The design and construction of a ceramics workshop and the utilization of local clays for ceramic use by Charles A Stablein

A THESIS Submitted to the Graduate Committee in partial fulfillment of the requirements for the degree of Master of Arts in Applied Arts
Montana State University


Abstract:
The material set forth in this thesis is directed to schools, interested groups and individuals who wish to build a ceramics workshop. A workshop was planned that is adequate in operation and complete in equipment for most use. In order to provide a well equipped shop the following items are discussed and, as far as possible, plans for their construction are presented in the thesis.

1. Electric Kilns 4. Dry Boxes, Bats, Damp Boxes 2. Potter's Wheel 5. Miscellaneous Equipment 3. Wedging Boards The sections concerning Low Fire and High Fire Kilns include a full report of the reasons for building electric rather than oil or gas fired kilns, as well as the method of arriving at the final specifications for their construction. This was thought to be necessary in order that persons desiring to work from the plans included in this paper might know the efficiency and capabilities of these kilns.

The Potter's Wheel was designed so that the different heights of students using the wheel would create as little handicap as possible.

The factor of varied heights must be considered wherever groups are using such equipment.

Items 3, 4 and 5 are self-explanatory and are somewhat standard in their requisites. The sizes of these items when listed in the thesis are given as adequate in size for a group of approximately fifteen (the average size group attending ceramics classes at Montana State College at this writing). The amounts or sizes of these items are readily adjusted to fit the need.

A unit on clay and clay bodies has been included to provide an understanding of the requirements of good pottery clays. Such a unit is of especial value when the possible use of local clays comes into consideration. Almost any locality has some clay that is readily adapted for use by the potter. Samples taken from various localities within this state were tested and, with one exception, were found to have possibilities for pottery. In some cases slight changes were necessary to create the best clay body from these local deposits.

Included at the close of the thesis is a list of books and articles of value to ceramists. It will be noted that for the most part these articles are from "The Ceramic Age," a trade type magazine. This magazine will be found to be a good reference in the ceramic workshop.

# THE DESIGN AND CONSTRUCTION OF A CERAMICS WORKSHOP AND THE UTILIZATION OF LOCAL CLAYS FOR CERAMICS USE

by

CHARLES A. STABLEIN

A THESIS

Submitted to the Graduate Committee

in

partial fulfillment of the requirements

for the degree of

Master of Arts in Applied Arts

at

Montana State College

Approved:

Cyril H Conrad
In Charge of Major Work

Cyril H Conrad
Chairman, Examining Committee

J A Nelson
Chairman, Graduate Committee



Bozeman, Montana
June, 1949

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ACKNOWLEDGEMENTS

The author wishes to thank Mr. Cyril Conrad, Miss Frances Senska, and Miss Jessie Wilber of the Art Department for their assistance during all stages of research for this paper and for their very helpful criticisms while preparing the following pages.

Mr. Robert Seibel of the Electrical Engineering Department has been most helpful in planning the element requirements of the kilns. Without his help this part of the thesis would have been impossible.

Mr. Halver Skinner has made it possible for the author to use the shop equipment in the Rural Engineering Department during the design and construction stages of the Potter's Wheel.

To those persons expressly mentioned above, to all interested individuals who have sent samples of local clays from their communities, and to all others who have in any way contributed to the work of this paper the heartfelt appreciation of the author is expressed.

Special thanks are extended to my wife, Virginia, for her patience during the writing, proof-reading and final typing. Her assistance has been of inestimable value at all times.

## ABSTRACT

The material set forth in this thesis is directed to schools, interested groups and individuals who wish to build a ceramics workshop. A workshop was planned that is adequate in operation and complete in equipment for most use. In order to provide a well equipped shop the following items are discussed and, as far as possible, plans for their construction are presented in the thesis.

1. Electric Kilns
2. Potter's Wheel
3. Wedging Boards
4. Dry Boxes, Bats, Damp Boxes
5. Miscellaneous Equipment

The sections concerning Low Fire and High Fire Kilns include a full report of the reasons for building electric rather than oil or gas fired kilns, as well as the method of arriving at the final specifications for their construction. This was thought to be necessary in order that persons desiring to work from the plans included in this paper might know the efficiency and capabilities of these kilns.

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A unit on clay and clay bodies has been included to provide an understanding of the requirements of good pottery clays. Such a unit is of especial value when the possible use of local clays comes into consideration. Almost any locality has some clay that is readily adapted for use by the potter. Samples taken from various localities within this state were tested and, with one exception, were found to have possibilities for pottery. In some cases slight changes were necessary to create the best clay body from these local deposits.

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# INTRODUCTION

It is not the aim of this thesis to develop a curriculum or a philosophy for the teaching of ceramics in our schools. The primary purpose is to present plans for the construction of equipment for a ceramic workshop adaptable for use in the average school program. Every effort has been made to present clear, workable plans in order that the average individual with a minimum amount of training in the average industrial arts shop can interpret them and construct the pieces of equipment presented.

The economic construction of the pieces to be set forth will also be taken into consideration. Utilization of existing materials is emphasized in order to further reduce the building costs. This economy will be kept in mind so that schools with limited budgets may still be in a position to have a ceramics shop that will provide adequate opportunity for student expression in the media.

