NBS TECHNICAL NOTE 525

The Flammable Fabrics Program 1968-1969

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UNITED STATES DEPARTMENT OF COMMERCE
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NATIONAL BUREAU OF STANDARDS • Lewis M. Branscomb, Director

NBS TECHNICAL NOTE 525

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The Flammable Fabrics Program 1968-1969

U.S. Department of Commerce Report of Activities Under the Flammable Fabrics Act 1968-1969

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PREFACE

The 90th Congress amended the Flammable Fabrics Act of 1953 to authorize the Secretary of Commerce to conduct research on the flammability of fabrics, related materials, and products; to conduct studies on the feasibility of reducing their flammability; to develop test methods and devices; and to offer training in the use of these devices. The responsibility for these activities was delegated by the Secretary to the National Bureau of Standards.

The amended Act (PL 90-189) requires annual reports to the Congress on the above activities. The first such report was transmitted to the Congress on March 23, 1970. It is believed that the information in this report is of interest to the public and should be made readily available. This Technical Note is thus a publication of that report.

Summary

This report describes the work carried out during 1968 and 1969, by the Department of Commerce to fulfill the responsibilities delegated to that Department under Section 14(b) of the Flammable Fabrics Act as amended (81 Stat. 568) December 14, 1967. This section of the Act states:

"Sec. 14(b) In cooperation with appropriate public and private agencies, the Secretary of Commerce is authorized to---

(1) conduct research into the flammability of products, fabrics, and materials;

(2) conduct feasibility studies on reduction of flammability of products, fabrics, and materials;

(3) develop flammability test methods and testing devices; and

(4) offer appropriate training in the use of flammability test methods and testing devices.

The Secretary shall annually report the results of these activities to the Congress."

This report describes the activities carried out under the above responsibilities and in addition describes cooperation with public and private agencies.

1. Under Research into the Flammability of Products, Fabrics, and Materials, Sec. 14(b)(1), work is described on seven projects being carried out in-house, and on three projects carried out under contract with outside research organizations.

In-house research is being carried out on the following items:

1.1 Products of combustion - This project is to learn the amounts and nature of combustion products (some of which are toxic) to be expected from fabrics during normal burning. The study is directed primarily at interior furnishings. Fires from such furnishings often are dangerous because of the toxic products produced.

1.2 Calorimetry - The amount of heat released from a burning fabric, and the rate at which it is released are basic in determining the hazard from the fabric. It is important to know these quantities when designing new and meaningful standards. In addition, these quantities are important to the nature of the flammability of fabrics.

1.3 Full Scale-Garment Burning - This research effort is an attempt to reproduce in the laboratory what happens in actual accidents. Measurements of such quantities as ease of ignition, heat transferred to the body, and the temperatures developed, with various garment configurations and with various materials, are important in determining the hazards from apparel fabrics. This information is necessary to develop meaningful test methods and reasonable and appropriate standards.

1.4 Analysis of Burn Case Data - A significant effort has been devoted to the analysis of burn case data supplied to NBS by the Department of Health, Education, and Welfare, as well as to the testing of garments recovered by that Department from some of the cases investigated. This analysis has been used to substantiate in part a finding of probable need for a new standard for apparel published on October 23, 1968. A finding of probable need for certain items of children's apparel, published on January 24, 1970, (shortly after the close of the reporting period) was also based on the analysis. In addition, the results of tests on the recovered garments, and the relationships of these results to the accident cases have yielded important information about what constitutes meaningful apparel standards.

1.5 Analysis of Data from Outside Laboratories - Data on the testing of carpets and rugs using the present Federal purchase specification DDD-C-95 were provided to NBS by Consumers Union, an organization located in Mount Vernon, New York, specializing in the testing of consumer products. After analysis, these data were used to substantiate in part a finding of probable need for standards for carpets and rugs published December 3, 1968.

1.6 Investigation of the Mechanism of Flame Retardants - One of the most important means of reducing the flammability of fabrics is by the addition of flame retardants. These are presently available for cellulosic fabrics, but are useful only for certain types and constructions. This effort is to understand the means by which the flammability is reduced.

Contract Research was carried out in the following three areas:

1.7 Characterization of Actual Hazards from Interior Furnishings Fires - Full-scale assemblies of beds were burned in a normal sized room, and temperature increase, smoke, and toxic gas concentrations were measured. These were related to the bedding materials and the means of ignition. Similar studies were carried out with upholstered chairs. The work was carried out by the Southwest Research Institute in San Antonio, Texas.

1.8 Heat Transfer from Burning Fabrics - Heat transferred from a burning fabric to the body, and the rate at which it is transferred are what ultimately cause injury in apparel fires. To determine the important factors in determining this heat transfer, a contract was funded at the Cornell Aeronautical Laboratory in Buffalo, New York.

1.9 Sampling Plan and Model Questionnaire - Data on burn statistics are important in assessing unreasonable risk. A project to develop a system to obtain such data was funded under contract with the Denver Research Institute of the University of Denver, in Denver, Colorado. This is expected to be completed in early 1970.

2. The activities carried out under Feasibility Studies, Sec. 14(b)(2), were all carried out in-house. These are grouped under the following headings:

2.1 Pyrolysis Products - A study of the pyrolysis products is a way of determining the manner in which flame-retardants act, and thus of improving present flame-retardant treatments, and aiding in the development of new flame retardants. This project was begun late in 1969.

2.2 Industry and Other Government Developments - Considerable effort has gone into keeping abreast of outside efforts in this area, for these efforts are important in determining what standards are reasonable.

2.3 Evaluation of Durability of Existing Treatments - Considerable effort has gone into the evaluation of the durability to laundering and drying existing treated fabrics. Some treatments were found to be quite durable.

3. The activities carried out in Test Method Development, Sec. 14(b)(3), were all carried out in-house. These activities were as follows:

3.1 Development of a standard for Carpets and Rugs - A test method and standard based on the Federal purchase specification DDD-C-95 was developed and published as a proposed standard on December 18, 1969. Comments on this standard were being received at the end of 1969.

3.2 Revision of Apparatus in CS 191-53 - The present mandatory standard for flammable fabrics has several technical deficiencies. Foremost among these are the inability to distinguish between time to ignition and rate of burning. To correct this, an ignition test and a rate of burn test were developed.

3.3 Vertical Test Method - The vertical test is the most stringent of those in present use, and is used for those special circumstances when maximum protection is required and other considerations are secondary. Considerable work was done with this test method.

3.4 Tests on Bed Materials - A program was begun during 1969, to develop methods for testing the flammability of bed materials. Mattresses are receiving considerable attention, using cigarettes as a source of ignition.

3.5 Heat Release Test - No present test method measures the heat released by a burning fabric, despite the importance of this quantity in determining the hazard from the fabric. Work was begun in 1969, to develop a test for measurement of heat released during burning.

4. Activities under Training, Sec. 14(b)(4), were carried out in these ways:

4.1 Research Associates - The Research Associate program of NBS is a direct means of providing training. One Research Associate (from Consumers Union) was on board during part of the reporting period, and discussions for others were held with various interested organizations.

4.2 Bibliographies and Information Center - Three bibliographies, quoting pertinent literature references in the areas of Wearing Apparel, Fabrics Used on Beds, and Carpets and Rugs were completed during 1969, and were scheduled to be published early in 1970. Other bibliographies are scheduled for preparation, and an information center for flammable fabrics has been set up at NBS.

In addition to the above, there have been numerous formal and informal contacts with outside organizations and individuals, either by talks given by Department of Commerce personnel or visits by interested parties.

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1. Introduction

The Flammable Fabrics Act was enacted in 1953, amended in 1954, and further amended in 1967, in order ". . . to protect the public against unreasonable risk of the occurrence of fire leading to death or personal injury, or significant property damage . . ." resulting from the accidental burning of fabrics, related materials or products.

The Act, as amended, states in part:

"Sec. 14(b) In cooperation with appropriate public and private agencies, the Secretary of Commerce is authorized to--

(1) conduct research into the flammability of products, fabrics, and materials;

(2) conduct feasibility studies on reduction of flammability of products, fabrics, and materials;

(3) develop flammability test methods and testing devices; and

(4) offer appropriate training in the use of flammability test methods and testing devices.

The Secretary shall annually report the results of these activities to the Congress."

The Secretary of Commerce delegated responsibility for activities under Section 14(b) to the National Bureau of Standards by revision of Department Organization Order 30-2A dated October 1, 1968.

Funds to carry out these activities were not made available to the Department of Commerce until October 1968. As a result, progress in calendar year 1968 was minimal, and this report covers both years 1968 and 1969.

At the end of calendar year 1969, the National Bureau of Standards had 17 staff members directly employed in the implementation of the Department's responsibilities under the amended Act, plus the partial efforts of other staff members equivalent to a rate of another three man-years. This is in contrast to a full time staff of five at the end of calendar 1968. In addition, three contracts with outside research organizations had been negotiated and initiated in 1969, to complement the in-house effort.

2. Activities Under Sec. 14(b)(1): Research

Although many thousands of persons have been injured or killed as a result of the burning of flammable fabrics, adequate details have not been available as to the causes of the accidents, the frequency of ignition of different kinds of garments and interior furnishings, the nature, extent and severity of injury, and the nature of the hazards to which the public is exposed from burning fabrics. Much of the emphasis in research has been to identify these hazards and obtain quantitative information about them. In addition to in-house research, three contracts with outside research organizations have been funded. The two types of research are complementary, but for clarity they will be described separately.

2.1 In-House Research

2.1.1 Products of Combustion

Both actual fire reports and laboratory studies indicate that interior furnishings frequently become involved in slow, smoldering combustion with production of large quantities of smoke and fumes, but without open flaming. Moreover, in a large percentage of interior furnishing fires, fatalities are believed to have resulted from oxygen depletion, toxic gases, smoke inhalation, heat, or combinations of these, rather than burns. It is known that burning fabrics may produce toxic gases such as carbon monoxide, particulate smoke, and non-burned residues, but it is not known how much of each particular kind of product a burning fabric will produce during normal combustion. The amounts and kinds of combustion products are clearly related to the hazard from the burning of the fabric, and the amounts and kinds can be determined by performing a material balance for the burning of the fabric.

A research project has been started to carry out such a material balance on interior furnishing materials. This project involves the collection of the solid, liquid, and gaseous products of combustion, as well as any solid residues. Typical gases expected from the combustion of most materials are carbon monoxide, carbon dioxide, and water. These are invisible and odorless. However, other products of combustion are liquids such as tarry aerosols, and solids such as carbon particles. Excessive inhalation of these can and does cause death. Some materials give off other, less common but still highly toxic, gases during combustion. These products, which often act as

lachrymators, must be collected, identified, and the amounts measured quantitatively.

The technique involves ignition of representative specimen materials in a sealed chamber, in the presence of a carefully controlled atmosphere, and gathering of the combustion products and residue for analysis. Preliminary results indicate that the visible smoke from burning mattress materials is composed mainly of tarry aerosols. To date, there has been no attempt to further characterize these tars, which would be a long and tedious task. In experiments with polyurethane bedding materials, special emphasis will be placed on the detection and identification of types and amounts of toxic gases, particularly hydrogen cyanide.

2.1.2 Calorimetry

The principal aim of test method research is to determine what fabric parameter is representative of the hazard from the burning fabric. It is tacitly assumed in the present mandatory standard (CS 191-53) that those materials that burn more rapidly are more dangerous. It is known, however, that the total amount of heat given off as well as the rate of burning are important in determining the hazard from a burning fabric; in order to be dangerous, a fabric must give off a significant amount of heat and must do this in a short time. Thus, in order to characterize the hazard from a burning fabric, the amount of heat given off must be known, as well as the rate at which it is given off.

A research study is in progress to measure the total amount of heat released from burning fabrics, by calorimetric techniques. The apparatus, shown in Figure 1, is currently capable only of measurement of total heat release, but further refinement will permit measurement of the rate of heat release as well. While calorimetry may be carried out in various atmospheres, and pure oxygen is used frequently, in this study, the atmosphere was air, as in normal use conditions. Preliminary results indicate the combustion of cotton flannelette in air is about 80 percent complete, in terms of the ratio of actual heat release to the theoretical heat release.

2.1.3 Full Scale Garment Burning

The measurements of flame spread, heat, and other parameters with small fabric specimens in a laboratory test device are of greatest value only if they can be related to the burning behavior of the materials in

actual fire conditions. Therefore, considerable work has been done on the burning of actual garments on mannequins (Figure 2). The initial phase of this study involved primarily visual observations of the pattern of burning as related to the design of the garment, the point of ignition, and the materials from which the garment was made. The second phase of the study involved the measurement of temperatures at various locations near the surface of the mannequins.

The results showed that temperatures of 600-700°C were attained near the surface of the mannequin shortly after ignition of the garment. They also showed that heat may concentrate in certain areas, such as the axilla (armpits) and that temperatures are lower where the garment is relatively close fitting. These results were compared with the experience of physicians specializing in the treatment of burn victims, and were found to be consistent with their observations.

The third phase of the study, still in progress at the end of 1969, involves an attempt to estimate the probability that the wearer of a garment will become aware that he is dangerously close to a source of ignition before the garment is ignited. This is accomplished by placing a series of temperature sensing devices along the surface of the body of the mannequin near the point at which the ignition of the garment takes place. Concurrent records are made of the temperature at the "skin" surface and of the time for the garment to become ignited. The temperature data will be related to the heat sensitivity reaction of humans, as given in the literature. Clearly, if garments are so designed, and are made of such materials that the wearer feels the heat of the ignition source before the garment is ignited, the wearer has a good chance of avoiding a burn injury. The object of this study is to determine how such factors as garment material and garment design influence probability of ignition, and relate these factors to possible laboratory tests on fabric specimens.

2.1.4 Research Associate

In May of 1968, a Research Associate was placed at the National Bureau of Standards by Consumers Union to study the flammability characteristics of blankets and other products used on beds, to study the applicability of existing flammability tests to these products, and, if existing tests proved to be inadequate, to identify the parameters that should be considered in the development of a new test. Figures 3, 4, 5 and 6 illustrate some

of the test methods studied. These studies will be of value in future test method development.

2.1.5 Analysis of Burn Case Data

During 1968, the primary research effort was devoted to the analysis of data provided to the Bureau by other agencies, or developed by the Bureau in cooperation with the Department of Health, Education and Welfare. The latter data are derived from the field investigations carried out by teams of HEW accident investigators. Data from the first 153 cases reported to the Bureau were analyzed in mid 1968, to identify the extent of risk in terms of sex and age of the wearer, and type of garment. In approximately half the cases investigated by HEW, garments involved in the accident were recovered. The flammability of these garments was measured using the present mandatory standard (CS 191-53). All the garments passed the present requirements of the Flammable Fabrics Act. Over half the garments did not ignite in the one-second exposure specified in that test. Figure 7 illustrates a garment recovered from one of the burn cases.

As a result of the above described research, the Department published, in the Federal Register of October 23, 1968, (33 F.R. 15662), a notice of finding that there may be a need for new or amended flammability standards for wearing apparel. The notice also instituted proceedings for the development of such standards.

During 1969, analysis was continued of data from burn cases reported by the Food and Drug Administration, Department of Health, Education, and Welfare, as was testing and fiber analysis of the materials recovered by that agency and sent to the National Bureau of Standards. Reports were received on 109 cases during 1969; 74 of these were accompanied by samples of items ignited. Of these 109 cases, 83 were cases involving only wearing apparel, 11 were cases involving interior furnishings, and 14 were cases involving both wearing apparel and interior furnishings. One case was reported in which no fabrics were involved. At the end of 1969, the FDA had reported 417 cases to NBS.

Analysis of the data from the wearing apparel cases and the testing of the garments recovered from them showed that the general results derived from the first analysis, carried out in mid 1968, were modified somewhat on the basis of the larger total number of cases reported through 1969. Whereas 24 percent of the cases in the initial analysis had involved contamination of the garment(s)

with flammable liquids, this percentage was raised to 28 on the basis of the cases in the latest analysis. Whereas 54 percent of the garments recovered from the initial group of cases did not ignite in the one-second exposure of the present test, 63 percent of the 1968-69 total did not ignite. These, and other changes in the overall averages, show the need for the continuation of the accumulation and analysis of such data. Even more, they indicate the need for the accumulation of data at a greatly increased rate, so as to develop a statistically valid data base.

With the enlarged body of data, it was possible to identify more clearly those categories of garments that represented particularly unreasonable risks. Some categories of garments were found to be involved in accident cases more frequently than other categories. Moreover, some categories of garments were found to be involved in accidents more frequently in certain age groups than in other age groups. For example, the frequency with which children's sleepwear, underwear, and dresses were involved in burn cases of children from 1 through 5 years of age, compared to all burn cases reported for those garments, was found to be 2.5 to 3.9 times as great as the frequency with which children of that age group occur in the total population.

As a result of the above described research, the Department had in preparation at the end of 1969, a notice of finding that there may be need for new or amended flammability standards for children's sleepwear, underwear, and dresses in the size range up through 6X, and instituting proceedings for the development of such standards. (Such a notice was published in January 1970.)

2.1.6 Analysis of Data from Outside Laboratories

In 1968, Consumers Union, an independent organization specializing in the testing of consumer products, provided the National Bureau of Standards with flammability test results for carpets and rugs. The Consumers Union had made a market analysis and had selected and tested carpets that the analysis indicated were representative of production. They found that several carpets failed the test presently used by the Federal Government as a purchase specification (DDD-C-95) for carpets, and recommended to the Secretary of Commerce that the data be the basis for development of a standard. To examine the basis for that recommendation, the data presented by Consumers Union were examined

critically, and their facilities and capabilities were investigated. The Bureau was satisfied that the experiments were well carried out and the data sound.

Figures 8 and 9 illustrate the test used and a burning specimen tested thereby.

As a result of this research, the Department published, in the Federal Register of December 3, 1968, (33 F.R. 17921), a notice of finding that there may be need for flammability standards for carpets and rugs, and instituting proceedings for the development of such standards. That proceeding has advanced to the publication of a proposed standard. This will be reported in more detail in the section on Test Development later in this report.

Other data provided by Consumers Union were the results of flammability tests of regular, electric, and children's receiving blankets. The tests were made in conformance with the present method for wearing apparel, but with a slightly different criterion of failure. Consumers Union selected the blankets on the basis of a market analysis in order to select representative samples and found that several blankets failed the test, and recommended to the Secretary that the data be the basis for development of a standard.

A finding that there may be need for a standard for blankets is presently under preparation, using these data as well as other data developed by in-house research.

2.1.7 Investigation of the Mechanism of Flame Retardants

Cellulosic fabric materials, such as cotton or rayon can be treated chemically to make them non-burning, although this is not esthetically or economically possible for all types of cellulosic fabrics. The chemicals which are used in this treatment are called "flame retardants."

There is surprisingly little that has been firmly established as to the chemical mechanism by which these retardants act. The thermal decomposition reactions involved have been studied conventionally by "thermal analysis" methods, such as thermogravimetric analysis, where the rates of the pyrolysis reactions are deduced from weight records of the reacting solids. Another method is differential thermal analysis, where the course of pyrolysis is determined from measurements of heat evolved or absorbed by the reactions. These methods have serious limitations in sensitivity, in permissible heating rates, and in ability to differentiate among concurrent reactions.

To circumvent these limitations, a new method was developed for deriving reaction kinetics through measurements of the rate of evolution of volatiles from pyrolyses. At the end of 1969, the apparatus for this purpose had been assembled, consisting of a tube furnace with appropriate power controls and temperature recording devices, a flow system for an inert carrier gas, and a continuous analyzer for detecting one or more constituents of the effluent gas flowing from the tube furnace. This apparatus is shown in Figure 10. The apparatus has been designed so that several different types of analyzers may be used interchangeably, thereby making it possible to study a wide range of materials. The system has been demonstrated to be operable and experimental test work has been initiated.

2.2 Contract Research

The program of research for the Flammable Fabrics Act is a new program for the National Bureau of Standards. In order to implement this program, it was necessary to recruit staff, obtain equipment, and modify facilities. During this period, it was desirable that research be initiated under contract with outside research organizations that were equipped to undertake relevant projects immediately. In this way, pertinent research could be undertaken with a minimum of delay. Three contracts were negotiated during 1969; all three were still in progress at the end of the year.

2.2.1 Characterization of Actual Hazards from Interior Furnishings Fires

Assumptions have been made concerning the actual life hazards that occur in a room as the result of the burning of interior furnishings. These assumptions were based on the limited evidence remaining after many fires, and have not been verified by sufficient laboratory experimentation. A contract was negotiated with the Southwest Research Institute for study of the actual life hazards occurring from interior furnishing fires. The study was accomplished by experiments in an instrumented room. The room, which had dimensions of 14 x 12 x 8 feet, was equipped for continuous measurements of smoke density (by light obscuration along a horizontal path), of temperatures (at several locations and levels in the room), and of concentrations of carbon monoxide, carbon dioxide, and oxygen (also at several locations and levels). Spot checks were made for other toxic fumes in some of the experiments.

A total of 30 experiments were conducted, 22 involving the ignition of a bed and the other eight involving the ignition of an upholstered chair. In each experiment,

The beds were furnished with a mattress, plus sheets, blankets, or spreads, the particular combination being one of the variables in the study. Of particular importance in the study was the variation among the types of materials used in the construction of the mattresses, and for the other bed items. One experiment involved treated mattress, sheets, and blanket, of types used by the Veteran's Administration in their hospitals. Similarly, the chairs were of standardized design, but the materials used for the upholstery varied among the experiments. Figure 11 shows the bed in a typical experiment.

The experimental work has been completed at the end of 1969, and the final report was under review. The preliminary results clearly showed that smoke was developed in all experiments but one in sufficient quantity to obscure completely a strong light source across the 13-foot room. Temperatures in the room sometimes did not rise appreciably above the starting temperature and, in some cases, were not high enough to constitute a hazard in themselves. However, previous studies have shown that even moderate elevations of temperature cause the body to become more susceptible to effects of toxic gases. Significant concentrations of carbon monoxide and of carbon dioxide were measured, and the oxygen content of the air was lowered by several percent. Lethal conditions were developed in all experiments with the possible exception of one.

It is expected that this study will provide guidance for research with reduced scale apparatus and specimens, and for the development of test methods related to life hazard conditions.

2.2.2 Heat Transfer from Burning Fabrics

A contract was negotiated with the Cornell Aeronautical Laboratories for a study of the variables affecting the transfer of heat from burning fabrics to skin. The study has two goals, the first being an understanding of the heat transfer parameters, and the second being the development of a test apparatus for the measurement of both amount and rate of heat transfer from various materials that might be used in apparel.

A test chamber with a flat vertical test surface has been constructed. Figure 12 shows the chamber with four heat meters mounted on a vertical center-line of an asbestos board. Figure 13 is a diagram of the heat meter. The meter output is dependent on the temperature gradient between the edge and center of the stainless steel disc.

As noted in Figure 12, the meters are spaced a known distance apart, and it is possible to measure the rate of heat released as well as the rate of upward progression of the flame front.

Ignition takes place across the bottom of the fabric and the air flow through the test chamber is maintained at a constant known value and is such as to approximate "open air" burning. The fabric is held between thin wire grids, to maintain a fixed distance from the meters. The grids are made of 0.025 inch diameter wire spaced six inches apart. Without these grids, thermal drafts changed the separation between the meters and the burning fabric and gave results that were not reproducible.

Figure 14 shows the results of burning a 5.44 oz/sq. yd. cotton fabric one inch from the heat meters. The ignition (by a quartz-iodide lamp), required about 17.5 seconds. Meters A, B, C, and D are 4, 10, 16, and 22 inches above the bottom of the fabric where ignition took place. Overlaid on the heat meter curves is the threshold curve for second degree burns taken from Derkson, et. al.[1] The data have been plotted from the time of ignition, and one can read directly from the curves the time required to achieve a second degree burn after ignition takes place. Heat meter A indicates that an individual has approximately eight seconds after ignition before a second degree burn results four inches above the ignition point.

The heat transfer data obtained will be related to available data in the literature on the thermal damage of skin. The literature data appear to be adequate, so that it will not be necessary to conduct experiments with actual skin or skin simulants.

The anticipated work was about half completed at the end of 1969.

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[1] Derkson, W. L., Monahan, T. I., and de Lhery, G. P., "The Temperature Associated with Radiant Energy Skin Burns in Temperature, Its Measurement and Control in Science and Industry." Vol. III, Reinhold (1963).

2.2.3 Data Collection

Mention has been made, under In-House Research, of the analysis of the data derived from the burn cases investigated by the HEW field investigators. However, as emphasized there, there is need for more and better data. This fact has led to additional efforts of a research nature, specifically a contract with the Denver Research Institute described below.

2.2.3.1 Cooperation With HEW in Data Collection Improvement

The number of cases investigated by HEW, and the nature of the sample represented in the cases investigated, are such as to limit their usefulness in making meaningful extrapolations to the total population. Nearly all the cases have been those of individuals brought to emergency rooms of hospitals. Such a sampling clearly is not representative, for example, of the cases that are treated by first aid, by a doctor in his office, or result immediately in death. Moreover, the FDA sampling plan, based essentially in Denver and Boston, is such that it does not lead to a knowledge of what happens in all hospital emergency rooms in the country. Therefore, the Office of Flammable Fabrics, NBS, and the Office of Product Safety, FDA, HEW have instituted a program to explore means to make the present data collection effort more effective. The discussions have involved not only those trained in investigation, but also persons trained in statistics, economics, and social behavior. This effort is expected to be a continuing joint effort.

