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EDITORIALS

PREPARE FOR CRITICAL MARKETS

To get ahead, the ceramic technologist and engineer must be eternally engaged in finding new uses for his products and new adaptations of his product materials. He must know how to work his materials into products that will meet definite quality specifications. He must know the conditions of use and the limitations of his product. He must know what quality standards to maintain and how to control their maintenance.

Product and product uses should be major items in each ceramic school curriculum; these should be the end purposes for acquiring knowledge and facility in the use of chemical, physical, and mathematical laws and concepts.

It was the translation of product requirements into terms of materials, processes, and products that prompted the production of artificial abrasives in electric furnaces, the production of cast mullite refractories, and many other products. The creation of special superior refractories was made by others than those engaged in the so-called standard refractory ware

SC-CER-2521

THE MOTION PICTURE AS AN AID TO REFRACTORIES RESEARCH[1]

By Thomas S. Curtis

ABSTRACT

The apparatus and technique employed in the study of plastic flow at high temperatures, crystal growth, thermal expansion, vitrification, spalling, etc., are described, and the method of preservation of permanent records of such phenomena in the act of occurrence is given. A description is also presented of the physical changes requiring days or weeks for their development which may be depicted in a few minutes on the motion picture screen.

I. Introduction

A motion picture film entitled "Evolution of Mullite Refractories" was presented at the Toronto meeting of the American Ceramic Society in 1930. The film presented a condensed record of several years of investigation covering the physical relationship of the amorphous and crystalline phases of refractory bodies. The elementary principles of the relationship were presented by means of simple analogy and culminated in the demonstration of crystal growth, the control of plastic flow at high temperature, and the attainment of stable volume in commercially-manufactured refractory materials.

Since that time many requests have been received for a written paper on the subject, but it has been found impossible to do justice to the film in view of the futility of an attempt to reduce to inanimate photographs and printed words what the living motion picture reveals. The present paper, however, does present a description of the technique and apparatus employed in the production of the film.

II. Technique of Manipulation

The idea which finally crystallized in the film was gained years ago with the viewing of a motion picture of a flower slowly opening. Motion that was so slow as to be imperceptible to the eye became clearly observable and understandable when reduced to a few minutes on the screen.

The first reduction to practice of the idea occurred several years ago when an accelerated motion picture was made of a bar of particularly treacherous clay during the act of shrinkage. Alongside the clay was a common alarm clock and a thermometer to form a record of time and temperature as the clay passed through the various stages of shrinkage and warpage. The information gained from a one-hundred foot strip of film, photographed over twenty-four hours of time, enabled a particularly troublesome drying problem to be solved in less than a week, although this

[1] Presented at the Annual Meeting, American Ceramic Society, Cleveland, Ohio, February, 1931 (Refractories Division).

same problem had been fought for three months prior to the advent of the living record of what happened.

The next attempt was the recording of the expansion of two refractory brick placed side by side in the same furnace. While the usual recording graph illustrates this same thing, the relative suddenness of expansion in a silica brick was much more graphically illustrated in the film record.

There followed a successful accelerated motion picture of the plastic flow of three brick stood on end. All three had approximately the same composition but were of different physical structure. From this last strip came the idea of studying the relation of crystal and glass concentrations in refractories.

FIG. 1.—Bausch and Lomb motion photomicrographic equipment showing change gear device to enable pictures to be taken at speeds of from 16 per second to one picture every four minutes.

With the gradual development of a technique came more ambitious plans. It was reasoned that if the shrinkage and vitrification of clay could be observed and recorded, it would be but a step to the observation of what happened to the individual particles of that clay as the temperature increased. Accordingly, some inquiries were made as to available thermal stages for the microscope.

After nearly a year's search both abroad and in this country, it was apparent that available equipment was not suitable nor could it be adapted. Since it was desired not only to observe but also to record, the first requisite was a stage upon which the specimen could be laid and upon which it could move about, at the same time being kept approximately in the focal plane of the lens.

