

School of
Architecture
and Allied
Arts

Murrow.

An oil burner for a
pottery kiln. 1967.

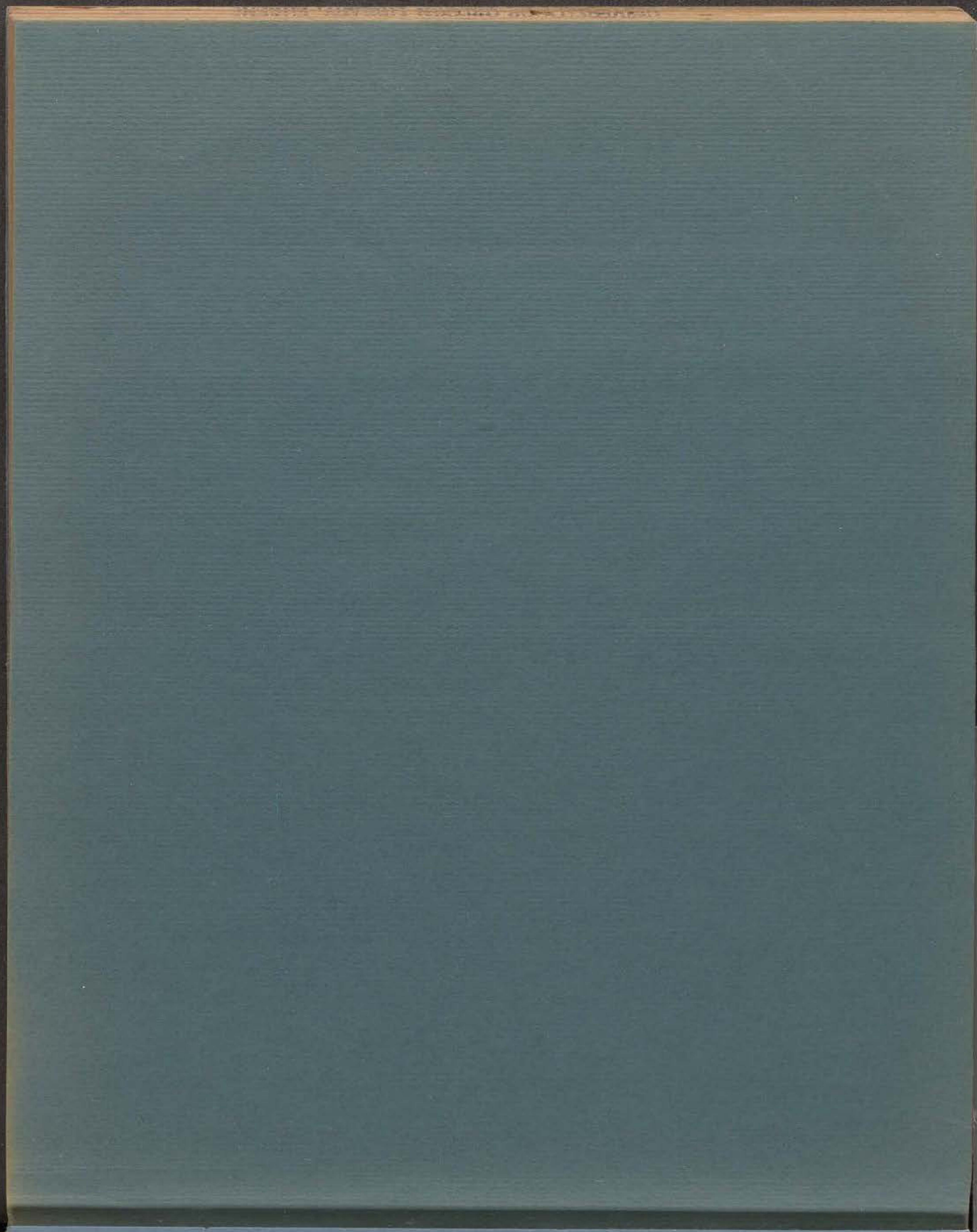
SCA
Archives
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Terminal
Project
1992

1992

Murrow, Richard

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1967



BIOGRAPHICAL DATA: HANK MURROW

Born 1939....graduated with an A.A. degree from Santa Monica City College in 1958...studied architecture at the University of Oregon from 1958 to 1960....worked for architect in Los Angeles through 1963...built ceramic studio and gallery in Venice, California, 1963-64...received B.S. in Applied Design at the University of Oregon in 1965...appointed as a graduate assistant 1965 through 1967...received M.F.A. degree in Ceramics, June 1967.