2.2.3.2 Sampling Plan and Model Questionnaire

In addition to the joint effort by NBS and FDA, a contract was let to the Denver Research Institute for the design of a sampling plan and the development of a model questionnaire for the collection of burn case statistics. The plan is intended to provide for identification of cases of individuals involved in a fire, on a random sample out of a defined segment of the national population. Since the sample will be well defined in relation to the total population, extrapolation of the data will be possible, to make estimates of national totals with reasonable degrees of accuracy. The model questionnaire is intended to provide for an in-depth investigation of the accident identified by the sampling.

The study involves design of the sampling plan and testing it on a limited basis. This has been done within the city of Denver. The results indicate that to obtain meaningful results in a final study, a larger sample will be necessary. The people who suffer burn accidents represent a small percentage of the total population. Therefore, large numbers of individuals must be contacted in order to find statistically meaningful numbers of persons who have experienced a fire within a reasonably recent time period.

The questionnaire to be used in the study had been designed by the end of 1969, but had not been tested. The work is continuing into 1970.

3. Activities Under Sec. 14(b)(2): Reduction of Flammability

Present knowledge indicates that flammability of a material is influenced by its chemistry, construction, weight per unit area, moisture content, and the presence of chemical treatments. Reduction of flammability might be accomplished by variations of any of these parameters. However, past experience suggests that construction, chemical treatments, and the chemistry of the basic material are the parameters that may be varied with the greatest prospects for significant improvement. Mention has been made earlier in this report, under Research, of in-house efforts toward fundamental understanding of the mechanisms by which retardants are effective in reducing flammability. It is expected that this understanding will provide guidance for the development of new and better retardants.

3.1 Pyrolysis Products

A variety of chemical fire-retardant treatments has been developed for cellulosic fabrics, mainly on an empirical basis. Many of the details of the chemical action of flame retardants remain obscure and a better understanding is required to provide a basis for the development of more effective retardants, and to advance the art of flame retardancy in man-made fibers.

In order to elucidate the detailed mechanism of the action of retardants, the Inorganic Chemistry Section of the National Bureau of Standards has initiated a program that will apply the techniques of measurement and characterization that have proven effective in related areas, such as high temperature chemistry, and vaporization phenomena. These techniques include electron spin resonance (ESR) to monitor free radicals produced during pyrolysis, mass

spectrometry for the identification of reactive decomposition products, and infrared spectrometry and gas chromatography.

This work will consist of an intensive investigation of a few carefully selected systems to elucidate the mechanism on a molecular level. This program will also study the thermal behavior of a few selected retardants of commercial importance, such as tetrakis(hydroxymethyl)phosphoniu derivatives (THPC, THPOH) and tris(aziridyl)phosphine oxide (APO

The chemical nature of many of the retardants (mainly phosphorous, halogen and nitrogen compounds) is such that many of their decomposition products may be toxic. Their use may, in effect, replace the flammability hazard with the danger of toxicity. Therefore, identification of toxic products will be emphasized.

The initial phase of this project was the development of general capabilities. A commercial quadrapole mass spectrometer is available, as is the ESR and infrared equipment. However, a differential high pressure/high temperature sampling system must be assembled. Development of this system was under way at the end of 1969.

3.2 Industry and Other Government Developments

Considerable work in the development of retardants has been done by the Southern Utilization Research and Development Laboratories, U. S. Department of Agriculture, where many of the currently available permanent flame-retardant treatments for cotton were developed. Advances have also been made by industry in the development of treated cellulosic fabrics which retain a large measure of the esthetic and other characteristics that make fabrics acceptable for wearing apparel and other uses. Several different treated garments made from cellulosic materials have been offered for sale to the consuming public by major distributors. No information is available on the public reaction to the garments, and the number of different types offered is still small in proportion to the total market. The Department of Commerce has been advised by several manufacturers of their efforts and progress toward the development of new treatments, or improvements on existing treatments, not yet marketed.

In view of the substantial efforts of other government agencies and industry, the level of effort toward the reduction of flammability was limited to that already described under Research, and to active liaison.

3.3 Evaluation of Durability of Existing Treatments

A limited study was initiated, late in 1969, to investigate the durability of the more common "permanent" treatments now available for cotton and other cellulosic fabrics. The objective of the study is to expose the various treated fabrics to controlled standard washing and drying cycles. Washing is carried out by standard machine washing technique. Drying is carried out in normal household dryers; in simulated sunlight; and in actual sunlight. In addition, testing is carried out in an instrument called a "weatherometer," in which the material is subjected to exposure to simulated sunlight (light from a xenon arc lamp) with intermittent water spray.

A limited supply was obtained of a few treated fabrics. Repeated cycles were carried out for machine washing and drying, and in the "weatherometer". The results indicate that commercial treatments for cellulosic materials are durable under these tests.

The weather has been unsuitable for outdoor drying in actual sunlight. This work will be undertaken as soon as feasible.

4. Activities Under Sec. 14(b)(3): Test Method Development

4.1 Proposed Carpet and Rug Standard

During 1968, notice was published instituting proceedings for the development of a standard for carpets and rugs. Such development was completed during 1969.

As the initial step, in this development, careful consideration was given to the various circumstances under which carpets or rugs might be exposed to ignition, and to the nature of the resulting hazard. These circumstances are:

(1) A carpet or rug might be exposed to a small ignition source, (such as a dropped match, cigarette, or an ember from a fireplace) become ignited therefrom, and cause fire spread to other combustible contents of the room or building.

(2) A carpet or rug might be exposed to a moderate to large source of thermal energy, and in the presence of significant air movement, become ignited, and cause fire spread to other parts of the room or building.

(3) A carpet or rug might become ignited, or be exposed to a moderate to large energy source, and give off smoke or toxic fumes in dangerous quantities.

Consideration of the above circumstances, and of the comments received in response to the published notice, led to the conclusion that circumstance (1) was the most appropriate for simulation in a first-generation standard, but that (2) and (3) should receive attention for second-generation tests.

A modification was developed of an existing flammability test for carpets and rugs, namely, that given in Federal Specification DDD-C-95, Carpets and Rugs, Wool, Nylon, Acrylic, Mod-acrylic. With the cooperation of a task group set up by Committee D-13 on Textiles, of the American Society for Testing and Materials and representatives of other interests, an interlaboratory evaluation was carried out on the modified test method. The evaluation was designed by NBS statistical experts, who also carried out the analysis of the data.

The new test is illustrated in Figure 15.

Twelve laboratories participated, six being those of producers of carpets or rugs, and six having consumer or general interest. Each tested twelve carpets selected as representative of the three major categories of interest in any test evaluation: those expected to pass consistently, those expected to fail consistently, and those expected to show marginal performance. One objective of test development is to minimize uncertainties among the results obtained both within individual laboratories and among them. Each laboratory tested 16 specimens of each of the twelve carpets. This required 192 specimens of each carpet.

All 192 specimens of each carpet were cut from a single roll of that carpet, according to a pattern defined in the statistical plan. Each specimen was assigned an identification from a table of random numbers provided by NBS. Upon receipt by the individual participating laboratories, the 16 specimens of each carpet were further randomized into two sets of eight. Figure 16 shows representative burn patterns of samples of the 12 carpets.

The experimental plan called for measurement of several different parameters. The data were analyzed in terms of the repeatability and reproducibility to

be expected from various criteria based on the measured parameters. A copy of the statistical analysis of the test data is given in Appendix 1.

The various possible criteria for which analyses had been made were considered in relation to their probable effect upon choices available to the consumer and to the effect on the industry. A criterion judged to be reasonable was selected.

A market sampling of carpets and rugs was purchased, indicative of the range of fibers and constructions available to the consuming public. These carpets and rugs were tested by the proposed method, using the proposed criterion, to assess the impact of the proposed test and standard. The proposed standard was published in the Federal Register of December 18, 1969, (34 F.R. 19812). A copy of the notice and proposed standard is given in Appendix 2.

4.2 Revision of Apparatus in CS 191-53

The present method for testing the flammability of fabrics, as embodied in CS 191-53, has several technical shortcomings. The major shortcoming is that, in attempting to measure both ease of ignition and burning rate of fabrics, neither characteristic is adequately measured. It was decided to separate the two aspects of fabric flammability and design independent tests to measure ease of ignition and burning rate.

4.2.1 Development of Test to Measure Rate of Burning

For the measurement of burning rate, a Burning Rate Test Method (BRTM) was developed during 1969. An extensive series of experiments was undertaken to pin-point the effects of several variables, to design means to minimize them, and to optimize the overall test. Various specimen sizes (6-1/4" x 2-1/2", 11" x 2-1/2" and 11" x 4") and two specimen inclinations (45° and 60°) above the horizontal were studied. The relative merits of edge ignition versus surface ignition were examined. In order to avoid the effects of transients during and just after ignition, study was made of the length of specimen (lead length) that should burn before measurement of burning rate was started. The minimum length over which burning should be measured (gage length) was also studied. Ignition at the edge rather than on the surface was found to lead to more consistent burning. For edge ignition, a lead length of about 4-1/2 inches and a gage length of six inches were found to be optimum, resulting in an overall specimen 11 inches long and 2-1/2 inches wide (width unchanged from the present standard).

The selection of a larger specimen size than that given in CS 191-53, and the demand for improved accuracy and precision of measurement led to several changes in the test cabinet, the flame burner, and the timing mechanism. The burning of the larger specimen in the present cabinet was accompanied by a collection of smoke and hot gases in the top of the chamber, with some inhibition of combustion during the test. Therefore, the overall height of the cabinet was increased by eight inches. For ease of operation, and in conformance with the use of edge ignition, the burner was simplified, and placed in a vertical orientation. A digital clock, started and stopped by microswitches, was substituted for the present system of a stopwatch activated by a lever and a falling weight. The modified apparatus is shown in Figure 17.

An extensive series of 58 representative fabrics was tested using this new method. The fabrics tested are given in the Table. For most of the fabrics tested, it was found that the heavier fabrics (higher weight per unit area) gave higher values for the time to burn the specified distance of six inches, and that the relationship of burn time to fabric weight per unit area was linear. The results are shown in Figure 18. In common with all other such tests, thermoplastic materials which melt away from the igniting flame are difficult to test and will require more research.

Work is continuing to modify CS 191-53 to permit the testing of loose, fibrous materials, and thin, narrow ribbons and tapes. The experience of the Federal Trade Commission has shown that the testing of these often constitute problems.

4.2.2 Ease of Ignition Test

Ignition has been recognized as the beginning of a chain of events that can end in tragedy. Therefore, the measurement of the ease of ignition of materials and fabrics is essential to characterization of their flammability. Mention has already been made of the study of the relationship of this parameter to the sensory reaction of an individual to heat from an ignition source, and of the failure of the present wearing apparel test to measure ignition. Therefore, the development of a test for ease of ignition under exposure to a small flame was initiated and completed during 1969.

The test utilizes the cabinet, burner, fuel, and burner rotation hardware from the present apparel test. However, the burner has been equipped with a mechanism and controls to permit varying the time of flame impingement, or contact, on the specimen from essentially zero to 15 seconds. The time is monitored by a digital clock. The specimen holder consists of two matching aluminum plates, of 8-inch diameter, with six 2-inch diameter holes in each. One large, or up to six smaller pieces, of the test material may be clamped between the plates. Figure 19 shows the equipment.

This test calls for subjecting the suitably conditioned specimen to successively varied periods of flame impingement until the minimum time is found that is required to produce sustained burning of the material. This time is measured by the clock, and has been found to be reproducible to 0.1 second. A new area on the specimen is used for each trial.

A group of 58 materials, representative of a wide selection of apparel fabrics now on the market, was purchased in retail outlets, and subjected to the ease of ignition test. This is the group shown in Table 1. Results ranged from 0.2 seconds for very light materials to 5.8 for a heavy wool flannel. The results for ignition time plotted against fabric weight per unit area are shown in Figure 20. Again there is a high correlation between ignition time and fabric weight for many fabrics.

A technical paper describing the test and its development is under review, and will be offered for publication in 1970.

4.3 Vertical Test Method

Strong arguments have been advanced for a test method for essentially non-burning fabrics. Such a test might be applied when the degree of risk to the public, or to a segment, such as small children, dictates the maximum possible level of protection. Of the types of tests currently applied to fabrics, those placing the specimen in a vertical orientation are more severe than those involving other orientations, all other factors being equal. Several voluntary standards organizations have published variations of a vertical test, and one appears in the Federal purchase specifications for items purchased by the Federal Government. Although there is overall similarity, there is variation in details among the versions of various organizations. The degree to which the dissimilarities influence the results

obtained is not well documented. A study has been started of some of the differences. The apparatus is shown in Figure 21.

The usefulness of such a test is dependent on the availability of products that will pass the test. Several fabrics have been evaluated by one of the several versions of the test.

A difficulty common to all the versions of the vertical test is experienced with thermoplastic materials. Although some of these materials have been known to ignite when used in garments, and lead to serious burns to the wearers, the same fabrics merely melt away from the exposing flame in the test and do not burn. The failure of a test method to give a measurement for a material subject to the test is a serious inadequacy. A study was carried out to investigate the effectiveness of several techniques in assuring the ignition and burning of thermoplastic materials. The study was similar to one carried out by a voluntary standards group (in which the National Bureau of Standards also participated), but involved some techniques not tried. The results confirmed those of the private sector group. The most effective means presently known for testing such materials is by stitching parallel rows of glass thread up the middle of the specimen.

4.4 Tests on Bed Materials

Both the results of research already described and the experiences of many fire departments show that a smoldering cigarette can, under certain circumstances, cause smoldering combustion or open flaming of bed materials (particularly mattresses), and upholstered furniture. Either type of combustion can lead to death of the occupants of the building within which the ignition occurs.

In order to investigate the circumstances under which cigarettes ignite beds, and to design a suitable test for that behavior, a program has been initiated for characterizing the flammability of bed materials when subjected to a smoldering cigarette. A series of simulated bed systems have been exposed to cigarettes. These systems have consisted of 3- by 5-inch arrays of mattress core materials and ticking (or mattress upholstery systems) with sheets and blankets. In addition to the 3- by 5-inch simulated bed arrays, various types of miniature mattresses, approximately 20-inches square, have been subjected to smoldering cigarettes, with and without overlaid sheets or blankets. Figure 22 shows such an experiment in progress.

At the end of 1969, agreement had been reached with representatives of mattress manufacturers for them to conduct a market survey to identify suitable representative materials to be used as specimens in an interlaboratory evaluation of a test using smoldering cigarettes as the ignition source.

4.5 Heat Release Test

A new test method, undergoing preliminary study, is designed to measure the rate at which sensible heat is evolved in the gases convected from burning fabrics - a parameter that previously has not been systematically quantified. Such measurements should prove to be a useful component of a hazard index for fabrics. Such data might usefully support, supplement, and/or correlate with the total heat data to be obtained with the calorimetry apparatus as well with the calorific indications that may be obtained in the study of pyrolysis reactions.

The gas-flow and temperature recording portions of the apparatus were tested briefly and appeared to operate satisfactorily. The apparatus is shown in Figure 23. The apparatus design calls for instruments for continuous analysis of the oxygen and the combustible gas contents of the effluent gas stream. Such analysis will permit a cross-checked total heat balance to be made. This instrumentation was ordered, but had not been delivered at the end of 1969.

5. Activities Under Sec. 14(b)(4): Training

Activities in training were carried on in three identifiable ways, each discussed separately below. None of these took the form of scheduled classes or lectures.

5.1 Research Associates

The Research Associate Program provides an excellent mechanism for training. The Consumers Union Research Associate, discussed above, obtained valuable training and experience in test methods, and in government research operations and procedures. The value of such experience to the sponsor may be as great as that of the research results. The technical accomplishments of the Research Associate furnished by Consumers Union have been described under In-House Research.

The use of the Research Associateship mechanism has been explored with several industry groups and associations.

Although no new associates were assigned to NBS during 1969, discussions under way at the end of that year indicate a strong possibility of one or more in 1970.

5.2 Bibliographies and Information Center

Bibliographies, which list all the literature articles pertinent to a technical subject, are very valuable to anyone conducting research or development in that subject. Such bibliographies thus constitute a valuable means of education and dissemination of information.

Three bibliographies were sent to the printer late in 1969, and are expected to be released early in 1970. These cover the areas of Wearing Apparel, Bed Fabrics and Carpets and Rugs. Citations have been collected for other areas of interest in the flammable fabrics program. The bibliographies will be published at irregular intervals during 1970. Interior furnishings and test method development will be the next two bibliographies to be published.

An information center has been established under the auspices of the National Bureau of Standards library. All of the citations reported in the various bibliographies are available there for public examination.

5.3 Symposium on the Measurement of Flammability

Over 600 persons attended a symposium in Washington, D. C., June 5 and 6, 1969, organized by the National Bureau of Standards. The symposium was opened by Secretary Stans, with additional opening remarks by Assistant Secretary Myron Tribus and the then NBS Director, A. V. Astin. The technical papers dealt with the reasons for measuring flammability, the particular phenomena that should be measured, the state-of-the-art for measuring those phenomena, and the applicability of those measurements to several categories of items subject to the Flammable Fabrics Act. The specific categories were wearing apparel, blankets, mattresses, upholstered furniture, drapes, rugs and carpets, and linens. The Proceedings of the Symposium are in preparation for publication.

6. Cooperation with Public and Private Agencies

The Flammable Fabrics Act as amended specifies that the activities authorized under Section 14(b) are to be done in cooperation with appropriate public and private groups.

6.1 Liaison With Industry and Other Groups

A continuous effort is being made to keep all concerned industry, government, and private sector groups informed of the status of research and test method development, and of the progress being made. Liaison is maintained with trade associations. As a consequence, outstanding cooperation has been received from these groups, for example in the development of the proposed carpet and rug standard. Liaison is also maintained with interested consumer groups and government agencies, some of which participated in the development of the proposed carpet and rug standard. Talks were given by NBS staff members before several meetings, including those of:

National Advisory Committee for the Flammable Fabrics Act;

National Cotton Batting Institute Workshop;

American Association of Textile Technologists;

Information Council on Fabric Flammability;

Chemical Finishing Conference, National Cotton Council;

Home Safety Workshop, National Safety Council;

Polymer Conference Series, University of Detroit.

The staff members made several visits to other laboratories engaged in testing, test method development, and product development.

6.2 Liaison With Voluntary Standards Organizations

Liaison has been maintained and strengthened with the appropriate committees of the national voluntary standards organizations concerned with tests for materials and products subject to the provisions of the Act. This has been of advantage to both the Department and the voluntary standards organizations. NBS staff members have been able to draw upon the expertise of the members of the committees in planning and carrying out the development and evaluation of test methods. Members of the committees were among the participants in the interlaboratory evaluation of the proposed carpet and rug standard. Similarly, NBS staff members have participated in interlaboratory evaluations of tests being developed by committees. Committees in which NBS staff members hold active membership include: the American National Standards Institute Ad Hoc Committee on Fabric Flammability, the

ASTM Committee D-13 on Textiles, the ASTM Committee E-5 on Fire Tests of Materials and Constructions, the American Association of Textile Chemists and Colorists Committee RA-46 on Fire Resistance Test Methods, and the National Fire Protection Association Committee on Wearing Apparel.

6.3 General Liaison

Finally, the Department and NBS have been host to numerous visitors, have responded to numerous inquiries, and handled voluminous correspondence. It is estimated that the Office of Flammable Fabrics has handled 5,000 telephone and 1,300 written inquiries, and 200 visitors during 1969.

7. Conclusion

The period covered by this report has been one in which the staff and facilities necessary to carry out the responsibilites delegated to the Department of Commerce under the Flammable Fabrics Act have been built up and organized. Within the limitations imposed by time and budget, a program designed to carry out these responsibilities has been developed. While the pace is still accelerating, a significant increase in the rate of progress will require further support.

FABRIC MATERIALS USED FOR IGNITION TEST
AND TIME OF FLAME SPREAD TEST

No.	MATERIAL	CONSTRUCTION	COLOR	WEIGHT	
				OZ/YD^2	G/M^2
1	COTTON	CORDUROY	BROWN W	6.3	214
2	COTTON	VELVETEEN	GRAY	5.6	190
3	RAYON	VELVETEEN	RED	4.2	142
4	RAYON	VELVETEEN	DARK RED	6.0	204
5	COTTON	SUEDE	BLUE	7.1	241
6	COTTON	FLANNELETTE	YELLOW	3.9	132
7	COTTON	TERRY CLOTH	WHITE	8.6	292
8	COTTON NYLON	95-5 LACE	PINK	3.9	132
9	COTTON ACETATE	BONDED LACE	ROSE	4.5	153
10	LINEN		L BROWN	6.8	230
11	COTTON	BROADCLOTH	ORANGE	3.5	119
12	COTTON	BATISTE	WHITE	1.9	64
13	COTTON POLYESTER	35-65 BATISTE	L GREEN	3.2	108
14	NYLON		PINK	0.5	17
15	NYLON	FLEECE	DARK GREEN	3.2	119
16	NYLON	NET	RED	0.4	14
17	POLYESTER	CREPE	L BLUE	1.8	61
18	RAYON	PEAU DE SOIE	YELLOW	5.4	183
19	ACETATE	SATIN	ROSE	5.3	180
20	NYLON	CHIFFON	WHITE	0.8	27
21	RAYON	CHIFFON	GRAY	1.0	34
22	SILK	CHIFFON	CREAM	0.6	20
23	NYLON		L GREEN	1.5	51
24	WOOL	FLANNEL	CHARCOAL	6.6	20
25	RAYON	METALLIC THREAD	GOLD	3.6	122
26	ACETATE	TAFFETA	ROSE	2.9	98
27	WOOL	FELT	WHITE	5.4	183
28	RAYON ACETATE	BONDED CREPE	PEACH	6.7	227
29	RAYON	CREPE	ROSE	4.3	146
30	WOOL	FLANNEL	YELLOW	6.0	204
31	ACRYLIC ACETATE	BONDED	PINK	7.6	258
32	RAYON	PLAIN	WHITE	2.3	78
33	ACETATE	TAFFETA	YELLOW	2.6	78
34	POLYESTER	DOUBLE KNIT	CREAM	6.9	234
35	POLYESTER		PINK	2.8	61
36	COTTON	PETTI POINT	WHITE	4.3	146
37	COTTON		PINK	4.0	136
38	COTTON POLYESTER	50-50	BLUE	5.1	173
39	WOOL NYLON	80-20	PLAID OGW	7.6	252
40	COTTON POLYESTER	50-50	CORAL	7.4	252
41	COTTON RAYON	50-50	WHITE	4.2	143
42	COTTON RAYON	35 65	PRINT PW	3.9	133
43	COTTON ACETATE	85-15	BROWN	6.7	227
44	ACETATE	BROCADE	WHITE	4.9	166
45	RAYON ACETATE	83-17	AQUA	9.4	319
46	RAYON ACETATE	50-50	CHECK OW	9.0	305
47	ACETATE NYLON POLYESTER SILK	44-39-11-3-3	WHITE	3.5	119
48	RAYON POLYESTER	92-5-3	GOLD	4.9	166
49	COTTON RAYON	34-63	WHITE	8.6	292
50	COTTON RAYON	55-45	BLUE	9.3	315
51	COTTON		BLUE	3.4	115
52	POLYESTER		PRINT BY	1.7	58
53	COTTON		PRINT GBR	3.6	122
54	ACRYLIC		CHECK	5.6	190
55	RAYON ACETATE	75-25	GREEN	6.2	210
56	RAYON ACRYLIC	50-50	PEACH-BLUE	6.7	227
57	RAYON	TWILL	BLACK	3.4	115
58	RAYON	SPUN	PINK BG	8.3	281

APPENDIX 1

Analysis of Data from Interlaboratory Study of Carpet Flammability Test

Introduction

This report presents the statistical analysis of data from an interlaboratory evaluation conducted cooperatively among the Carpet and Rug Institute, Committees of the American Society for Testing and Materials, and the National Bureau of Standards. The subject of the evaluation was a procedure for flammability tests of carpets and rugs. Several parameters were measured and considered as possible end-point criteria.

The test procedure involves the ignition, by a match, of a specified timed burning tablet (methanemine) on a piece of carpet within a draft shield. The carpet specimens had been dried in an oven and cooled in a desiccator. During the test, each specimen is held flat by a steel plate 9 x 9 x 1/4 in. with a 6 in. diameter hole in its center. The various parameters considered as possible end-point criteria are described in a later section of this report. This test method is a modification of the flammability test given in Federal Specification DDD-C-95, Carpets and Rugs, Wool, Nylon, Acrylic, Modacrylic.

The Carpet and Rug Institute was represented by an executive of the Institute and by six member companies. This group formed the nucleus of a task group operating under an ASTM committee, and drafted the initial version of the test method.

Committee D-13 on Textiles of ASTM, in cooperation with Committee E-5 on Fire Tests, and under direction of the ASTM Board of Directors, has initiated a program of development of flammability tests for many textile items, including wearing apparel and interior furnishings. A task group on carpets and rugs provides the direct ASTM contact with this study.

On December 3, 1968 there appeared in the Federal Register notice of finding that that there may be need for flammability standards for carpets and rugs. That notice was published

under authority to set standards granted to the Secretary of Commerce by PL 90-189, Amendments to the Flammable Fabrics Act. Pursuant to that notice, the National Bureau of Standards has been engaged in the development and evaluation of possible test methods for measuring the flammability of carpets and rugs. This interlaboratory evaluation and statistical analysis are part of that effort.

Data

The data subjected to a statistical analysis consist of measurements of the char radius and of the time of burning made on two sets of 8 specimens each, for each of 12 carpets, in each of 12 laboratories. The complete data are given in Table 1.