The result was the designing and building of simple, perhaps crude, but withal quite useful makeshifts which served their purpose sufficiently well to permit the production of what is believed to be the first living record of silicate fusions ever placed upon motion picture film.

III. Types of Apparatus Required

The budget required for the apparatus may be expressed in three or more figures. If infinite precision is demanded, the cost may reach thousands of dollars. If something short of near-perfection will answer, a few hundred dollars will make a good start.

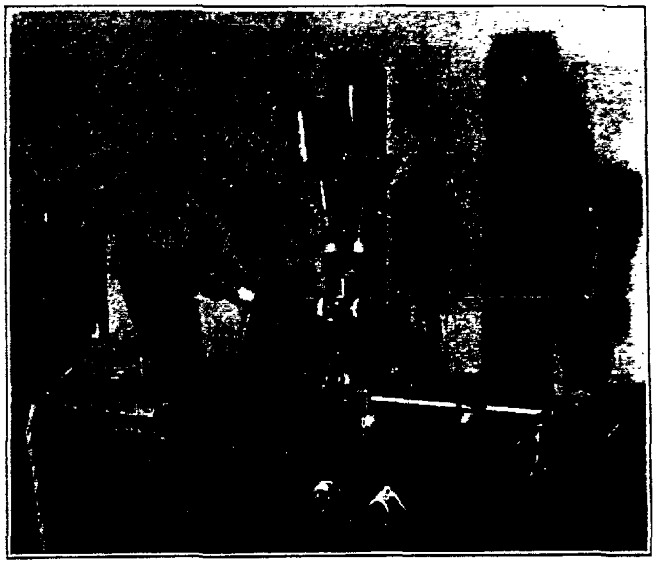


FIG. 2.—Binocular microscope set up with thermal stage and 35-mm. motion picture camera. Ground-glass viewing screen at right of camera with rheostat for control of temperature in right foreground.

Since the earlier work in the Vitrefrax Laboratories was done, an American manufacturer of optical equipment has introduced a beautifully designed and executed apparatus which could not better have been made to order both for macroscopic and microscopic work. This apparatus is moderately priced and is adapted for use with the amateur standard or 16-mm. film which is much less costly than standard 35-mm. stock. This apparatus is probably the ideal for the average laboratory unless precision in reproduction is paramount. In the latter case, if the appropriation permits, the best records are made upon 35-mm. film in one of the regular professional cameras equipped with change gear device and electric motor drive.

Recourse may also be had to one of the amateur cameras of either 35-mm. or 16-mm. size equipped with hand crank and at least four speeds, that is, one, two, four, or eight pictures per revolution of the crank. Such cameras may be had for less than one hundred dollars.

For motion photomicrographs, no camera lens is required, the optical system of the microscope affording the necessary lenses. For direct motion pictures of gross objects, one good lens of F/3.5 speed or more is needed, and for the photography of objects inside furnaces a telephoto lens will be necessary. This latter enables large images of relatively small objects to be photographed through a small aperture in the furnace wall without bringing the lens so near the opening as to damage the equipment from heat.

FIG. 3.—Thermal stage shown at full heat and without protective sheath illustrating method of illumination with arc lamp.

For the photography of melts of ceramic material to show the relative activity of various fluxes and the influence of particle size, the most convenient set-up is afforded by one of the modern binocular, stereoscopic microscopes. One leg of the instrument projects its image into the motion picture camera, while the other projects the image upon a ground glass in a suitable hood so that continuous observation of the field is possible while running the film. There are many standard binocular instruments on the market, but the author's choice is one in which the objectives may be focused independently to bring both fields in focus at the same plane on the respective ground glasses. This convenience will be appreciated when the instrument is used for motion photography as above described.

The thermal stage upon which the specimens are placed is simple. It consists of a strip of pure platinum foil approximately one-quarter inch wide by one inch long, held at either end by brass clamps which in turn are supported by spring brass strips, the whole so disposed as to permit the platinum to expand longitudinally without moving out of the plane of focus of the lens. The current for heating the strip is supplied by a small 6-volt transformer such as is used in connection with ribbon-filament microscope lamps. A rheostat wound with approximately No. 12 wire is placed in series with platinum and transformers to enable temperature to be controlled.

