three divisions, according to the method of locking the car and the hoistway door.

THE MECHANICAL TYPE.—This type of door safety depends on mechanical action to lock the car-control mechanism while the door is open and to hold the door in the locked position when the car is not at the landing. The functions of this device are generally as follows: (*a*) Release of hoistway door, (*b*) locking control mechanism, (*c*) release of control mechanism, and (*d*) locking of hoistway door.

In most types the locking of the hoistway door is accomplished by holding locked, either by means of a very substantial latch or a properly shaped slot in a rotating member, a bar fastened rigidly to the hoistway door. Generally, the door-locking mechanism is substantial in construction and will stand a large amount of wear without loss of function. Mechanisms which do not depend entirely on spring action to hold the door locked are preferable.

The methods of interlocking the car and door are varied. A variety of methods are necessary, owing to the large number of different types of control mechanism used on different makes and types of elevators. Two popular styles in use are (*a*) a slotted flap which upon the opening of the landing door drops from a vertical to a horizontal position, the slot engaging and holding inoperative the car-control lever in the neutral position; (*b*) a device in which an arc of a circle properly slotted is fastened to the control lever. A bolt or rod engages in this slot, thus preventing the motion of the operating lever when the lever is in the neutral position and the car door open. As a rule these devices are satisfactory. Occasionally, however, installations are found in which there is too much lost motion, and in certain hydraulic installations it is possible to start the car very slowly, due to the slight motion allowed on the control lever when the

car is in the "locked" position. This objection does not ordinarily hold true in case of electrically controlled elevators, as the operating lever must move through an appreciable arc before the operating circuit is completed, although in controllers with a number of contact steps the first contact may be so close to the "stop" position that cases have been noted in which the car may be moved slowly with the interlocking mechanism in the "locked" position. As installed at the present time, a great many of these devices have accessible metal parts in the car, the removal or blocking of which may render the device inoperative. Such parts as are located within the car should be inclosed.

One of the features generally incorporated in this type of lock is some form of limiting device which will prevent the opening of the hoistway door except when the car is within 3 or 4 inches of the landing at which the stop is to be made.

The inclusion of a landing range in an interlock device is not a necessary adjunct to the interlocking function. It is a mechanical detail which is inherent in certain types of devices where interlocking is secured by mechanical means. The absence of a landing range detracts in no way from the proper functioning of a well-designed interlock. The use of a device of this kind is intended to lessen the number of accidents due to persons tripping on entering or leaving the car. Such accidents are, however, relatively unimportant, the minor nature of these accidents being emphasized by the fact that statistics concerning them are not generally recorded separately.

At the request of the Bureau of Standards a list of tripping accidents was prepared by one of the largest casualty insurance companies, the list including all tripping accidents occurring on elevators insured by them during the year 1919. An analysis of this list shows that more tripping accidents occurred when the car platform was within 3 inches of the landing level than occurred when the car platform was more than 3 inches away. In other words, a 3-inch stopping range would not have prevented the majority of these accidents. The consideration of a more or less parallel case may be of interest: A person frequently trips over a projection in a sidewalk where the difference of elevation is slight, but almost never trips over a curbstone where the difference of elevation is considerable. It appears that threshold illumination is an important consideration in preventing tripping accidents and should be given careful attention, if such accidents are to be avoided.

Leveling devices, both automatic and manually controlled, are now on the market and can be used on either passenger or freight elevators. These devices bring the car flush with the landing, and in the case of the automatic device maintain it there during loading and unloading and are doubtless the most effective devices available for decreasing accidents from tripping.

ELECTROMECHANICAL.—The second broad division into which door safety devices may be placed is the electromechanical type, in which the door is mechanically held closed but in which the car is interlocked by means of some form of electrical control. This may be accomplished either by interrupting the master or control circuit or by running an independent circuit which will interrupt the operating current on the machine control board or, in the case of hydraulic installations, by using a current to actuate a solenoid which in turn mechanically locks the car-control lever or holds closed a valve in the supply line, thus preventing motion of the car.

This type of device (electromechanical) may or may not limit the stopping of a car to within a few inches of the landing platform before the door can be opened. Those devices in which the electric contact is placed under the car must necessarily be provided with a stopping range limit, and their operation prevents the opening of the hoistway door unless the car is within a predetermined distance of the landing floor level, while those depending on switches placed in the hoistway can generally be opened without respect to the relative position of the car and hoistway landing platform.

The door-locking mechanisms used in devices of this kind are varied. Those with the undercar contact generally use the same mechanism as is employed in the purely mechanical type, while those with a hoistway contact generally make use of a bar-lock or some form of toggle-joint device. Of the two the latter is preferable, as it does not depend on springs to hold the door locked.

ELECTRIC CONTACT DEVICES.—The third class of door safety devices comprises a wide variety of electric hoistway-door contacts. These devices are generally connected in series known as shaft-series system and operate on the car-control circuit, although they may be wired so that each door is a separate unit, this wiring being known as a door-unit system. Those in which the switch is actuated by the door itself (there are a large variety of this type) give considerable trouble, due to lack of alignment of the door and switch and to vibration and the impact of the door.

The difference between a hoistway-door contact and an electromechanical interlock should be clearly kept in mind. A contact device holds the car inoperative when the door opposite which the car is standing is open. An electromechanical interlock is a device which holds the car inoperative when the door opposite which the car is standing is open or unlocked and in addition holds locked the hoistway door when the car is not at the landing. This door-locking function is accomplished by a mechanism independent of, and separate from, the ordinary door latch.

In other words, a contact is a device which can only prevent the motion of the car when a door is open. It can not and does not hold locked the door when the car is not at the landing. The ordinary hoistway-door latch must be used as the door-locking device.

The electromechanical device has a bar or other form of lock incorporated in it and so arranged and interconnected that the door must be closed and locked before the car can be started.