At no point will economy or utilization of material not originally planned for use in ceramics become the controlling factor over good, sound workability. The utmost of efficiency will be sought at all times in order that the expense of repairs and upkeep can be kept to a minimum.

Special emphasis has been placed on the study of local clays and their adaptability to use in ceramics. No effort will be made to estimate the amount of clay in the deposits from which the test samples were taken. The principal intent will be to show that there are many sources from which clays may be locally obtained. The educational aspect of ceramics is greatly enhanced by eliminating the expense and inconvenience of commercial clays.

Group efforts can play an active part in the various phases of digging and preparing local clays for use. The satisfaction of having completed the cycle from digging to finished product as the result of the cooperative effort of a class or group should not be overlooked.

For the individual, as well as the group, local clays reduce the expense that is necessarily connected with commercial clays. Shipping charges account for a great percentage of the cost of commercial clays at the present time. With this in mind it seems feasible that a section on preparing and testing of local clays be included with the proposed plan for a ceramic workshop.

## LOW FIRE KILN

Before building or buying a ceramics kiln it is necessary that the general requirements of a kiln are known in order that the most suitable design may be chosen. It matters little what method of firing is used; whether it is electricity, gas, or oil the following features must be considered:

1. Economical operation.
2. Adequate muffle volume.
3. Ease of charging.
4. Ease of maintenance.
5. Economical upkeep.
6. Uniform heat rise.
7. Efficiency of operation to allow for proper maturing of ware.
8. Efficient and economical installation.
9. Compliance with local fire and safety ordinances.

It cannot be too strongly stressed that a thorough analysis of the requirements and qualifications of a kiln be made. Before the first kiln was built at Montana State College such a study was made. The result was the design and construction of an electric kiln of a type similar to many of the cone 04 kilns now on the market.

The following reasons determined the choice of such a kiln:

1. Properly built it would have all the features listed above.
2. It would eliminate the necessity of providing the special vent that would have been necessary with a gas or oil fired kiln.
3. Constructed at the college the kiln would be less expensive than if purchased ready built.

4. Being of multi-unit construction the kiln's muffle would be variable, thus allowing for greater economy in firing special tests, where only a small volume is necessary.

5. Electricity would be more convenient than other fuels.

The kiln was planned to be octagonal in shape and constructed of insulating brick. Two manufacturers of such a brick, Armstrong Cork Company, 222 North Bank Drive, Chicago, Illinois, and Robinson Insulation Company, Great Falls, Montana, distributors for Zonolite products, were contacted for information regarding the characteristics of their bricks. Armstrong's A-20 brick proved to be the most suitable. It has the following characteristics:

1. Temperature Limit - 2,000° F. on hot face
2. Thermal Conductivity - 2.2 B.t.u./sq. ft./ in. thick/ per hour
3. Size of Brick - $4\frac{1}{2}$" x $2\frac{1}{2}$" x 9"
4. Weight of Brick - 1.9 lbs. ea.
5. Brick can be easily cut to desired shape by hand or power saw.

After the type of brick had been decided upon and the general plan drawn up, Mr. Robert Seibel, Assistant Professor of Electrical Engineering at Montana State College, was consulted for advice and assistance in regard to the technical details of plotting the size of element wire as well as firing control and voltage requirements.

Listed below are the data arrived at and used as a basis for the construction of the first Low Fire, Cone 04, Multi-Unit, electric kiln built at Montana State College.

Octagonal Area - 238 sq. in.

| | | |
|---|---|---|
| Muffle Volume | - | 3220 cu. in. - 1.86 cu. ft. |
| Outer Surface Area | - | 15.1 sq. ft. |
| Heat Loss Through Walls | - | 3.4 Kw. (Est.) |
| Spec. Heat of Bricks | - | 0.22 (Est.) |
| Brick Weight | - | 2.0 lbs. used. Actual weight 1.9 lbs. |
| Number of Bricks | - | 48 |
| B.t.u. to Heat Brick | - | 53,000 |
| Furnace Charge | - | 5.0 lbs. (Average) |
| B.t.u. to Heat Charge | - | 1930 |
| B.t.u. for Air | - | 1730 (Allowing for six complete changes in kiln during firing due to air space between elements.) |
| TOTAL B.t.u. | - | 56,660 for six hour period |
| B.t.u. per Hour | - | 9,443.3 |
| TOTAL Kw. | - | 3.4 (Heat Loss) 2.78 Kw. for above plus 8% for regulating margin 6.6 Kw. TOTAL |

CALCULATIONS FOR ELEMENTS

| | | |
|---|---|---|
| Power Dissipation | - | Bottom and middle units, 2.5 Kw. ea. Top row, 1.6 Kw. |
| Voltage Available | - | 118V and 236V |
| Voltage for Peak Fire | - | 236V with all units turned on |
| Ohms at 2,000° F. | - | 22.3 |
| Resistance Factor | - | 1.078 at 68° F. |
| Resistance at 68° F. | - | 20.7 (Bottom and middle elements) |
| Mandrel Size | - | 3/16" |
| Element Dia. Wound | - | ¼" due to springing |
| Element Stretched | - | Approx. 7 turns per inch |
| Path Length of Element | - | 112" |
| Wire Used | - | Nichrome V |
| Wire Gauge | - | #18 B&S 0.4062 ohms per ft. at 68° F. |
| Amount of Wire | - | 53 ft. each unit (Bottom and middle only) |