The stage as above described is clamped to the base of the microscope with the center of the platinum in line with the focal axis of the objective lenses. Over the platinum is placed a sheath of any pure refractory material, magnesium oxide being used in this set-up. This sheath rests upon the brass clamps and through an opening in the top may be seen the object on the platinum stage, while the beam of light from the arc lamp is projected obliquely upon the object through an open end of the sheath.

Fig. 4 —Close-up of simple type of thermal stage showing strip of platinum at the focal point of the binocular lens. Sheath removed.

Thus most of the radiant heat is kept within the little refractory sheath and for all but prolonged exposures no further protection is needed for the optical system. Where the reaction is to take hours of continuous heating it is our practice to introduce a moving slide of heavy sheet aluminum over the sheath and under the objective, the slide covering the little furnace at the completion of each exposure. This is arranged to function automatically by means of a small, home-made solenoid actuated by contact every time the camera shutter opens.

Thus, in substance, may be seen the essential principles of the apparatus. As described, motion photomicrographs up to 150 diameters may be made of silicate fusions in the act of fusing and in the act of cooling to glass or

crystal. The only real limitation is the life of the platinum which is very short, but in consideration of the value of the results obtained, it may well be discarded after each fusion as part of the raw material cost of the investigation.

The practical working temperature for one observation is limited by the delicacy with which the platinum support is made. The foil breaks long before it melts due to the tension exerted by the springs. If this apparatus be delicately made to serve only to keep the platinum taut against its expansion, fusions may be made up nearly to the melting point of the platinum.

For ceramic body work, the author has had no difficulty in running to cone 12 liquid on the stage. To study the formation of mullite and the solution of mullite in glasses and slags, a more rugged strip of platinum is required and the cost becomes excessive, since there is a decided vaporization loss in the platinum each time it is used at such high temperatures.

For all of the above, it is presupposed that ordinary light will be used. For the most interesting as well as the most valuable of work, it is necessary to use polarized reflected light which involves the introduction of nicol prisms, one in the optical path of the arc light and the other as a cap analyzer over the eyepiece. The results are most gratifying in that contrasts are markedly accentuated.

It will be understood that the illumination of the melting object in all of this apparatus is partially by light reflected from the object and partially by light reflected from the platinum and transmitted through the object. Thus an entirely new vision or perspective of the subject is necessary for the operator who has heretofore worked solely by reflected or transmitted light in the usual apparatus.

IV. Photographic Technique

It has been the aim so far to offer the salient features of the apparatus required with no reference to the purely photographic technique. This phase is discussed separately in order to avoid confusion.

The photography of an object, large, small, or microscopic, by reflected light of ordinary photographic value offers no problem, given good equipment. It is the rendering of highlights, halftones, and shadows in their relative values. This is true whether the photograph be a "still" or a motion picture which is nothing but a series of stills made at definite, periodic intervals of time.

For photographing close-ups of a piece of clay shrinking or warping, for example, it is only necessary to illuminate with some uniform source of artificial light such as a bank of incandescents in a box, which will serve the twofold purpose of lighting the subject and of providing sufficient heat to do the drying.

The opening in the box may well be closed with two pieces of optical plate glass with an air space between them. This little device will keep both glasses and the lens of the camera free from fog which otherwise would ruin the definition. The slow-speed camera is mounted directly over the aperture in the box so that the object is in the field while drying, warping, cracking, etc. Such a set-up will permit a record to be made for several days if desired without requiring the slightest attention on the part of anyone.

So much for straight photography of slowly changing objects at room temperature or slightly higher, illuminated by ordinary Mazda lights. Suffice it to say that panchromatic film should be used and if the color contrasts are delicate, with much yellow, orange, or red, a simple K filter should be used over the lens.