In order to obtain information regarding the effectiveness of the ordinary hoistway-door latch, a survey was made of several hundred hoistway doors. The results of this survey indicate that 30 per cent of the latches were out of order, the principal causes of failure being worn latch parts, worn door hangers, loosening of latch from door, and lack of lubrication. Many latches were so poorly designed that if the door were closed quickly the rebound of the door would occur before the latch engaged. An analysis of elevator-accident statistics shows that about one-third of the accidents occur by persons falling down the shaft. This is in itself an indication that the ordinary latch is unreliable and shows why a contact device can not of itself offer complete hoistway-door protection. In the other two types of device (mechanical and electromechanical) the door is held shut mechanically whether or not the car interlocking feature is working.

2. EMERGENCY RELEASE

Every elevator car equipped with interlocks should be provided with an emergency switch or release device located in the car. If there is a fire, panic, or other emergency, or if the car becomes stalled in the shaft due to failure of the door safety circuit, the operation of the emergency device will permit the elevator to continue in operation. Unless this device is properly designed and installed its use may be subject to much abuse.

An undesirable feature of an emergency switch so designed that the switch can be turned "on" or "off" is that, in event of failure of any contact, the throwing of an emergency switch leaves the entire system with no protection other than that offered by the ordinary door latch, which is notoriously unreliable. The emergency release generally consists of a two-pole push or snap switch sometimes placed in a case under a glass cover, often without even this protection, and when once thrown is quite likely to be left in the "emergency" position for weeks or months. Except where required by law, the spring-type switch, which must be held in the emergency position by the operator, is seldom seen, although it is obviously the most desirable type. The emergency-release device for mechanical locks which remains in the emergency-operating position without being held there by the operator is equally undesirable.

3. FIELD SURVEY

In order to obtain reliable information regarding door protective devices, a large number of passenger elevators were inspected by representatives of the Bureau of Standards and thousands of doorways and landings examined. These inspections covered a considerable range of territory, and territories in which the legal requirements for the protection of entrance doors to elevators differ widely. The following statement gives the various cities and States in which data were secured and the legal requirements in each place:

	Requirements
Philadelphia	Mechanical or electromechanical interlocks of the undercar contact type.
Pennsylvania (outside of cities of first or second class)	Mechanical or electromechanical interlocks and car-door contacts on cars driven by electricity.
New Jersey	Mechanical or electromechanical.
New York City	No interlock requirements.

4. DIVISION OF BUILDINGS INTO CLASSES ACCORDING TO CONDITIONS OF SERVICE AND MAINTENANCE

For the convenience in analyzing the performance under actual operating conditions of any given interlock device or group of such devices it is desirable to divide the elevators which they protect into three general classes, the classification being naturally somewhat elastic. The two factors which govern this classi-

fication are the amount of duty rendered and the maintenance service they receive. The grouping adopted is as follows:

CLASS A.—Those in which the volume of travel is heavy and for which there is a special elevator maintenance and inspection service. Into this class will fall: (*a*) Large office buildings, (*b*) first-class hotels, (*c*) high-grade apartment houses, (*d*) large railroad terminals, (*e*) municipal and State buildings in cities, and (*f*) large department stores. This class is generally limited to the larger cities.

CLASS B.—Buildings in which the travel is heavy, but in which no regular maintenance or inspection service is provided. In this are included the following types of buildings: (*a*) Small office buildings in large cities, (*b*) large office buildings in small cities, (*c*) loft and manufacturing buildings, (*d*) small hotels in cities, (*e*) medium-size apartment houses, (*f*) small department stores in cities, and (*g*) other retail stores in cities.

CLASS C.—Buildings that have light service and receive but little care and attention. In this class will fall: (*a*) Small office buildings in towns or small cities, (*b*) storage or warehouse buildings, (*c*) small hotels, (*d*) manufacturing plants where the upper floors are used largely for storage, and (*e*) very small shops and retail stores (such as furniture stores) where most of the selling is done on the ground floor.

5. DISCUSSION OF CONDITIONS UNDER WHICH DEVICES MUST OPERATE

In Class A buildings the vital consideration is speed of service. In most installations of this class there are several load peaks, and at such times every car is run at capacity. A loss of a half minute a trip per elevator would mean a serious curtailment of service. Any device that is installed must not reduce the operating speed to any marked degree. Further, it must be provided with some form of emergency release, so that the failure of the device or of any part of it will not tie up the car during the rush period.

The survey showed that there is generally very little operating trouble due to failure of door-safety equipment in Class A buildings, because ample maintenance service is provided. As a rule, the elevator maintenance crew take pride in the condition of the equipment under its care and keep parts properly adjusted and in repair.

In Class B buildings the vital consideration is simplicity and ruggedness, as the service in this class of buildings is severe and

the maintenance and attention which elevator parts and devices will receive is slight. Lack of alignment on the part of the elevator or of the hoistway door may cause excessive wear of the interlock or contact, causing rapid deterioration, which results ultimately in failure to operate.

As a usual thing the only attention which a Class B elevator receives is an occasional "going over" by some mechanic or handy man for the purpose of lubrication. Even this perfunctory oiling is done at odd times and at very irregular intervals. It is very seldom that the elevators in a Class B building are in charge of a starter, and it is only in very exceptional cases that the operators are given any definite instructions as to the operation of the car; in other words, operating rules are usually unknown.

This class (Class B) will contain by far the largest part of the elevators in almost any city or large town. For this reason the behavior of the various door-protective devices in Class B buildings is a matter of vital interest. For this class of service the most simple and rugged type of mechanical interlock or electromechanical device is desirable. Almost invariably electric door contacts seem to give trouble, under the combination of heavy duty and little or no attention.

For elevators in Class C buildings the requirements which are to be met are not so severe. Any device that will stand up under occasional use, but with almost entire lack of attention, will probably give satisfaction. Most mechanical devices give fairly good service, although in some cases which were noted they have worn rapidly owing to lack of lubrication. Electromechanical and contact devices give fair service provided they are used often enough to prevent the contacts from oxidizing and corroding. This class is probably smaller than either Classes A or B, and is confined very generally to smaller cities and towns. Frequently in Class C installations may be found various types of makeshift devices, some of which fail to accomplish the purpose for which they were intended.