TOP ELEMENT

| | | |
|---|---|---|
| Ohms at 2,000° F. | - | 34.8 |
| Resistance Factor | - | 1.078 at 68° F. |
| Resistance at 68° F. | - | 32.2 ohms. |
| Mandrel Size | - | 3/16" |
| Element Dia. Wound | - | ¼" due to springing |
| Element Stretched | - | Approx. 6 turns per inch |
| Path Length of Element | - | 112" |
| Wire Used | - | Nichrome V |

| | | |
|---|---|---|
| Wire Gauge | - | #20 B&S 0.6347 ohms per ft. at 68° F.[1] |
| Amount of Wire | - | 51.6 ft. |

Rapid heat rise is a disadvantage rather than an advantage when firing a kiln. It is first necessary to pass off any remaining moisture in the green ware during the initial stages of heat rise or explosion of pieces is likely to take place.[2] In order to assure a slow heat rise with greater efficiency the top unit was wired with a smaller gauge wire for initial heating on 118V. Following the initial firing of the top unit the bottom and middle elements were then turned on according to a set firing plan plotted by use of a pyrometer in order to consume no less than six hours.[3] The wiring had to be fused with 30 amp. fuses to accommodate the use of all three elements on 236V during the final stages of firing.[4]

From the outset it was found that the efficiency of the first kiln was far above expectations. Heat loss was not as great as was estimated and the change of air through the muffle was negligible. At the peak of operation it is possible to touch the outer brick surfaces of the kiln. The kiln is placed upon a star pattern of eight ordinary bricks to allow for air space underneath. These bricks in turn are placed upon $\frac{1}{4}$" sheet asbestos covering a wooden table. Such a method of placing the kiln was approved by the fire chief of the city of Bozeman, Montana, and the col-

1. See Nichrome and Other High Nickel Electrical Alloys, Catalogue R-46, Driver Harris Co., Harrison, N. J., PP. 17-19, for ohm rating of #18 and #20 B&S gauge wire.
2. Binns, C. F., Lectures on Ceramics, 1946, PP. 45-47.
3. See Figure 13, P. 45.
4. Ibid.

lege plant supervisor. No venting over the kiln was required by them at the time of inspection.

Two kilns have been built by the Art Department at Montana State College using the above specifications and constructed from the plan as set forth in a subsequent chapter. Both kilns have been highly satisfactory in performance. Two changes have been made in the second kiln and these changes have been incorporated in the plans. One change is in the method of holding the element in the grooves. In the first kiln this was accomplished by use of staples made of #30 Nichrome V wire which were hand formed, then driven into the walls of the kiln. The staples had a tendency to pull free as the element expanded due to the heat. It was necessary to replace these staples frequently. In order to overcome the disadvantages of staples, strips of insulating brick have since been fastened to the kiln wall with Airset Cement or Latite.

The second change was to wind all three elements alike using 55 feet of Nichrome V #18 B&S wound on a 3/16" mandrel. This change was made in order that only one size of wire would need to be stocked and also to distribute the heat more evenly. So that a reasonable degree of heat would be available during the warm-up period the ohm rating was increased by the addition of two feet of wire to each element, thereby providing greater heat potential on 118V. This change necessitated heavier fuses inasmuch as the amperage at full heat now reached 31.5 amps. whereas with the smaller element the amperage rating was 30.0.

The first kiln has been in use since March, 1948, and to date has been fired about one hundred times on the original set of elements.

As of May, 1949, there is no indication of immediate element failure. Records show that this kiln has been fired as many as 18 days in succession with time allowed only for cooling, unloading and restacking.

The second kiln was built in September, 1948, and indications are that it will give equal service. Changing the method of fastening the elements has been a decided improvement in ease of maintenance.

Basic construction of the college kilns was accomplished through the cooperative efforts of Mr. Cyril Conrad, Head of the Art Department, Miss Frances Senska, Ceramics Instructor, Mr. Robert Story, and the author.

## HIGH FIRE KILN

Nichrome V wire will give good results in kilns operating in the cone 04 range but due to the characteristics of the wire it has an operating ceiling of 2150° F. for best life expectancy. The temperature of the element is greater than the temperature of the muffle at the peak of firing. Taking this fact into consideration, it is necessary to set the maturing point of the kiln below 2150° F.[1]

In order to fire electrically above cone 04 another type of wire must be used. For cone 4-5 ranges such a wire as produced under the trade name of Kanthal is satisfactory. Globar elements are necessary for heat above the range of Kanthal. Globar units would be too complicated and expensive for most schools, clay clubs, adult education activities or individuals. As ceramics work has progressed at Montana State College it has been desirable to do some work in the stoneware range, or around cone 5.[2] With the success of Armstrong Insulation Brick for the first kilns there seemed to be no indication that a high fire kiln could not be designed to fire satisfactorily using Armstrong brick and Kanthal.