The next step in high-temperature photography is far more exacting in its technology for many reasons, chief of which is the fact that at the start of the picture, straight highlight-halftone-and-shadow photography is being used but as the temperature rises the object itself becomes luminous and the impinging light becomes of lesser and lesser value in affording the necessary contrasts.

The realization of this truth, as a result of several failures, completely and in a simple manner solved the problem. It was realized that as an object, a fire brick for instance, is heated, the first conscious color is a gloomy red. Then bright red, orange, yellow, and still more yellow. The so-called white heat that one reads of on the color-temperature charts does not really exist except to the eye, since the spectroscope shows a tremendous predominance of the red in all heated objects examined by the author at temperatures up to cone 32.

The relative luminosity in such a heated object increases tremendously as the temperature increases, and with the increase in luminosity comes increasing difficulties in the photography of the object, since it is necessary practically to destroy this self-luminosity and to photograph by means of the light reflected from the surface of the object. This is done in order to afford sufficient contrasts to make a recognizable photograph.

Fortunately, the modern materials available in photographic emulsions give exactly what is required. Since the predominating color that must be absorbed is yellow (emitted by the self-luminous object), a sharp-cutting deep blue filter such as Wratten L or No. 50 is used over the lens. The object is illuminated by intense light from an arc spotlight, using carbon electrodes that give an arc rich in the blue end as compared with Mazda, which light is deficient in blue for this purpose.

The film to be used in such a case should not be panchromatic but should be the usual commercial emulsion in which the blue sensitivity is far higher than the red. Thus it will be seen that by two means, *i.e.*, the absorbing filter cutting out the yellow, and the highly blue-sensitive film, the self-luminosity of the object is minimized as it is being heated. The resulting photograph does not look to the eye as though the object were being heated at all except for a gradual increase in the brilliance of the lighting.

Thus it will be seen how the photographs of a fire brick being heated under load at high temperature may be made. The camera is equipped with a telephoto lens that enables a relatively small aperture in the furnace wall to be picked up full size at some distance from the furnace. Through this aperture may be focused the object under treatment. Another aperture at an oblique angle to the first admits the beam from the arc lamp which picks out the object clearly against the furnace wall.

Such studies made upon several brick in the same furnace with a really good telephoto lens and an optical flat filter (or plain gelatin filter) are of extreme value, since the actual failure of the texture, grain-by-grain, can readily be recorded if sufficient care is used in focusing. Herein lies the value of the precision type of equipment which enables such focusing to be done through a microscope eyepiece to bring out maximum detail.

V. Photomicrographic Technique

Precisely the same principles obtain in the application of the idea to photomicrography at high temperature, and incidentally the difficulties multiply as the cube of the magnification.

The apparatus has been described previously, but the filter has been neglected in order to place it where it properly belongs, *i.e.*, in the purely photographic section. It is not possible to obtain a cemented gelatine filter for use over the furnace sheath to absorb the yellow, and neither can plain gelatine be used there owing to the heat. Either the plain gelatine may be used or a B-glass cemented L-No. 50 filter over the aperture in the motion picture camera. This position is perhaps the most satisfactory since the slightest distortion of a filter over the microscope lens degrades the image tremendously.

There is one other way out, however, that may prove as useful. The Swiss glass filters may be obtained in a deep blue-violet that is sufficiently sharp-cutting to serve as an actual cover for the little refractory sheath of the thermal stage and for the recording of a refractory melt at extremely high temperature. A chip of one of these blue filters will afford sufficient protection to the objective to enable an extra 100° to be reached on the platinum by virtue of the absorption of the red rays coming from the stage. Definition is degraded, but that extra temperature repays the loss in photographic perfection.

As in the case of the direct motion pictures of heated objects, the film to be used for thermal photomicrography is the blue sensitive stock, not the panchromatic, since the effect of the self-luminosity of the heated object should be held back as far as possible.

VI. Summary of Results Obtained

The apparatus and technique described are in almost daily use in the author's laboratory. Many observations are made without photographing, since the cost of the film precludes the making of casual records.