6. TABULATION OF RESULTS OF SURVEY

The data regarding interlocks and electric contacts given on the following pages were obtained by examining substantially all of the elevators in many of the smaller cities and towns of Pennsylvania and New Jersey and all of the elevators in representative blocks in the larger cities. In uptown New York the blocks were

between Fifth Avenue and Broadway and Thirty-sixth and Forty-fifth Streets. In downtown New York both sides of Broadway were covered for a number of blocks. This was done in an effort to observe an average condition, and it is believed that the data given here are typical of the various towns or sections in which inspections were made.

Summary of Conditions of Interlocking Devices in Pennsylvania (Exclusive of First-Class Cities)

GENERAL ANALYSIS

Elevators inspected	79
Landings inspected	513
Cars not provided with car-gate contacts (required by Pennsylvania law)	20
Per cent not up to requirements of Pennsylvania law	25.2
Landings provided with interlocks	513
Landings provided with interlocks found to be inoperative	47
Per cent of landings with interlocks inoperative	9.2

ANALYSIS BY TYPE OF DEVICE

Landings provided with mechanical interlocks	244
Landings with mechanical interlocks inoperative	26
Per cent of landings with mechanical interlocks inoperative	10.6
Landings provided with electromechanical interlocks	269
Landings provided with electromechanical interlocks found to be inoperative	21
Per cent electromechanical interlocks found to be inoperative	7.8

ANALYSIS BY CLASS OF BUILDINGS IN WHICH ELEVATORS ARE LOCATED

CLASS A

Landings in this class	149
Landings with interlocks inoperative	10
Per cent of landings with interlocks inoperative	6.7

CLASS B

Landings in this class	313
Landings with interlocks inoperative	36
Per cent of landings with interlocks inoperative	11.5

CLASS C

Landings in this class	51
Landings with interlocks inoperative	1
Per cent of landings with interlocks inoperative	2.0

Summary of Conditions of Interlocking Devices in New Jersey

GENERAL ANALYSIS

Elevators inspected	189
Landings inspected	1466
Landings with no hoistway-door protection	227
Per cent of landings with no hoistway-door protection	15.5
Landings not provided with mechanical or electromechanical interlocks (as required by New Jersey law)	559

Per cent of landings not provided with mechanical or electromechanical interlocks (as required by New Jersey law)	44.8
Landings provided with interlocks or contacts	1239
Landings with interlocks or contacts inoperative	73
Per cent of landings with interlocks or contacts inoperative	5.2

ANALYSIS BY TYPE OF DEVICE

Landings provided with mechanical interlocks	243
Landings provided with mechanical interlocks found to be inoperative	29
Per cent of mechanical interlocks found to be inoperative	11.9
Landings provided with electric contacts [1]	329
Landings provided with electric contacts found to be inoperative [1]	44
Per cent of electric contacts found to be inoperative [1]	13.3
Landings provided with electromechanical interlocks [2]	667
Landings provided with electromechanical interlocks found to be inoperative [2]	0
Per cent of electromechanical interlocks found to be inoperative [2]	0

ANALYSIS BY CLASS OF BUILDING IN WHICH ELEVATORS ARE LOCATED

CLASS A

Landings in this class	845
Landings with interlocks or contacts inoperative	19
Per cent of landings with interlocks or contacts inoperative	2.2

CLASS B

Landings in this class	350
Landings with interlocks or contacts inoperative	53
Per cent of landings with interlocks or contacts inoperative	15.1

CLASS C

Landings in this class	44
Landings with interlocks or contacts inoperative	1
Per cent of landings with interlocks or contacts inoperative	2.3

Summary of Conditions of Interlocking Devices in Philadelphia

[NOTE.—Municipal regulations require the use of mechanical or undercar contact electromechanical interlocks.]

GENERAL ANALYSIS

Elevators inspected	49
Landings inspected	503
Landings provided with interlocks	503
Landings with interlocks inoperative	66
Per cent of landings with interlocks inoperative	13.0

ANALYSIS BY CLASS OF BUILDING IN WHICH ELEVATORS ARE LOCATED

CLASS A

Landings in this class	404
Landings with interlocks inoperative	9
Per cent of landings with interlocks inoperative	2.2

[1] While contact devices without door-interlocking mechanisms are not permitted under the New Jersey law, a number of such devices were found. Some of these devices were installed prior to the enactment of the law and will, no doubt, eventually be changed to comply with the legal requirements.

[2] Seventy-five per cent of the electromechanical devices were found in one "Class A" group, where the maintenance service was excellent.

CLASS B

Landings in this class	99
Landings with interlocks inoperative [3]	57
Landings with interlocks inoperative (final)	28
Per cent of landings with interlocks inoperative	56.0
Per cent of landings with interlocks inoperative (final)	28.0

Summary of Conditions of Interlocking Devices in Uptown New York City [4]

GENERAL ANALYSIS

Elevators inspected	294
Landings inspected	3,043
Landings provided with interlocks or contacts	229
Per cent of landings provided with interlocks or contacts	7.5
Landings with interlocks or contacts inoperative	50
Per cent of landings with interlocks or contacts inoperative	21.8

ANALYSIS BY TYPE OF DEVICE

Landings provided with electric contacts	190
Landings with inoperative electric contacts	37
Per cent of landings with inoperative electric contacts	19.2
Landings provided with electromechanical interlocks	39
Landings provided with electromechanical interlocks inoperative	13
Per cent of landings with electromechanical interlocks inoperative	33.3

DATA ON CAR-GATE CONTACTS

Cars provided with car-gate contacts	22
Car-gate contacts in operating condition	10
Per cent of car-gate contacts in operating condition	45.5
Car-gate contacts tied up or plugged	7
Per cent of car-gate contacts tied up or plugged	31.8
Car-gate contacts broken or defective	5
Per cent of car-gate contacts broken or defective	22.7

Summary of Conditions of Interlocking Devices in Downtown New York City [5]

GENERAL ANALYSIS

Elevators inspected	241
Landings inspected	5,304
Landings provided with interlocks or contacts	1,926
Per cent of landings provided with interlocks or contacts	36.4
Landings with interlocks or contacts inoperative	2
Per cent of landings with interlocks or contacts inoperative	0.10

ANALYSIS BY TYPE OF DEVICE

Landings provided with mechanical interlocks	892
Landings with mechanical interlocks inoperative	1
Per cent of landings with mechanical interlocks inoperative	0.10
Landings provided with electromechanical interlocks	1,014
Landings with electromechanical interlocks inoperative	1

[3] As 29 of the 57 defective landings were in a single group of buildings which had evidently been overlooked by the inspector, this estate was omitted from the final statistics as not being representative.