As in building the first kiln, the qualifications and advantages of this new kiln were analysed.

1. Economy of construction.
2. Ease of construction with a minimum amount of tools and equipment.
3. No special firing mechanisms or constructions needed such as air vents, flues and firing rooms.

1. Op cit Driver Harris Co. P. 13.
2. See Cone-Temperature Chart, P. 80.

4. Uniform heat rise.

5. Multi-unit firing allowing for a change of muffle volume.

6. Ease of charging.

7. Compliance with local fire regulations.

A series of tests were run on the first kiln to determine its heating characteristics and the peak efficiency of the elements. These figures were then interpolated to verify what might be expected with a similar kiln operating at 2350° F.

Figure 1 indicates the heat rise at intervals of fifteen minutes with kilowatt ratings varying from 1.6 kilowatts to 6.6 kilowatts being tested.

Figure 2 graphs the correlation between the kilowatts per square foot of kiln and the heat obtained.

Figure 3 indicates the rate of heat rise as the kilowatt rating was increased. As the heat from the first element reached its peak, the second element was connected, then, as that peak was reached, the third element was turned on.

In order to more fully understand the facts gained from these tests it is necessary to set up the specifications for a kiln to fire at 2300° F.

| | | |
|---|---|---|
| Brick Used | - | Armstrong A-26 - 2600° F. Face Heat |
| Octagonal Area | - | 238 Sq. In. |
| Muffle Volume | - | 3220 Cu. In. - 1.86 Cu. Ft. |
| Outer Surface Area | - | 15.1 Sq. Ft. |
| Spec. Heat of Bricks | - | 0.22 (Est.) |
| Brick Weight | - | 3.0 Lbs. used - Actual Weight 2.8 Lbs. |
| Number of Bricks | - | 48 |
| B.t.u. to Heat Brick | - | 73,814 |
| Furnace Charge | - | 20 Lbs. (Average) |

| | | |
|---|---|---|
| B.t.u. to Heat Charge | - | 9320 |
| Heat Loss B.t.u. | - | 10,570 (Est.) Per Hour[1] |
| Heat Loss Kw. | - | 3.1 Kw. Per Hour of Firing |
| TOTAL B.t.u. | - | 111,790 for 8 Hour Period |
| B.t.u. Per Hour | - | 20,961.8 |
| TOTAL Kw. Per Hour | - | 6.13 Plus 10% for Operating Margin |
| | | 6.8 Kw. Per Hour |

Reference to figure 1 will show that 2,000° F. is reached when 5 Kw. are used as the power source. The direction of the curve indicates that the peak heat obtainable would be in the area of 2,100° F. The curve based upon the use of 6.6 Kw. has not begun to level off when the 2,000° F. point is reached. Extending this curve indicates a peak of 2,350 - 2,400° F. could be obtained. Facts gained from figure 1 substantiate the projected kilowatt rating as listed above.

Figure 2 reveals that from the tests and extension of the curve, 0.43 Kw. per sq. ft. are necessary to reach a heat of 2,300° F. Comparing this with the specifications above show a close relationship between the 0.43 Kw. per sq. ft. by test and 0.45 Kw. per sq. ft. in specifications which were arrived at mathematically.

Figure 3 indicates the rate of heat rise as the power is increased. It shows the necessity of a set firing pattern to allow for proper maturing of ceramic ware.

All tests graphed on figures 1, 2 and 3 were made at 236V. On the basis of the specifications previously set forth and the findings of the tests graphed in figures 1 and 2, Kanthal A-1 B&S gauge #17 wire was selected as the element material. The principal reason for using



1. Specification Chart, Universal Zonolite Insulation Co., Chicago, Illinois, Copyright 1942.

this size wire was that it would simplify the turning of the element inasmuch as the same mandrel used for turning the elements for the low fire kiln could be used for the Kanthal A-1 wire. Using #17 wire for proper resistance would necessitate turning the elements on a 3/16" mandrel from 55 feet of wire.

Two hundred and forty feet of #17 Kanthal A-1 were ordered from the Jelliff Co. of Southport, Connecticut. Some changes had been made in the type of wire being produced by that concern since their catalogue had been received. A-1 wire is no longer drawn in smaller sizes than #15. The correspondence carried on between the author and Jelliff Co. is significant enough to warrant reproduction at the end of this chapter inasmuch as it was due to the interest of the Jelliff Co. in ascertaining that the best use be made of their product that the final wire size was chosen.

Eighty-five feet of Kanthal A-1 B&S gauge #15, diameter .057, with a resistance of .272 ohms per foot was used for each element. Two changes were made from the suggested plans set forth in the letter from Jelliff Co. dated April 6, 1949. The element was turned on a 3/8" mandrel to reduce the close wound length and make it possible to turn the element on a lathe rather than by hand. No indication of free silicate has been evident in the previous two kilns. Therefore, the element track was not painted with resistor cement.