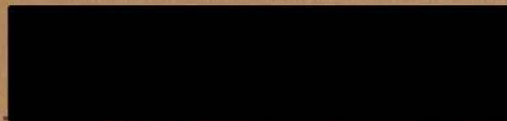
AN OIL BURNER FOR A POTTERY KILN

Submitted as partial fulfillment of the
Requirements for the Master of Fine Arts Degree

by
Richard Murrow



APPROVED:



Robert C. James

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INTRODUCTION TO PROJECT



To introduce my terminal project I am referring to some previous work. This history indicates the interests which have jelled in the terminal study. While some examples are more relevant, each holds an aspect to be organized in the project. The selection of pottery is included to show the range of variables with which a "palette" can be built.

2.



These pots (fig. 2) were fired for about four minutes at 1700°F . Looking into a hot kiln to see the glaze sinter, boil, and then settle down on the surface provides an image applicable to fires of much longer duration. It is important to remain able to refer to some general image while trying to develop specific results. The blue bottle (fig. 3) was fired in a neutral atmosphere until the glaze had melted, protecting the clay from the effects of a reducing atmosphere at the end of the cycle (circa 2400°F). This minimized the effect of the iron in the clay on the color of the glaze. To develop the contrast in this bowl (fig. 3) I wanted the differing amounts of iron in the clay to react with the glaze. To encourage this interaction the firing cycle included some reduction (increase of the fuel to air ratio) in the early stages before the glaze had melted (circa 1800°F). Assuming that these observations and interpretations are accurate, makes

3.



4.



it possible to take advantage of the atmospheric variation within the kiln. For instance, any part of a kiln where cold air can enter through the walls to the ware is likely to be more oxidizing than a part of the kiln where there are no leaks. A way of testing this variable is to try the same glaze in different places in the kiln, as on the two bowls shown here (fig. 4). The glaze turned green when fired near the door of the brick kiln where air leaks in, and it came out dark when placed in the middle of the stack. As such assumptions can be made, they give direction to the testing, which then checks and refines the assumptions. These cups (fig. 5) have the same glaze but were fired under different atmospheric conditions. The reddish one was attributed to a more reducing atmosphere.

5.



6.



Many tests are necessary to establish some context within which the variables can then be identified. It is fitting that the basic pottery materials are inexpensive as so much is consumed in addressing these simple questions. Many of these pots (fig. 6) with drawings on them were lost in the firing. Some did not get hot enough to fuse the ingredients and develop the colors, while some were rendered unintelligible because the glaze ran off the pot due to overfiring.

7.



A solution to this problem was found outside the fire (fig. 7). In these three plates the coloring oxides were embedded in the clay surface (in the form of engobes) rather than in the glaze, making them less subject to the above-mentioned effects of under and overfiring. Their form, by having little vertical surface for the glaze to run from, helps to compensate for loss from overfiring.

8.



In this example, contrast was achieved by using four glazes and two clays (fig. 8). The drawing with oxides (inside lid) was confined to horizontal surfaces, and the figure was left unglazed (except for her bouquet of yellow daisies) to preserve detail.

Another set of possibilities exists in salt firing. With this method, glaze is developed on the ware during the fire by introducing salt into the chamber. If the kiln is hot enough, the salt (NaCl) vaporizes and the resultant sodium oxide (Na_2O) fuses with the silica at the exposed surfaces in the kiln. The more silaceous the surface, the more the glaze builds up (fig. 9). Since the sodium is carried by the draft, the shape of the flame becomes more directly important than in previously described fires. When I began salt firing (see page 13), I did not imagine the use of anything but sodium salt, but as I began to think of the process as "vapor glazing",

9.



10.