[4] Only one mechanical interlock was found in the particular uptown section inspected, so that statistics on this type are not given. Buildings equipped with interlocks or contacts in this tabulation may be regarded with very few exceptions as Class B.

[5] All of these downtown buildings provided with interlocks or contacts in this tabulation are Class A buildings.

Per cent of landings with electromechanical interlocks inoperative	0.10
Landings provided with electric contacts	20
Landings provided with electric contacts inoperative	0

Summary of an Inspection to Determine the Effectiveness of Emergency Releases, Uptown New York City [6]

ELECTROMECHANICAL DEVICES

Elevators inspected	43
Landings inspected	504
Landings working satisfactorily	225
Per cent of landings working satisfactorily	44.6
Landings where elevators were running with emergency switch thrown; no electrical or mechanical trouble	148
Per cent of landings unprotected, due to emergency switch being thrown	29.4
Landings where elevators were running with emergency switch thrown or system disconnected, due to electrical or mechanical breakdown	131
Per cent of landings unprotected, due to electrical or mechanical breakdown	26.0

This survey was made to determine to what extent the emergency release is used as a means of defeating the purpose of door-protective devices.

The emergency releases were all of the two-pole, push-button type. Most of them were without a cover glass or even a means of holding a cover glass. The results of this survey show that an emergency release of this type will be misused. The only type which should be permitted is that in which the operator is required to hold the emergency release in the emergency operating position.

Practically all of the devices inspected on this survey were poorly designed and cheaply made, which may in part account for the large number of defective landings noted.

7. DISCUSSION OF SURVEY

Relation of Law Enforcement to Elevator Safety.—There is a marked difference between the condition of elevators in a State or city where the law or code relating to elevators is strictly enforced and a State or city where the law does not have the backing of an active and thorough administrative organization. In many parts of one State the law calling for interlocks did not seem to be generally known, and even in the larger cities no particular efforts had been made to enforce it. In many cases it has been through the notification given the building owners by insurance inspectors that the devices have been installed. By way of contrast, however, in another State there was not a single elevator examined that was not equipped with the required inter-

[6] Nearly all of these are Class B buildings.

lock, although in a few electric-elevator installations the additional car-door contact which was required by law was lacking.

Perhaps the most badly needed addition to present State rules and city ordinances is a set of simple, brief, and concise operating rules to be posted in every elevator under the jurisdiction of the particular State or city. Certain cities have already provided for the licensing of car operators. The passing of an examination is necessary before the applicant is granted a license. In this way it is possible to discourage the operation of elevators by the ignorant or uninstructed. Unfortunately, during the war it was deemed necessary to waive this ruling in certain cases, and the strict enforcement of this rule has not yet been insisted upon.

Performance of Interlocks in Various Classes of Buildings.—In regard to the performance of interlocking devices, there seems to be but little difference between the mechanical and electromechanical interlocks. Many installations, both mechanical and electromechanical, were met with in Philadelphia that had been giving satisfactory service for periods of 15 years and upward, with a cost for repairs and renewals not exceeding $1 per landing for the entire period, while numerous installations met with in the smaller cities of Pennsylvania were found to be in good condition after 10 years or more of service.

As might be expected as the result of the combination of hard service with little or no maintenance, the Class B installations in every case have made the poorest showing, but even here the percentage of installations in working order indicates that the protection afforded by such devices is decidedly worth while.

For Class A installations the average percentage of devices in working order was 98. When the fact that an interlock may be called on to function several hundred times a day is taken into consideration, this percentage must be considered remarkable.

Class C installations were generally in fairly good condition, due mainly to light service requirements.

Interlock Installations in Large Office Buildings.—The results of the inspection in the down-town section of New York City brings forth two points of particular interest.

First, the relatively large number of interlock installations. While interlocks are not required by the city ordinances, over one-third of the landings inspected had been so safeguarded.

Second, the remarkably low number (two) of defective landings found despite the severe duty imposed on the elevators in the

large office buildings down town. Excellent maintenance service and the carefully designed and well-built interlocks which predominate in this section are, no doubt, largely responsible for this fine showing.

Suggestions for Improvement in Design.—From a general survey of results obtained it would seem that there is room for considerable improvement in the types of interlocking devices. Of the hundreds of elevators inspected none were equipped with a mechanical interlock in which the four vital functions of unlocking hoistway door, locking car mechanism, unlocking car mechanism, and locking the door are performed by means of positive mechanical motion. In other words, at least one, and generally more, of these functions are accomplished by means of springs or the force of gravity, or a combination of the two. An interlock in which all four of these functions are performed without the aid of a spring or the action of gravity should be not particularly difficult of design. Rules to be drafted should, however, take cognizance of present well-designed apparatus and should be so worded as to not hinder improvement in design or new designs.

Door contacts, while usually of ample current-carrying capacity, are seldom rugged enough to stand up under the impact and vibration of the hoistway door, where they are actuated by the impact of the door itself. Another characteristic feature about them is that in nearly every case the making and breaking of the current is dependent directly upon and is accomplished at the same speed as the opening and closing of the door. Many such devices, if the door fails to latch, are left in but slight contact and may produce an arc which will rapidly destroy the contact surfaces. The use of a sequence coil or a quick make-and-break switch will do much to eliminate such arcing and pitting.

There are several well-designed devices with switches that are not subject to door impact and which give long and satisfactory service when made a part of a substantial interlock mechanism. Well-designed mechanical locks are also available. A substantial door-locking mechanism is necessary whether the method of interlocking the car is electrical or mechanical. The door-locking function should be so interconnected with the car interlock that the car can not be started until the door is locked in the closed position.

