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BUREAU OF STANDARDS
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SOME OUTSTANDING ACCOMPLISHMENTS OF THE BUREAU OF STANDARDS IN 1926

1. Fuel Requirements for Automobile Engine Starting

The third major project of the fuel research which has been carried on at the Bureau since 1922 in cooperation with the automotive and petroleum industries was a study of the fuel requirements for automobile starting. The specific question proposed for solution was this, what changes in fuel would be needed to give the same starting ability in winter as in summer? The results answer this question and several others. They show that in the past motor fuels have been marketed without much regard to varying requirements for starting because the necessary knowledge of what was required for starting did not exist. They show how engine design might be modified to improve starting and what fuel characteristics are required for easy starting at any temperature. Easy starting implies a small number of engine revolutions necessary to start and means not only convenience to the operator but also economy in fuel consumption, saving in batteries and the minimum dilution of the lubricant.

It is now possible for the motorist to specify fuels which will give reasonably good starting at any desired temperature and for the refiner to produce such fuels. Existing methods of testing are found adequare for this purpose without material change. Moreover, only a small percentage of the components of gasoline are involved in starting ability at low temperature, where it is most important; thus the economic problems involved are probably less serious than might have been expected. It may not be necessary any longer to use fuels that, like some of those tested, will give less than 20 starts per gallon at 32°F when others differing only a little from them will give over 100 starts per gallon at the same temperature.

This investigation was definitely limited to starting,(i.e., getting the first explosion). What happens during the "warming up" period is still another question, which is now being studied.

2. Endurance Tests of Tires

During the past 2 1/2 years the Bureau has installed and operated endurance machines for testing the durability of tires. The type of machines and the conditions under which each particular size of tire is run are based on the results of cooperative tests made by the Bureau and the Rubber Association of America. The tire is mounted on a wheel free to revolve on a spindle secured to a movable carriage and pressed against the drum with the desired axle load. The load is applied by means of weights acting through

a bell crank lever (3 to 1 ratio). The drum (60" in diameter) is driven at a surface speed of 30 miles per hour, and in turn drives the tire. A speedometer connected to each drum shows directly the miles traveled by the tire. In the first test run on this type of machine no cleats were used on the drums. The tires tested in this manner often showed no indication of failure within the practical time limit of an accelerated test and furthermore the type of failure differed from the type commonly found in tires. Several types of cleats bolted to the surface of the drum were tried out before arriving at the size and number finally adopted.

Since this equipment has been in operation, approximately 250 cord tires of the 3 1/2, 4, 4 1/2 and 5 inch sizes, comprising 36 different brands, have been tested. The results of tests of 230 of them are shown graphically in Technologic Paper No. 318 -- each brand of tire being shown separately. Data are given showing the cause of failure in each tire where such has taken place and also whether or not each particular tire meets the Federal specification requirements. As a whole about 50% of the tires tested have met those requirements.

Balloon tires of several different sizes have been tested under loads corresponding to the loads of high pressure tires which they replace and with air pressures varying from 32 lbs. for the 4.40 inch tire to 38 lbs. for the 7.30 inch tire. The mileages obtained in general were about the same as for high pressure tires but the type of failure differed. In practically all cases the failures were due to the breaking of the carcass rather than separation as is common with high pressure tires.

Several 6 and 7 inch truck tires have been tested under axle loads of 2400 and 3000 lbs., respectively. These tires in general showed a higher mileage performance than the smaller sizes. It was also observed that a higher temperature was developed in these tires than in the smaller sizes and frequently the inner tubes failed under this excessive temperature before the test was completed. The types of failures were similar to those found with the smaller sizes.

3. Stevenson Creek Experimental Arch Dam

During the past year the Bureau cooperated with the Research Committee of the Engineering Foundation in an exhaustive test of an experimental arch dam, specially built for the purpose at Stevenson Creek, Fresno County, California. This is the most comprehensive experiment upon any type of dam that has ever been attempted. It was the original scheme to build the dam 60 feet high and if failure did not occur at full load or before to increase the height by increments of 10 feet to 100 feet and to apply tests as each addition was made.