Objective of the Analysis

The data were collected for the purpose of developing a satisfactory discrimination test between acceptable and unacceptable materials. This task comprises two phases:

a) A "test criterion" must be established to decide whether any single test specimen passes or fails the test.

b) A "sampling plan" must be selected, specifying the number of specimens that shall be tested and the manner in which the number of passes and failures leads to acceptance or rejection of the material.

Establishing a Test Criterion

The test criterion suggested by the Carpet and Rug Institute was described as based on the concept of self-extinguishment. For measurement purposes, a carpet is considered to be self-extinguishing under that criterion if the flame goes out before it reaches the metal ring; i.e. the char radius is less than three inches. For convenience, this criterion shall be referred to as the "Three Inch" criterion.

Another concept that was considered in this test is that of ignition. To establish whether ignition has taken place, two possibilities suggest themselves. Ignition may be considered to have occurred when burning continues for a length of time longer than that required for the timed burning tablet to be completely consumed in the absence of other fuel. Also, ignition

may be considered to have occurred whenever the flame travels beyond the distance that would be reached by burning of the tablet on a non-combustible carpet. One can also combine these two requirements.

A number of possibilities listed below, were considered as possible test criteria in the statistical evaluation of the interlaboratory results. The first is based on the self-extinguishing concept, the other six on the ignition concept.

1. Char radius less than 3 inches.
2. Char radius 1 inch or less.
3. Char radius 2 inches or less.
4. Time of burning 120 seconds or less.
5. Time of burning 150 seconds or less.
6. Char radius 1 inch or less and time of burning 120 seconds or less.
7. Char radius 2 inches or less and time of burning 120 seconds or less.

Table 2 shows the overall percentage of "passing" specimens for each carpet, for each of the seven criteria. Among these, criteria 6 and 7 turn out to be the most promising for the sharpest separation of materials as acceptable or unacceptable. It also appeared that these two criteria lead to almost identical results for all carpets included in the study. In view of these results, one test criterion, in addition to the "Three Inch" criterion, was selected for study. This criterion is formulated as follows:

Dual Test Criterion:

A specimen shall be considered to have passed the test if the char radius is 1 inch or less and the burning time is 120 seconds or less. If either one of these two requirements, or both, are not fulfilled, the specimen is considered to have failed.

Analysis of the Two Test Criteria

Table 3 summarizes the results of the interlaboratory test, using the "Three Inch" criterion. For each laboratory and carpet, two values are given. These are the number of specimens that passed in each of the two sets of 8 specimens.

Table 4 summarizes, in a similar fashion, the results of the interlaboratory test, this time using the "Dual Test" criterion.

For each of the two test criteria, an analysis was made to determine the degree of consistency of the 24 results obtained for each carpet. Table 5 exhibits this analysis for the "Three Inch" criterion, and Table 6 for the "Dual Test" criterion. In each of these tables, a comparison is made between the observed and the theoretical frequency distribution of passing specimens in sets of eight; the theoretical frequency distribution is calculated on the basis of the overall percent of passing specimens, also given in the tables, using the binominal distribution. It is seen from these tables, that the binominal distribution is by and large an adequate representation of the results. This conclusion is discussed in more detail in the following section.

Repeatability and Reproducibility

It is customary to characterize methods of test by measures of repeatability and reproducibility. The former is related to variability of test results obtained by repeated measurements of the same material in a single laboratory. The latter refers to the variability of test results obtained on the same material in different laboratories. In the present instance, the result of the test is not a quantitative measurement, but rather a count: the number of passing specimens in either one or two groups of eight specimens each. If the distribution of these counts follows the binomial law, the variance of the count can be derived by mathematical theory from the overall percent of passing specimens in the carpet. This formula is:

$$\text{Variance } (n) = m \frac{P}{100} \left(1 - \frac{P}{100}\right) \qquad (1)$$

where n is the number of passing specimens in a group of m specimens, and P is the overall percent of passing specimens for the carpet under consideration. The standard deviation of n is the square root of the variance. In our study, m is either 8 or 16, depending on whether we compare the two results obtained within a laboratory or the twelve results, on 16 specimens each, between laboratories.

We could conceivably define the standard deviation of the count n, or an appropriate multiple of this standard deviation, as repeatability or reproducibility. The former

would apply to the within laboratory comparison and the latter to the between laboratory comparison. These standard deviations would be calculated in the usual fashion from the observed counts, and Equation (1) would be used as a theoretical check. However, according to Equation (1), we would expect a variance twice as large for m = 16 as for m = 8, and consequently a reproducibility which is $\sqrt{2}$ times larger than repeatability. For this reason we will define repeatability and reproducibility in a slightly different way, namely as the ratios of the standard deviations just described to the corresponding theoretical values, i.e., to $\sqrt{8 \frac{P}{100}(1 - \frac{P}{100})}$ for repeatability, and to $\sqrt{16 \frac{P}{100}(1 - \frac{P}{100})}$ for reproducibility[1/]. To avoid ambiguity, we will call these ratios the repeatability ratio and the reproducibility ratio.

Table 7 exhibits the repeatability and reproducibility ratios for all carpets, for each of the two test criteria. On the whole, the ratios tend to be close to unity. Ratios exactly equal to unity generally occur for carpets in which specimens either all pass or all fail. Where the ratios differ from unity, there is seen to exist a tendency to obtain values less than unity for the repeatability ratio and larger than unity for the reproducibility ratio. This indicates a tendency for slightly better agreement (smaller standard deviation) within laboratories than between laboratories. In the cases where the differences between the two ratios is pronounced, or where both ratios depart appreciably from unity, the binomial distribution, when applied to all 24 sets of 8 specimens, will not be a perfect representation of the data because of unequal distribution within and between laboratories. For those cases, the agreement between theory and observation in Tables 5 and 6 is somewhat poorer than for those in which the repeatability and reproducibility ratios are close to unity.

1/ It may be useful to point out that these calculations are mathematically equivalent to a partitioning of the chi-square criterion within and between laboratories (of A. E. Maxwell, Analysing Qualitative Data, Chapter III, Methuen's Monographs on Applied Probability and Statistics, John Wiley & Sons, N. Y. 1961). The quantities defined by us as the repeatability ratio and the reproducibility ratio are the square roots of the quotients of the partitioned chi-squares divided by their degrees of freedom.

Selection of a Sampling Plan

Here again, two sampling plans were considered. One had been originally proposed and consists of the following rule.

Single Sampling Plan: Eight specimens shall be tested. The material shall be considered acceptable if and only if at least seven of the eight specimens pass the test.

As an alternative, we propose the following double sampling plan.

Double Sampling Plan: Eight specimens shall be tested. If all eight pass, the material is considered acceptable. If less than seven specimens pass, the material is considered unacceptable. If exactly seven specimens pass, a second set of eight specimens are tested. In order for the material to be considered acceptable, all eight specimens of the second sample must pass.

Figure 1 shows "operating characteristic curves" (OC curves) for both plans. The ordinate represents the probability of accepting a material for which the overall fraction of individual "passing" specimens is plotted on the abscissa. The double sampling plan is seen to be appreciably more discriminating than the single sampling plan.

The Probability of Agreement

For a fuller evaluation of the two test criteria and the two sampling plans, we introduce a further concept, defined as follows.

The probability of agreement is the probability that two independent tests, carried out on the same carpet, will result in the same verdict of acceptable or non-acceptable.

It should be noted that the qualification "independent tests" implies the use of the binominal distribution. Using this law, the probability of agreement can be derived mathematically for any given sampling plan, as a function of the overall percentage of passing specimens (% P). The latter depends of course on the choice of the test criterion. These calculations have been made and the results are given

in Table 8 and in Figures 2, 3, 4, and 5. The first two of these figures show the results for the Single Sampling Plan. In Fig. 2, the values of the overall percentage of passing specimens for the twelve carpets are those based on the Three Inch criterion; whereas in Fig. 3, they are based on the Dual Test Criterion. Fig. 4 and 5 are similar to Fig. 2 and 3, but show the probability of agreement in accordance with the Double Sampling Plan.

Summary of the Analysis

Table 9 is an overall summary of the statistical analysis of the data. It shows the percent of "passing" specimens (% P) for each carpet according to both test criteria; the probability of acceptance of each carpet for both test criteria and both sampling plans; and the corresponding probabilities of agreement for independent tests. An examination of this table shows that for the twelve carpets included in this study the double sampling plan, used in conjunction with the dual test criterion, provides a fairly sharp distinction between acceptable and non-acceptable carpets. Furthermore, the probability of agreement is reasonably close to 100 percent for all twelve carpets, when this test criterion and sampling plan are followed.

To the extent that conclusions may be drawn from this study, the adoption of the dual test criterion and the double sampling plan seems clearly indicated.

TABLE 1 MAXIMUM BURN RADIUS AND BURNING TIME 1/

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Laboratory / Carpet No.	1		2		3		4		5		6		7		8		9		10		11		12	
	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T
1	1.3	111	1.2	126	1.8	161	0.8	115	2.1	124	3.0	168	3.0	159	1.0	114	3.0	137	2.1	179	2.1	137	2.0	177
	3.0	216	2.0	129	1.0	115	1.4	104	0.8	107	1.1	114	1.0	113	3.0	145	0.6	115	0.9	116	3.0	240	3.0	180
	0.8	116	3.0	202	3.0	151	3.0	184	0.8	101	3.0	214	3.0	157	3.0	181	3.0	124	3.0	171		454	1.5	112
	2.3	168	3.0	163	1.8	152	0.9	110	3.0	145	1.4	192	0.9	103	1.9	231	0.6	112	3.0	204		159	1.0	117
	0.8	109	0.8	104	1.5	128	3.0	231	0.5	107	3.0	193	0.9	138	3.0	262	1.6	144	0.9	121		126	2.3	130
	3.0	180	0.6	115	2	12 311	3.0	153	1.4	116	2.6	361	1.5	170	2.0	187	1.5	132	3.0	164		181	3.0	270
	3.0	155	2.0	165	0.6	104	0.6	107	0.6	107	3.0	211	1.1	113	1.3	127	3.0	191	3.0	175	0.9	107	3.0	320
	3.0	190	0.6	102	0.6	92	1.5	171	0.6	102	1.4	100	3.0	136	3.0	224	3.0	171	1.2	133	0.8	112	3.0	140
	1.3	122	3.0	190	2.7	165	0.5	96	3.0	154	2.0	277	1.0	162	1.5	135	0.8	134	2.5	401	1.3	117	3.0	166
	0.8	104	3.0	160	3.0	262	0.5	96	0.4	106	3.0	232	1.4	194	1.0	116	3.0	160	0.7	114	1.4	136	3.0	157
	0.8	110	0.6	118	0.7	107	3.0	212	3.0	143	3.0	233	3.0	159	2.5	225	0.6	104	3.0	156	0.6	121	0.8	160
	3.0	186	0.5	101	0.7	115	3.0	201		143	1.1	153		150	2.5	391	0.6	125	1.3	129	2.5	162	2.3	150
	3.0	164	0.6	111	1.8	169	0.8	110		142	1.0	106		215	3.0	218	2.1	188	1.9	251	3.0	139	0.8	125
	1.0	128	0.5	107	3.0	187	3.1	240		123	3.0	214	0.9	155	3.0	210	0.6	112	0.8	100		178	1.0	105
	1.0	167	0.5	110	1.5	109	1.0	115	0.9	96	3.0	269	0.5	175	1.0	116	0.7	110	3.0	175		169	3.0	180
	0.8	106	0.6	118	0.8	108	0.6	170	3.0	164	2.3	152	3.0	188	3.0	276	1.5	178	0.9	137	2.5	144	3.0	140
2	0.8	115	0.7	113	0.7	108	0.9	326	0.9	133	0.7	112	1.5	347	0.8	138	0.7	120	0.8	129	3.0	414	3.0	360
	0.5	112	0.6	114	0.8	115	0.8	126	1.5	94	0.7	131	0.6	158	0.8	131	0.8	160	3.0	424	0.9	123	1.0	126
	1.0	192	1.7	109	0.8	175	3.0	452	1.0	107	0.8	115	0.6	157	1.0	131	0.8	120	0.9	128	3.0	464	0.9	145
	0.5	124	1.6	110	2.3	602	1.0	224	0.6	136	0.7	118	0.9	130	0.8	118	0.7	118	3.0	462	0.7	122	0.8	150
	0.8	119	0.8	131	0.9	113	3.0	444	0.8	163	0.7	115	0.8	160		120	1.0	124	0.9	114	1.0	130	1.0	118
	0.6	111	0.6	128	3.0	485	0.8	130	0.6	121	0.6	154	3.0	328		123	0.8	121	0.9	132	1.0	135	1.5	317
	0.8	114			1.0	133	0.9	168	0.5	116	0.8	120	0.6	105	0.8	147		127	1.0	113	0.7	121	0.8	166	0.8	135
	0.8	125			1.0	127	0.8	141		150	0.6	110	0.7	106	0.8	172	0.9	116	1.0	121	0.9	142	0.7	169	1.0	118
	1.0	128	0.7	112	0.8	100		125	0.8	119	0.6	106	0.6	122		208	3.0	494		160	0.9	165	0.6	122
	0.8	115	0.5	115	1.0	101		118	0.8	125	1.2	236	0.8	116		211	1.0	130		142	0.8	139	1.0	145
	0.8	140	1.7	130	0.9	125	0.8	125	0.6	114	3.0	488	0.8	122		170	1.0	141	3.0	568	0.8	176		120
	0.8	102	0.6	120	0.7	123	0.5	108	0.8	113	0.6	122	3.0	418	0.8	114	0.8	180	3.0	387	1.2	133		150
	0.6	122	0.5	135	0.8	111	0.8	118	0.5	109	0.6	118	0.8	130	0.8	107	0.9	167	0.8	135	0.9	136	0.8	122
	0.8	105	0.7	139	0.8	127	0.9	118	0.8	113	1.0	104	1.0	175	0.9	115	1.0	125	0.7	124	3.0	438	0.8	130
	0.8	117	0.8	125	0.6	129	0.6	122	0.8	122	3.0	461	0.8	125	1.0	112	0.9	107	0.8	121	2.5	390	3.0	390
	0.8	112	0.5	135	0.9	141	0.8	118	1.0	121	0.6	110	0.8	168	1.0	135	0.9	112	0.8	116	1.1	152	0.8	140

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Carpet No. \ Laboratory	1		2		3		4		5		6		7		8		9		10		11		12	
	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T
3	0.4	107	0.4	103	0.4	109	0.4	100	0.5	107	0.4	98	0.4	111	0.4	105	0.4	89	0.4	107	0.5	107	0.4	100
		98		105	0.4	114	0.3	110	0.4	120	0.9	112		107	0.4	109		108	0.5	122		106		105
		110		108	0.5	106	0.4	109		124	0.4	111		114	0.3	110		117	0.4	115		98		102
		92		111	0.5	105		115		95		101		106	0.4	110		110		122		113		120
		105	0.3	107	0.4	101		106		106		97		101		107		106		117		118		105
	0.5	115	0.4	110	0.4	105		115		106	0.3	115		98		104		100		120	0.4	113		110
	0.4	112	0.4	105	0.5	97	0.3	118		99	0.4	101		115		116		110		106		102		118
		105	0.3	110		110	0.4	119		97		99		100	0.5	105		108		99		99		115
		108		105		109		114		121		109		105	0.4	101		102		114		110		98
		105		101	0.4	118		106		106		107		110		131		100		117	0.7	120		110
		119		110	0.5	107		110		106		110		112		112		115		107	0.4	98		95
	0.1	85		90	0.4	100		120		107		108		108		99		125		106	0.5	107		95
	0.4	106		101		103		98		104		100		91		123		123		116	0.4	105		118
		116	0.4	112		111		118		101		100		111		63		103		113	0.4	113		97
		156	0.4	97	0.5	101		107		106		100		106	0.5	104		100		118	0.5	101		102
		109	0.3	92	0.5	107		113		98		85		99	0.4	114		110		108	0.5	112		127
4	3.0	244	3.0	190	3.0	154	3.0	175	3.0	146	3.0	300	3.0	132	3.0	267	3.0	217	3.0	265	3.0	170	3.0	220
		195		140		168		196		197		267		165		285		297		216		280		255
		200		160		200		188		180		297		166		296		217		189		136		190
		201		171		170		262		226		298		169		267		253		257		186		240
		191		174		317		219		170		233		239		255		199		190		207		165
		297		154		184		201		209		170		215		218		174		243		193		205
		191		170		181		225		186		302		243		246		166		222		186		270
		204		217		167		187		139		187		286		279		170		192		152		235
		319		233		365		214		204		240		196		216		220		215		160		290
		193		379		234		216		200		251		303		236		260		213		169		185
		197		171		224		210		194		214		197		252		172		210		184		180
		193		160		157		234		222		263		199		274		205		161		179		180
		191		161		218		254		202		220		185		240		183		230		160		210
		205		144		162		249		180		234		178		210		201		222		210		212
		183		179		217		225		190		229		266		198		196		166		175		180
		186		180		166		206		193		248		197		228		192		231		195		187

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Laboratory / Carpet No.	1		2		3		4		5		6		7		8		9		10		11		12	
	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T
5	0.4	95	0.3	100	0.4	95	0.4	96	0.4	96	0.4	99	0.4	96	0.4	102	0.4	93	0.3	104	0.5	104	0.4	105
		96		100	0.5	101	0.5	98		103	0.3	95	0.5	102	0.4	109		104	0.3	105		98		105
		99	↓	98	0.4	97	0.4	101		107	0.4	96	0.4	99	0.5	115		105	0.5	105		104		102
		91	0.4	100		97		98		98	0.3	102	0.5	100	0.4	105		102	0.4	106	↓	95	↓	100
		98	0.3	101		101		108		103	0.4	97	0.4	100	0.4	101	↓	101	0.3	106	0.4	107	0.5	100
		90		99	↓	98	↓	95		100	0.3	97	↓	98	0.5	112	0.5	102	0.3	100	0.5	99	0.4	97
		103		101	0.5	101	0.3	96		97	0.4	95	↓	116	0.4	95	0.5	100	0.4	97	0.5	104	0.4	105
		98		105		96	0.5	89		98		97	0.3	105		104	0.4	98		109	0.4	97	0.5	97
		107		100		96	0.4	91		98		104	0.4	98		112	0.5	99	↓	99	0.5	94	0.4	97
		96		96		96		97		104		100		92		109	0.4	105	0.3	102	0.4	95		95
		100	↓	98	↓	87	↓	100		103		100		99		105	0.3	98	0.4	101	0.5	100		95
		104	0.4	111	0.4	96	0.3	94		91		109		101		100	0.4	101		99	0.5	104		110
		102	0.3	100	0.3	96	0.3	97		100		105		115	↓	104		97	↓	102	0.4	101		97
		103	0.4	89	0.4	98	0.4	92		101		103		98	0.5	98	↓	104	0.5	108	0.5	97		95
		84	0.3	104	0.4	102		116		87		104		100	0.3	109	0.3	103	0.4	97		101		
	↓	120	0.3	98	0.6	89	↓	99	↓	97	↓	94	↓	67	0.4	99	0.5	96	0.4	99	↓	99	↓	
6	0.9	108	3.0	375	3.0	454	0.5	106	0.8	140	3.0	575	3.0	484	3.0	374	0.8	112	0.6	165	3.0	407	0.8	110
	0.6	107	0.7	170		477	0.8	99	0.6	133	3.0	437		467	0.9	177	3.0	610	3.0	495	3.0	368	3.0	450
	0.5	121	3.0	550	↓	555	0.6	112	1.4	143	0.7	110		363	3.0	460	0.8	155	3.0	470	0.8	104	0.8	115
	0.4	94	3.0	420	0.9	104	0.8	107	3.0	432	3.0	512		458	0.8	110	0.6	131	0.8	104	3.0	401	0.6	97
	3.0	424	1.2	110	1.0	125	3.0	425	3.0	491	3.0	131	↓	423	0.9	152	0.7	112	0.7	139		358	3.0	390
	0.8	117	0.7	122	3.0	521		391	0.8	113	0.6	172	0.8	173	3.0	275	3.0	529	0.8	120		411	0.8	95
	3.0	317	0.7	150	2.9	302		455	1.0	205	3.0	539	3.0	412	3.0	484	0.8	119	0.7	115		405	0.8	105
	0.5	102	0.5	100	0.7	107	↓	406	1.8	145	0.8	104		432	0.9	107	0.7	143	3.0	445	↓	398	1.5	142
	0.8	105	0.5	106	2.5	128	0.5	125	0.8	105	0.7	141		495	0.9	102	3.0	466	0.6	118	0.8	134	0.8	138
	3.0	472	0.5	108	3.0	536	0.8	114	0.8	110	0.7	97		585	0.6	115	0.7	105	3.0	436	0.6	126	3.0	435
	0.8	105	0.6	105	1.1	154	3.0	425	3.0	434	0.6	140		537	3.0	459	1.0	112	0.7	118	3.0	348		495
	3.0	451	0.5	113	1.0	97		484	0.8	102	3.0	397		424	0.9	122	0.7	114	0.6	106	3.0	423		470
	0.8	162	3.0	410	0.8	124		485	0.8	115	0.6	129		510		128		122	3.0	354	0.7	105	↓	420
	0.8	106	0.5	110	2.0	118		321	0.9	100	3.0	326	↓	461		104		116		430	0.8	138	0.8	120
	0.9	145	3.0	410	0.8	119		350	0.8	179	3.0	445	0.6	161	↓	159	↓	102		480	3.0	463	3.0	490
	0.8	110	0.5	108	1.3	171	↓	457	3.0	375	0.7	122	3.0	462	0.8	120	3.0	444	0.7	106	3.0	405	0.8	108

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Laboratory / Carpet No.	1 R	1 T	2 R	2 T	3 R	3 T	4 R	4 T	5 R	5 T	6 R	6 T	7 R	7 T	8 R	8 T	9 R	9 T	10 R	10 T	11 R	11 T	12 R	12 T
7	1.3	146	0.4	105	0.5	108	0.6	104	0.5	105	0.5	114	3.0	209	0.6	109	0.6	160	0.5	104	0.6	114	0.8	117
	1.1	112	0.5	112	0.6	106	3.0	202	0.5	113	0.5	121	0.4	112	0.5	114	0.5	114		114		110	0.6	105
	0.6	111	0.4	100	0.8	125	0.6	108	0.8	98	0.6	120	0.7	107	0.6	105	3.0	227		101		117	0.6	115
	3.0	209	0.4	112	0.5	103	0.5	104	3.0	211	0.5	106	0.9	127	0.5	114	0.6	131	3.0	233	0.9	108	3.0	325
	0.6	128	0.5	107	1.1	100	0.5	102	0.5	105		111	0.8	129	0.6	114		117	0.6	115	0.5	108	0.6	115
	3.0	227	0.4	110	0.7	109	3.0	202	0.5	113		124	3.0	211	3.0	261		113	0.5	112	3.0	168	0.5	115
	0.5	112	0.4	105	3.0	248	0.5	113	3.0	228		122	0.7	112	0.8	125	3.0	192	0.5	118	3.0	207	0.6	115
	0.5	111	0.5	108	0.8	106	0.5	107	0.8	104		107	0.5	120	0.6	113	3.0	207	3.0	202	0.7	117	1.5	195
	0.8	107	0.6	104	0.5	114	0.6	106	0.5	113	3.0	291	3.0	228	0.5	112	0.6	112	0.7	108	0.7	107	3.0	210
	0.5	109	0.4	108	0.7	104	0.5	116	0.6	115	0.5	112	0.7	114	0.6	126	0.5	105	0.5	111	0.5	108	0.6	115
	3.0	244	0.4	112	3.0	227	0.5	112	0.6	119	0.4	115	0.5	126	0.5	108	0.4	94	3.0	249	0.5	106		117
	1.0	133	3.0	166	3.0	187	0.6	121	0.8	110	1.1	185	0.5	123	0.6	112	0.5	105	0.6	126	0.6	117		115
	0.6	117	0.4	110	0.7	112	0.4	115	0.6	112	0.5	110	3.0	169	0.8	114	0.6	116	0.8	118	3.0	216	0.8	140
	0.8	124	0.5	107	0.9	107	0.5	119	0.5	110	0.5	107	0.6	127	0.6	111	2.4	211	0.6	117	0.7	108	3.0	200
	0.8	107	3.0	195	0.5	107	0.6	119		113	0.6	116		127	0.5	105	0.6	113	2.4	219	3.0	174	0.6	110
	0.5	107	0.5	119	3.0	169	0.8	152		112	0.5	115		124	0.9	132	3.0	231	3.0	227	0.7	116	3.0	210
8	3.0	126	3.0	60	3.0	111	3.0	56	3.0	56	3.0	93	3.0	44	3.0	135	3.0	98	3.0	104	3.0	46	3.0	40
		80		62		62		52		58		82		43		127		73		83		56		50
		100		55		76		49		53		97		47		145		108		54		66		50
		95		60		49		45		44		79		46		107		74		68		48		40
		97		65		51		67		58		67		45		106		60		54		66		35
		165		63		86		50		57		74		39		109		85		59		58		50
		175		51		52		58		37		65		44		117		100		68		56		55
		114		50		77		58		45		83		49		127		61		63		46		60
		116		49		55		51		126		74		63		103		73		64		52		55
		120		65		72		56		64		61		52		136		71		56		56		55
		114		61		56		63		52		64		47		158		95		63		56		65
		100		74		63		68		49		74		48		157		105		64		59		55
		120		65		67		56		51		74		56		157		62		47		57		55
		127		55		69		62		52		71		48		133		81		55		99		70
		87		48		73		56		63		65		50		118		81		56		58		42
		93		50		101		65		58		74		44		230		74		63		78		55