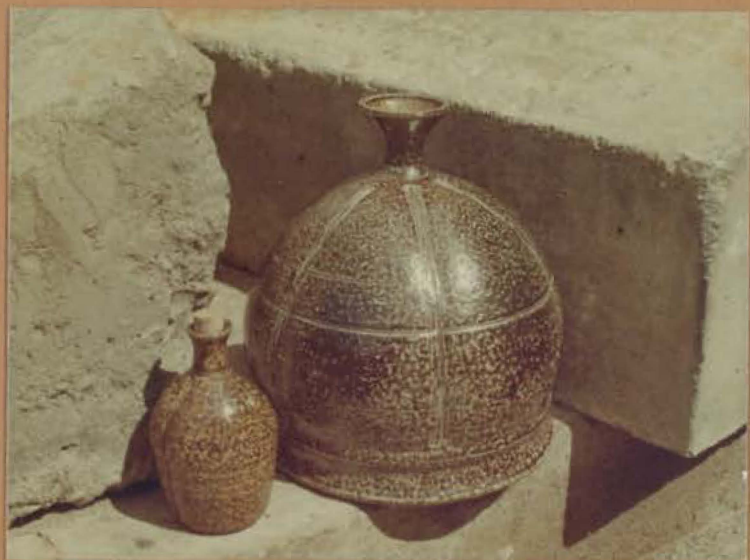
I tried muriate of potash (a commercial fertilizer) with some success. Introduction of the salt into the kiln is also an interesting problem. I have shoveled it in both wet and dry, bagged it and thrown it in, placed it in the kiln during stacking, and finally squirted it in as a brine solution. When firing a propane kiln similar to the one in this photograph (fig. 10), we found that the hot spot near the burners could be transferred to the colder region near the flue by squirting water in front of the burners. Dissolving the salt in this water (4-5 lbs/gallon) proved to be fitting as it put the material to be vaporized at the hottest place.

A Salt Firing in Progress



Vapor glazing facilitates working at large scale, as many of the handling and glaze application problems don't occur. I glazed the inside of this 16" bowl (fig. 11), and stacked it into a salt firing. With no foot ring to hang onto, normal exterior glaze application would have been awkward, but vapor glazing met that requirement of this form. Handling may be further reduced by loading green ware directly into the kiln and firing slowly to salting temperature (circa 2300°F). Since the materials in the clay body contribute the bulk of the glaze, altering the composition of the clay will produce a changed glaze at the surface. The apparent differences between these two pots (fig. 12), result from the use of two clay bodies. The bottle is stone-ware clay containing moderate amounts of iron, while the bowl is iron-free porcelain.





This bottle is also an example of compensation for temperature variations within the kiln. I added 15 per cent Lepidolite (a source of lithium and silica) to a regular stoneware body and fired several tests in the area in which I had achieved poor salting (near the flue) in previous fires. The large form, (fig. 13), made of the regular stoneware clay, was fired in a hotter spot. Both pieces show heavy glazing. Also revealed in these last two photographs is how the distribution of silica at the surface affects the appearance of the glaze. The stoneware clay tends to build a spotty glaze as the silica is distributed in patches. A more homogenous formation of glaze occurs on porcelain, due to the more even and denser arrangement of silica particles on the surface.

Moving from surface content to surface form reveals another opportunity (figs. 14, 15, 16). Since the glaze forms fastest at the points of greatest surface area, relief is accentuated rather than hidden.

9.

This fact can be used to great advantage by someone working at the small scale revealed in these three pictures.



FIRING RECORD

Note: The drawings will follow these conventions;



Most air
to
least air



Most oil
to
least oil



Hottest burning
to
coldest burning

To draw nearer to my project, I will trace the history of my work in relation to the kiln and combustion. During 1963 I set up a studio in Venice, California, with Mrs. Jane Heald. By January of the next year we had nearly exhausted the manufactured Alpine kilns we were using. The kiln pictured here (fig. 17), was built as a test model for the development of a larger design. The model was four cubic feet in volume using wood and natural gas for fuel. After three months of firing it, I had developed the confidence to begin a 75 cubic foot kiln (fig. 18), to be fired with natural gas. I was particularly anxious to achieve a longer firing cycle than the Alpine kiln afforded, and so I started with two layers of firebrick, and allowed for an additional skin of common brick if the cycle was not long enough. We sold the shop and I returned to the University of Oregon in the fall of 1964, leaving the kiln uncompleted.