The site was so chosen and the dam so built that the amount of water retained back of the dam was comparatively very small so that the water level could be changed without too much delay. The concrete for the dam was very carefully prepared in order to produce a material of as uniform a strength as possible. Electric telemeters, the new type of strain gage developed by the Bureau embedded in the concrete of the dam, innumerable gage points for readings by the Petrenko strain gage, clinometer attachments, etc., gave means for measuring in detail the action of the dam under load. The instruments were capable of measuring the minute stretches and compression of the concrete, the change in shape from the cylindrical form of the arch, the slip of the dam on the foundation, etc. Besides the measurements on the dam, quantities of test specimens were made of the concrete to furnish information on its physical properties. The ultimate strength, modulus of elasticity, flow under load, extensibility under change in moisture, etc., were all carefully and exhaustively measured.

Tests were made by filling the dam to the predetermined level and making a complete set of readings. In order to eliminate temperature effects as far as possible the readings were started at 1:00 A.M. and the number of these was so great that a complete set took some six to seven hours to complete. Tests were made with water at every 10 foot level up to the top of the dam.

Cracks formed at the abutment between the dam and the foundation rock a short time after the completion of the dam, presumably because of shrinkage or temperature changes. These cracks were covered with a fillet of mortar in order to facilitate their observation. Very little change has occurred in them.

The only signs of failure are two vertical cracks in the center line of the dam, one extending from the lowest point upward some 13 feet, the other from the highest point downward some 19 feet. The top crack opens widest at a head of 45 to 50 feet and at a head of 60 feet returnspractically to the same width as when no water is in the reservoir. This crack does not permit water to seep through. Its maximum width is about .03 inch, and the lower crack is still smaller.

From the tests it has been learned that:

With the reservoir full, (60 foot level) the load carried by the horizontal elements (arch ribs) due to the horizontal thrust, is a maximum at approximately mid-height, and decreases slightly, both at the top and bottom of the dam.

The greater part of the load carried by the vertical elements appears to be at the bottom of the dam, practically all of the load at this place being so carried. At the top of the dam no load appears to be carried by these vertical elements; the vertical elements being supported by the horizontal elements.

4. Working Stresses in Building Materials

A report on working stresses in building materials has been issued by the building code committee which functions as a part of the division of building and housing. From a study of the widely varying stress requirements in local building codes, the committee was led to the conclusion that a restatement of minimum requirements in line with modern improvements in materials, design, and methods of construction, was justified. The report is based upon a thorough study of test data, supplemented by information from a great number of well qualified persons engaged in various branches of construction work. The report covers reinforced concrete, cast iron, steel, and timber. Masonry has already been treated in a previous report.

Approval is given to the modern theory that the ultimate strength of concrete is governed by the ratio between the water and cement used in the mixture. Within the limits of a practicable working mixture, less water means stronger concrete. Not only does this operate to produce better structures, but it tends to economy.

Recognition is also given to an increased basic stress for structural steel. This is set at 18,000 lbs. per square inch, provided the steel meets the specifications of the American Society for Testing Materials. Material of unknown grade is to take the old customary stress of 16,000 lbs. per sq. in. in order that safety shall not be sacrificed.

In the requirements for timber, the report supports the program of basic grading rules contained in the American Lumber Standards. It presents a revised table of timber stresses derived by methods recently developed at the Forest Products Laboratory.

The report is the 6th of a series of recommended minimum requirements suitable for inclusion in local building codes.

5. Better Homes in America

That families throughout the United States may benefit to the fullest extent from the research work of the division of building and housing and other branches of the Bureau, is one of the objectives of the division in lending its support to Better Homes in America.