There is considerable need for some sound engineering work in connection with the proper design of interlocks. Many of the devices on the market were designed without due regard for the stresses set up by door impact, lack of alignment, and abuse of equipment at the hands of careless operators. Such devices are generally sold at a low price, the manufacturer depending upon this low price to obtain business. In many cases such devices fail after a short period of service and are, in the end, more expensive than a well-designed and carefully installed outfit, the initial cost of which would have been greater.

III. SUMMARY OF ADVANTAGES AND DISADVANTAGES OF VARIOUS TYPES OF DEVICES

The following tabular arrangements set forth the advantages and disadvantages of the various types of elevator door safety devices and the characteristic methods of failure of the various types of devices for the various classes of service:

Comparison of Functions and Maintenance of Various Types of Elevator Door Devices

Mechanical	Electromechanical		Electric contacts
	Undercar-contact type	Hoistway-contact type	
Locks door and prevents operation of car if door is unlatched or unlocked.	Locks door and prevents operation of car if door is unlatched or unlocked.	Locks door and prevents operation of car if door is unlatched or unlocked.	Does not lock door and does not prevent operation of car if door is unlatched.
Interlocks car when door is open	Interlocks car when door is open	Interlocks car when door is open	Interlocks car when door is open.
Slows down service slightly	Slows down service slightly	Slows down service very slightly	Slows down service very slightly.
Usually designed to prevent opening of shaftway door with key unless car is at the landing.	Usually designed to prevent opening of shaftway door with key unless car is at the landing.	May or may not prevent opening of door with key unless car is at the landing, depending on design.	Door may be opened with key when car is not at landing.
Failure of mechanical parts on one door does not affect protection of other doors.	Failure of electric contact will eliminate interlocking of car, but will not affect the mechanical locking of shaftway doors (partial protection until repairs are made).	Failure of electric contact will eliminate interlocking of car, but will not affect the mechanical locking of shaftway doors (partial protection until repairs are made).	Failure of device at one door necessitates running the entire door system without the interlocking protection until repairs are made. Doors may or may not be latched, depending on condition of door latch.
Prevents opening of door by operator unless car is within a few inches of the landing.	Prevents opening of door by operator unless car is within a few inches of the landing.	Door can be opened when operator is in position to reach door-opening device.	Door can be opened when operator is in position to reach door-opening device.
MAINTENANCE AND OPERATION			
Renewals infrequent	Renewals not frequent	Renewals not frequent	Renewals frequent.
Necessary to use emergency release very occasionally.	Necessary to use emergency release very occasionally.	Necessary to use emergency release occasionally if switch is not subject to door impact; much oftener if switch is subject to such forces.	Necessary to use emergency release fairly often if switch is subject to door impact and vibration, otherwise much less often.
Danger of crushing passengers slight, as doors must be closed and locked before car starts.	Danger of crushing passengers slight, as doors must be closed and locked before car starts. Short-circuit, ground, or an emergency switch thrown may set up a very dangerous crushing hazard.	If contact is not made until door is shut, crushing hazard is slight. If contact is made before door reaches full closure, the entering passenger may be caught and crushed by the starting car. Short-circuit, ground, or an emergency switch thrown may set up a very dangerous crushing hazard.	If contact is not made until door is shut, crushing hazard is slight. If contact is made before door reaches full closure, the entering passenger may be caught and crushed by the starting car. Short-circuit, ground, or an emergency switch thrown may set up a very dangerous crushing hazard.

Comparison of Service of Hoistway-Door Interlocking Devices for the Various Classes of Buildings

Mechanical	Electromechanical	Electric contact
CLASS A		
Parts fail through wear due to heavy service.	Parts fail through wear and arcing due to heavy service.	Parts fail by wear and arcing due to heavy service and where the switch is actuated directly by the door, by mechanical breakdown due to door impact and vibration.
CLASS B		
Fail through rapid wear and mechanical breakdown due to lack of proper lubrication and lack of alignment combined with severe conditions of service.	Fail through mechanical or electrical breakdown due to lack of proper lubrication, lack of alignment, dirt and grit on contact surfaces combined with severe service conditions.	Fail through mechanical and electrical breakdown due to dirt and grit on contact surfaces, lack of proper lubrication combined with severe service conditions and where the switch is actuated directly by the door, to breakdown due to impact of door, vibration, lack of alignment between door and switch.
CLASS C		
Fail through mechanical wear augmented by lack of proper lubrication.	Fail through mechanical wear or failure of contacts due to oxidation, corrosion, or pitting due to infrequent use and dirt on contact surfaces.	Fail through oxidation, corrosion, and pitting of contact due to infrequent use and dirt on contact surfaces.

IV. ELEVATOR-ACCIDENT STATISTICS

There are attached a number of tables of elevator statistics obtained from various sources. The public accidents have been separated from the industrial accidents where this was possible, and the classification has been made to show the number of accidents by causes.

Accidents have been classified as public, semipublic, or industrial, according to the nature of the occupancy of the building, as follows:

Public accidents	Hotel Apartment house Department store (patrons). Office building
Semipublic accidents	Hospital Garage
Industrial accidents	Factory Mercantile establishment (employees only).

The accidents have been further grouped into shaft-door and nonshaft-door accidents and the percentages computed on this basis for each table. For convenience in analysis the statistics have been divided into groups according to sources, as noted below and shown in the tables following:

Group I. General: Reports of accidents received through clipping bureaus. These cover the entire United States.

Group II. State industrial reports of State industrial commissions. These are taken from records of industrial accidents and do not cover accidents to the general public.

Group III. Municipal statistics from records of coroners of cities or records of elevator inspection departments.