It will be necessary to operate the high fire kiln for several firings to determine its full capabilities. On the basis of tests upon existing kilns, specifications of the brick, and the verification of the element requirements by the Jelliff Co., manufacturers of Kan-

thal, there is every reason to believe that the kiln will prove successful.

THE C. O. JELLIFF MFG. CORPORATION

Southport, Conn.

C O P Y

March 29, 1949

Associated Students Store
Montana State College
Bozeman, Montana

ATT: Mr. Edwin Howard, Mgr.

Gentlemen:

Thank you very much for your order #5194.

We would like to point out to you that this seems to be the initial order we have received from you for KANTHAL wire, and in line with our customary procedure we would deeply appreciate your giving us complete information as to your proposed method of installation on this KANTHAL so that our engineers may satisfy themselves that your intended use will be a suitable one for KANTHAL. The electrical and mechanical properties of KANTHAL vary so much from those of other resistance wires that this is a precaution we must take in order to assure that KANTHAL is properly installed for long wear and complete operating satisfaction.

Therefore, if you will be kind enough to give us this data, we will be very happy to enter your order.

Incidentally, the #17 gauge we can furnish in KANTHAL "A" only. Number 16 represents the smallest size that can be furnished in KANTHAL "A-1"; all sizes smaller than that are furnished of KANTHAL "A".

We hope you will send us along complete data as to your installa-

tion so that it may have the immediate attention of our engineering department.

Very truly yours,

THE C. O. JELLIFF MFG. CORP.

(s) J. F. Kelly, Asst. Secy.

JFK:RC

Bozeman, Montana
April 2, 1949

C O P Y

The C. O. Jelliff Mfg. Corporation
Southport, Connecticut

Att: Mr. J. F. Kelly, Asst. Secy.

Gentlemen:

Your letter of March 29, 1949 to the attention of Mr. Edwin Howard has been forwarded to me inasmuch as the material ordered by the Associated Students Store is for my use.

The KANTHAL ordered is to be used in a ceramics kiln which I am designing in connection with work for a Master's Degree. I have worked in close cooperation with the Electrical Engineering Department here at Montana State College in the designing of this kiln and submit the following data for your approval.

| | | |
|---|---|---|
| Kiln Shape | - | Octagonal |
| Number of Elements | - | 3 |
| Outlets | - | 3 - 220 Volt<br>2 - 110 Volt<br>(110 for Warm-up) |
| Firing Time | - | 6 Hours |
| Capacity | - | 1.86 Cu. Ft. |
| Kw./Unit | - | 1.93 |
| Ohms/Unit | - | 23.2 Cold |
| Temperature Desired | - | 2300° F. |
| Element Path Length | - | 112" |
| Brick | - | Armstrong A-26<br>A-26 Face Heat Permissible 2600° F. |

Elements are drawn through the brick and connected outside the kiln proper to brass contacts set in asbestos.

The method of setting the element in the brick is illustrated on the attached sheet.

This kiln is similar to two kilns which we have built here at the college for Nichrome V wire and have proven satisfactory within the operating limits of Nichrome. At this time, however, it is desired to attain the higher heat and also to do away with the reduction in glaze ware due to the nickel wire. These two kilns have over a year's service and have proven satisfactory in every way. With the construction of the new one we have changed the brick to 2600° F. face heat and planned to set the element in in a more protected manner to compensate for the brittle quality of KANTHAL after it has reached its heat.

We had planned to use KANTHAL A-1 because of its higher capacity which would allow us a greater operating margin, but if you feel that KANTHAL A is all right, we can adapt it to our use. If, however, it would be more practical to use Number 16 KANTHAL A-1, we can adapt that. The order originally placed by us was enough wire for four complete elements when turned on a 3/16" mandrel and stretched to approximately five turns per inch. Therefore, I would appreciate it if you would make any proportionate change in the order to accomplish this.

I believe this information will be sufficient to establish our correct use of KANTHAL in our kiln but I will be glad to forward any additional information you may need.

Thank you for the trouble you have taken to make sure we can

get the most out of KANTHAL.

Very truly yours,

(s) Charles A. Stablein

THE C. O. JELLIFF MFG. CORPORATION

Southport, Conn.
April 6, 1949

C O P Y

Mr. Charles A. Stablein
95 Cedar Avenue
Bozeman, Montana

Dear Mr. Stablein:

Thank you for your letter of the 2nd in which you furnished data on the experimental ceramic kiln which you are designing.

We regret that we cannot recommend No. 17 KANTHAL "A" wire for your kiln. It would undoubtedly be an improvement over the nickel chromium wire you are now using but would not permit you to reach the high temperature which KANTHAL makes possible, because the surface loading would be approximately 20 watts per square inch. This means that the wire would run considerably hotter than the work in the kiln.

We would recommend that you use 85 ft. of No. 15 (.057" dia.) KANTHAL "A-1" wire for each element. If this wire is coiled on a 9/32" diameter mandrel and stretched to twice the close wound length, it will be approximately 112" long. However, since it will be about 4/10 of an inch in diameter, it will be necessary to use 7/16" grooves for supporting.