Nearly one-half of all the construction in the United States during the past few years has been residential, and in order that the new structures as well as old may serve their greatest usefulness, the better homes organization, of which Secretary Hoover is president and in the direction of which several other cabinet officers and bureau chiefs are concerned, was incorporated in December, 1923. Last year 2965 local committees were in touch with national headquarters. Local committees exhibited 330 demonstration

houses in which they endeavored to display attractive, healthful houses built, furnished, and equipped as economically as possible. Their progress is shown by the fact that the median cost of the houses demonstrated in the 1923 campaign was more than $6600, while in the 1926 campaign it was below $4500. Sixty-one of the houses in the latter year cost less than $3000 each.

The local committees make extensive use of publications of the Bureau and of other Government departments in working up their exhibits and in preparing leaflets designed to aid families in their own localities. Recommendations of the Building Code Committee of the Department of Commerce, for example, are followed in the erection of many of the houses, and tables and other material from the Department of Commerce publication "How To Own Your Home" are frequently included in circulars on household budgeting.

From present indications, the number of local committees and of demonstration houses will be higher in 1927 than ever before.

6. Fire Resistive Properties of Materials

In setting up standards for the fire resistive properties of materials and construction, it is customary to subject specimens to fire tests of specified intensities and duration.

To interpret the results of such laboratory tests in terms of the probable behavior of the materials or construction in fires to which they may be subjected in different types of buildings used for different purposes, it is necessary to have reliable information as to the probable intensity and duration of fires occurring under these varied conditions.

For the purpose of securing adequate information on this subject the Bureau has completed a special test furnace of 30 by 60 feet floor area and one building story in height. In this furnace have been measured the intensity and duration of fires resulting from the complete burning out of contents incident with office occupancy, the amount of combustible material ranging in different cases from 19 to 40 pounds per square foot of floor area. The heaviest of these amounts corresponds to about the maximum amount of combustible material which would ordinarily be found in a record storage room or lawyer's library. These results supplement similar ones obtained with a furnace of smaller size, in which office occupancies giving combustible contents from 9 to 59 pounds per square foot of floor area were burnt out, metal furniture being used in some of the tests.

With metal furniture and ordinary office occupancy consisting of desks, filing cabinets and open and closed shelving, the equivalent intensity and duration of the fires did not exceed the first half hour of the standard fire test, even where nearly one-half of the paper contents of the room were

freely exposed. With wood furniture and combustible contents from 12 to 15 pounds per square foot the equivalent duration obtaining was between one and 1½ hours, and with 19 pounds per square foot, between 1½ and two hours. The record room occupancies with wood shelving gave durations approximately equivalent to the first four hours of the standard furnace test.

7. Vapor Pressure of Liquid Carbon Dioxide

The properties of carbon dioxide are of interest, not only because of its use as a refrigerating medium, but because its critical temperature, 31.1°C is at a point where temperatures can be very easily and accurately controlled and measured. The investigations of the critical phenomena in carbon dioxide constitute one of the classical researches of thermodynamics. The temperature range within which carbon dioxide can exist as a liquid in contact with its own vapor is not large, extending from the triple (freezing) point at -56.59° and a pressure of 5.113 atmospheres to 31.1°C at a pressure of 72.95 atmospheres. The publication of the Bureau's measurements of the vapor pressure of carbon dioxide makes available accurate data for all temperatures and pressures at which liquid and vapor are in equilibrium. The measurements give the temperature corresponding to any pressure to an accuracy of 0.01°, and give the pressure corresponding to any temperature to an accuracy of a few parts in 10,000. These measurements are part of an extensive program to determine the important thermodynamic properties of carbon-dioxide and other fluids used in power production or refrigeration.

8. The Characteristics of Pyrometric Cones

Pyrometric cones are small, slender pyramids of triangular cross-section. They are made of ceramic materials and form a series of about sixty members, each member differing slightly in refractoriness from its neighbor in the series.

They are used extensively, especially in the ceramic industry, in the control of processes which require regulation of the rate of firing. Being inexpensive, they may be distributed throughout a kiln and a predetermined heating schedule may be maintained by so regulating the firing as to cause the various cones of a series to soften and bend down at the proper time.