The melting behavior of clays of given analysis but varying mineral composition is observed. The solution of grains of clays, grogs, etc., in various slags is studied. The correlation of particle size, pore size, and slag activity is thus made possible. The design of the necessary body structure to accomplish a given result is based upon such observations.

The shrinkage, warpage, and overall drying and firing properties of clays are observed and recorded. From the exact data thus secured, certain clays have been determined especially suitable for high-temperature cements when admixed with certain other nonplastics that had been studied in connection with the clays.

The influence of particle size and composition on the load-bearing value of clay-bonded refractories was studied, demonstrated by analogy, and proved in practice from a formula written beside the thermal microscope and applied to a close-up picture of brick heated while under load.

The physical behavior of cyanite, sillimanite, pyrophyllite, and many similar minerals has been studied at temperatures close to their melting points. The failure of the platinum prevents the actual observation of the latter, but in combination with certain suitable fluxes, melting and reformation can be observed.

The change of the silica minerals is easily observed and recorded especially with polarized-reflected light. The alpha to beta reversible reaction is beautifully depicted. The effect of particle shape on this phenomenon has been studied.

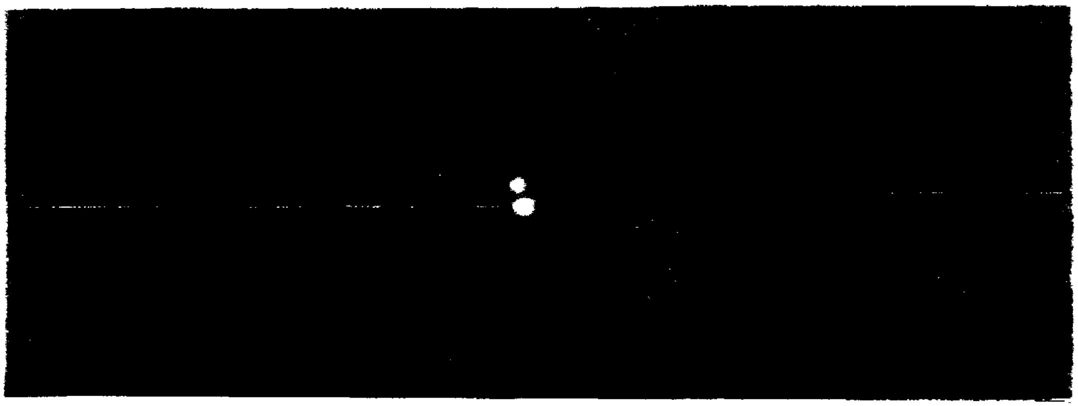
The exudation of glass from artificial aggregates for porcelain and the absorption of glass by others have been studied and these properties have been developed into commercial products.

The melting behavior of feldspars has been observed and substitutes for feldspar with lengthened range of vitrification have been developed. The influence of particle size, shape, and percentage of impalpable flour is of profound importance and the vision of the function of such physical characteristics has greatly facilitated an understanding of the subject.

The use of the film records in educational channels is now of recognized value. Even the men who are in daily contact with the properties delineated seem to gain something from each new showing of the reels.

VII. Commercial Utility

It is unlikely that the results of the three years' use of the technique will



fully be felt in the market for as many more years. The data being recorded are fundamental, and as such will have slow recognition and adaptation. Certain it is, however, that the use of motion picture records of ceramic and refractory substances, bodies, and structures, at room temperature, drying, watersmoking, and vitrification, through the microscope and through the camera eye, will not be permitted to rest at the point to which our efforts have carried them, but will be taken far beyond the few suggestions embodied in this paper, the object of which has been to whet the appetite of the true investigator and to stimulate an interest in a research tool that has repaid rich dividends to its user.

VITREFRAX CORPORATION
LOS ANGELES, CALIF.

Engineers, and Western Society of Engineers, to hold a Summer Meeting in Chicago, week of June 25, 1933, designated as "Engineers' Week." This invitation was issued through Edgar S. Nethercut, Secretary, Western Society of Engineers, dated March 4, 1932.