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Laboratory / Carpet No.	1 R	1 T	2 R	2 T	3 R	3 T	4 R	4 T	5 R	5 T	6 R	6 T	7 R	7 T	8 R	8 T	9 R	9 T	10 R	10 T	11 R	11 T	12 R	12 T
9	0.4	95	0.4	95	0.4	92	0.4	93	0.4	92	0.4	85	0.3	88	0.5	110	0.4	95	0.3	93	0.5	103	0.4	95
	0.5	90	0.4	90	0.5	95	0.4	84		91		89	0.4	116		94	0.5	102	0.4	91	0.6	96		92
	0.4	87	0.3	89	0.4	90	0.5	94		95		93		90	↓	99	0.4	98	0.3	95	0.5	92		95
		94	0.4	93	0.4	87	0.4	92	0.5	92		89		91	0.4	101		105	0.4	92		91		105
		94		96	0.5	97	0.3	89	0.4	104		97		85	0.8	93		98		93	↓	90		95
		91		95	0.4	88	0.4	87		98		92		86	0.4	94		90		99	0.6	95		93
		93		94	0.4	85		93		90		94		94	0.5	97		94		96	0.4	96		95
		84		97	0.5	102		87		89		98		97	0.5	102		103		93	0.5	91		110
		95		94	0.4	96	↓	90		107		94		101	0.4	99	↓	91		89	0.4	93		98
		95		95	0.5	102	0.3	87		93		92		118	0.4	101	0.5	96		89	0.4	95		100
		91		96	0.4	113	0.4	98		98		85		97	0.5	102	0.4	99		102	0.6	96		97
		90		87	0.6	95		96		98		87		91	0.5	97		92		95	0.5	87		95
	↓	99		93	0.5	89		98		88	↓	98		87	0.6	100		122		97	0.5	92		92
	0.5	86		92		92		94	0.5	96	0.3	92		84	0.4	99		101		92	0.4	97	↓	94
	0.4	92	↓	98		88		91	0.4	92	0.3	90		97		107	↓	97		93	0.5	90	0.5	92
	0.4	90	0.4	91	↓	94	↓	93	0.4	91	0.4	91	↓	97		103	0.5	97	↓	94	0.5	99	0.4	90
10	0.5	244	0.5	334	0.6	309	3.0	984	3.0	976	30	1142	30	1065	0.6	277	30	1190	30	1206	30	1346	0.5	252
	30	1187	30	1202	30	1275		985		1005	2.0	967	0.6	311	0.5	304		1096	0.4	282	30	1262	30	1125
		1192	1.5	631	28	1250		1068	↓	1329	0.5	287	0.5	293	0.6	246		932	29	1140	0.5	304	0.6	305
		1082	30	1245	30	1275		794	1.5	659	0.5	328	30	1067	0.5	256		1207	30	1196	30	1198	3.0	825
		1117	0.4	259	30	1072		833	30	1510	0.4	266		1125		309		834		1058	29	1326		1245
	↓	1020	30	1623	0.5	310	↓	814	28	1045	0.5	289		1026	↓	267		1178		994	30	1408		870
	0.5	280	0.5	340	30	1253	0.4	285	30	1762		362	↓	1343	30	1571		1020		1241		1558		1215
	3.0	855	2.5	1040	28	1442	3.0	969	06	332	↓	323	0.5	165	0.5	248		1131	↓	1206		1070	↓	915
	↓	1551	25	1068	28	1468	↓	870	30	1164	0.4	279	3.0	1272	0.5	309		1024	0.5	245	↓	1404	0.4	275
	0.8	224	30	1065	30	1130	↓	1080	0.5	278	30	1413		887	0.6	311		990	30	1259	29	1463	30	1085
	30	1042	04	310		1239	05	303	3.0	971	0.4	278		1081	30	1338		938	30	1148	29	1335	0.5	290
		1060	30	1150		1155	0.5	294		1000	0.5	312	↓	1150	30	1442		976	27	1326	30	1451	30	1040
	↓	901	0.4	263	↓	1098	30	1113	↓	1522	0.4	250	0.4	271	0.5	269		1016	30	1736		938	0.5	295
	0.5	301	30	1020	0.7	347		959	25	1457	0.5	317	30	1161	0.6	271		1086	0.5	309		1160	30	1425
	3.0	854		1142	0.7	317		947	26	1074	30	1447		1199	0.5	314		850	0.5	275		1092	30	1310
	3.0	943	↓	440	0.8	292	↓	972	25	1032	09	302	↓	986	0.5	254	↓	822	30	1321	↓	1204	0.5	320

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Laboratory / Carpet No.	1 R	1 T	2 R	2 T	3 R	3 T	4 R	4 T	5 R	5 T	6 R	6 T	7 R	7 T	8 R	8 T	9 R	9 T	10 R	10 T	11 R	11 T	12 R	12 T
11	3.0	168	3.0	153	0.9	112	3.0	161	3.0	153	3.0	205	3.0	173	3.0	195	0.5	131	3.0	170	1.5	137	3.0	225
		196		126	3.0	170	3.0	117	3.0	122	0.5	113		129	3.0	143	3.0	321		176	3.0	131	3.0	135
		227		159	3.0	129	1.0	120	1.5	106	3.0	178		134	0.6	134	3.0	159		183		124	1.1	130
		160		119	2.2	207	3.0	129	3.0	168		172		124	0.8	123	1.0	108		199		194	3.0	120
		120		165	3.0	115		139	1.5	114		172		135	1.8	122	3.0	135		147		183		150
	0.8	230		134		120		153	3.0	131		235		219	3.0	171		148	0.8	113		128		120
	3.0	135		150		152		149		123		127		181		143		210	3.0	119		137		150
	1.3	135		130		168		105		145		310		156		190		182		133		132		275
	3.0	156		122	0.7	141	0.5	167		134		191		158	2.9	142		122		177	0.7	130		163
		135		120	3.0	138	3.0	190	0.6	122		242		153	3.0	296	0.9	103	1.2	107	3.0	131		165
		150	2.0	109		124	0.9	127	3.0	164	0.8	142		115		155	3.0	190	0.5	114		148		132
		136	3.0	125		149	3.0	180	3.0	116	3.0	182		170		191		128	3.0	221		113		150
	0.9	132		130		169		115	1.3	109		133		140		100		198		122		152		180
	1.3	174		147		136		154	3.0	117		183	3.0	165		182		120		144		136		130
	3.0	209		131		165		159		115		196		153		176		190		150		125		132
	3.0	233		114		146	1.0	105		116		162		126	0.9	116		116		125	1.5	125		135
12	3.0	531	2.2	108	2.5	191	3.0	462	3.0	511	3.0	565	3.0	333	3.0	373	3.0	173	3.0	368	3.0	465	2.3	250
	1.0	211	2.0	162	3.0	343		351		425		568		387		620		459		444		103		125
	3.0	667	3.0	565	1.3	199		472		454		527		457	1.1	253		405		347		454	3.0	540
	3.0	446		415	3.0	95		863		465		641		451	2.0	272		335		395		572	2.6	217
	0.9	119		410		77		512		573		505		207	3.0	487		441		518		88	3.0	520
	2.8	181	1.6	175		76		623	2.5	106		373		144		113		647		411		456		465
	3.0	116	3.0	585		113		456	3.0	550		500		364		480		408		413		456		260
		110		95		61		501		71		533		582		135		433		338		422		455
		200		300		350		571		419		634		128		113		710		388		483		570
	2.8	190		95		245		563	0.9	163		215		160		470		406		525		452		410
	3.0	329		536		136		511	3.0	406		148		453		126		460		514		397		470
		475	0.7	175		102		423		361		487		171				437	2.7	651		434		290
		476	3.0	580		336		170		576		524		367	2.4	152		439	3.0	93		121		115
		385	3.0	525		62		470		406	2.8	368		540	3.0	293		590		503		458		105
		226	3.0	440		87		623		406	3.0	437		410		110		568		545		478	2.0	170
		365	1.8	105		554		512		331	3.0	270		150		558		512	1.8	512		492	3.0	115

1/ R = Burning Radius in inches to 0.1 inch T = Burning Time in seconds

Table 2

Percent of Specimens Passing for Various Test Criteria

Test Criterion Carpet No.	R <3 in.	R≤1 in.	R ≤2 in.	T ≤120 sec.	T ≤150 sec.	R ≤1 in. and T ≤120 sec.	R ≤2 in. and T ≤120 sec.
1	61	28	51	32	52	28	32
2	91	74	85	35	75	34	35
3	100	100	100	95	99	95	95
4	0	0	0	0	2	0	0
5	100	100	100	100	100	100	100
6	56	49	55	34	49	33	34
7	82	79	81	67	79	66	67
8	0	0	0	95	97	0	0
9	100	100	100	99	100	99	99
10	40	31	32	0	0	0	0
11	18	9	17	18	58	5	7
12	12	1	6	14	18	1	1

R = Burn Radius

T = Burning Time

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TABLE 3 NUMBER OF PASSES IN EACH GROUP OF EIGHT SPECIMENS
3-INCH CRITERION

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Lab. No. \ Carpet No.	1	2	3	4	5	6	7	8	9	10	11	12
1	4	8	8	0	8	6	6	0	8	2	2	3
	6	8	8	0	8	6	7	0	8	2	2	1
2	6	8	8	0	8	5	8	0	8	5	0	3
	6	8	8	0	8	6	6	0	8	3	1	2
3	7	7	8	0	8	4	7	0	8	4	2	2
	6	8	8	0	8	7	5	0	8	4	1	0
4	5	6	8	0	8	4	6	0	8	1	1	0
	5	8	8	0	8	2	8	0	8	2	3	0
5	7	8	8	0	8	6	6	0	8	3	3	1
	2	8	8	0	8	6	8	0	8	4	2	1
6	4	8	8	0	8	3	8	0	8	7	1	0
	4	6	8	0	8	5	7	0	8	6	1	1
7	5	7	8	0	8	1	6	0	8	3	0	0
	4	7	8	0	8	1	6	0	8	1	1	0
8	4	8	8	0	8	4	7	0	8	7	3	2
	5	8	8	0	8	7	8	0	8	6	1	1
9	4	8	8	0	8	6	5	0	8	0	2	0
	7	7	8	0	8	6	7	0	8	0	1	0
10	4	6	8	0	8	5	6	0	8	2	1	0
	6	6	8	0	8	4	6	0	8	4	2	2
11	3	6	8	0	8	1	6	0	8	2	1	0
	5	7	8	0	8	4	6	0	8	2	2	0
12	4	7	8	0	8	6	7	0	8	2	1	3
	4	7	8	0	8	3	5	0	8	4	0	1

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Number of Passes in Each Group of Eight Specimens

1 - inch Burn Radius and 120 Seconds Criterion

* U.S. GOVERNMENT PRINTING OFFICE : 1964 OF—731-638

Lab. No. \ Carpet No.	1	2	3	4	5	6	7	8	9	10	11	12
1	2 3	5 5	8 7	0 0	8 8	5 4	3 5	0 0	8 8	0 0	0 0	1 0
2	3 6	4 3	8 8	0 0	8 8	1 6	8 6	0 0	8 8	0 0	0 0	0 0
3	3 3	3 3	8 8	0 0	8 8	2 2	5 5	0 0	8 8	0 0	1 0	0 0
4	3 4	1 5	8 8	0 0	8 8	4 1	6 6	0 0	8 8	0 0	1 1	0 0
5	5 2	3 5	7 7	0 0	8 8	1 5	6 8	0 0	8 8	0 0	0 0	0 0
6	0 1	6 4	8 8	0 0	8 8	2 1	5 6	0 0	8 8	0 0	1 0	0 0
7	3 0	0 1	8 8	0 0	8 8	0 0	4 1	0 0	8 8	0 0	0 0	0 0
8	1 2	3 4	8 6	0 0	8 8	2 4	6 6	0 0	8 8	0 0	0 1	0 0
9	2 3	4 2	8 6	0 0	8 8	3 5	3 6	0 0	8 7	0 0	1 1	0 0
10	1 2	1 1	6 8	0 0	8 8	3 4	6 4	0 0	8 8	0 0	1 1	0 0
11	2 0	0 0	8 8	0 0	8 8	1 1	6 6	0 0	8 6	0 0	0 0	0 0
12	1 1	2 1	8 7	0 0	8 8	5 2	6 4	0 0	8 8	0 0	0 0	0 0

TABLE 5 COMPARISON OF RESULTS WITH BINOMIAL DISTRIBUTION
3-INCH CRITERION 1/

Carpets	1		2		3		4		5		6	
	% P = 61		% P = 91		% P = 100		% P = 0		% P = 100		% P = 56	
No. of Passes in sets of 8	Theor.	Observed	Theor.	Observed	Theor.	Observed	Theor.	Observed	Theor.	Observed	Theor.	Observed
0	0	0	0	0	0	0	24	24	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	3
2	1	1	0	0	0	0	0	0	0	0	2	1
3	3	1	0	0	0	0	0	0	0	0	4	2
4	5	9	0	0	0	0	0	0	0	0	6	5
5	7	5	1	0	0	0	0	0	0	0	6	3
6	5	5	3	5	0	0	0	0	0	0	4	8
7	2	3	9	7	0	0	0	0	0	0	1	2
8	0	0	11	12	24	24	0	0	24	24	0	0

Carpets	7		8		9		10		11		12	
	% P = 82		% P = 0		% P = 100		% P = 40		% P = 18		% P = 12	
No. of Passes in sets of 8	Theor	Observed	Theor.	Observed	Theor.	Observed	Theor.	Observed	Theor.	Observed	Theor.	Observed
0	0	0	24	24	0	0	0	2	5	3	9	10
1	0	0	0	0	0	0	2	2	9	11	9	6
2	0	0	0	0	0	0	5	7	7	7	4	5
3	0	0	0	0	0	0	7	3	3	3	1	3
4	1	0	0	0	0	0	6	5	1	0	0	0
5	3	3	0	0	0	0	3	1	0	0	0	0
6	7	10	0	0	0	0	1	2	0	0	0	0
7	9	6	0	0	0	0	0	2	0	0	0	0
8	5	5	0	0	24	24	0	0	0	0	0	0

1/ % P = the overall percent of passing specimens for carpet in question; the tabulated values are the number of sets (of 8 specimens each) out of 24 sets for which the number of passes is the number in the column at the extreme left of the table.

TABLE 6 COMPARISON OF RESULTS WITH BINOMIAL DISTRIBUTION
ONE INCH AND 120 SECONDS CRITERION[1/]

Carpets	1		2		3		4		5		6	
	% P = 28		% P = 34		% P = 95		% P = 0		% P = 100		% P = 33	
No. of Passes in sets of 8	Theor.	Observed	Theor.	Observed	Theor.	Observed	Theor.	Observed	Theor.	Observed	Theor.	Observed
0	2	3	1	3	0	0	24	24	0	0	1	2
1	5	5	4	5	0	0	0	0	0	0	4	6
2	7	6	6	2	0	0	0	0	0	0	7	5
3	6	7	7	5	0	0	0	0	0	0	7	2
4	3	1	4	4	0	0	0	0	0	0	4	4
5	1	1	2	4	0	0	0	0	0	0	2	4
6	0	1	0	1	1	3	0	0	0	0	0	1
7	0	0	0	0	7	4	0	0	0	0	0	0
8	0	0	0	0	16	17	0	0	24	24	0	0

Carpets	7		8		9		10		11		12	
	% P = 66		% P = 0		% P = 99		% P = 0		% P = 5		% P = 1	
No. of Passes in sets of 8	Theor.	Observed	Theor.	Observed	Theor.	Observed	Theor.	Observed	Theor.	Observed	Theor.	Observed
0	0	0	24	24	0	0	24	24	16	15	22	23
1	0	1	0	0	0	0	0	0	7	9	2	1
2	0	0	0	0	0	0	0	0	1	0	0	0
3	2	2	0	0	0	0	0	0	0	0	0	0
4	4	3	0	0	0	0	0	0	0	0	0	0
5	7	4	0	0	0	0	0	0	0	0	0	0
6	6	12	0	0	0	0	0	0	0	0	0	0
7	4	0	0	0	2	1	0	0	0	0	0	0
8	1	2	0	0	22	23	0	0	0	0	0	0

1/ % P = the overall percent of passing specimens for carpet in question; the tabulated values are the numbers of sets (of 8 specimens each) out of 24 sets for which the number of passes is the number in the column at the extreme left of the table.

Table 7

Repeatability and Reproducibility Ratios [1/]

Carpet	3-inch Criterion		1-inch and 120-second Criterion	
	Repeatability Ratio	Reproducibility Ratio	Repeatability Ratio	Reproducibility Ratio
1	1.03	.82	.98	1.38
2	.84	1.15	.86	1.74
3	1.00	1.00	1.22	1.05
4	1.00	1.00	1.00	1.00
5	1.00	1.00	1.00	1.00
6	.98	1.62	1.28	1.40
7	.97	.80	.95	1.34
8	1.00	1.00	1.00	1.00
9	1.00	1.00	1.00	1.00
10	.66	1.96	1.00	1.00
11	.75	.88	.59	1.02
12	.97	1.37	1.00	1.00

1/ For definition, see body of report.

Table 8

Probability of Agreement Between Two Laboratories

Overall Percentage of Passing Specimens	Probability of Agreement, in Percent	
	Single Sampling Plan	Double Sampling Plan
0	100.	100.
10	100.	100.
20	99.98	100.
30	99.74	99.99
40	98.31	99.87
50	93.21	99.20
60	80.99	96.41
65	71.90	93.02
70	61.98	87.14
75	53.53	77.85
80	50.02	65.47
85	54.94	53.01
90	69.61	51.81
92	77.42	57.72
94	85.42	67.92
96	92.66	81.18
98	97.95	93.98
100	100.	100.

TABLE 9 SUMMARY OF ANALYSIS

	Passing Specimens, %		Probability of Acceptance, %				Probability of Agreement, %			
Sampling Plan			Single		Double		Single		Double	
Test Criterion[1/]	A	B	A	B	A	B	A	B	A	B
Carpet										
1	61	28	12	0.1	2	0	79	99.8	96	100
2	91	34	84	0.3	64	0	73	99.4	54	99.96
3	100	95	100	94	100	85	100	89	100	74
4	0	0	0	0	0	0	100	100	100	100
5	100	100	100	100	100	100	100	100	100	100
6	56	33	7	0.2	1	0	87	99.5	98	99.97
7	82	66	56	18	28	4	51	70	60	92
8	0	0	0	0	0	0	100	100	100	100
9	100	99	100	99.7	100	99.1	100	99.5	100	98
10	40	0	1	0	0.1	0	98	100	99.8	100
11	18	5	0	0	0	0	100	100	100	100
12	12	1	0	0	0	0	100	100	100	100