Here I met Bill Welch, who returned with me to Los Angeles where we constructed this kiln (fig. 19) over Christmas recess for Mrs. Heald. The prime concern here was economy, which dictated the use of only one layer of firebrick, "seconds", backed up with two layers of common brick. The use of these minimal materials also determined that it should be easy to repair. It has since been rebuilt twice by the owner and a potter friend.

Bill and I designed the burners (fig. 20) for this kiln from plumbing parts. The chrome venturi (hero tubes) are from an automotive supply house. The flue draws cold air through the venturi where it mixes with the gas as they flow into the kiln to burn. This worked quite well, but for a tendency to blow out at very low settings.

19.



20.



The next experience was with a small (4 cubic feet) test kiln I built behind the Pottery in March of 1965 (fig. 21). In it I tried out a louvre burner referred to by David Stannard in a lecture.

The louvre plates were cut from one eighth inch steel plate to about 2.5 by 5 inches. They were arranged in a stack of four, staggered (towards the kiln) inside a brick tunnel (fig. 22). Stove oil dripped from a copper tube to the top plate where it either vaporized, or ran down and on to the next plate. I had trouble keeping the oil from running off the sides and rear of the plates. A red heat (circa 1500°F) was obtained. After several hours at this plateau, a fan was turned toward the burner pushing the kiln up to cone ten (circa 2380°F) where it was salted.

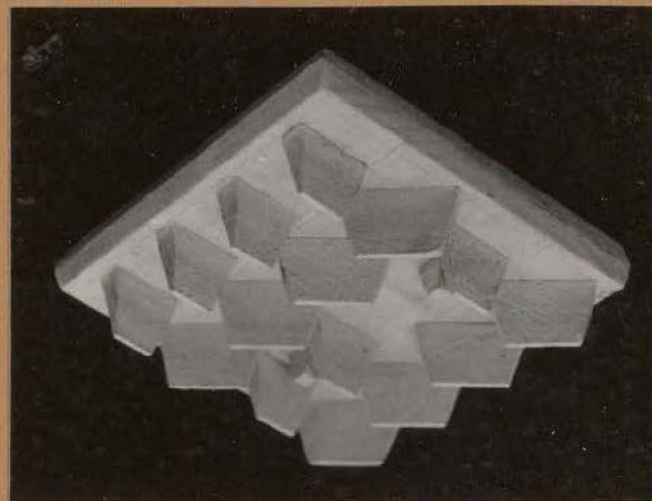
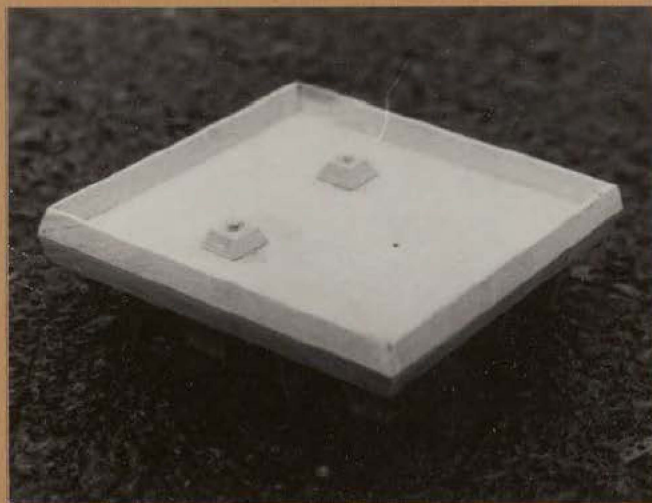
21.



22.



23.