(E) Coöperation with Other Organizations

(1) Communication dated February 29 from Advisory Management Corporation, Integrity Building, Philadelphia, by Wm. P. Barba, was referred to Management Committee.

(2) The Executive Committee decided that the SOCIETY shall not at present take association membership in Color Council, but will advise Walter P. Suter to take a personal membership.

(3) It was unanimously approved that Secretary Purdy should follow through with the Chicago Exposition in (*a*) industrial arts, (*b*) science, and (*c*) text-books, but not to incur expense incident thereto.

(4) It was unanimously agreed to inquire into possibilities of appointing an official representative in England.

(5) It was agreed to accept payment of dues from Canada and England on Canadian dollar and English pound basis, the SOCIETY to absorb the exchange rate.

(6) Greetings and congratulations were voted to be extended to the Canadian Ceramic Society.

(F) Status of the Society

The following informational data were presented to the Committee in addition to the March financial reports:

(1) The A.R.I. folder in reference to a financial rebate claim was referred to Mr. McKinley for judication.

	Proposed budget for year	1/4 of budget	Expenditures for 3 months
Cost of Publication	$20000.00	$5000.00	$3856.38
Abstracts	1800.00	450.00	479.84
Editor's Office Expense	1250.00	312.50	796.19
Salaries	13000.00	3250.00	3111.25
Secretary's Office Expense	1700.00	425.00	440.32
Postage	1250.00	312.50	360.22
Office Rental	1080.00	270.00	250.00
Traveling Expense	500.00	125.00	38.13
Depreciation	250.00	62.50	57.00
Bad Accounts	200.00	50.00	48.00
Reprints	No allowance		84.21
President's Office Expense	No allowance		4.90
Annual Meeting*	No allowance		221.41
Miscellaneous	No allowance		139.40
Committee	No allowance		
Total	$41030.00	$10257.50	$9887.25

* Through March $885.65 were spent on Annual Meeting. The figure shown above ($221.41), however, is that which has been allocated for the first three months. The balance ($664.24) is a deferred expense.

MEETING OF THE JOINT COMMITTEE ON FOUNDRY REFRACTORIES[1]

The meeting of the Joint Committee on Foundry Refractories was held in Chicago, May 5, 1931, in conjunction with the A.F.A. convention. The members present were as follows:

[1] For complete Committee personnel see *Bull. Amer. Ceram. Soc.*, 10 [6], 190 (1931).

Chairman, L. C. Hewitt
Secretary, J. L. Cummings
H. M. St. John
W. Harvey Payne
Major Bull (visitor)
E. E. Marbaker
James R. Allan
H. J. Hoff
S. S. Feldman (visitor of the Amtorg Trading Corporation, New York, N. Y.)
P. H. H. Dunn (Bureau of Standards)
H. L. Smalley
H. C. Elliott
A. G. Gierach

The minutes of the last meeting held March 8, 1930, were read and approved.

The next subject of the meeting was new by-laws which had been drafted and submitted to the various members of committees and sub-committees. The by-laws were passed around to the members present for discussion.

The membership list of the present committees and sub-committees was read by Secretary Cummings. The layout of the new by-laws was also read and they were declared proper and sufficient.

L. C. Hewitt was reelected chairman of this Committee and James R. Allan, International Harvester Co., was elected vice-chairman. Mr. Hewitt then called for the committee chairman's report and reports from the sub-committees.

Mr. St. John of the Nonferrous Committee stated that his committee has felt that it is an almost impossible task to simplify and standardize on shapes for furnace linings for the non-ferrous industry. This committee has collected data on cement, ramming mixtures, etc., and has published some reports in *The Foundry* and other publications pertaining to the industry. All of the reports are not yet completed, such as the lining of electric furnaces, etc.

One of the most striking developments of Mr. St. John's committee was the accumulation of data from various foundrymen which showed such a difference in character and application that only a few seemed to be getting the very best results, and the committee is endeavoring to broadcast the data they have collected to such foundries not obtaining good results.