1. GROUP I. GENERAL

TABLE 1.—Elevator Accidents Reported Through Clipping Bureaus by the Public Press of the United States, January, 1913, to July, 1918

Cause	Fatal				Nonfatal			
	Public	Semi-public	Indus-trial	Not classi-fied	Public	Semi-public	Indus-trial	Not classi-fied.
Fell into shaft from landing floor or due to motion of the car	150	15	198	.....	121	10	181	.....
Crushed between car and sill of landing floor or frame of door	150	10	168	.....	107	5	138	.....
Accident occurred inside shaft	96	11	150	.....	330	12	486	.....
Cause not given	11	0	12	7	11	0	24	11
Total	407	36	528	7	569	27	779	11

TABLE 2.—Summary from Table 1: Entire United States from Newspaper Clippings, January, 1913, to July, 1918

Classification and cause	Fatal	Nonfatal
Public:	Per cent	Per cent
Nonshaft-door accidents	26.2	60
Shaft-door accidents—		
Fell into shaft	36.9	21.3
Crushed between car and sill or frame of door	36.9	18.7
Total	100	100
Semipublic:		
Nonshaft-door accidents	30.5	44.5
Shaft-door accidents—		
Fell into shaft	41.7	37
Crushed between car and sill or frame of door	27.8	18.5
Total	100	100
Industrial:		
Nonshaft-door accidents	49.6	59
Shaft-door accidents—		
Fell into shaft	37.4	23.2
Crushed between car and sill or frame of door	13	17.8
Total	100	100

2. GROUP II. REPORTS FROM STATE INDUSTRIAL COMMISSIONS OR DEPARTMENTS OF LABOR

TABLE 3.—Elevator Compensable Industrial Accidents, New York State, June 1, 1914, to July 1, 1915

[From data submitted by the New York Industrial Commission. N. O. C.=Not otherwise classified]

NONFATAL ELEVATOR ACCIDENTS

Cause	Number	Per cent	Cause	Number	Per cent
Caught between floor and car	113	19.6	Caught between car and gate	13	2.3
Falls into shaft from floor	63	10.9	Struck by counterweight	11	1.9
Caught between shaft and car	26	4.5	Objects falling down shaft from car	13	2.3
Fall of car	41	7.1	Struck by car in pit	9	1.5
Struck by car (N. O. C.)	36	6.3	Machinery breaking	10	1.7
Gates (N. O. C.)	39	6.7	Load catching between car and shaft	6	1.0
Unknown	33	5.7	Cables unwinding	4	.7
Objects falling into shaft	61	10.0	Struck while on top of car	4	.7
Cables breaking	32	5.6			
Caught by machinery	25	4.3			
Caught by cable	25	4.3	Total	577	100.0
Falls into shaft from car	13	2.3			

TABLE 3.—Elevator Compensable Industrial Accidents, New York State, June 1, 1914, to July I, 1915—Continued

FATAL ELEVATOR ACCIDENTS

Cause.	Number.	Per cent.	Cause.	Number.	Per cent.
Falls into shaft from floor	13	27.7	Unknown	1	2.1
Caught between shaft and car	6	12.8	Machinery breaking	1	2.1
Caught between floor and car	5	10.6	Load catching between car and shaft	1	2.1
Struck by car (N. O. C.)	4	8.6	Cable unwinding	1.	2.1
Fall of car	3	6.4	Struck while on top of car	1	2.1
Falls into shaft from car	3	6.4			
Struck by counterweight	3	6.4	Total	47	100.0
Struck by car in pit	3	6.4			
Caught between car and gate	2	4.2			

TABLE 4.—Elevator Accidents in Industries and Mercantile Establishments in the State of Pennsylvania, 1918

[From statistics furnished by the Department of Labor and Industry of Pennsylvania]

	Fatal		Nonfatal				Total	
	Number	Per cent	Serious: Number	Minor: Number	Total		Number	Per cent
					Number	Per cent		
Cable breaking	4	8	27	29	56	6.5	60	6.6
Cable unwinding	1	2	9	7	16	1.7	17	1.9
Cable, caught by	3	6	43	49	92	10.7	95	10.5
Car, caught by	17	34	134	171	305	35.7	322	35.5
Car, struck by	3	6	30	36	66	7.8	69	7.6
Counterweight, struck by	2	4	10	7	17	2.0	19	2.0
Defective equipment	1	2	10	17	27	3.1	28	3.1
Entering or leaving car	1	2	10	35	45	5.3	46	5.1
Fall of car	5	10	35	26	61	7.1	66	7.3
Fall of person	7	14	34	27	61	7.1	68	7.5
Falling objects	1	2	15	16	31	3.6	32	3.5
All others	5	10	31	50	81	9.4	86	9.4
Total	50	100	388	470	858	100.0	908	100.0

TABLE 5.—Wisconsin Industrial Accidents on Elevators

[From published reports of the Wisconsin Industrial Commission, 1915–1917]

Cause	Fatal		Nonfatal		Total	
	Number	Per cent	Number	Per cent	Number	Per cent
Falling from floor down shaft	5	35.6	24	11.7	29	13.2
Platform floor catching person	2	14.3	55	26.8	57	26.0
Caught between cage and side	.....	.....	14	6.9	14	6.4
Struck by objects falling down shaft	1	7.1	14	6.9	15	6.9
Car struck person	1	7.1	14	6.9	15	6.9
Car falling	1	7.1	16	7.8	17	7.7
Car sudden start or stop	.....	.....	4	1.9	4	1.8
Struck by counterweight	1	7.1	4	1.9	5	2.3
Hoisting cable striking person	.....	.....	10	4.9	10	4.6
Hoisting machinery catching person	.....	.....	22	10.7	22	10.1
Platform and gate catching person	2	14.4	18	8.8	20	9.1
Falls from car	1	7.1	6	2.9	7	3.2
Load or other object catching person	.....	.....	4	1.9	4	1.8
Total	14	100.0	205	100.0	219	100.0

TABLE 6.—Elevator Accidents in Industries in Massachusetts (Freight and Passenger, Insured, not Insured, and Common Law Rights)