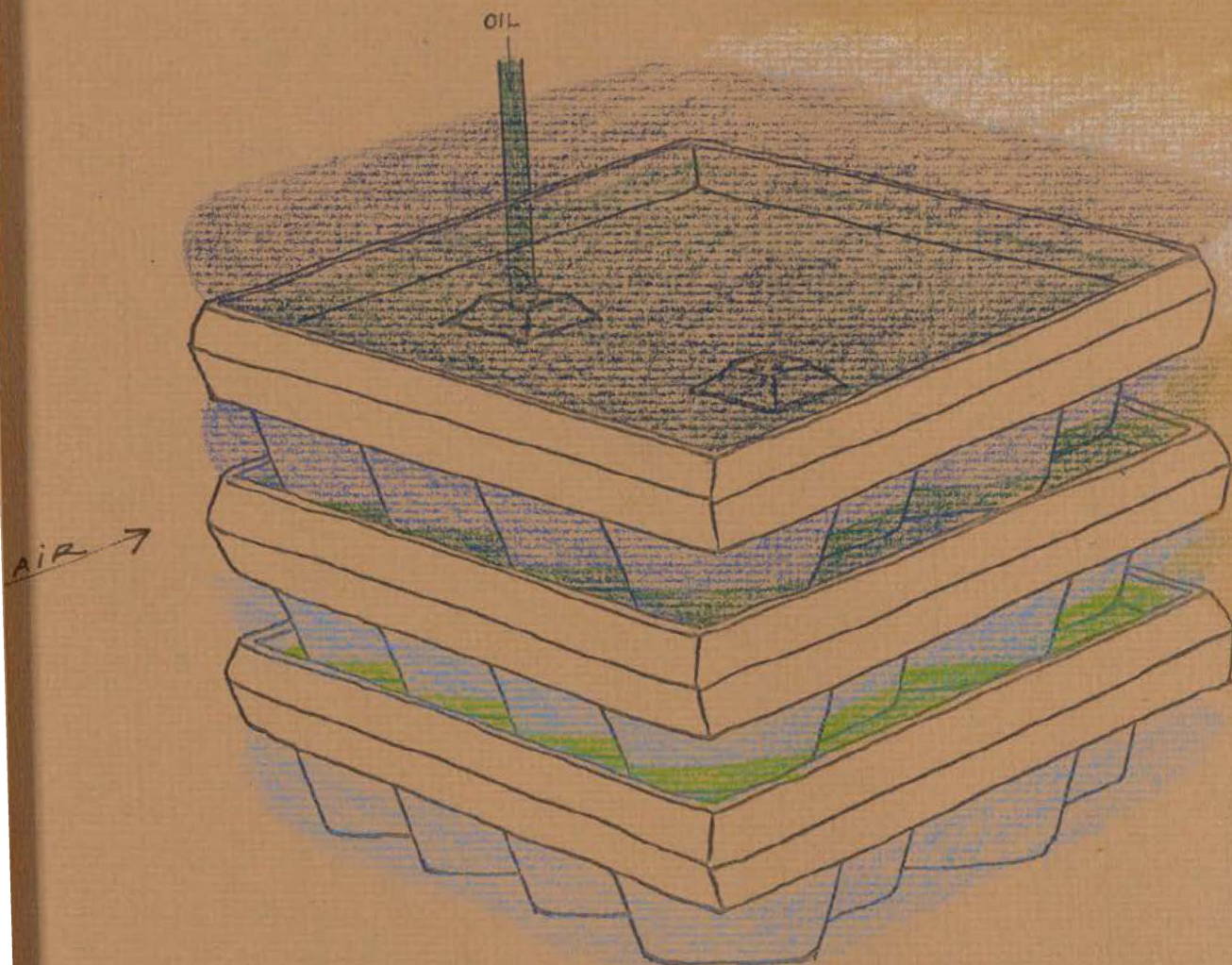


This design for a burner was in response to the preceding experiences. I made two wood models and had three copies of each design cast in iron.

The idea was to control the oil on the plate by means of the surrounding dikes and the two lugs cast into it (fig. 23). Since the dikes prevented oil from leaving at the edges, a "lake" of oil could be controlled by the height of the lugs. Alternate lugs were drilled through on each plate to let the overflow pass to each plate in succession.

To conduct the tests on this idea as well as the burners of others, I built a new kiln behind the Sculpture Bubble in May of 1965. Much of the form was given to pre-heating the burner. I thought I could accomplish this by routing the flue through the burner region.