Information as to the temperatures at which the various cones of the series soften as well as to the degree of uniformity with which each member is being manufactured is obviously of very great value to the users of these pyrometric cones. The Bureau of Standards therefore has determined their temperature characteristics under various conditions of firing.

It was found that the temperature at which a given cone will soften generally depends on the rate at which its temperature is raised as well as on the gaseous atmosphere surrounding it during the heating.

A table was prepared showing the temperatures at which the cones start to bend and that at which the tip touches the base (end point) for two different rates of heating in clean air.

The effect of various furnace gases in changing the softening points from those in the table were also determined so that corrections may be made by each user according to the atmosphere present in his kilns. The results of the investigation were published in the November1926 number of the Journal of the American Ceramic Society.

9. Resistance of Chinaware Glazes to Abrasion and Cutlery Marking

The modern potter does not thoroughly understand why some ceramic glazes on chinaware resist abrasion and cutlery marking better than others. Ware which easily "marks" must often be discarded because of its poor appearance long before its useful life has been completed by breakage. Consequently the Bureau of Standards investigated the factors which influence glaze hardness and has also determined the relative resistance to abrasion of the glazes on several typical brands of foreign and domestic ware. A final report has been prepared for publication in the Journal of the American Ceramic Society describing in detail the apparatus and method used in determining relative resistance to abrasion and also the results which were obtained in the examination of foreign and domestic ware and of twelve experimental glazes.

The data in general indicate that high-fired and relatively thin glazes show the greatest resistance, whether on domestic or foreign ware. The relative effects of some variations in composition were also determined and the results will assist in developing among manufacturers a better understanding of the factors controlling the resistance of glazes to cutlery marking and abrasion.

10. Reduction in Variety of Vitreous China Plumbing Fixtures

In January 1925 the division of simplified practice was requested by a group of manufacturers of vitreous sanitary china plumbing fixtures to assist in an effort to secure a more uniform grading of this type of ware. A committee was appointed to meet with representatives of the division for a preliminary discussion.

Several preliminary conferences were held in Washington and elsewhere during 1925. At its final meeting in May 1926 the Advisory Committee of the industry requested the secretary compile all recommendations of the Advisory Committee and submit them to the division of simplified practice with a request that a general conference be called for September 22, 1926, at the Department of Commerce. Tentative recommendations were developed and used

as the basis for discussion at this meeting. In accordance with the unanimous action taken at this conference of representatives of manufacturers, distributers and users, a simplified practice recommendation was adopted which resulted in the establishment of standards for staple vitreous china plumbing fixtures.

This recommendation included standard grading rules, standard nomenclature, definitions, marking and labeling, and dimensional standards. The varieties were reduced from 441 to 58 items, to become effective October 1, 1926, subject to a revision at the end of one year from the effective date.

11. Simplification of Sizes of Wrought Iron and Steel Pipe

Wrought-iron and wrought steel pipe form the arteries and veins of modern power, heating, plumbing, and other piping systems, domestic as well as industrial. As systems have grown in complexity there have crept into the open market a great variety of sizes of pipe, valves and other fittings. The consumers have had to sustain, with the manufacturers and distributers, the burden of cost caused by this excessive variety.

In 1924 the Manufacturers Standardization Society of the Valve and Fittings Industry, through its subcommittee on simplification of product, inaugurated a survey of current practice, to discover which sizes of pipe could be dropped from production with consequent advantage to all concerned.

A study of the situation brought out the fact that the mention of a "special" size in the catalogue of an individual manufacturer inspired other manufacturers to adopt similar sizes, until finally the total list of advertised sizes assumed unwieldy proportions. The subcommittee discovered that the turnover of some of the sizes was exceedingly small and that the requirements which prompted the specification of the odd varieties could be met satisfactorily with those sizes for which there was a recorded major demand. Therefore the immediate purpose of the survey has been the lightening of the burden that is at present sustained by all interests.