Several of the items Mr. St. John discussed pertained to direct-flame improvement from surveys over 1926.

It was suggested that Mr. St. John's committee include the brass melting cupola in the survey of the coming year.

No report was presented from Mr. Reese's Committee on Stoppers and Nozzles.

Major Bull stated that there was no report ready as yet on the recent meeting of the Foundry Standardization Committee of the American Standards Association in New York. It seemed desirable that the Joint Committee on Foundry Refractories should have representation on the A.S.A. committee because of their interest in standardization of foundry materials and supplies.

In Mr. Allan's report for the malleable industry, he stated that the attention of the division has been given largely to publicity on standard shapes and to the matter of tolerances for such shapes.

Dr. Marbaker's report of the Cast Iron Committee is attached. He stated that the American Refractories Institute had an excellent line-up on cupola blocks as per the A.R.I. standards and suggested that these standards be adopted. This committee is issuing a new questionnaire pertaining to tap-out and slag-hole blocks, a report of which will be made at the next meeting.

The next report on the electric furnace, by Harvey Payne, *Chairman*, follows.

Respectfully submitted,

J. L. Cummings, *Secretary*

Report of Work Done by Sub-Committee on Gray Iron Foundry Refractories

In October, 1930, E. E. Marbaker, Chairman of the Sub-Committee on Gray Iron Foundry Refractories of the Joint Committee on Foundry Refractories, sponsored by the AMERICAN CERAMIC SOCIETY and the American Foundrymen's Association, contacted with the Division of Simplified Practice of the Bureau of Standards.

Dr. Marbaker suggested that inasmuch as this Division had coöperated with a committee of similar status as his in the malleable foundry industry, it might be able to be of some assistance in any work that he might undertake. After an exchange of correspondence a representative of the Division of Simplified Practice met with Dr. Marbaker's committee in Pittsburgh and the entire matter of possibilities of simplifying cupola lining blocks, as well as tap-out and slag-hole blocks, was discussed in detail. It was decided that the most logical procedure in this case would be to circularize the refractories manufacturers with the idea of ascertaining the variety of sizes and shapes of the above-mentioned blocks produced by them.

The Division of Simplified Practice circularized some 150 firebrick manufacturers and obtained a wealth of data. These data were submitted to another meeting of the Sub-Committee on Gray Iron Foundry Refractories.

After a careful discussion of the data on hand, it was decided to divide the committee's recommendations into two parts. The first part would deal with the cupola lining blocks themselves. In this connection the survey had revealed that the American Refractories Institute standard sizes and shapes were in common use throughout the trade. It was, therefore, deemed desirable to use these sizes and shapes as a basis for that part of the recommendation which had to do with the ordinary lining of the blocks. The second part of the recommendation was to cover tap-out and slag-hole blocks. The information in hand regarding these materials was inadequate and could not be used as a basis for a representative recommendation. It was therefore decided by the committee that the Division of Simplified Practice should make a further survey in an effort to obtain data which could be used for a recommendation covering tap-out and slag-hole blocks. At this date[2] that survey is under way and immediately upon receipt of sufficient information to be used as a basis for a recommendation, this information will be submitted to the committee of which Dr. Marbaker is chairman.

Report of the Sub-Sub-Committee on Survey and Standardization for Electric Melting Furnaces in the Ferrous Industry[3]

Your Committee on Survey and Standardization for the Steel Casting Industry submits the following report:

(1) This Committee has been functioning so far largely on the study of electric furnace refractories, although it is classified to study refractories for the electric steel castings industry.

(2) Two years ago 160 questionnaires were sent out to electric furnace operators. This questionnaire was designed to bring out all possible points relative to refractory shapes and sizes. The net result of some 40% replies to this questionnaire was to show that there are very few furnaces of even similar size, which operate under conditions close enough to warrant trying to standardize on refractory shapes. In addition to this the electric melting furnace is being changed to improve efficiencies and is being adapted to new uses, all of which lend to the opinion that broad standardization of these shapes is rather impractical at present.