When stretching coils of wire this large we would recommend that you heat them to about 1200 degrees F. by means of an electric current while slowly stretching them to the desired length. This results in a more uniform coil with considerably less effort than

stretching cold.

The method of supporting the element shown in your sketch is very satisfactory for KANTHAL elements. However, we would suggest that you paint the grooves before installing the elements with either No. 78 electric resistor cement made by the Sauereisen Cement Co. in Pittsburgh, Pa., or with No. 1161 Alundum Cement made by the Norton Company in Worcester, Mass. These cements have no effect on KANTHAL and would prevent possible attack at high temperatures by the free silica and impurities in the insulating brick.

We would appreciate your consideration of the remarks above and will hold your order, pending your decision on the larger size of wire which we recommended.

Very truly yours,

THE C. O. JELLIFF MFG. CORP.

(s) C. W. Armstrong,
Wire Division

CWA/dbf

P.S. A KANTHAL Handbook is being forwarded to you under separate cover. C.W.A.

Bozeman, Montana
April 8, 1949

C O P Y

The C. O. Jelliff Mfg. Corp.
Southport, Conn.

Att: Mr. C. W. Armstrong, Wire Division

Gentlemen:

Thank you very much for your letter of April 6th and the interest you have shown in making sure that I receive the proper KANTHAL for my ceramics kiln. I can assure you that your advice has been well received because, as you say, you are in a better position to see that the "KANTHAL" is put to its proper use.

I can cut my grooves to 7/16" for proper support of No. 15 KANTHAL A-1 with no trouble at all. Therefore, I would like to use the No. 15 KANTHAL A-1, as you suggested.

Do you prefabricate KANTHAL elements to order? If this is the case, will you please coil this as you suggested in your letter of April 6th. If not, please send at your earliest possible convenience 340 feet of No. 15 KANTHAL A-1, our order No. 5194, The Associated Students Book Store, Montana State College, Bozeman, Montana, Attention Mr. Edwin Howard, Mgr.

Thank you again for every attention you have afforded me in this matter.

Very truly yours,

(s) Charles A. Stablein

THE C. O. JELLIFF MFG. CORPORATION

Southport, Conn.
April 21, 1949

C O P Y

Mr. Charles A. Stablein
95 Cedar Avenue
Bozeman, Montana

Dear Mr. Stablein:

The material covered by your recent order for KANTHAL was shipped to you on the date of April 13th.

In this connection we sincerely hope when using KANTHAL that you follow our Mr. Armstrong's suggestions contained in his letter of April 6th.

If you have any questions about this, won't you please write to us so we can help you before you start using the material.

Very truly yours,

THE C. O. JELLIFF MFG. CORP.

(s) J. F. Kavanaugh,
Wire Division

JFK/dbf

## KILN CONSTRUCTION

The two kilns (High Fire and Low Fire) previously described were designed with the average school shop in mind.

While it is a help, a power saw is not absolutely necessary to cut the bricks of the kiln. If a hand saw is to be used, a cutting guide should be constructed so that all cutting will be accurate. In the event that a power saw is used, it is advisable that an old blade be employed as the grit of the brick will dull a blade quite rapidly. Five sets of kiln brick seem to be the maximum possible to cut with an eight inch blade. After that many kilns had been cut no tooth was left on the blade.

General hand tools for metal work are all that are necessary in fabricating the bands and corner plates.

A lathe simplifies turning the elements but is not a necessity. A hand operated turning jig is easily constructed.

Bill of Materials - Low Fire Kiln[1]

| | |
|---|---|
| Armstrong A-20 Insulating Brick | - 50 (25 Per Box) |
| Airset Cement | - 16 Lbs. |
| .024 Gauge Sheet Metal 1" x 76" | - 8 Bands |
| .024 Gauge Sheet Metal 3" x 4" | - 24 Corner Plates |
| .024 Gauge Sheet Metal 2" x 3" | - 16 Corner Plates |
| 3/16D x ¼" Tinner's Rivets | - 16 |
| 1" x 1" x 1/8" Angle Iron | - 16 |
| ¼" x 3" Roundhead Stove Bolts | - 8 |

1. See List of Supply Houses P. 81.

| | | |
|---|---|---|
| Nichrome V #18B&S Gauge | - | 165 Ft. (3 Elements) |
| Nichrome V #20B&S Gauge | - | 53 Ft. (Top Element Optional) |
| 3" x 3" Hard Faced Asbestos Sheet | - | 3 Element Plate |
| 10/32 Brass Bolts | - | 6 Element Connection |
| Brass Washers for Above | - | 12 |
| Brass Nuts for Bolts (Above) | - | 18 |
| Lead-in Wire to Suit Needs (Must be at Least 10 Amp.) | - | 3 Lengths |