1/
A = 3 inch
B = 1-inch and 120 second

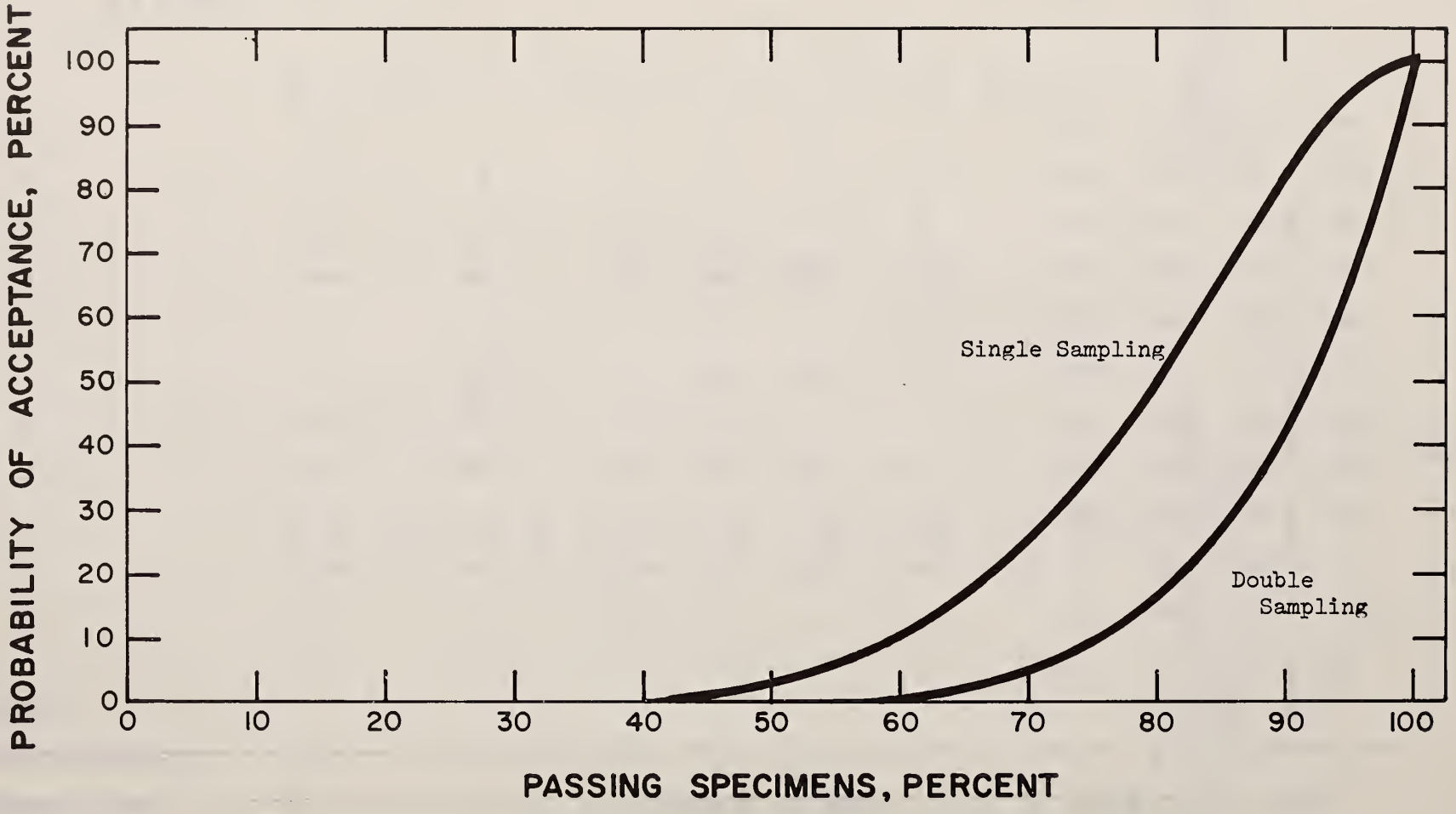

FIGURE A1. OPERATING CHARACTERISTIC CURVES FOR TWO SAMPLING PLANS

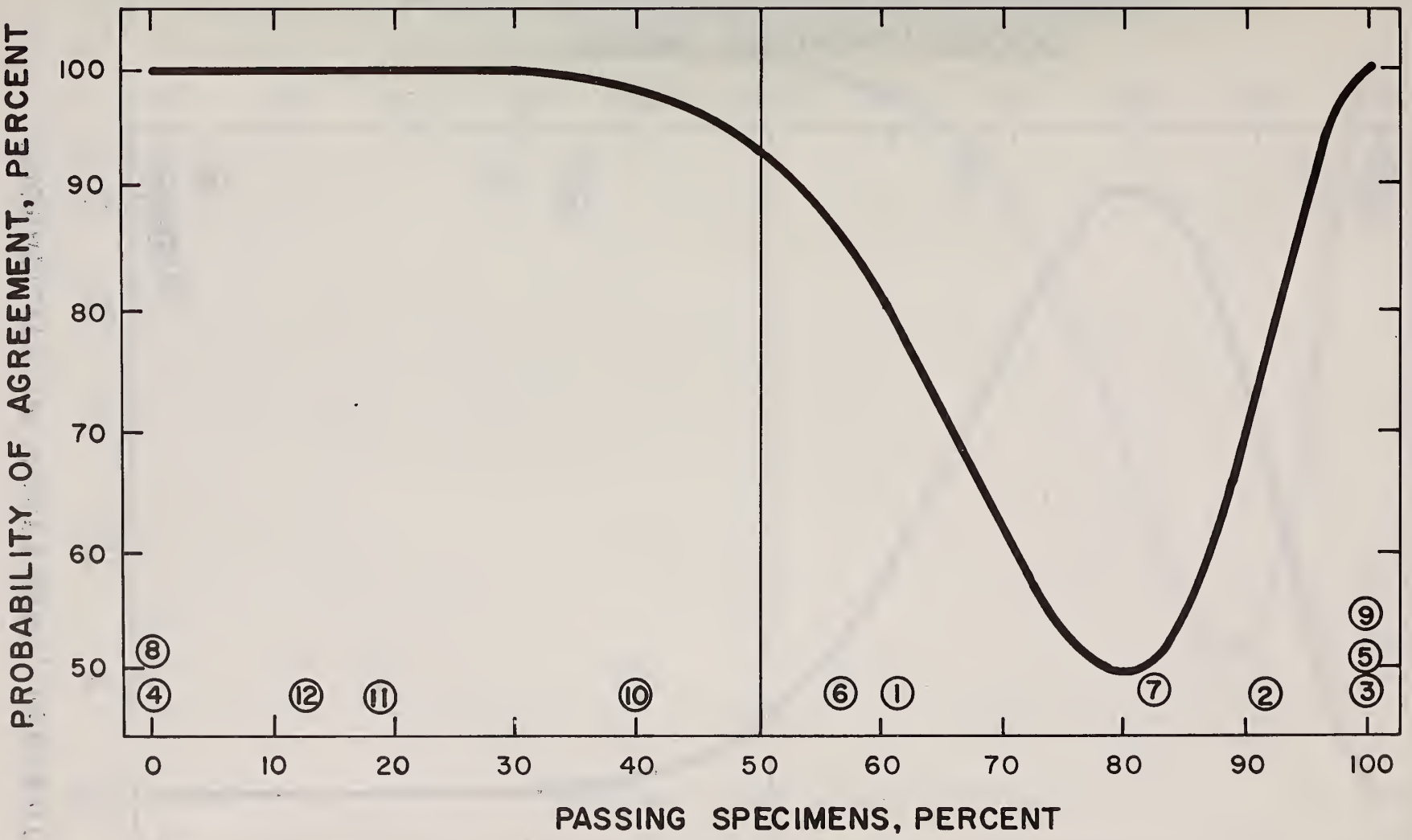

FIGURE A2. PROBABILITY OF AGREEMENT FOR SINGLE SAMPLING PLAN
O POSITION OF CARPETS USING THREE
INCH CRITERION

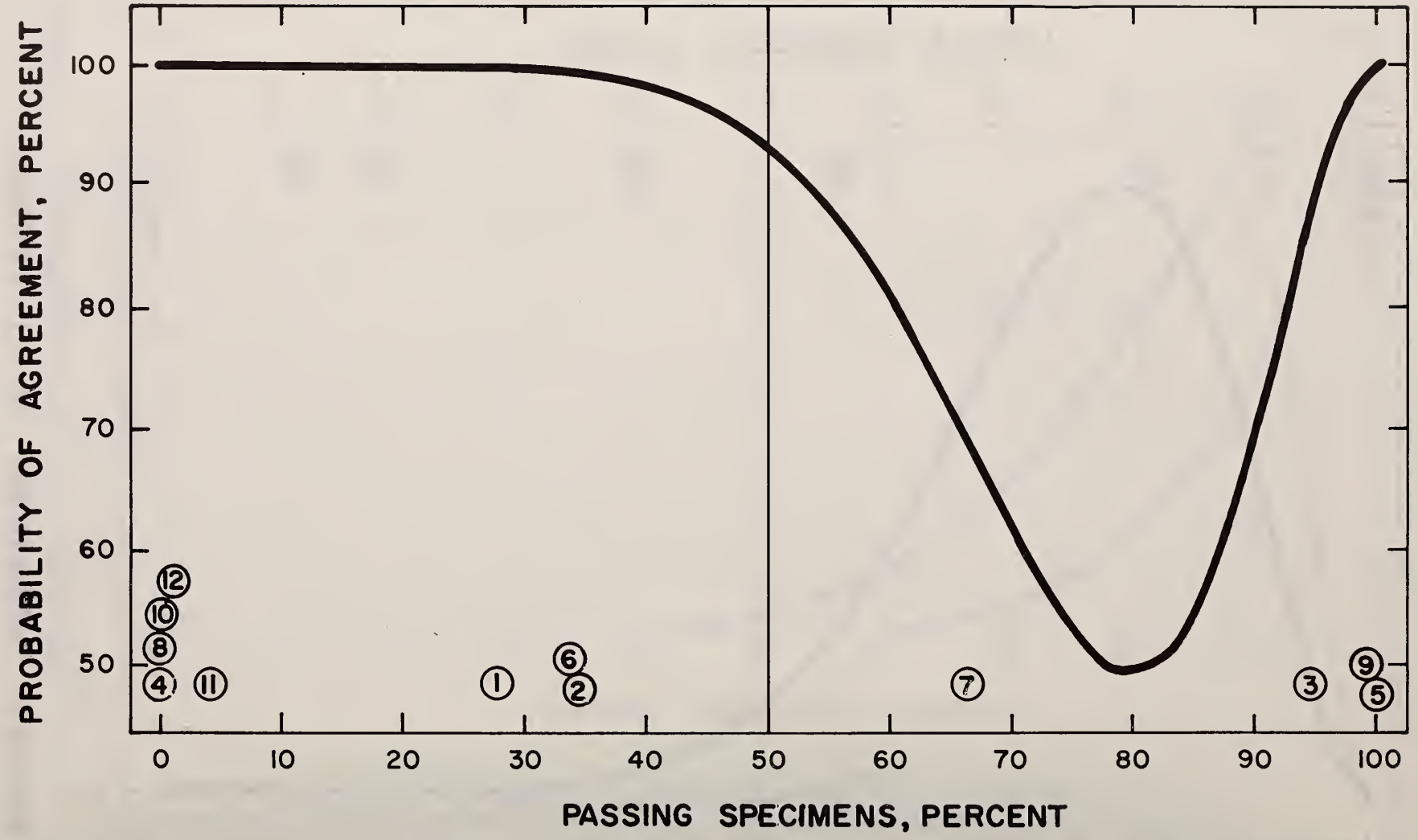

FIGURE A3. PROBABILITY OF AGREEMENT FOR SINGLE SAMPLING PLAN
O POSITION OF CARPETS USING DUAL TEST CRITERION

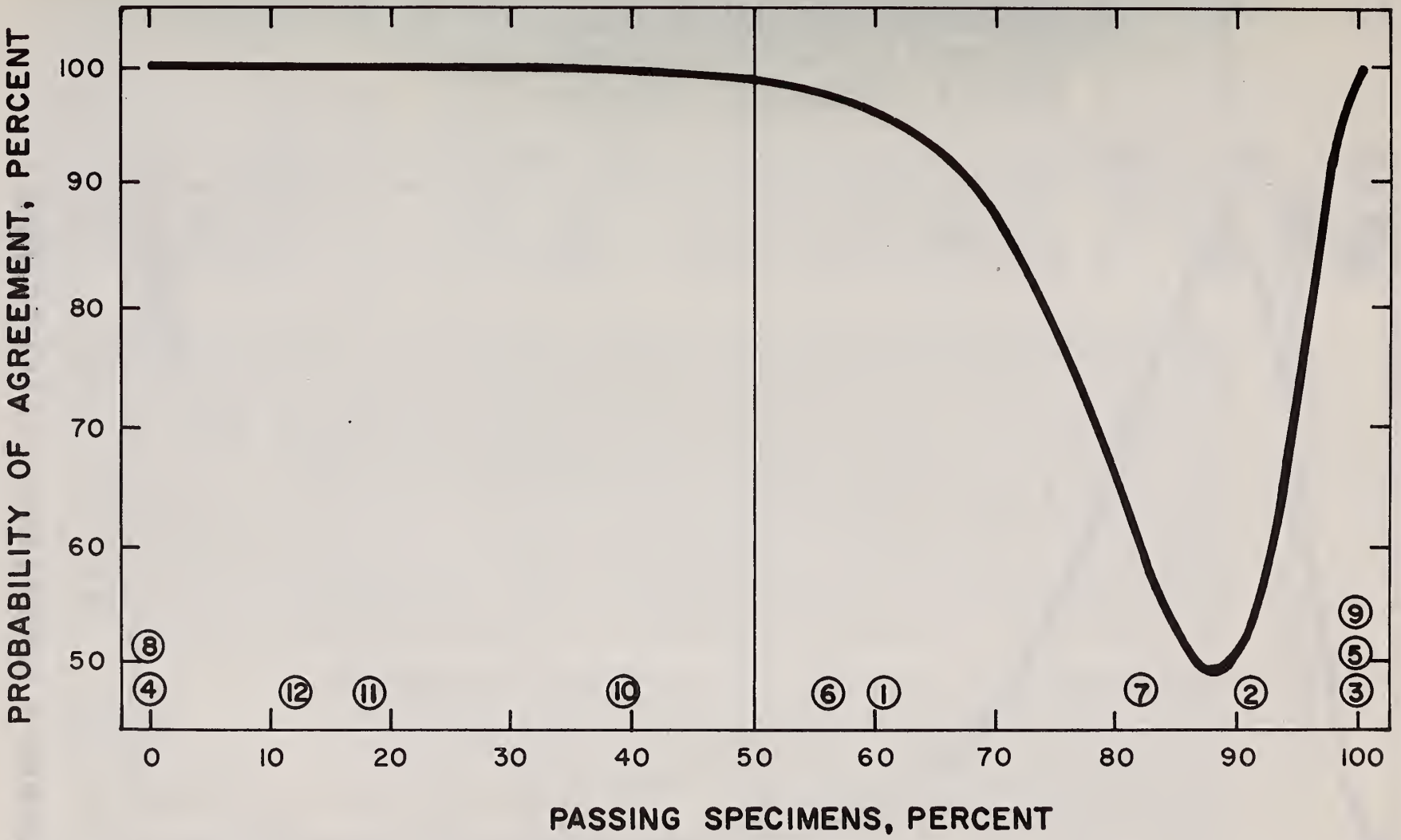

FIGURE A4. PROBABILITY OF AGREEMENT FOR DOUBLE SAMPLING PLAN
○ POSITION OF CARPETS USING THREE INCH CRITERION

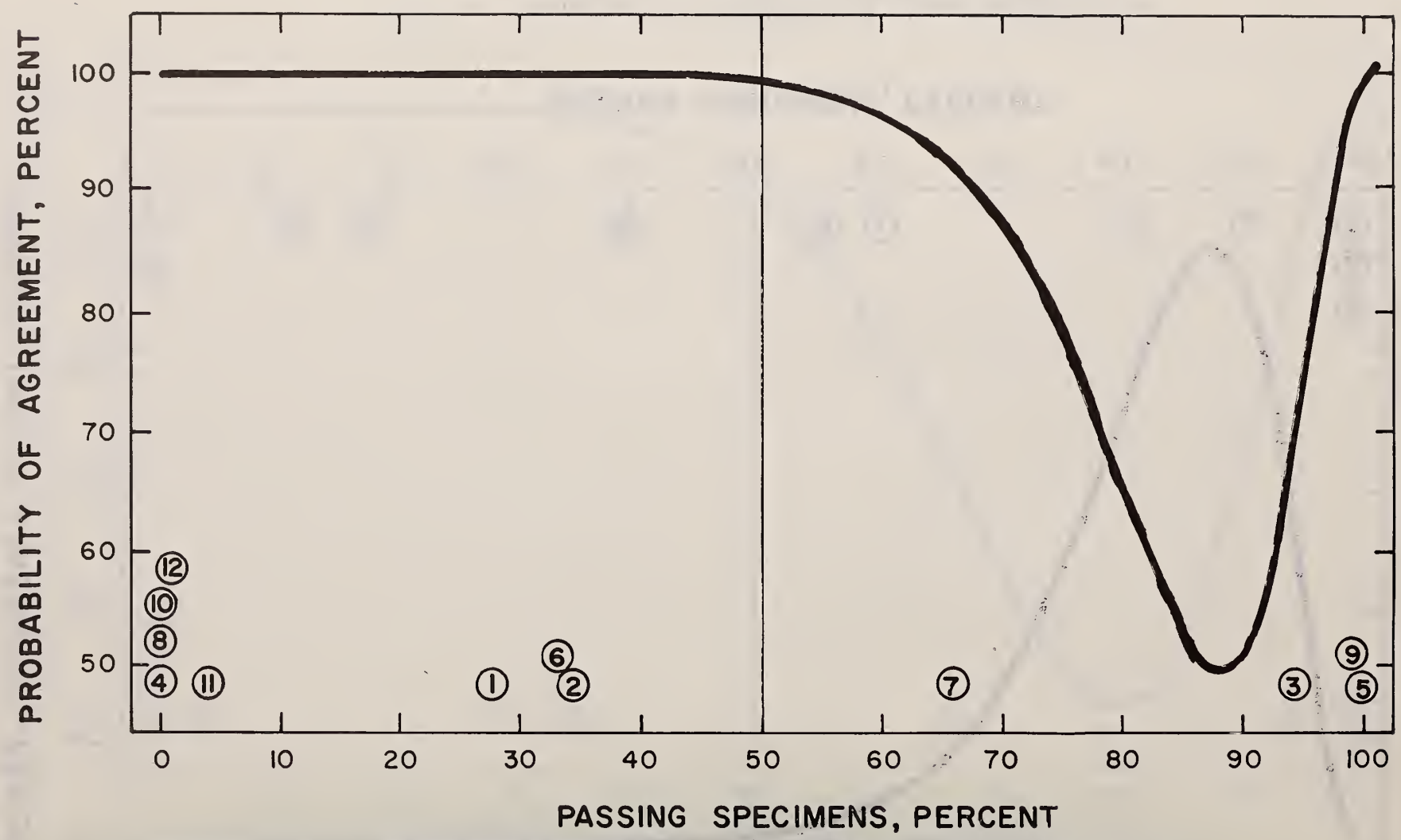

FIGURE A5. PROBABILITY OF AGREEMENT FOR DOUBLE SAMPLING PLAN
○ POSITION OF CARPETS USING DUAL TEST CRITERION

Proposed Rule Making

DEPARTMENT OF COMMERCE

Office of the Secretary

[15 CFR Part 7]

CARPETS AND RUGS

Notice of Proposed Flammability Standard

On December 3, 1968, there was published in the FEDERAL REGISTER (33 F.R. 17921) a notice of finding that a flammability standard or other regulation, including labeling, may be needed for carpets and rugs, to protect the public against unreasonable risk of the occurrence of fire leading to death, injury, or significant property damage, arising from the hazards of rapid flash burning or continuous slow burning or smoldering, and for institution of proceedings for the development of an appropriate flammability standard or other regulation. In order that the Department of Commerce, hereinafter referred to as the "Department," might receive adequate and deliberative responses representing the considered views and recommendations of interested persons and to accommodate a number of requests for additional time to respond to the December 3 notice, the Department by notice in the FEDERAL REGISTER on January 10, 1969 (34 F.R. 398), extended the period for filing comments to February 3, 1969.

After review and analysis of the comments received, analysis of material developed through research, and after further review of information previously cited in the December 3, 1968, FEDERAL REGISTER (33 F.R. 17921), it is hereby found that a flammability standard for carpets and rugs is needed to protect the public against unreasonable risk of the occurrence of fire leading to death, injury, or significant property damage arising from the hazards of rapid flash burning or continuous slow burning or smoldering.

Proposed standard. It is preliminarily found that the proposed flammability standard as set out in full at the end hereof as Appendix I:

(a) Is needed for carpets and rugs to protect the public against unreasonable risk of the occurrence of fire arising from the hazards of rapid flash burning or continuous or slow burning or smoldering, and leading to death, personal injury, or significant property damage;

(b) Is reasonable, technologically practicable and appropriate and is stated in objective terms; and

(c) Is limited to carpets and rugs which currently present the unreasonable risks specified in (a) above.

Basis for proposed flammability standard. Although there are standards for certain specialized applications, there now exists no national flammability standard for carpets and rugs affording protection to the general public from an unreasonable risk of the occurrence of fire. An analysis of data and all comments received and research conducted pursuant to inquiry by this Department into flammability problems in carpets and rugs reveals that carpets and rugs are being produced and made available for consumer purchase which present, through ordinary use, an unreasonable risk of the occurrence of fire leading to death or personal injury, or significant property damage, arising from the foreseeable hazards of rapid flash burning or continuous slow burning or smoldering. The proposed standard would remove from the market those rugs and carpets which present either of these hazards. This analysis further reveals that the proposed standard will protect against such risks and, at the same time, is reasonable, technologically practicable and appropriate and is stated in objective terms. The current state of the art in carpet and rug manufacture can conform to this proposed standard, and rugs and carpets are, in fact, available to the public which meet the requirements of this proposed standard. This proposed standard is limited to rugs and carpets which present the hazards of rapid flash burning or continuous slow burning or smoldering. The information upon which the finding is made indicates that such items present the unreasonable risks mentioned above unless produced in conformance to the proposed standard.

In federally owned or leased buildings, a measure of protection against hazards from the flammability of carpets and rugs is afforded through the requirement of the Federal Supply Service, General Services Administration, that all rugs and carpets purchased for use in such buildings must comply with the flame resistance criteria of Federal Specification DDD–C–95, Carpets and Rugs, Wool, Nylon, Acrylic, Modacrylic. Under the test procedure prescribed therein, each of two specimens of carpet, conditioned at a prescribed temperature and relative humidity and placed in a horizontal position, is subjected to controlled ignition from a timed burning tablet. Flammability is evaluated by measuring the maximum dimension of the charred area produced.

The Department proposes that all carpets and rugs, and fabrics or related materials intended to be used, or which may reasonably be expected to be used as carpets or rugs, shall be classed as "resistant to flammability" in the test method described in Appendix I. This test method is a modification of the test method in Federal Specification DDD–C–95, Carpets and Rugs, Wool, Nylon, Acrylic, Modacrylic. The method tests the resistance to flammability of rugs and carpets only under draft-protected conditions by requiring that the maximum dimension of charred area produced under certain carefully prescribed conditions and after controlled ignition from a timed burning tablet shall not exceed a certain limit as set forth in the Standard in Appendix I. From observations made during development of this method, it can be concluded that if combustion has progressed to the limit defining failure in the test, combustion, wherever initiated, may reasonably be expected to progress in actual service to the edges of the carpet and provide a possible source for subsequent ignition of other furnishings.

The Department has (1) conducted an interlaboratory evaluation to develop the test method; (2) developed the test method for use in connection with the proposed flammability standard; and (3) used the test method on a selected sample of carpets and rugs being offered at retail outlets selling to the consuming public. The results of these latter tests are given in Appendix II.

Based on the analysis of the test data and subsequent economic investigations by the Department's Office of Textiles, the proposed standard in Appendix I has been developed.

Participation in proceedings. All interested persons are invited to submit written comments relative to the proposed flammability standard within 30 days after the date of publication of this notice in the FEDERAL REGISTER. Written comments should be submitted in at least four (4) copies to the Assistant Secretary for Science and Technology, Room 5051, U.S. Department of Commerce, Washington, D.C. 20230, and may include any data or other information pertinent to the subject.

Inspection of relevant documents. The written comments received pursuant to this notice will be available for public inspection at the Central Reference and Records Facility of the Department, Room 2122, Main Commerce Building, 14th Street between E Street and Constitution Avenue NW., Washington, D.C. 20230.

Issued: December 12, 1969.

MYRON TRIBUS,
Assistant Secretary
for Science and Technology.

[Appendix I]

CARPETS AND RUGS

PROPOSED STANDARD FOR THE RESISTANCE TO FLAMMABILITY OF CARPETS AND RUGS (METHENAMINE PILL)

.1 Definitions
.2 Scope and Application
.3 General Requirements
.4 Test Procedure
.5 Labeling

.1 *Definitions.* In addition to the definitions given in section 2 of the Flammable Fabrics Act, as amended (sec. 1, 81 Stat. 568; 15 U.S.C. 1191), and section 7.2 of the Procedures (33 F.R. 14642, Oct. 1, 1968), the following definitions apply for the purposes of this Standard:

(a) "Acceptance Criterion" means that at least seven out of eight individual specimens of a given carpet or rug shall meet the test criterion as defined in this Standard.

(b) "Carpet" means any type of finished product made in whole or in part of fabric or related material and intended for use or which may reasonably be expected to be used as a floor covering which is exposed to traffic in homes, offices, or other places of assembly or accommodation, and which may or may not be fastened to the floor by mechanical means such as nails, tacks, barbs, staples, adhesives, etc. Mats, hides with natural or synthetic fibers, and other similar products are included in this definition, but resilient floor coverings such as linoleum, asphalt tile and vinyl tile are not.

(c) "Rug" means, for the purposes of this Standard, the same as carpet and shall be accepted as interchangeable with carpet.

(d) "Resistant to Flammability" means that a carpet or rug complies with the acceptance criterion.

(e) "Timed Burning Tablet" means the methenamine tablet, weighing approximately 0.149 grams, sold as Catalogue No. 1588 by the Eli Lilly Co. of Indianapolis, Ind. 46206.

(f) "Test Criterion" means the basis for judging whether or not a single specimen of carpet or rug has passed the test, i.e., the charred portion of a tested specimen shall not extend to within one inch of the edge of the hole in the flattening frame at any point.

(g) "Underlayment" means any pad, cushion, mat, or other material, used between the floor and the carpet or rug.

(h) "Fire-Retardant Treatment" means any chemical or process to which a carpet or rug has been exposed, which significantly modifies the resistance to flammability, as defined in this standard, of the carpet or rug.

.2 *Scope and application.* (a) This Standard provides a test method to determine the resistance to flammability of finished carpets and rugs when exposed to a standard source of ignition under carefully prescribed draft-protected conditions. It is applicable to all types of carpets and rugs used as floor covering materials regardless of their method of fabrication or whether they are made of natural or synthetic fibers or films, or combinations of or substitutes for these.

(b) This Standard requires the determination of the resistance to flammability of carpets and rugs as such. However, because an underlayment may modify the resistance to flammability of these materials under some conditions of use, where the combination of carpet and underlayment is available, consideration should be given to performing the test on the combination as it would be used in service.

.3 *General requirements*—(a) *Summary of test method.* This method involves the exposure of each of eight conditioned, replicate specimens of a given carpet or rug to a standard igniting source in a draft-protected environment and measurement of the proximity of the charred portion to the edge of the hole in the prescribed flattening frame.

(b) *Test criterion.* A specimen passes the test if the charred portion does not extend to within one inch of the edge of the hole in the flattening frame at any point.

(c) *Acceptance criterion.* If at least seven of the eight specimens meet the test criterion, the material shall be classified as resistant to flammability.

.4 *Test Procedure*—(a) *Apparatus*—(1) *Test chamber.* The test chamber shall consist of an open top hollow cube made of noncombustible material[1] with inside dimensions 12 x 12 x 12 inches (30.5 x 30.5 x 30.5 cm.) and a minimum of ¼-inch (6.4 mm.) wall thickness. The flat bottom of the box shall be made of the same material as the sides and shall be easily removable. The sides shall be fastened together with screws or brackets and taped to prevent air leakage into the box during use.

(A minimum of two chambers and two extra bottoms are suggested for efficient operation.)

(2) *Flattening frame.* A steel plate 9 x 9 inches (23 x 23 cm.), ¼-inch (6.4 mm.) thick with an 8-inch (20.3 cm.) diameter hole in its center is required to hold the carpet or rug flat during the course of the test. It is recommended that one be provided for each test chamber.

(3) *Standard igniting source.* No. 1588 methenamine timed burning tablet. These tablets shall be stored in a desiccator over a desiccant for 24 hours prior to use. (Small quantities of sorbed water may cause the tablets to fracture when first ignited. If a major fracture occurs, any results from that test shall be ignored, and it shall be repeated.)

(4) *Test specimens.* Each test specimen shall be a 9 x 9 inches (23 x 23 cm.) section of the carpet or rug to be tested. Eight specimens are required.

(5) *Circulating air oven.* A forced circulation drying oven capable of removing the moisture from the specimens when maintained at 105° C. for 2 hours.[2]

(6) *Dessicating cabinet.* An air- and moisture-tight cabinet capable of holding the floor covering specimens horizontally without contacting each other during the cooling period following drying, and containing an efficient desiccant, such as calcium chloride or silica gel.

(7) *Glove.* A nonhygroscopic glove (rubber, polyethylene, etc.) for raising the pile on specimens prior to testing.

(8) *Hood.* A hood capable of being closed and having its draft turned off during each test and capable of rapidly removing the products of combustion following each test. The front or sides of the hood should be transparent to permit observation of the tests in progress.

(9) *Mirror.* A small mirror mounted above each test chamber at an angle to permit observation of the specimen from outside of the hood.

(10) *Vacuum cleaner.* A vacuum cleaner to remove all loose material from each specimen prior to conditioning. All surfaces of the vacuum cleaner contacting the specimen shall be flat and smooth.

(b) *Sampling*—(1) *Selection of samples.* If there is an applicable material specification, take a lot sample. If not, select a sample of the material representative of the lot and large enough to permit cutting eight specimens 9 x 9 inches (23 x 23 cm.), free from creases, fold marks, delaminations or other distortions. The sample of material representative of the lot may be more than one carpet or rug.

If the carpet or rug has had a fire-retardant treatment, or is made of fibers which have had a fire-retardant treatment, the selected sample shall be washed, dry-cleaned or shampooed 10 times in a manner normally used for that carpet or rug in service prior to cutting of specimens.

(2) *Cutting.* Cut eight 9±¼-in. (23±0.6 cm.) square specimens of each carpet or rug to be tested.

(c) *Conditioning.* Clean each specimen with the vacuum cleaner until it is free from all loose ends left during the manufacturing process and from any material that may have been worked into the pile during handling.[3] Care must be exercised to avoid "fuzzing" of the pile yarn.

Place the specimens in the drying oven in a manner that will permit free circulation of the air at 105° C. around them for 2 hours.[4] Remove the specimens from the oven and place them horizontally in the desiccator with pile side up and free from contact with each other until cooled to room temperature, but in no instance less than 1 hour.

(d) *Testing.* Place the test chamber in the draft-protected environment (hood with draft off) with its bottom in place. Remove a test specimen from the desiccator, brush its surface with a gloved hand in such a manner as to raise its pile. Place the specimen on the center of the floor of the test chamber, pile side up, exercising care that the specimen is horizontal and flat. Place the flattening frame on the specimen and position a

[1] ¼-inch (6.4 mm.) cement asbestos board is a suitable material.

[2] Option 1 of ASTM D 2654–67T, "Methods of Test for Amount of Moisture in Textile Materials," describes a satisfactory oven. ("1969 Book of ASTM Standards," Part 24, published by the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pa. 19103.)