[From published reports of Massachusetts Industrial Accident Board

Cause	July 1, 1913, to June 30, 1914		July 1, 1914, to June 30, 1915		July 1, 1915, to June 30, 1916		July 1, 1916, to June 30, 1917		Total			
									Fatal		Nonfatal	
	Fatal	Non-fatal	Fatal	Non-fatal	Fatal	Non-fatal	Fatal	Non-fatal	Number	Per cent	Number	Per cent
Caught in machinery	.....	62	.....	40	.....	30	1	47	1	1.5	179	6.92
Caught between car and shaft	7	50	6	186	7	204	6	289	26	38.8	728	28.1
Caught underneath or on top of car	.....	36	.....	16	4	25	3	18	7	10.5	95	3.67
Falling car	1	38	.....	49	1	44	1	47	3	4.48	179	6.87
Falling down shaft (person)	1	59	3	59	9	56	9	61	22	32.9	235	9.08
Struck by falling object	.....	53	1	55	.....	24	.....	29	1	1.5	161	6.22
Caught by fire hatch or trap	.....	9	.....	6	.....	1	.....	9	.....	.....	25	.96
Miscellaneous	.....	284	3	265	2	213	2	228	7	10.5	990	38.2
Total	9	591	13	676	23	597	22	728	67	100.0	2,592	100.0

NOTE.—The classification used here is not as suitable for grouping the hoistway-door accidents into two general classes as the other tables presented.

TABLE 7.—Analysis of State Elevator Statistics

Cause	Fatal	Nonfatal
INDUSTRIAL ELEVATOR ACCIDENTS, NEW YORK STATE, JUNE 1, 1914, TO JULY 1, 1915		
	Per cent	Per cent
Nonshaft-door accidents	51.1	64.9
Shaft-door accidents:		
Fell into shaft	34.1	13.2
Caught between floor and car or gate and car	14.8	21.9
Total	100	100
INDUSTRIAL AND MERCANTILE ELEVATOR ACCIDENTS, PENNSYLVANIA, 1918		
Nonshaft-door accidents	50	51.9
Shaft-door accidents:		
Fell into shaft	14	7.1
Caught by car and entering or leaving car	36	41
Total	100	100
INDUSTRIAL ELEVATOR ACCIDENTS, WISCONSIN, 1915–1917		
Nonshaft-door accidents	35.7	52.7
Shaft-door accidents:		
Fell into shaft	35.6	11.7
Platform floor catching person; platform and gate catching person	28.7	35.6
Total	100	100
INDUSTRIAL ELEVATOR ACCIDENTS, MASSACHUSETTS, JULY 1, 1913, TO JUNE 30, 1917, INCLUSIVE		
Nonshaft-door accidents	28.3	62.82
Shaft-door accidents:		
Fell into shaft	32.9	9.08
Caught between car and shaft	38.8	28.1
Total	100	100

3. GROUP III. MUNICIPAL STATISTICS

TABLE 8.—Philadelphia Elevator Accidents

Type	1914		1915		1916		1917		1918	
	Injured	Killed	Injured	Killed	Injured	Killed	Injured	Killed	Injured	Killed
Passenger:[a]										
Electric	.....	1	.....	1	.....	.....	6	1	.....	.....
Hydraulic	3	1	3	1	5	3	6	3	.....	4
Freight:										
Electric	7	2	14	2	8	2	5	5	5	2
Hydraulic	6	6	4	1	9	6	5	2	2	3
Belt	17	4	22	4	24	2	24	7	12	12
Hand	.....	2	3	.....	.....	.....	3	.....	2	1
Sling	.....	.....	.....	.....	.....	.....	.....	1	1	1
Total	33	16	46	9	46	13	49	19	22	23

[a] Interlocks required by law on passenger elevators.

TABLE 9.—Fatal Accidents on the Elevators of Borough of Manhattan, New York City, 1907 to 1918, Inclusive

[From coroner's reports]

Cause	Number	Per cent
Fell down shaft	292	40.5
Crushed between moving car and sill or frame of shaft door	335	46.5
Miscellaneous (broken cables, falling cars, workmen in the shaft struck by moving car, etc.)	94	13
Total	721	100

TABLE 10.—Fatal Elevator Accidents, Cook County, Ill., 1904 to March, 1916, Inclusive

[From coroner's reports]

Cause	Number	Per cent
Fell down elevator shaft	169	42.2
Crushed between elevator and floor, wall, door, etc	152	37.9
Killed by falling elevator	24	6.0
Struck by elevator	23	5.7
Crushed by counterweights	12	3.0
Crushed in elevator	8	2.0
Struck by falling objects other than elevator	7	1.7
Crushed by machinery of elevator	4	1.0
Unknown how accident occurred	2	.5
Total	401	100.0

TABLE 11.—Summary of Elevator Accidents of Two of the Largest American Cities

[Reported from coroner's records]

	Fatal		Fatal
Borough of Manhattan, New York City, 1907 to 1918, inclusive, public and industrial:	Per cent	Cook County, Ill., 1904 to March, 1916, inclusive:	Per cent
Nonshaft-door accidents	13	Nonshaft-door accidents	19.9
Shaft-door accidents—		Shaft-door accidents—	
Fell down shaft	40.5	Fell down shaft	42.2
Crushed between car and sill or frame of shaft door	46.5	Crushed between elevator and floor, wall, door, etc	37.9
Total	100	Total	100

An analysis of these statistics shows that the weighted average percentage of accidents presented in the preceding tables, due to causes originating from the lack of an interlocking device with which is combined a substantial lock, is as follows:

Fatal accidents to public, per cent of total accidents given in preceding tables.	73.8
Fatal accidents to industrial employees, per cent of total	54
Nonfatal accidents to public, per cent of total	40
Nonfatal accidents to industrial employees, per cent of total	53.2

The statistics show that the largest number of accidents is caused by falling down the shaft, the weighted average percentage of the total fatalities to the public from this cause being 36.9, and to industrial employees being 36. In the case of nonfatalities these percentages are, public 21.3, industrial employees 14.7. It should be noted that the percentage of all fatalities from falls is about the same for both classifications, public and industrial. This is a strong indictment of the ordinary door latch, and the results of the survey bear out the conclusion reached by a study of accident statistics. A substantial lock should, therefore, be made a part of every interlock and the ordinary door latch discarded. A somewhat minor point which should not be neglected in the design of interlocks, since it bears directly on the hazard of falling down the shaft, is the possibility of opening the door from the landing side when the car is passing a landing. Devices which permit this should not be installed.