The survey of existing practice was completed in December 1925, and in April 1926, the subcommittee on simplification of product advised the Department of Commerce that it was prepared to submit a tentative recommendation to a general conference of representatives of manufacturers, distributers, and users of wrought-iron and wrought-steel pipe, valves and fittings for their consideration, revision, and ratification. In accordance with this request a general conference convened in Washington on May 28, 1926, under the joint auspices of the National Metals Utilization Committee and the division of simplified practice, to discuss the proposed list of pipe sizes.

The combined efforts of this general conference resulted in a reduction from a total of 62 sizes to 49 sizes of pipe, corresponding to an elimination of 20.96 per cent and an elimination of 762 sizes of valves and fittings, or a 3.8 per cent reduction in the current variety.

When consideration is given to the equipment that is necessary to make these seldom called for items, the causes for heavy overhead production costs for the manufacturers, the excessive storage and inventory expenses for the distributers, and the final cost to the ultimate consumer become obvious. One concern has stated that their sale of the $4\frac{1}{2}$, 7, and 9 inch sizes alone represents only one-third of the investment that is required to produce them, so heavily does the fabrication and stocking of the odd sizes drain their resources. If this condition characterizes the entire industry, it is plain that potential economies rest within this program.

12. Laboratory Tests for the Study of Non-Ferrous Corrosion

Much of the uncertainty concerning the relative corrosion-resistance which has been reported for various commercial metallic materials can be attributed to the form of corrosion test used in the study of the material. In cooperation with the American Society for Testing Materials, through its Committee on Non-Ferrous Corrosion, an extensive series of tests was carried out to determine to what extent the apparent corrosion-resistance of any given metal depends upon the corrosion test used and how closely the results obtained by one type of test agree with those from another type of test. The corrosion rate, as expressed as loss of weight per unit of surface area per unit time ($g/cm^2/day$) and as the rate of penetration (cm. per month) was determined for five metals; copper, nickel, zinc, aluminum and lead, and four alloys: brass, monel, "admic" and cupro-nickel when corroded by means of six different solutions: hydrochloric acid, acetic acid, sodium hydroxide, ammonium hydroxide, sodium chloride and potassium dichromate.

Four types of tests, according to the method of applying the solution to the metal, were used: simple immersion tests (a, aerated and b, non-aerated solutions), wet-and-dry tests (a, continuous and b, intermittent repeated immersion), spray tests and accelerated electrolytic, the specimen being the anode of the electrolytic cell.

The results definitely show that the corrosion-resistance of a metal for the various conditions covered by the tests used cannot be predicted on the basis of the results of single test. In short, the essential features of the service conditions under which a metal is to be used should be incorporated in the corrosion test which is designed to give information concerning the suitability of metal for any particular type of service.

13. Gage Wear Testing

Wear accounts for a very large loss of metals each year, and with the possible exception of corrosion is probably one of the most destructive agencies encountered in the application of metals. Despite its importance, comparatively little is known regarding the fundamentals of the resistance to wear of metallic substances, and it is therefore necessary at this time to consider each application or problem of wear resistance by itself.

There are not at present any standard methods of test nor is it easy to obtain results in the laboratory which may be translated into conditions of practical service.

A machine has been devised and built by the Bureau for studying and testing the wear of plug gages, and the results obtained by its use have been consistent with results obtained in practical service. Its operation is essentially a duplication of the "wringing action" commonly used while gaging under actual service conditions. The gages are automatically moved (vertically) in and out of the "work" at a rate of about 1300 strokes per hour (one insertion and removal is equal to one stroke). The "work" or gaged specimen is a split ring which is held together under fixed pressure, thereby insuring uniform conditions of test. This ring is rotated horizontally at about 900 revolutions per hour.