[3] The vacuum cleaning described is not intended to simulate the effects of repeated vacuum cleaning in service.

[4] If the specimens are moist when received, permit them to air-dry at laboratory conditions prior to placement in the oven. A satisfactory preconditioning procedure may be found in ASTM D 1776–67, "Conditioning Textiles and Textile Products for Testing." ("1969 Book of ASTM Standards", Part 24, published by the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pa. 19103.)

methenamine tablet on one of its flat sides in the center of the 8-inch (20.3 cm.) hole.

Ignite the tablet by touching a lighted match or an equivalent igniting source carefully to its top.[5]

Continue each test until one of the following conditions occurs:

(1) The last vestige of flame or glow disappears (this is frequently accompanied by a final puff of smoke).

(2) The flaming or smoldering has approached within 1 inch of the edge of the hole in the flattening frame at any point.

When all combustion has ceased, ventilate the hood and measure the shortest distance between the edge of the hole in the flattening frame and the charred area. Record the distance measured for each specimen.

Remove the specimen from the chamber and remove any burn residue from the floor of the chamber. Before proceeding to the next test, the floor must be cooled to room temperature or replaced with one that is at room temperature.

(e) *Report*—The number of specimens of the eight tested in which the charred area does not extend to within one inch of the edge of the hole in the flattening frame shall be reported.

(f) *Interpretation of results*—If the charred area does not extend to within one inch of the edge of the hole in the flattening frame at any point for at least seven of the eight specimens, the carpet or rug meets the acceptance criterion.

.5 *Labeling*—If the carpet or rug has had a fire-retardant treatment during the manufacturing process, or is made of fibers which have had a fire-retardant treatment, it shall be labeled with the letter "T."

[Appendix II]

TESTS OF SELECTED CARPETS AND RUGS

In order to determine to what extent carpets and rugs that would not pass the acceptance criterion were sold on the market, the National Bureau of Standards purchased a sample of carpets and rugs indicative of the fiber and construction types available to the public.

Forty-three separate and distinct carpets and rugs were purchased from six retail outlets. Twenty-nine of these were cut from large rolls of material, or were floor samples taken originally from rolls, and fourteen were items made up for sale in predetermined sizes. Of these forty-three carpets and rugs, 33 were labeled as having a single fiber type in the pile and 10 were labeled as containing blends of two or more fibers in the pile. The former contained the following carpet fibers: Acrylic, cotton, nylon, olefin, polyester, rayon and wool. The blends contained two or more of the following: Acetate, acrylic, cotton, modacrylic, nylon, olefin, polyester, and rayon.

[5] Care must be exercised to avoid igniting the carpet prior to the tablet. If more than 2 minutes elapse between the removal of the specimen from the desiccator and the ignition of the tablet, the conditioning must be repeated.

The results of the resistance to flammability tests are summarized in Table 1.

TABLE 1.—RESISTANCE OF CARPETS AND RUGS TO FAMMABILITY

Item	Number tested	Number meeting acceptance criterion
Carpets (from rolls)	29	22
Rugs and mats	14	6
By pile fiber material: [1]		
Acrylic	6	5
Cotton	2	1
Nylon	10	10
Olefin	8	5
Polyester	2	1
Rayon	3	0
Wool	2	1
Blends	10	3
By construction: [1]		
Indoor-Outdoor	4	4
Loop	10	8
Plush	5	5
Sculptured	7	4
Shag	5	2
Tweed	1	1
Twist	2	2
Rugs and mats	14	6

[1] Fiber content and construction information as provided by the retailer. Some construction designations were combinations of three types of construction, and are listed with each type. Therefore, the individual numbers do not add up to the total number of carpets and rugs tested.

[F.R. Doc. 69-14969; Filed, Dec. 17, 1969; 8:45 a.m.]

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

Office of the Secretary

[24 CFR Part 31]

GUARANTEE OF PRIVATE OBLIGATIONS FOR FINANCING NEW COMMUNITY LAND DEVELOPMENT

Notice of Proposed Rule Making

Notice is hereby given that the Secretary of Housing and Urban Development proposes to issue the regulations set forth below as a new Part 31 of Title 24, pursuant to the New Communities Act of 1968 (title IV of the Housing and Urban Development Act of 1968, 42 U.S.C. 3901 et seq.). Although the proposed regulations relating to a guarantee are not subject to the rule-making requirements of 5 U.S.C. 553, interested persons are invited to submit written comments or suggestions regarding the proposed regulations to the Assistant Secretary for Metropolitan Development, 451 Seventh Street SW., Washington, D.C. 20410, within 30 days of the publication of this notice in the FEDERAL REGISTER.

The proposed regulations are as follows:

PART 31—GUARANTEE OF PRIVATE OBLIGATIONS FOR FINANCING NEW COMMUNITY LAND DEVELOPMENT

Subpart A—General

Subpart B—New Community Criteria and Standards

Subpart C—Financial and Economic Criteria and Standards

SPECIFIC FINANCIAL ELEMENTS

Subpart D—Procedures

Subpart E—Fee and Charge Schedule

AUTHORITY: The provisions of this Part 31 issued under section 413 of the New Communities Act of 1968, 42 U.S.C. 3912; and sec. 7(d), Department of HUD Act, 42 U.S.C. 3535(d).

Subpart A—General

§ 31.1 Statement of applicable law.

(a) The New Communities Act of 1968 (42 U.S.C. 3901–3914) authorizes the Secretary of Housing and Urban Development to guarantee obligations issued by private developers to help finance new community development projects. It also authorizes the Secretary to make grants to State and local public bodies and agencies to supplement the Federal assistance that is otherwise available for certain water, sewer, or open-space projects if these projects are needed or desirable in connection with a new community which will make available a substantial number of housing units for persons of low and moderate income. The amount of such grants may not exceed 20 percent of project costs, and, since this is to supplement other Federal assistance, the projects must also meet the applicable requirements for regular grants under section 702 of the Housing and Urban Development Act of 1965, as amended (42 U.S.C. 3102); section 306(a)(2) of the Consolidated Farmers' Home Administration Act, as amended (7 U.S.C. 1926(a)(2)); or title VII of the Housing Act of 1961, as amended (42 U.S.C. 1500–1500e).

(b) The Act (1) amends section 202 (b)(4) of the Housing Amendments of 1955, as amended (42 U.S.C. 1492), to permit public facilities loans without regard to the population limits otherwise applicable for facilities serving a new community development; (2) amends

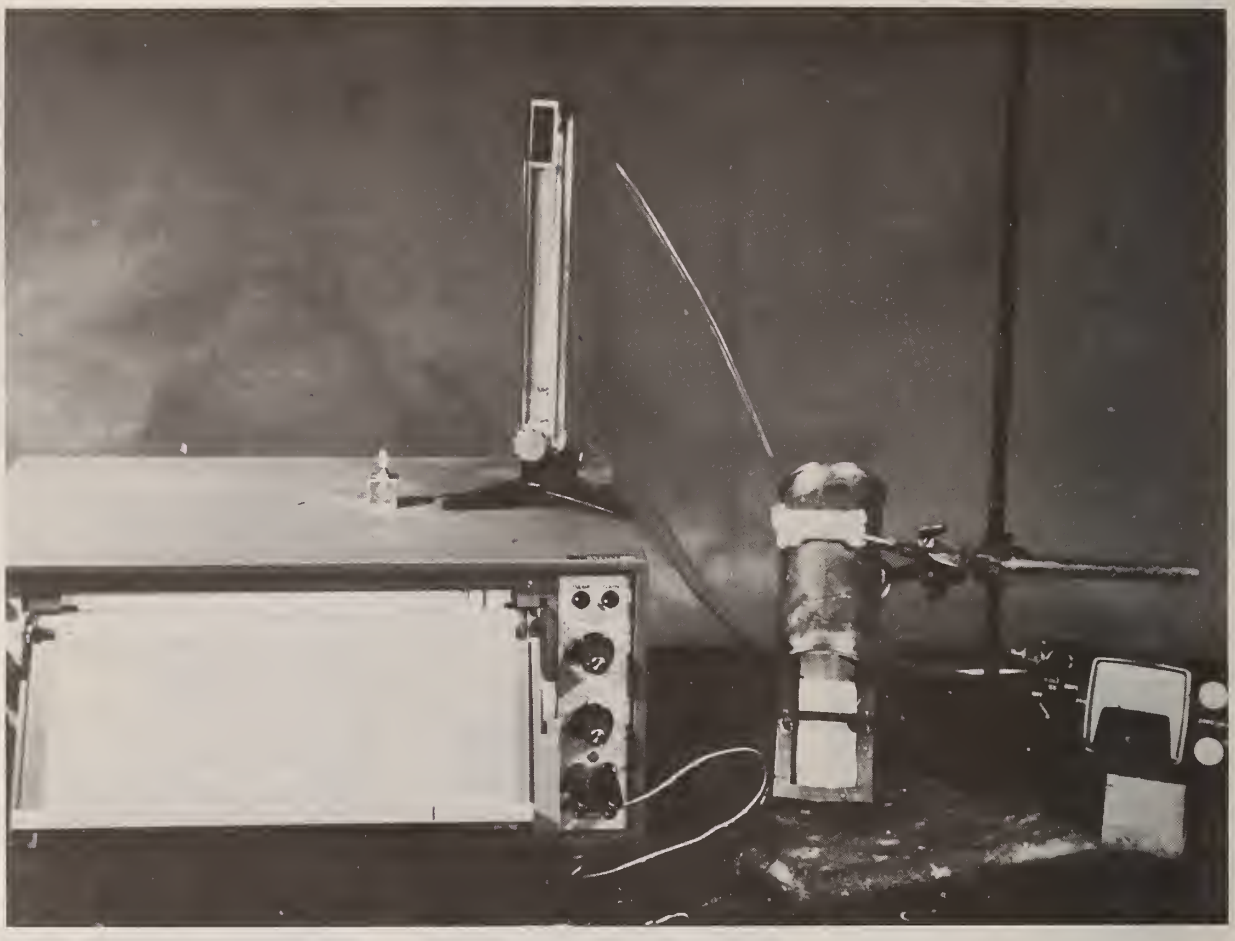

FIGURE 1

PROTOTYPE CALORIMETER. THIS INSTRUMENT, SHOWN HERE IN ITS EARLY DEVELOPMENT STAGES, WILL MAKE IT POSSIBLE TO MEASURE THE TOTAL HEAT GIVEN OFF BY A BURNING FABRIC AS WELL AS THE RATE AT WHICH IT IS GIVEN OFF. THE AMOUNT OF HEAT GIVEN OFF, AND THE RATE AT WHICH IT IS GIVEN OFF ARE IMPORTANT IN DETERMINING THE HAZARD FROM A BURNING FABRIC.

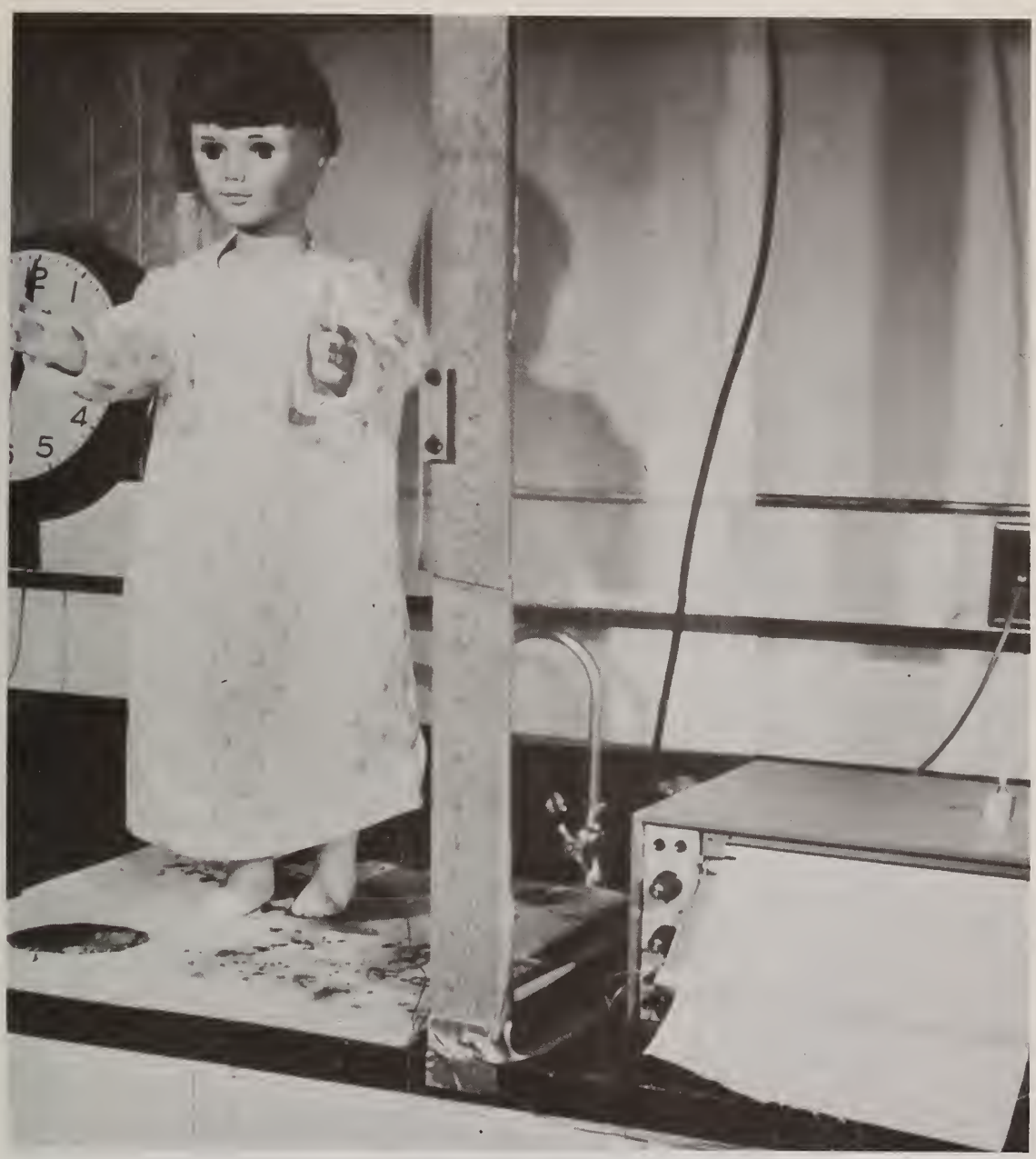

FIGURE 2

AN INSTRUMENTED MANNEQUIN. THE BURNING OF GARMENTS ON SUCH MANNEQUINS, AND THE MEASUREMENT OF TEMPERATURES AND AMOUNT OF HEAT TRANSFERRED TO THE BODY WILL MAKE POSSIBLE THE DEVELOPMENT OF MORE MEANINGFUL TESTS FOR APPAREL FABRICS.

FIGURE 3

BURNING OF A SAMPLE OF FABRIC IN THE TEST (CS 191-53) PRESENTLY SPECIFIED IN THE FLAMMABLE FABRICS ACT. THIS TEST HAS SEVERAL TECHNICAL INADEQUACIES, FOREMOST OF WHICH IS THE INABILITY TO DISTINGUISH BETWEEN EASE OF IGNITION AND RATE OF BURNING.

FIGURE 4

A VERSION OF THE VERTICAL FLAMMABILITY TEST. THIS IS THE MOST STRINGENT OF THE TESTS PRESENTLY IN USE. IN ORDER TO PASS IT, A MATERIAL MUST ONLY CHAR AND NOT BURN. ONLY A VERY FEW MATERIALS CAN PRESENTLY PASS THIS TEST, WHICH IS USED WHERE A MAXIMUM DEGREE OF PROTECTION IS DESIRED AND OTHER CONSIDERATIONS ARE SECONDARY.

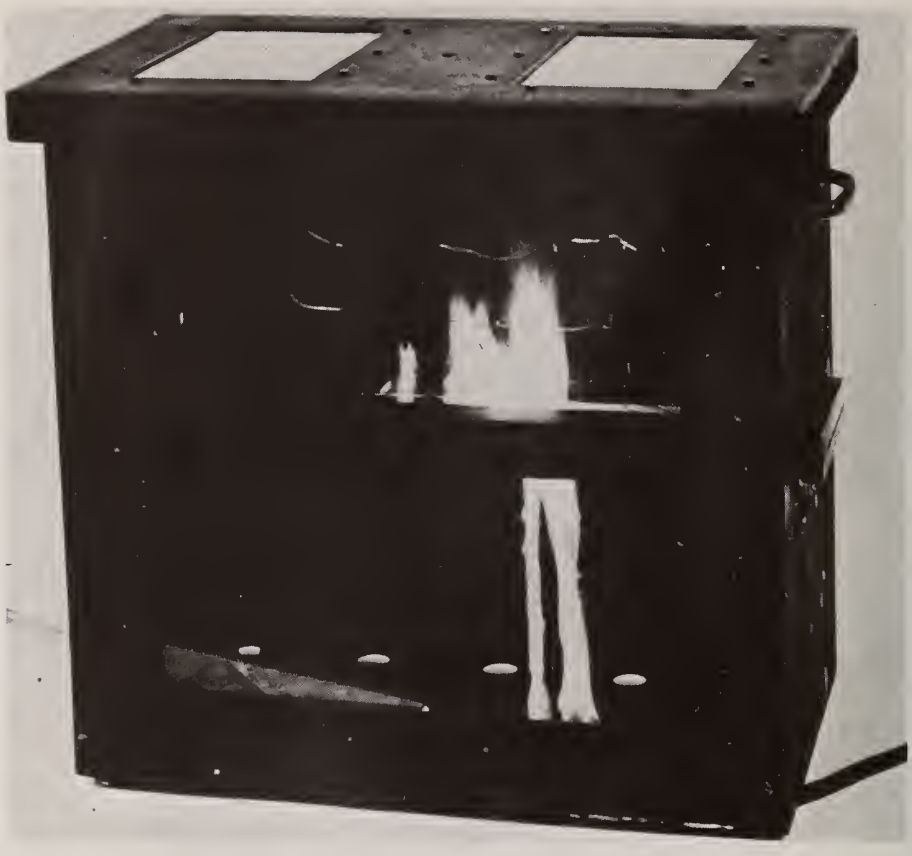

FIGURE 5

HORIZONTAL BURNING TEST METHOD. IN THIS TEST, THE SAMPLE OF FABRIC TO BE TESTED IS HELD IN A HORIZONTAL POSITION. THE TEST IS NOT USED IN STANDARDS AT THE PRESENT TIME.

FIGURE 6

THE SO-CALLED "SEMICIRCULAR" TEST. THIS TEST HAS THE ADVANTAGE OF INVOLVING ALL ANGLES OF BURN. IT IS A RESEARCH TEST, AND NOT USED FOR ANY TEST METHOD.

FIGURE 7

A PORTION OF A SHIRT RECOVERED FROM AN ACCIDENT CASE, SUBMITTED TO THE NATIONAL BUREAU OF STANDARDS BY THE OFFICE OF PRODUCT SAFETY, FDA. THE CORRELATION OF THE BEHAVIOR OF THE FABRIC IN SUCH GARMENTS ON THE TESTS UNDER DEVELOPMENT, AND THE DETAILS OF THE ACCIDENT FROM WHICH THE GARMENT WAS RECOVERED, WILL PERMIT THE DEVELOPMENT OF PROPER STANDARDS.

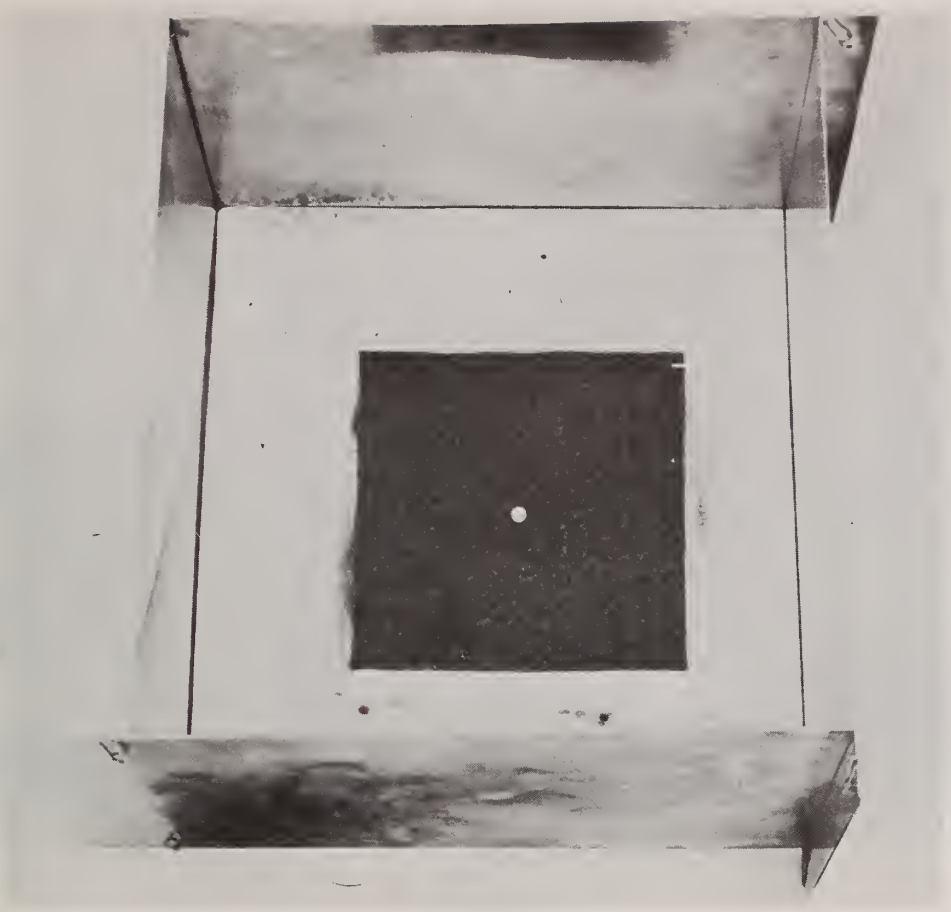

FIGURE 8

THE APPARATUS USED IN THE STANDARD DDD-C-95 PRESENTLY USED TO CONTROL THE FLAMMABILITY OF CARPETS PURCHASED FOR FEDERAL GOVERNMENT INSTALLATIONS. THE SAMPLE OF RUG IS 6" X 6", AND THE WHITE TABLET IN ITS CENTER IS A TIMED BURNING TABLET WITH THE NAME "METHENAMINE". THIS TABLET BURNS WITH AN APPROXIMATELY MATCH-SIZE FLAME FOR ABOUT 90 SECONDS.

FIGURE 9

A SPECIMEN OF RUG BURNING IN THE APPARATUS DESCRIBED IN FIGURE 8. IN ORDER TO PASS THIS TEST, TWO SPECIMENS OF RUG MUST NOT BURN MORE THAN TWO INCHES IN ANY DIRECTION. THE BURNED SQUARE OF CARPET ON THE RIGHT IS ONE SIMILAR TO THE ONE IN THE BOX AFTER TESTING. IT HAS FAILED THE TEST.

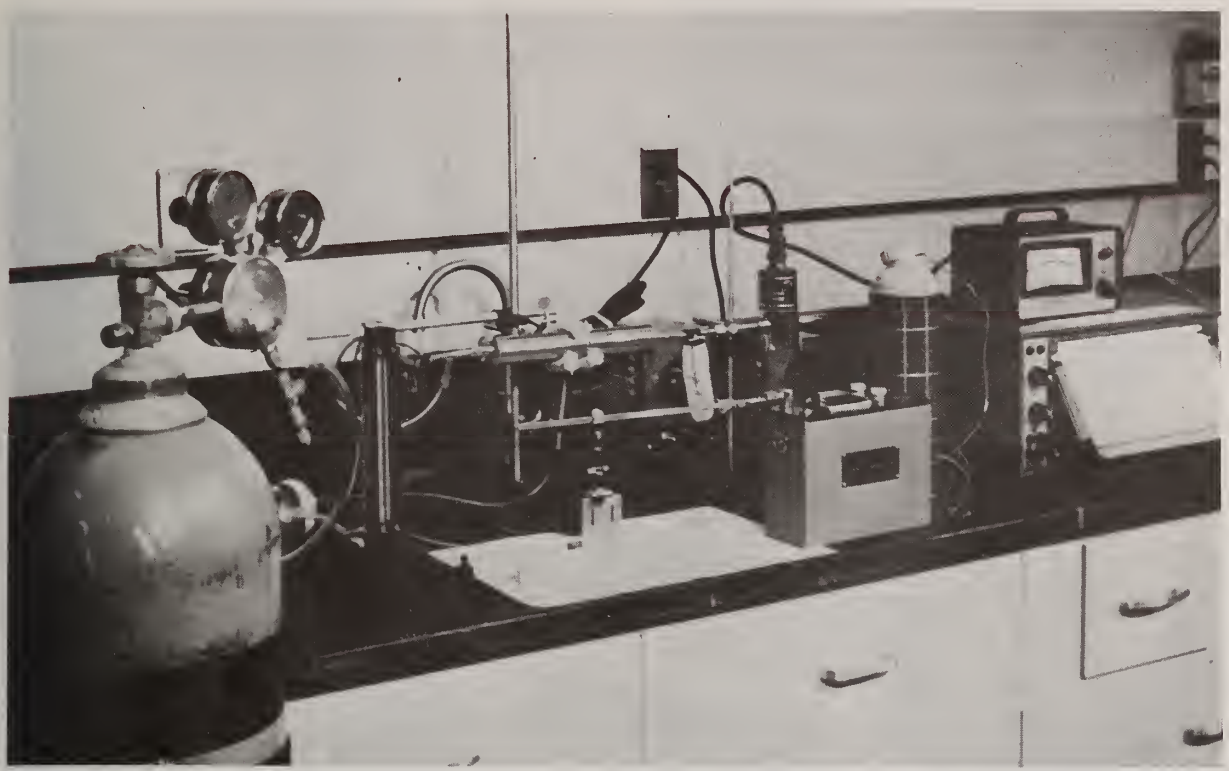

FIGURE 10

APPARATUS FOR PYROLYSIS STUDY. IN THIS APPARATUS, A SMALL SAMPLE OF THE FABRIC TO BE STUDIED IS HEATED TO A TEMPERATURE THAT CAUSES DECOMPOSITION. THE RESULTING GASES WOULD BURN IN NORMAL CIRCUMSTANCES. THE MEASUREMENT OF THE RATE OF EVOLUTION OF THESE CASES, AND A MEASUREMENT OF THEIR CALORIFIC CONTENT, PERMITS A STUDY OF THE FLAMMABILITY OF A MATERIAL.