(3) A great deal of attention is now being given to the adoption of standard manufacturing tolerances of fire brick.

(4) This Committee has studied this subject as related to the manufacture and use of silica shapes for electric melting furnaces. It is understood that producers are at present working to a size tolerance of $\pm 3\%$ on linear dimensional variations due to shrinkage and warpage of 4 inches or less, and $\pm 2\%$ for over 4 inches.

(5) The members of this Committee agree that the best equipped producers are

[2] May 2, 1931.

[3] By W. H. Payne, Pittsburgh Electric Furnace Corp., Chicago, *Chairman*, to J. R. Allan, *Chairman*, Sub-Committee on Survey and Standardization.

now making brick better than these tolerances and that closer tolerances as de manded by the large refractory users are being met also. The last tolerances are give in the form of plus or minus fractions of an inch allowable variations from a given d mension for both shrinkage and warpage.

(6) It is the opinion of this Committee that this tolerance should be simplified to statement of a plus or minus variation in percentage of given dimensions, and we there fore recommend a tentative plus or minus tolerance of 1.2% of specified right angle fac dimensions for so-called standard silica shapes.

(7) While it is felt that improvements along these lines are a part of the program of the producers, and that the tolerances recommended are just a step ahead of presen practice of the best producers, the fact must not be ignored that some small refractorie users will take advantage of these closer limits and possibly reject brick, the actual use o which would not be affected by small variations. For instance, in laying up electric melting furnace side walls, it is the opinion of this committee that the above tolerances are closer than necessary for width and length dimensions. Close *stacking* dimension are important here. For electric furnace silica side wall shapes, the committee agree that the present statement of ten 9-inch straights stacked to an added dimension of 9 inches shall not exceed 90 inches and shall be not less than $89\frac{1}{2}$ inches; this figure $\pm 0.55\%$, as compared to the recommended 1.2% of the other general dimensions.

(8) The so-called special hand-rammed silica shapes for electric furnace roof re fractories are being made by the best producers to closer tolerances now than in the past This is partially due to the use of rigid metal molds.

(9) The producers' present allowable tolerance for these shapes is ± 0.25 inch for face dimensions and warpage. This may seem a total variation of $\frac{1}{2}$ inch in the case of two adjacent brick faces, each being on the plus extreme. With these faces coming approximately 12 inches apart, the summation of such plus extremes would add to make 3 inches over in a 12-ft. diameter roof.

While this will not happen in practice, the example is cited to show the crudeness of such fixed tolerances.

(10) It is, therefore, the opinion of this Committee that tolerances in all shapes should be tied to a plus or minus average allowable variation in a number of joints.

(11) This Committee also wishes to bring out the fact that there are many cases of an electric furnace user who may have a complaint in refractory life and who at once picks out what is to his mind, a weakness in the detail cut-up of certain shapes, and who makes life miserable for his friend the producer to change at once the shapes in some way. If the producer cannot talk the user out of such changes he must, in order to hold the account, go to the expense of changing his metal molds for one customer. Some of these claims are well founded and many of them are not, and the user should keep in mind that such unwarranted changes, while accepted in good grace by his friend the producer, are finally passed on the user simply because they unnecessarily increase the cost.

(12) One set of these metal molds for a fairly large electric furnace will cost around \$600.00 and the producers have on hand an astonishing inventory in molds due in part to such changes.

Respectfully submitted,

W. HARVEY PAYNE, *Chairman*
Sub-Sub-Committee on Survey for the Steel Castings Industry

REPORT OF ENAMEL DIVISION STANDARDS COMMITTEE

BY C. J. KINZIE

(1) Deflection Tentative Method for Determination of the Resistance of Sheet Steel Enamel to Deflection: this method stands as revised in the 1930 report.[1] No action has as yet been taken by the Enamel Division as to its adoption as a Standard Method

[1] See *Bull. Amer. Ceram. Soc.*, 9 [9], 269 (1930).

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