Gages are tested under conditions termed "metal to metal wear" and "abrasive wear". In the former case, the gaging is done in the presence of water containing approximately 1 per cent potassium dichromate, which is used to keep the gauges cool and to prevent the formation of oxide between the ring and the gage. Oxide was found to form when the tests were made dry. In the "abrasive wear" test, the dilute dichromate solution is replaced by a well agitated mixture of about 25 grams of 300 mesh emery per liter of lard oil, this mixture being fed in continuously between the gage and ring.

Chromium plated gages were found superior in wear resistance under the service conditions described to gages made of the customary or special gage steels.

Under "metal to metal wear" conditions, chromium plated gages showed about 500 per cent greater wear resistance than that shown by the better of the commonly used gage materials which were tested, while under "abrasive wear" conditions they excelled by about 35 per cent in wear resistance. They also have the advantage that a machinable base metal may be chosen upon which to plate the hard, wear-resistant chromium; they are not subject to dimensional changes encountered in hardening the customary gage steels, and do not then change in dimensions with time.

It was also shown for some of the customary gage steels that "file hardness" is not an indication of best wear resistance. This does not, however, mean that file soft steels are now recommended for gages, on account of the ease with which they are dented or scratched and for other reasons related to practical applications rather than the properties of the steels.

14. The Making of an Absolutely Flat Surface

As the result of extreme skill in polishing and measurement, the Bureau now possesses three standards of planeness of unequaled accuracy. These standards are in the form of circular disks of fused quartz from 10 to 11 inches in diameter and $1\frac{1}{2}$ to 2 inches thick. Silica glass, or fused quartz,

possesses a great advantage over glass for a standard of this kind because of its low coefficient of expansion (about one-fifteenth that of glass). The disks were purchased by the Bureau and were roughed into form in the optical shop. They were then brought to a high state of precision as optically true planes by hand polishing on a circular pedestal, which permitted the operator to move freely around it as he swept the disk in ever-varying loops or turns over the polishing plate.

The three disks were ground on each other until both faces were as flat as a straight edge would reveal. The surfaces were then carefully inspected to discover any bubbles, which if not reamed out might chip off at the edges and cause scratches during the polishing process.

The polishing was carried out in three stages. The first process gave a high-grade polish on both faces of the three disks, no flatness tests being made. The second brought one face of each disk to planeness as nearly perfect as ordinary tests with the working (glass) standard would reliably indicate. The test was made by bringing the surfaces of the quartz disk and the glass standard together and observing the straightness of the system of interference fringes produced when monochromatic light fell upon the surfaces.

At the beginning of the third stage of polishing tests were made with a "Pulfrich instrument," which provides for viewing the fringes over the entire disk in a perpendicular direction. An initial comparison of each of the three surfaces with reference to a fourth, known to be nearly plane, revealed certain uneven places on the surfaces of the disks, the order of variation, however, being only about 0.06 wave length.

The final polishing operations resulted in surfaces which the most careful tests show differ from a true plane by less than one one-hundredth wave length (two ten-millionths of an inch). "It is one of those rare accomplishments in which the craftsman has worked with a degree of precision equal to that with which the laboratorian can measure."

Should these disks prove to be permanent in form, which time alone can reveal, the Bureau will be provided with a permanent self-checking standard of planeness, with an accuracy adequate to meet all demands.

15. Method for the Complete Analysis of Dental Gold Alloys

Gold alloys are extensively used in dental work because they do not tarnish or corrode in the mouth. For some very important applications of such alloys, they must have certain physical properties which are not often associated with the precious metals, notably stiffness, toughness and elasticity. It must also be possible to temper the alloys so that the desired mechanical properties may be given to the work after it has been shaped. These requirements have led to the development of a wide variety of alloys, many of them being of complex composition. Gold is usually the predominant

metal, the other commonly used constituents being silver, copper, and platinum or palladium or both. Base metals such as tin, zinc, nickel, manganese and magnesium are often used in small quantities and occasionally the precious metals rhodium and iridium are also present.