Bill of Materials - High Fire Kiln[1]

| | | |
|---|---|---|
| Armstrong A-26 Insulating Brick | - | 50 (25 Per Box) |
| Airset Cement | - | 16 Lbs. |
| .024 Gauge Sheet Metal 1" x 76" | - | 8 Bands |
| .024 Gauge Sheet Metal 3" x 4" | - | 24 Corner Plates |
| .024 Gauge Sheet Metal 2" x 3" | - | 16 Corner Plates |
| 3/16D x ¼" Tinner's Rivets | - | 16 |
| 1" x 1" x 1/8" Angle Iron | - | 16 |
| ¼" x 3" Roundhead Stove Bolts | - | 8 |
| Kanthal A-1 #15B&S Gauge | - | 255 Ft. (3 Elements) |
| 3" x 3" Hard Faced Asbestos Sheet | - | 3 Element Plate |
| 10/32 Brass Bolts | - | 6 Element Connection |
| Brass Washers for Above | - | 12 |
| Brass Nuts for Bolts (Above) | - | 18 |
| Lead-in Wire to Suit Needs (Must be at Least 10 Amp.) | - | 3 Lengths |

1. See List of Supply Houses, P. 81

Cut Sheet for Kiln. (Makes one kiln.
Use for either high fire or low fire kiln.)

| | | |
|---|---|---|
| Pattern A | - | Ea. 16 |
| Pattern B | - | Ea. 4 |
| Pattern C | - | Ea. 4 |
| Pattern D | - | Ea. 24 |

Patterns A, B, C and the two full bricks make up the parts for the bottom and lid. Pattern D makes the parts for the element units.[1]

Two alternatives are possible in cutting the element grooves. If Nichrome wire is to be used, the groove may be cut at a $90^{\circ}$ angle to the inside face of the brick. Kanthal requires a greater support due to its characteristic of becoming quite brittle after being fired. The element groove for Kanthal wire is cut at a $22^{\circ}$ angle to the face of the brick. Figures 8 and 9 should be noted before cutting the brick.

Assembly of Bottom and Lid

The bottom and lid are identical in construction and should be assembled first.

The bricks are cemented together with Airset cement for greater strength. Only enough cement is used to provide a good bond between the bricks. Due to the porous quality it has been found advisable to dip the brick first in order that the moisture may not be drawn too rapidly from the cement.

Guard plates are set at each corner and held in place by one clamping band as indicated in figure 5.

1. See Figure 8, P. 40.

Clamping Bands

It is suggested that as soon as the first set of bricks is assembled all of the bands be made to fit it. For best results about 2" is left between the ends of the bands when they are first clamped. This will allow for room to tighten them if they stretch as a result of the heat. One kiln was made with aluminum bands. These bands have given good service but tend to stretch more than galvanized iron. Stainless steel makes a good band but increases cost with no increase in efficiency.

Unit Assembly

All but three of the unit bricks previously cut to Pattern D are grooved by either method of grooving, as in figure 8 depending upon which type of element is to be used. The three bricks not previously grooved will be cut as in figure 8 in the same style groove as used in the other 21 unit bricks. Three of the regular bricks must have observation holes cut in them and will be used one to each unit. The shape of the observation hole is dependant upon the style groove chosen. See figure 8. Actual assembly can be started after the grooves have been cut in the bricks. The element retainer bars are cut from scrap brick or the two remaining bricks. These retainer bars are attached to the kiln wall with Airset cement in the same manner as the lid and bottom were cemented. After placing the elements in the grooves, use ample cement for cementing the bars in place and allow to dry well before firing the units. It will be necessary to re-cement these bars from time to time because the high degree of heat acting upon

them causes some cracking.

The element units are not cemented and are only clamped snugly to allow for expansion during heating. The wear surfaces of the units are painted with a thin coat of cement to prevent wear or chipping when the units are removed to clean the kiln or to change the muffle area. See figure 6. The position of the brick incorporating the observation hole and the brick used as the element outlet have no fixed position in each element and may be placed to the best advantage of the operator. The plans, however, indicate their position on the constructed kilns.

Element Assembly

For the low fire kiln three 55 foot lengths of Nichrome wire of the size listed in the bill of materials are turned on a mandrel 3/16" in diameter. A length of welding rod serves as a good mandrel. After the element has been turned it will spring to about ¼" in diameter. The elements are close wound and stretched to a length of 112" before being set in the units. Enough wire is left at each end of the element to extend out of the brick where the outlet attachment is made. This is necessary because the temperature in the muffle is high enough to melt the brass connections if they were inside. The element is attached to a hard faced asbestos plate ¼" x 3" x 3" with 3/16" brass bolts. Figure 11 indicates the method of attaching the element and outlet plugs. Offset wall plugs are used inasmuch as the wiring is 230V as indicated and this will eliminate the possibility of inadvertently plugging in lights or fixtures made for regular 115V outlets. Such a method is a precautionary measure of especial value in schools or where groups are working.

The Kanthal or high fire elements are turned in the same manner as the Nichrome. The diameter of the mandrel has been changed to 3/8" in the kiln constructed rather than the 9/32" as suggested by the Jelliff Co. inasmuch as this size is more readily available. Turning the element on a larger diameter indicates that the element will be stretched greater than twice the coiled length. The element is stretched hot to help the wire hold its length. Warm the wire just past the glow point and while it is still hot stretch the element to 112". The element and outlet wire are attached in the same manner as listed above for the low fire kiln except that the brass bolt used is ¼" in diameter.