FIGURE 11

A BED AND MANNEQUIN AT THE BEGINNING OF ONE OF THE TESTS USED TO DETERMINE THE LIFE HAZARDS FROM BEDDING FIRES. THE SMOLDERING SPOT NEAR THE END OF THE ARM OF THE MANNEQUIN WAS CAUSED BY A CIGARETTE. TOXIC GAS SENSORS AND THERMOCOUPLES WERE PLACED AT VARIOUS LOCATIONS IN THE ROOM. SMOKE DENSITY WAS DETERMINED BY MEASURING THE OBSCURATION OF A LIGHT BEAM ACROSS THE ROOM. THE TEST BEGAN AT 12:00 ON THE CLOCK.

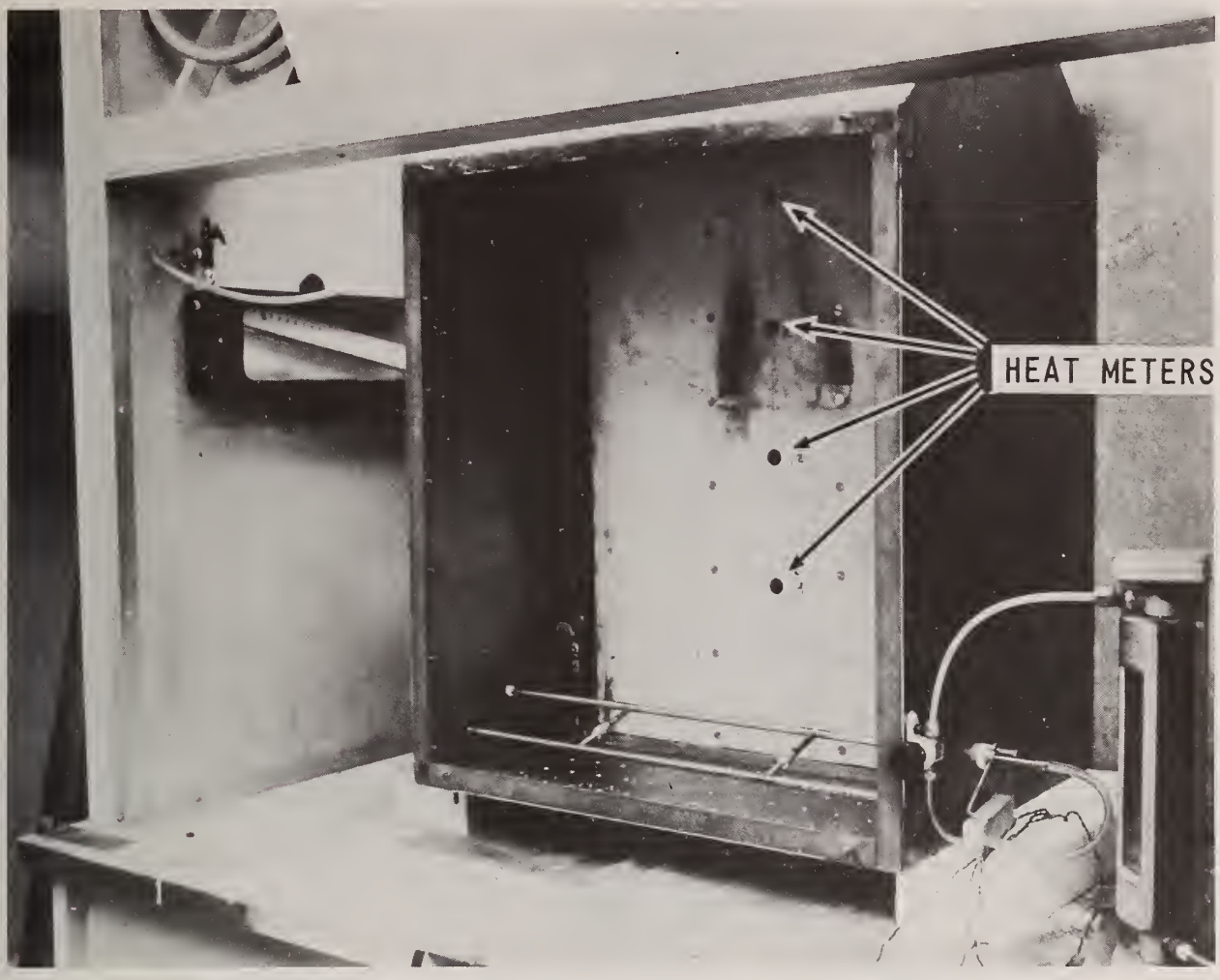

FIGURE 12

A VIEW OF THE APPARATUS USED TO MEASURE HEAT DELIVERED TO A SUBSTRATE FROM A BURNING FABRIC. THE BLACK DOTS ARE HEAT METERS. IN PRACTICE, A PIECE OF FABRIC IS SUSPENDED IN FRONT OF THEM AND BURNED, AND THE HEAT SENSED BY THE METERS IS MEASURED. IN COMBINATION WITH THE RESULTS OBTAINED WITH THE APPARATUS SHOWN IN FIGURES 1 AND 2, THIS IS EXPECTED TO LEAD TO MORE MEANINGFUL TEST METHODS.

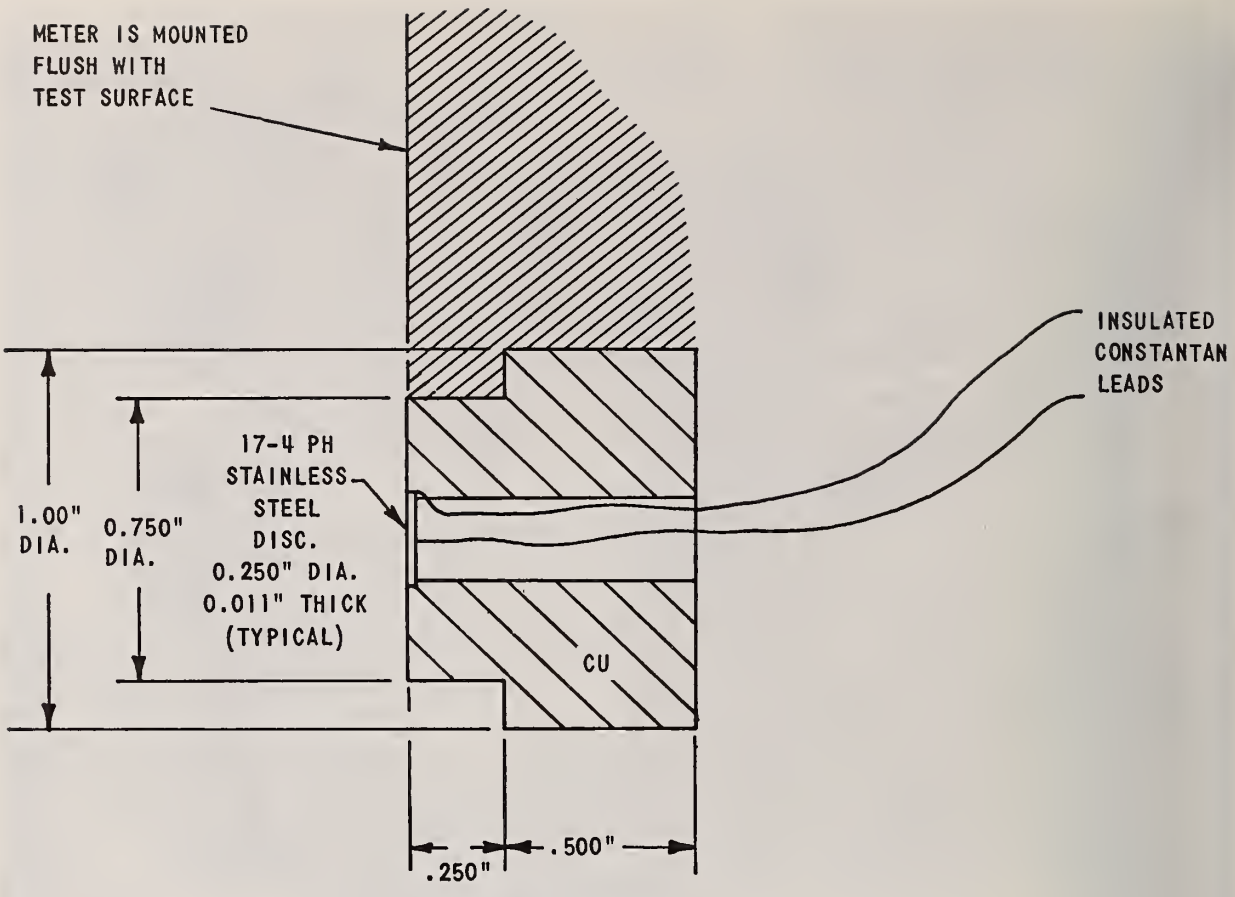

FIGURE 13

A DIAGRAM OF THE HEAT METERS SHOWN IN FIGURE 12.

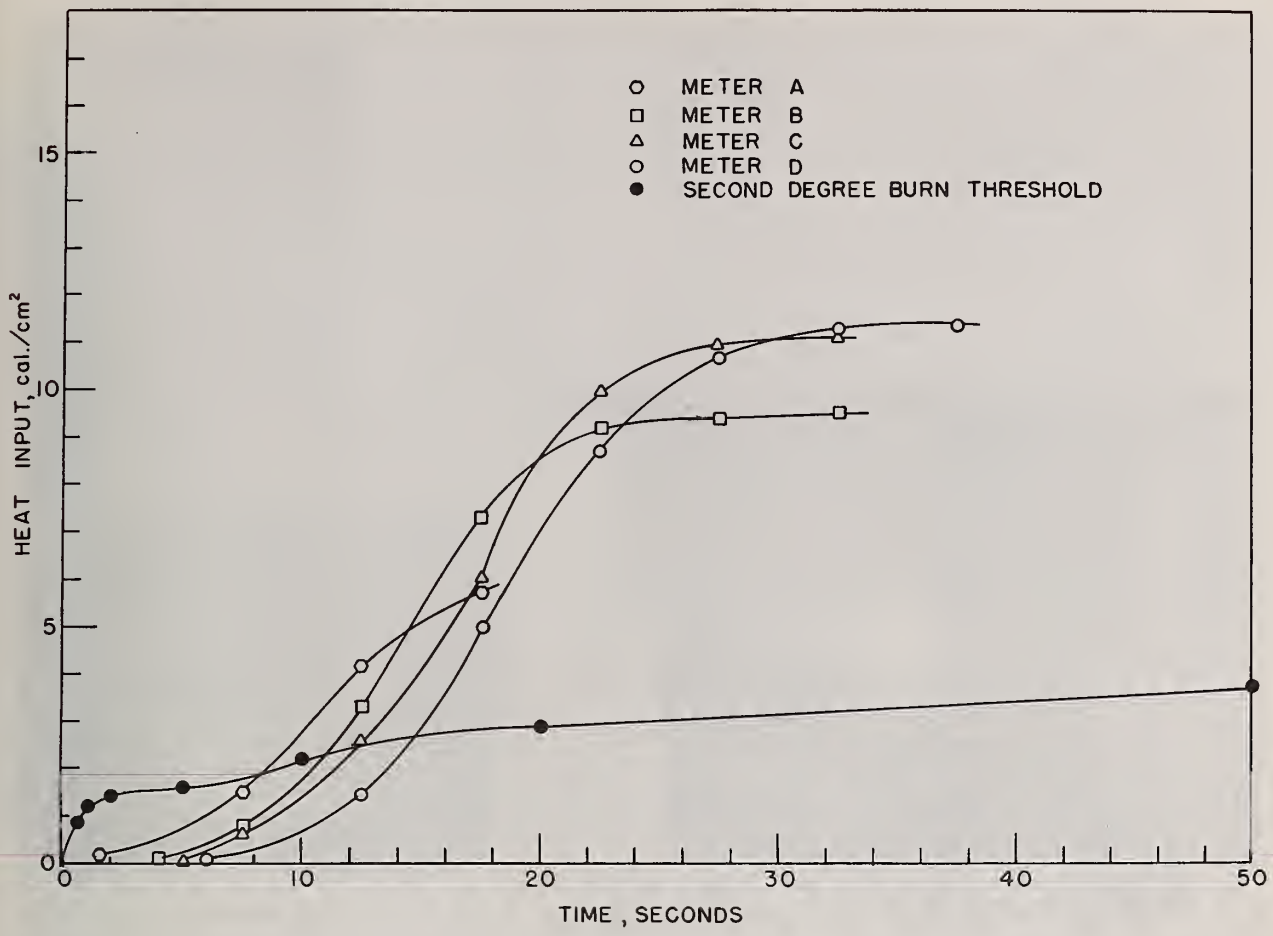

FIGURE 14

RESULTS OBTAINED WITH THE APPARATUS SHOWN IN FIGURES 12 AND 13. THESE RESULTS INDICATE THAT, FOR THIS PARTICULAR SPACING OF FABRIC AND SUBSTRATE, SECOND DEGREE BURNS WOULD HAVE BEEN SUSTAINED FOR SKIN AT THE POSITION OF THE LOWEST METER EIGHT SECONDS AFTER IGNITION. THESE RESULTS DO NOT TAKE INTO ACCOUNT HUMAN REACTION TIMES.

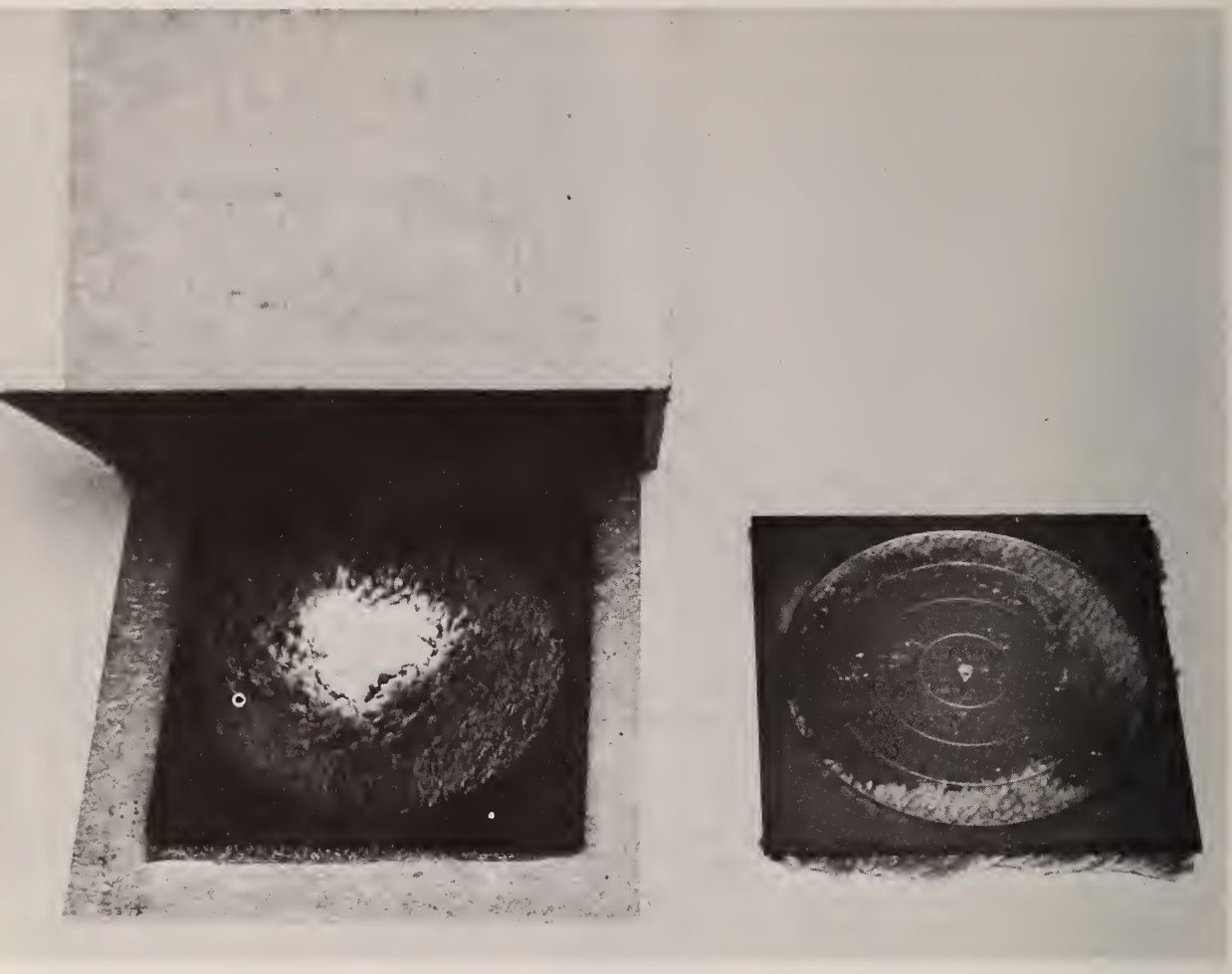

FIGURE 15

AN ILLUSTRATION OF THE APPARATUS USED FOR THE CARPET AND RUG STANDARD PROPOSED ON DECEMBER 18, 1969. THE TEST IS SIMILAR TO THAT SHOWN IN FIGURE 8. THE SAME BURNING TABLET IS USED, BUT IN THIS PROPOSED STANDARD AT LEAST SEVEN OUT OF EIGHT SPECIMENS MUST NOT BURN THREE INCHES OR MORE IN ANY DIRECTION. THIS REQUIREMENT, ALONG WITH THE REQUIREMENT THAT THE SAMPLES OF CARPET BE TESTED DRY, MAKES THIS A MORE STRINGENT STANDARD THAN THAT USED IN DDD--C-95.

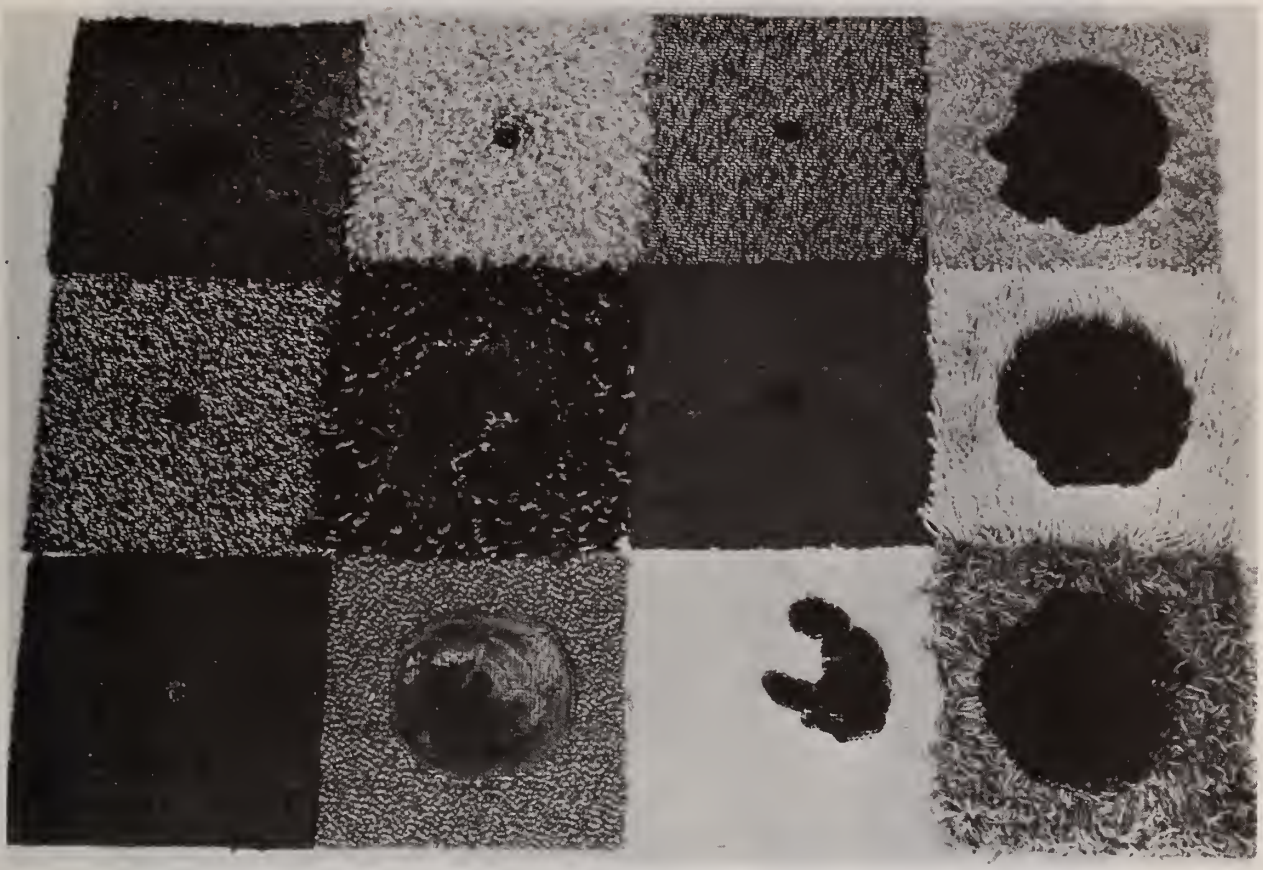

FIGURE 16

SPECIMENS OF THE TWELVE RUG TYPES USED IN THE DEVELOPMENT OF THE PROPOSED CARPET AND RUG STANDARD.

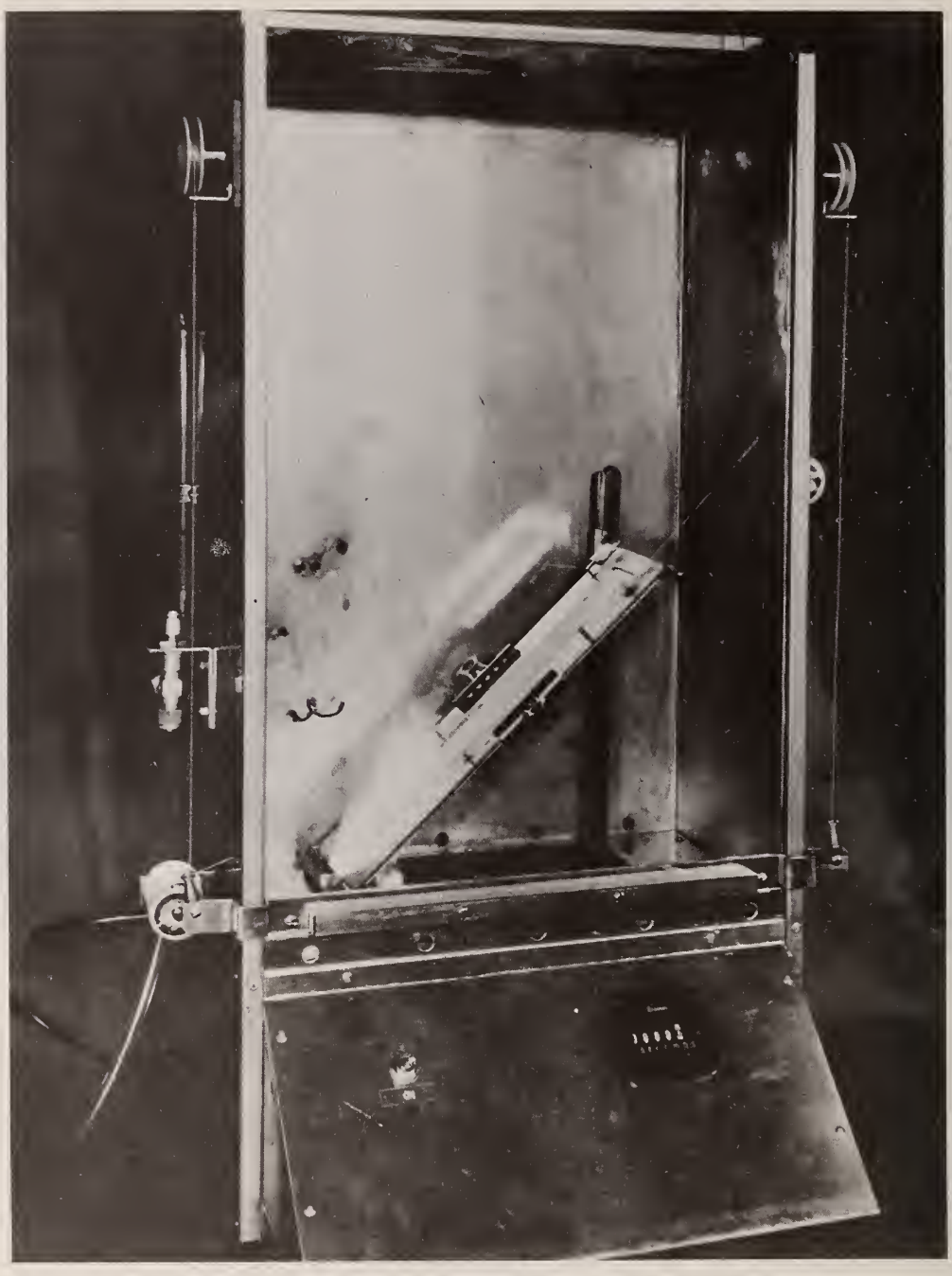

FIGURE 17

A PICTURE OF THE NEWLY DEVELOPED RATE-OF-BURN TEST. WHILE SUPERFICIALLY SIMILAR TO THE TEST SHOWN IN FIGURE 3, THIS TEST MEASURES ONLY BURN TIME. THE RESULTS ARE NOT COMPLICATED BY THE ADMIXTURE OF TIME TO IGNITION IN THE RESULTS.