The work of the Bureau on the physical properties of dental gold alloys has demonstrated fully the need for and possibilities of standardization in this class of materials. A necessary element in such standardization is a satisfactory method for the analysis of the alloys. The analysis of precious metal alloys is one of the most difficult fields of analytical chemistry and the dental alloy industry as a whole has been greatly handicapped by the lack of adequate analytical methods.

In cooperation with the Weinstein Research Laboratories, the Bureau has developed a complete procedure for the accurate chemical analysis of gold alloys such as are used in dentistry. This work was begun in 1924 and completed in 1926 with the publication of Bureau of Standards Scientific Paper No. 532, entitled "The Analysis of Dental Gold Alloys." Besides giving the detailed analytical procedure and the results of experimental work done in developing some of the separations, the paper gives the composition of thirteen typical alloys, selected from about forty commercial alloys which were analyzed.

It is believed that this work will be of material benefit in the standardization of dental gold alloys. It permits the necessary correlations to be made between physical properties and chemical composition. It enables manufacturers to control the composition of their alloys and purchasers to examine materials offered on the market.

16. Carbon Arc Found to be Closest Approach to Sunlight

At the present time great efforts are being made by the medical profession to utilize sunshine to the best advantage for healing purposes. Proof of this is found in the thorough search now being made for a window material that will transmit the shortest ultra-violet solar rays to which ordinary window glass is opaque. However, sunshine is not available at all times and in every desirable place. Hence the Bureau has been investigating the spectral energy distribution of various artifical illuminants to find the one which most closely approaches the ultra-violet spectral energy distribution of the sun.

Such a source has been found to exist in the carbon arc. Of all the artificial illuminants tested it is the nearest approach to sunlight. The observations, as a whole, showed that the ultra-violet radiation emitted is a complex function of the electrical current through, and the chemical composition of, the electrodes. The high-intensity arc, using 90 to 125 amperes, will be useful in large installations. By choosing the proper kind of cored carbon electrodes, and the proper working distances, the same relative proportions of ultra-violet and total radiation can be obtained from a

20-ampere arc as from the high-power installation. This is fortunate as it will be possible to meet all requirements in light therapy.

17. United States Currency Paper

For some time the Bureau has been investigating the paper used in the production of United States paper currency with the object of improving its quality, as well as to establish standards of quality and of the processes for obtaining them. This work is being done in cooperation with the Treasury Department, the Bureau of Efficiency, and the manufacturer.

The main problem relates to wearing quality, as the life of the paper currency had decreased to about one-third of its former value, causing excessive expenditures for replacement. The paper manufacturing processes are being studied on a semi-commercial scale in the Bureau's paper mill. Modification of the nature of the beating treatment of the paper fiber resulted in a marked improvement in the strength of the currency paper. By brushing out the fibers well and leaving them long, paper of satisfactory printing quality and having over double the strength of the paper in use was produced. The manufacturer applied this practice developed in the Bureau's semicommercial plant to commercial mill practice with satisfactory results. Another line of research being followed deals with the surface sizing of the printed currency. It was found that increased resistance to surface wear could be obtained by hardening the present glue sizing by after treatment with formaldehyde.

This work has enabled the Treasury Department to revise the technical requirements of its currency paper specifications in such a way as to provide for paper of more than double the strength previously specified and such paper is now being obtained with no increast in cost. The Treasury Department records show that already somewhat more than a 30 per cent increase in the life of the paper currency has been effected. A still further increase is anticipated as the old style of paper is not yet entirely displaced by the improved paper.

18. New Gas Cell Fabric for Dirigibles

For a number of years, under grant from the Navy Department, the problem of obtaining a new type of gas cell fabric has been under investigation at the Bureau. During the past year this problem has shown great promise of approaching final solution. At the present time goldbeater's skin fabric is used to retain the buoyant gases in airships of the Zeppelin type. It is made by laying goldbeater's skins (the lining of one of the intestines of the ox) on rubberized fabric. The fabric so made is light in weight, durable, and has low permeability to the buoyant gases, hydrogen and helium, and to the chief gases of the atmosphere. The manufacture of a set of such cells, however, is a very expensive procedure inasmuch as it requires tedious

hand labor throughout. Thus, for example, the cells of the Shenandoah required the hand laying of a half million goldbeater's skins. Furthermore, with the continued development of the Zeppelin type of airship, since the supply of goldbeater's skins is necessarily limited, it will become more and more essential to replace this fabric with some other type.