The next most prolific cause of accidents is the crushing hazard; that is, the possibility of being crushed between car and sill of landing floor or frame of door. The average percentage of the total fatalities to the public from this cause is 36.9 and to industrial employees 18. In the case of nonfatalities the percentages are, public 18.7, industrial employees 38.5.

These values, on comparison with those for causes originating within the shaft, show the necessity of interlocking the movement of the car with the opening and locking of the door. Not only should the interlocking function be associated with the closing of the door but also the locking of the door, inasmuch as the unlocked door exposes the user to the hazard of falling into the shaft.

Another cause of accident resulting from lack of interlock devices is stepping into the shaft under the mistaken idea that the car is at the landing. A study of 978 elevator fatalities showed that 1.3 per cent of the accidents were due to this cause, and of 1386 nonfatalities the percentage was 0.9. This is a real hazard and is comparable with many of the accident percentages due to causes originating within the shaft. It is recommended that provision be made against it.

Perhaps the most striking figures are those of the city of Philadelphia, which show the remarkable results obtained by the compulsory use of interlocks in a large city. Of the four people killed on passenger elevators in 1918 only one was a passenger, the other three being elevator operators or mechanics. The fact that there was not a passenger nor an operator killed in an electric elevator during the entire year of 1918 is a remarkable tribute to the effectiveness of the interlocks required by the Philadelphia law and to the administration of the code in force in that city. The contrast in the experience with freight elevators, for which interlocks are not required, is very marked.

The following requirements cover, in general, the desirable interlock features to be incorporated into an elevator code. It is urgently recommended, however, that the latest issue of the A. S. M. E. Elevator Code be consulted as to the exact wording; so that greater uniformity may be secured and that advantage may be taken of criticisms of earlier drafts of that code.

V. SUGGESTED REQUIREMENTS TO BE INCLUDED IN AN ELEVATOR CODE

The following definitions and specifications are submitted as tentative suggestions suitable for inclusion in an elevator code and are intended to give adequate protection and to mitigate the hazards previously set forth. From the evidence thus far accumulated the use of a hoistway-door interlock seems advisable, and this protection should be required on passenger elevators at least.

The material presented in this report was gathered for use in formulating an elevator safety code and was placed at the disposal of the joint committee which was formulating a national code for the American Society of Mechanical Engineers and with which the Bureau of Standards has been cooperating. The definitions and specifications which follow and those tentatively adopted by the committee agree in all essentials. Any evidence tending to support or modify these conclusions will be gladly received by the Bureau of Standards.

1. DEFINITIONS

Hoistway-Door Interlock.—A hoistway-door interlock is a device the purpose of which is—

1. To prevent the normal operation of the car, except by the use of a leveling device, unless (*a*) (door unit system) the hoist-

way door opposite which the car is standing is locked in the closed position; or (*b*) (hoistway unit system) every hoistway door is locked in the closed position.

A hoistway door or gate shall be considered locked in the closed position when within 4 inches of the full closure. If in this position, and any other up to full closure, the door or gate can not be opened from the landing side more than 4 inches.

Interlocks which permit the starting of the car before the door is fully closed shall be so equipped that except when the door is locked in the position of full closure the door or gate can be opened from the landing side to the position approximately 4 inches from full closure.

2. To prevent the opening of a hoistway door (except by use of a key) from the landing side when the car is passing a landing; except when the car-control mechanism is in the "stop" position.

Hoistway-Door Electric Contact.—A hoistway-door electric contact is an electrical device the purpose of which is to prevent the normal operation of the car except by the use of a leveling device unless (*a*) (door unit system) the hoistway door opposite which the car is standing is in the closed position, or (*b*) (hoistway unit system) every hoistway door is in the closed position.

Emergency Release.—An emergency release is a device the purpose of which is to make hoistway-door electric contacts or hoistway-door interlocks inoperative.

2. SPECIFICATIONS

Hoistway-Door Interlock Specifications.—(*a*) The prevention of the operation of the car by a hoistway-door interlock shall not be dependent on the action of springs in tension nor solely upon the completion or maintenance of one electrical circuit.

(*b*) The agency used to perform any interlocking function shall be such that even without lubrication of the mechanism the intended functioning of the device will be completely performed.

(*c*) The locking of the hoistway door and the interlocking of the car control shall be accomplished by an interconnection between the parts of the device. This interconnection may be mechanical, electrical, hydraulic, or pneumatic.

(*d*) It shall be necessary to accomplish the locking of the hoistway door opposite which the car is standing before the car can be moved by normal operation.

This paragraph applies to both the door unit and the hoistway unit system.

(*e*) If without damage to, removal of, or interference with any part of the elevator or hoistway equipment the door opposite

which the car is standing becomes unlocked, it shall be impossible to start the car by normal operation.

HOISTWAY-DOOR ELECTRIC CONTACT SPECIFICATIONS.—(*a*) The prevention of the operation of the car by an electric contact shall not be dependent on the action of springs in tension nor solely upon the completion or maintenance of one electric circuit. The failure of the device shall manifest itself by preventing the starting of the elevator from the landing.

(*b*) The device shall be such that without lubrication of the mechanism the intended functioning will be completely performed.

(*c*) All live parts shall be inclosed.

EMERGENCY RELEASE.—(*a*) The emergency release shall be in the elevator car, plainly visible to the occupants and reasonably, but not easily, accessible to the operator.

(*b*) To operate under emergency conditions, it shall be necessary for the operator to hold the emergency release in the emergency position. The emergency release shall be so constructed and installed that it can not be readily tampered with or "plugged" in the emergency position.

(*c*) Rods, connections, and wiring used in the operation of the emergency release that are accessible from the car shall be inclosed to prevent their being tampered with readily.

WASHINGTON, May 14, 1921.