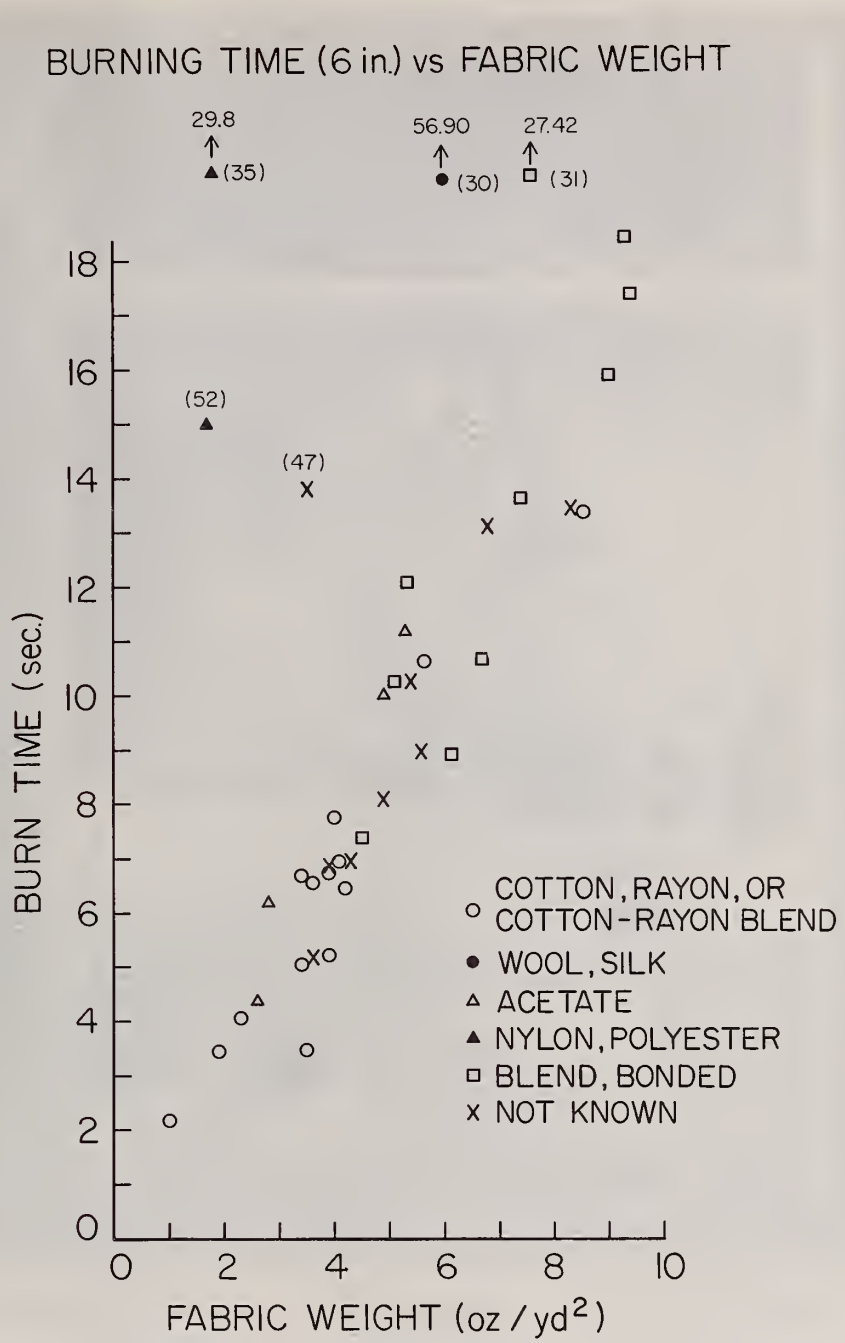

FIGURE 18

RESULTS OF BURN TIMES OBTAINED IN THE APPARATUS SHOWN IN FIGURE 17 PLOTTED AGAINST FABRIC WEIGHT PER UNIT AREA. FOR MANY FABRICS, THE BURN TIME IS LINEARLY DEPENDENT ON THE FABRIC WEIGHT PER UNIT AREA. OTHER FABRICS DO NOT FOLLOW THIS CORRELATION.

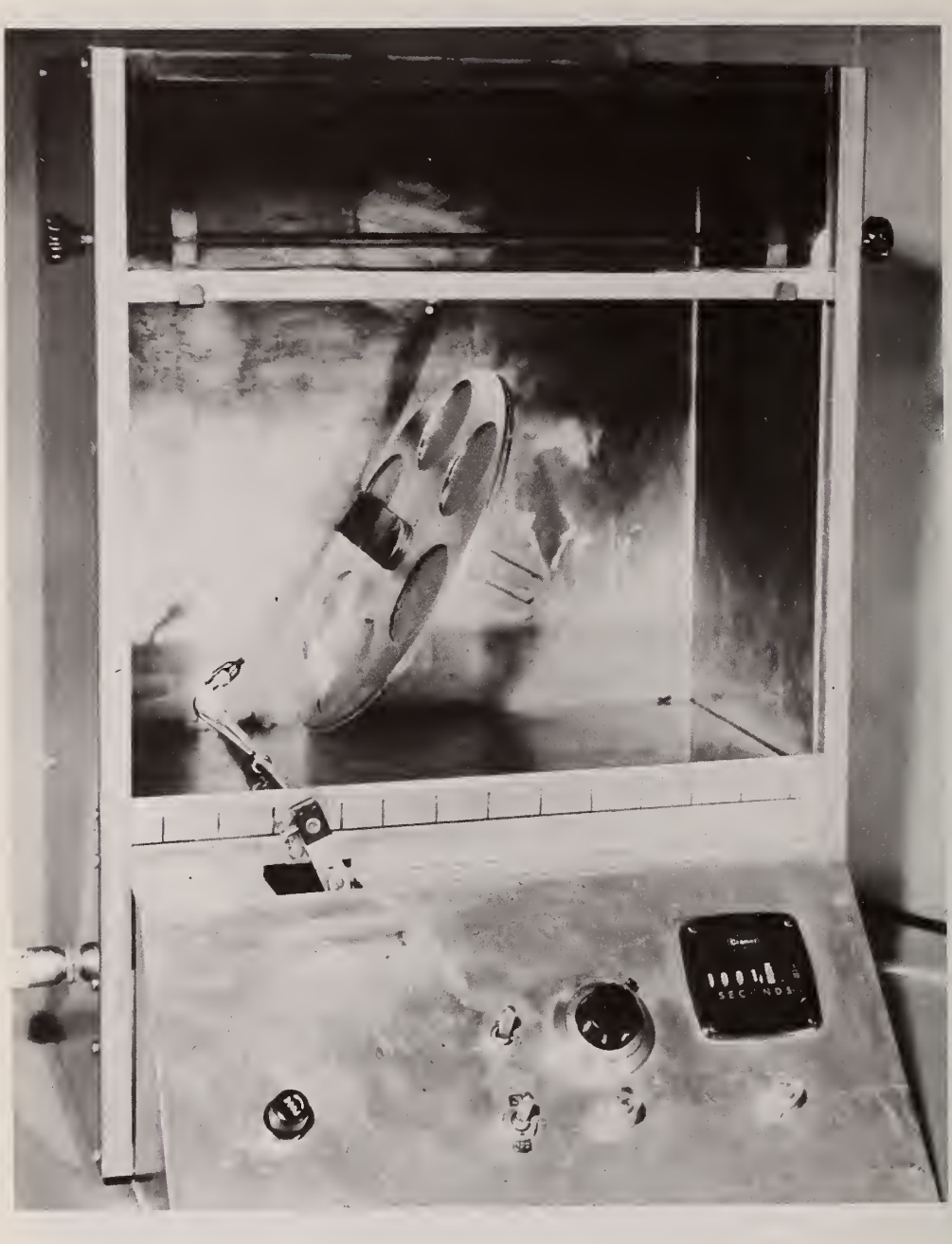

FIGURE 19

A PHOTOGRAPH OF THE APPARATUS USED IN THE NEWLY DEVELOPED TEST METHOD FOR EASE OF IGNITION. THE SMALL FLAME IS IMPINGED ON THE SPECIMEN OF FABRIC FOR SUCCESSIVELY LONGER TIMES UNTIL THE SHORTEST TIME FOR WHICH IGNITION IS OBTAINED IS FOUND.

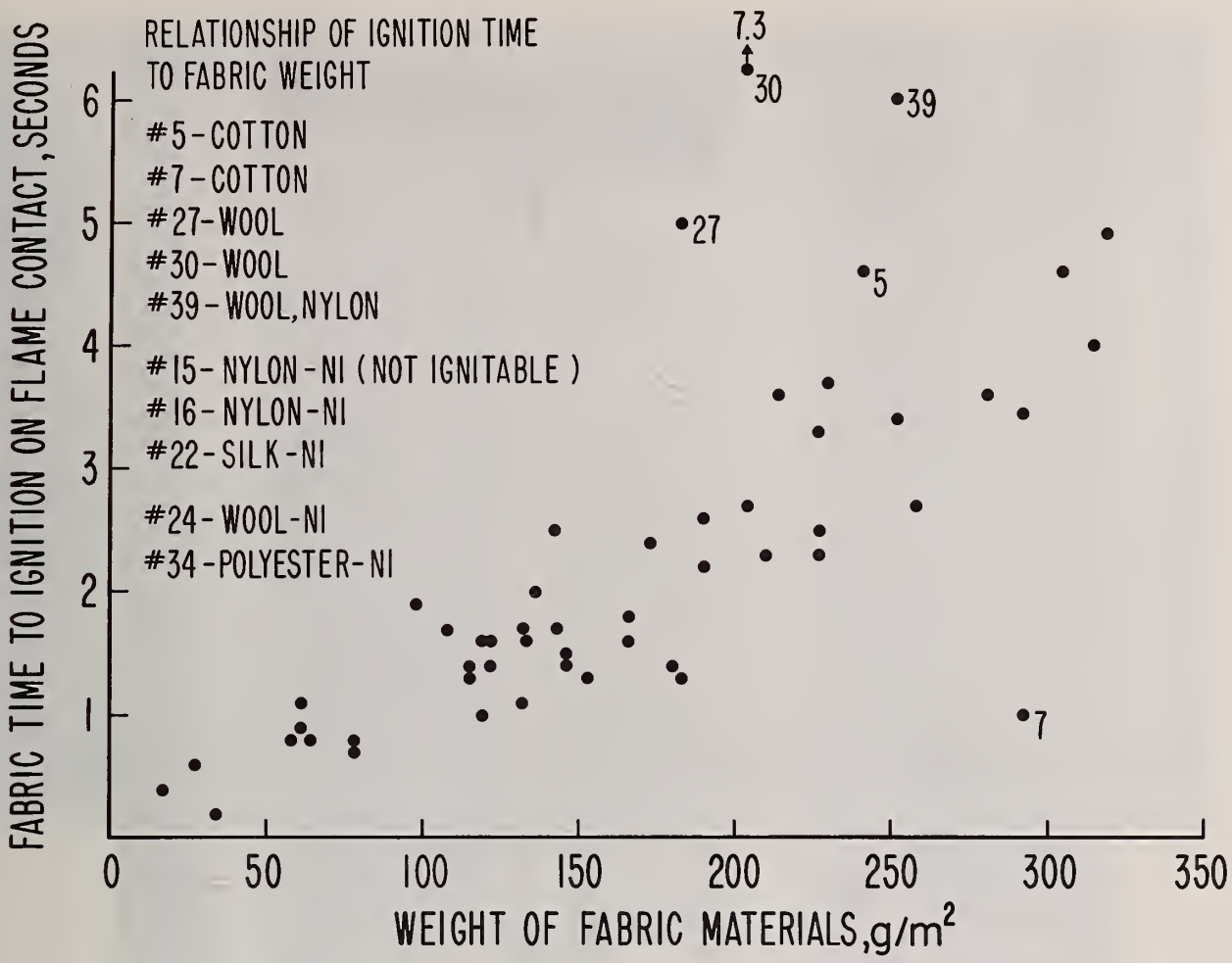

FIGURE 20

RESULTS OBTAINED ON A REPRESENTATIVE SERIES OF FABRICS WITH THE TEST METHOD SHOWN IN FIGURE 19 PLOTTED AS A FUNCTION OF FABRIC WEIGHT PER UNIT AREA. THE FABRICS ARE THE SAME AS THOSE USED TO OBTAIN THE RESULTS SHOWN IN FIGURE 18. THE TIME TO IGNITION IS A LINEAR FUNCTION OF THE FABRIC WEIGHT PER UNIT AREA FOR SOME TYPES OF FABRICS, BUT OTHERS DO NOT FOLLOW THIS CORRELATION.

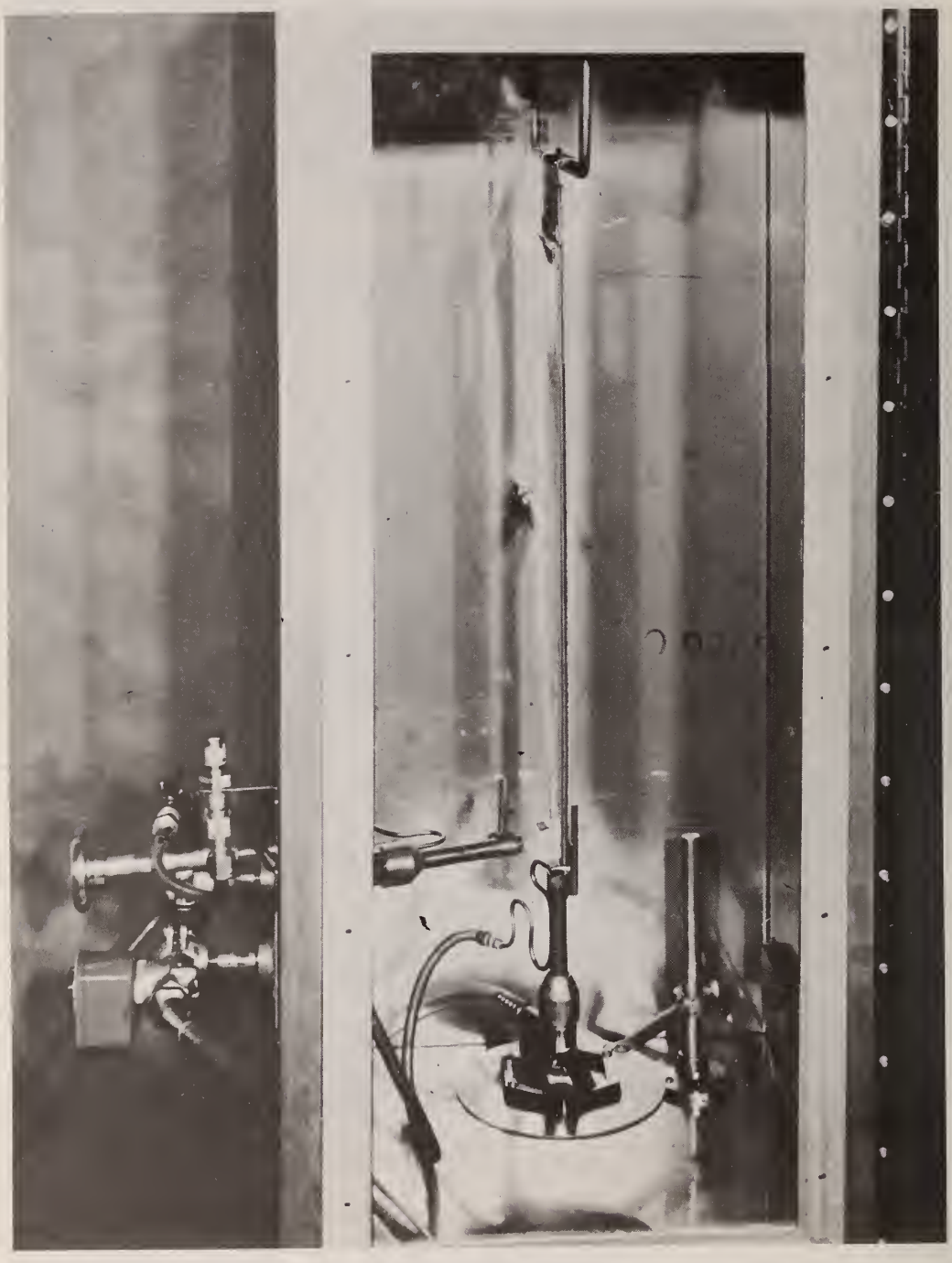

FIGURE 21

THE MOST MODERN MODIFICATION OF THE VERTICAL TEST DESCRIBED IN FIGURE 4. THE COMMENTS MADE THERE APPLY EQUALLY TO THIS TEST.

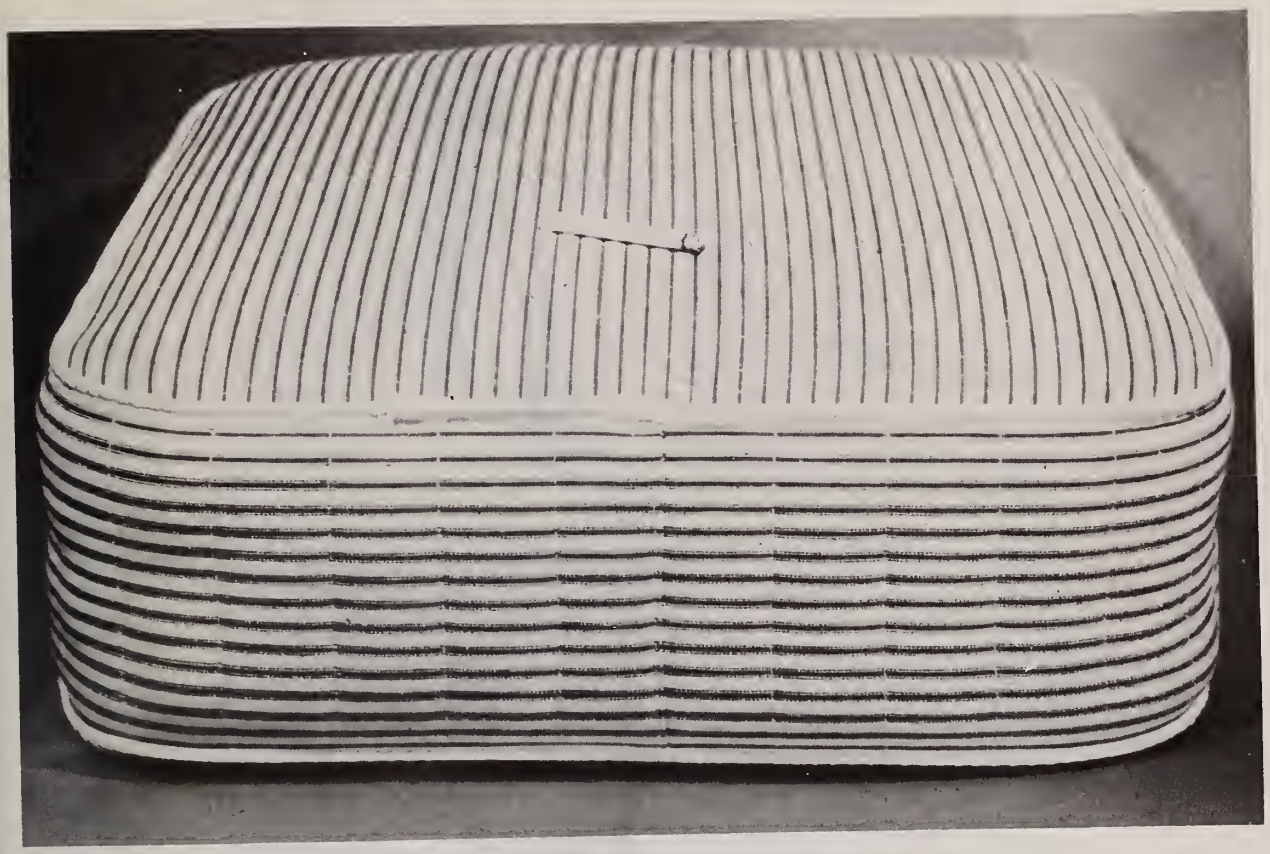

FIGURE 22

A SMALL MATTRESS BEING USED TO DEVELOP A MATTRESS TEST. ONE OF THE POSSIBILITIES FOR THIS TEST IS A CIGARETTE TEST SUCH AS ILLUSTRATED HERE. IN THIS PARTICULAR TEST WITH THIS PARTICULAR MATTRESS, THE MATTRESS WILL BEGIN TO SMOLDER SHORTLY AFTER PLACEMENT OF THE CIGARETTE, AND EVENTUALLY EMIT COPIOUS QUANTITIES OF FUMES.

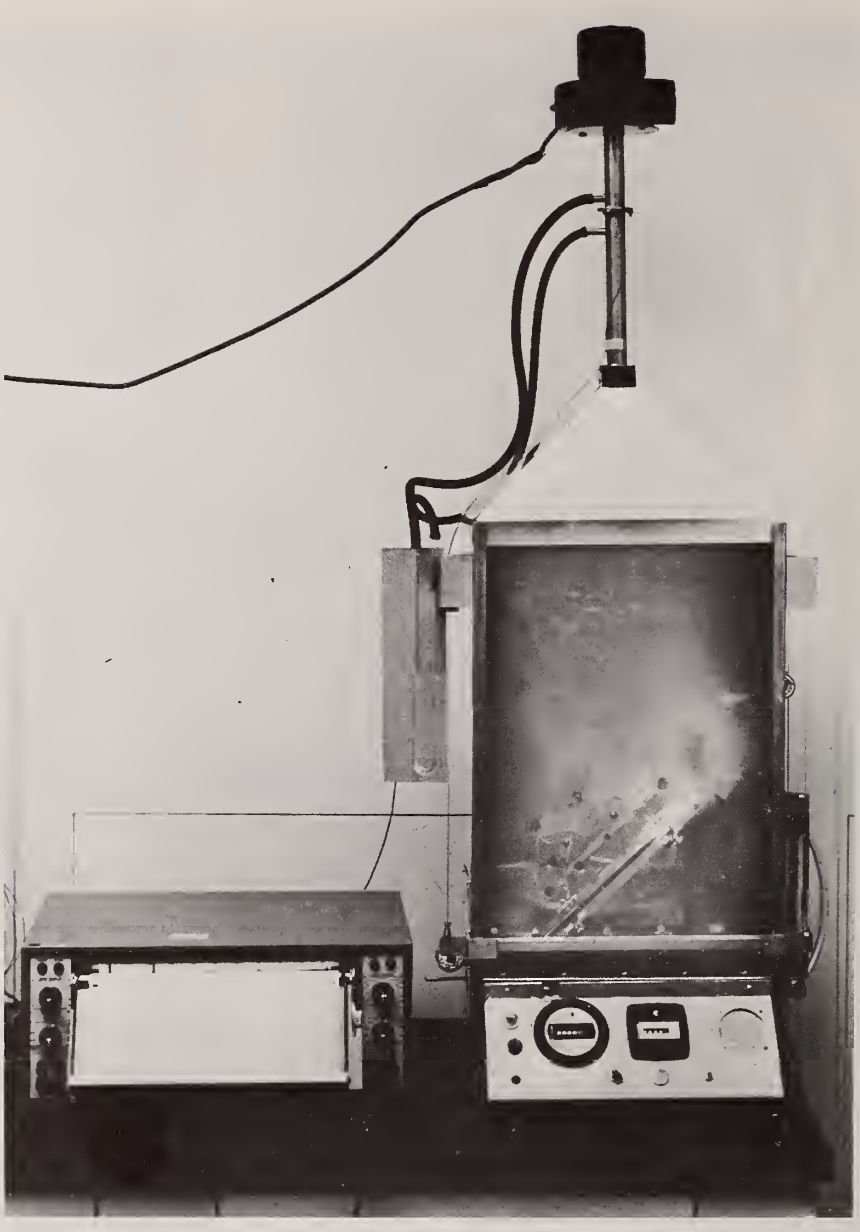

FIGURE 23

A TEST BEING DEVELOPED TO MEASURE THE CONVECTIVE HEAT GIVEN OFF DURING BURNING OF A FABRIC. THE HOT GASES ARE DRAWN UP THROUGH THE COPPER TUBE BY THE FAN AND THEIR TEMPERATURE MEASURED. THE RESULTS OF THIS TEST METHOD, COMBINED WITH THOSE SHOWN IN FIGURES 1, 2 AND 12, WILL MAKE MORE MEANINGFUL TEST METHODS POSSIBLE.

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