As the result of an extended investigation the Bureau has developed a fabric which promises to displace the goldbeater's skin fabric now in use. The new fabric is lighter in weight and of lower permeability than the goldbeater's skin fabric. The raw materials are available in unlimited quantities and as the coating can be applied as a continuous film by a mechanical process, the finished fabric is more uniform than the goldbeater's skin fabric and can be made at a relatively low cost. At the maximum, a completed cell made of the new fabric should cost less than one-half as much as a similar cell made of goldbeater's skin fabric. Furthermore, as the methods of manuracture are improved and cheapened, and, as greater qualities of the fabric are required, even the present cost of manufacture can be reduced materially. However, using the present high estimate of production costs there can be effected in the manufacture of the gas cells for the two new airships proposed by Congress a saving of approximately one million dollars, or one-ninth of the total estimated cost of these ships.

The production of this fabric has passed the laboratory stage and samples have been made successfully on a factory scale. The manufacture of a full-size experimental gas cell for installation in the Los Angeles is now under way.

19. National Electrical Safety Code

The revision of the National Electrical Safety Code which has been in progress for several years was completed in 1926. This code deals with the construction and operation of generating stations and substations, the installation and maintenance of electrical supply and communication lines, and electrical utilization equipment. Operating rules for employees handling machinery and lines are included and a special section deals with proper methods for effective grounding of circuits and equipment. The fourth edition contains a new part dealing with radio installations.

This revision was carried out under the procedure of the American Engineering Standards Committee, the inside and outdoor work being assigned to separate sectional committees. These committees were made up of representatives of every branch of the industry actively concerned, including manufacturers, contractors, pole producers, electrical workers, utility companies, insurance underwriters and Federal, state and municipal officials. The rules were gone over in great detail, two of the parts being entirely rearranged and rewritten.

The fourth edition is being published not only as a whole but as separate parts. The latter are designated as Handbooks Nos. 6, 7 8, 9 and 10. The entire code will be reprinted as Handbook No. 3.

20. Lists of Laboratories and Certification Plan

In accordance with the law the National Bureau of Standards makes tests and carries out investigations for other Government departments. Because of the large amount of this official work it is impracticable for the Bureau to make tests for private individuals if other laboratories can do the work. To inform interested persons of the location of other laboratories, and in antifipation of a marked increase in the demand for independent testing service in both domestic and export trade, the Bureau has compiled a list of the 207 commercial testing laboratories throughout the country, together with indications of the types of commodities which they are prepared to test. Special care has been exercised to make this list complete. To accompany the list of commercial testing laboratories there has also been compiled a list of the laboratories of 141 colleges which are used not only for the purposes of instruction but also to a considerable extent for research work. In fact, many important industrial research problems are being solved in the college laboratories.

The existence of a thoroughly classified list of testing laboratories will have a number of beneficial effects in promoting the use of specifications, not the least important of which will be the inducement offered to the large number of purchasers who have hitherto hesitated to buy on specifications, because of their inability to determine whether or not commodities delivered correspond to the specification requirements.

For the purpose of minimizing the disadvantages incident to the use of specifications, the Bureau has inaugurated a so-called "certification plan" in accordance with which there are compiled lists of manufacturers who have expressed their desire to supply material complying with certain selected nationally recognized specifications and willing to certify to the purchaser upon request that the material thus supplied is guaranteed to meet the requirements and tests of the specifications. This plan has already been applied to 48 United States Government Master Specifications. Copies of any of the 48 lists of manufacturers, to which additions are being made from time to time, can be obtained upon request.

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