Relative Cost of the Kilns

Due to present day in changes in costs, availability of the required materials in the locality, and the adaptability of scrap tin, etc. usually available at tin shops, no attempt has been made to set an actual cost price for the kilns. The cone 04 kiln was built at a total cost of about $25.00, not including the stacking shelves and the stand for the kiln itself. Listed below is an itemized cost sheet for the high fire kiln.

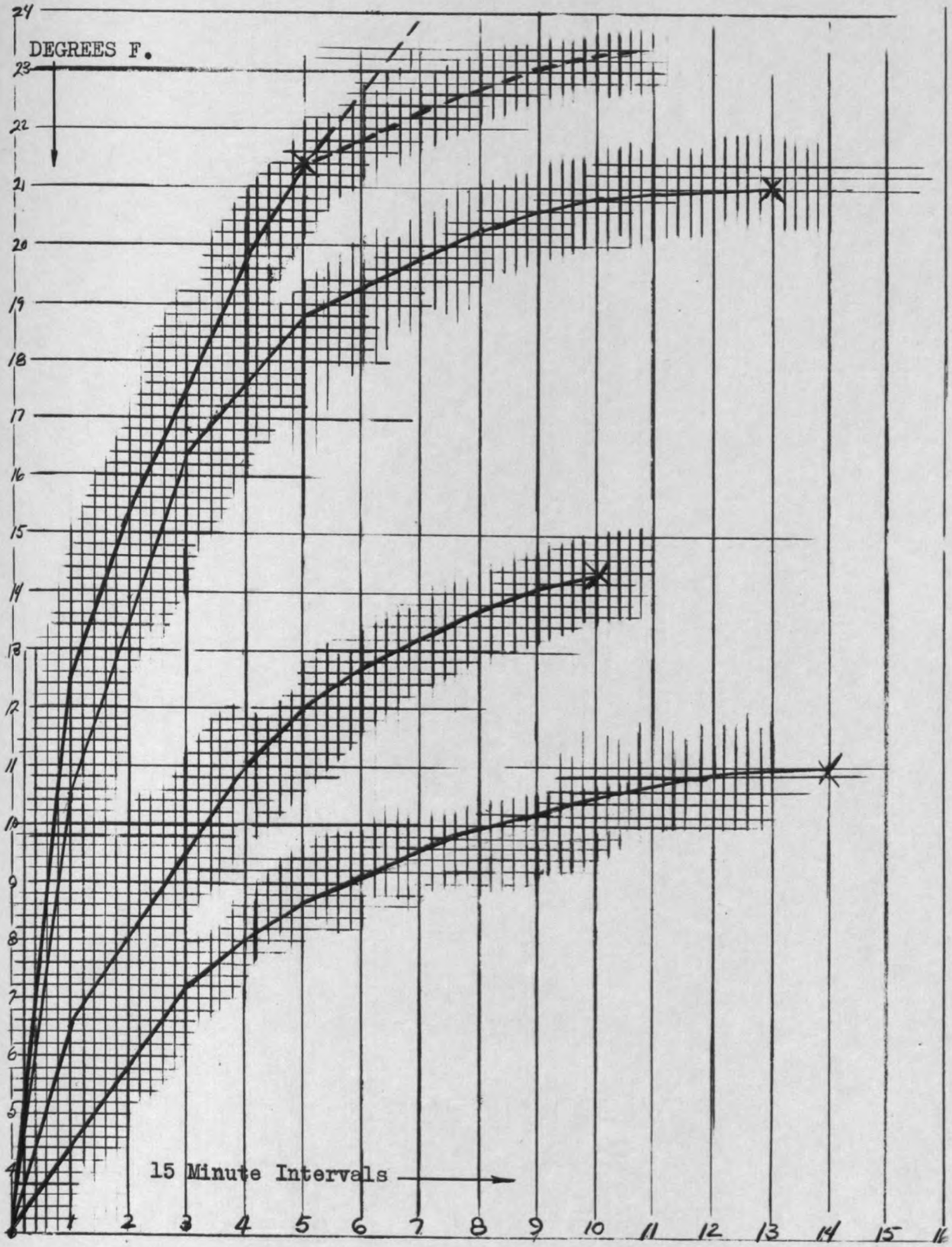
| | |
|---|---|
| Insulation Bricks, Airset Cement, and Transportation | $ 21.58 |
| Clamping Bands and Angle Iron, 3/16" Tinner's Rivets | 1.20 |
| Brass Bolts and Nuts | .40 |
| Kanthal A-1 Wire and Postage | 15.21 |
| Outlet Cord #12 | 1.00 |
| ¼" Stove Bolts | .15 |

| | |
|---|---|
| Plug Bodies | 3.00 |
| Corner Plates Cut from Scrap | **** |
| TOTAL | $ 42.54 |

The increased cost of the high fire kiln is due to the cost of the Kanthal wire and the A-26 brick which run a little higher in cost than the Nichrome V wire and the A-20 brick used in the cone 04 kiln.

Enough wire for one low fire kiln costs about $1.50.


ARMSTRONG


DEGREES F.
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15 Minute Intervals
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Figure 1