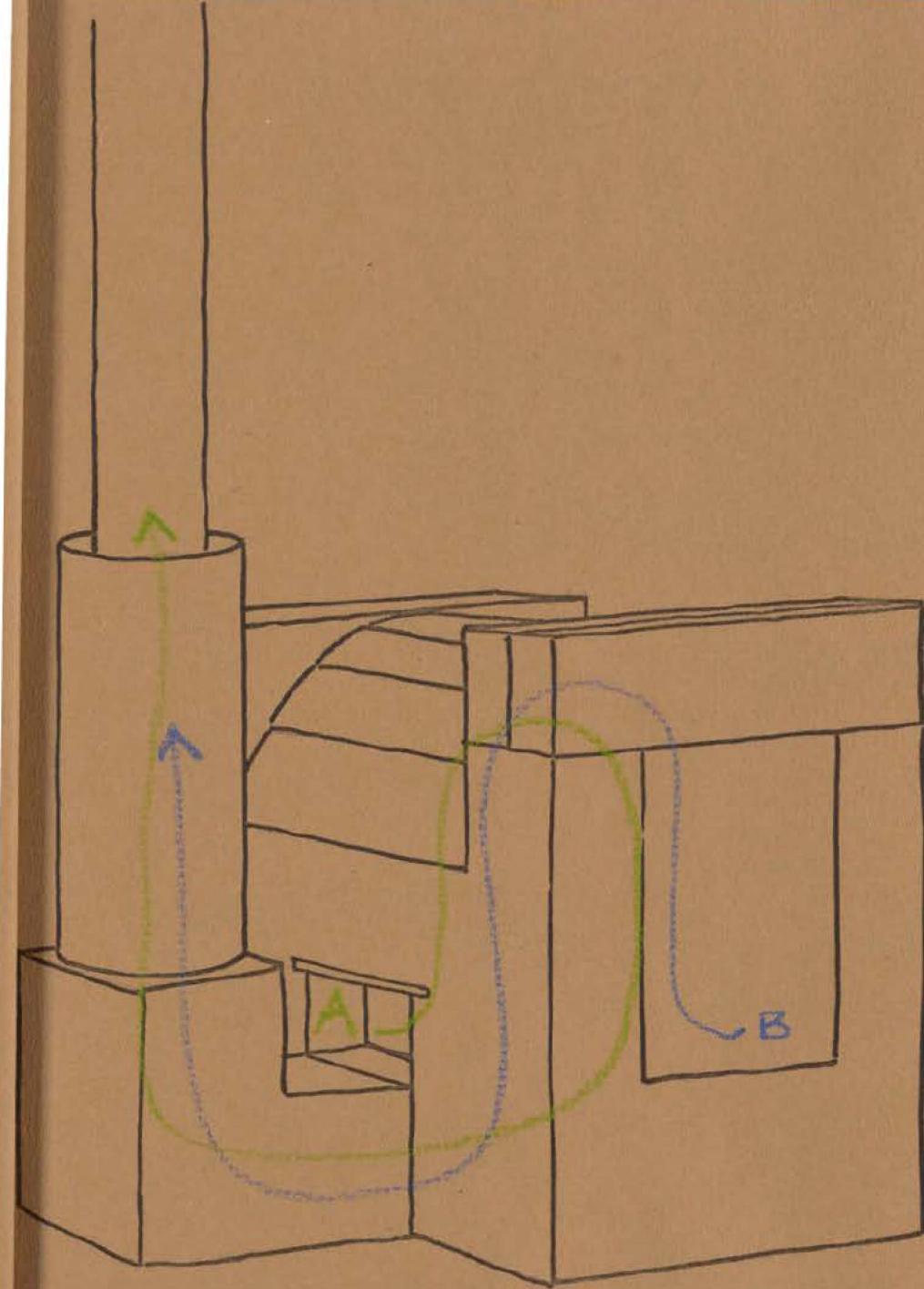
A Stack of Cast Iron Plates



When I began firing the kiln, with the burner located in position "A", oil leaked into the flue and the fire began burning in the entire burner area. After another try I decided to move the port to the other side of the kiln as in "B", abandoning the preheating idea for the present.

The fires attempted with this configuration showed me that as the plates developed their respective "lakes", this depth of oil cooled the surface, preventing efficient burning.

Red heat was reached on the last try, but the fire was completed with natural gas and salted. At night and when the kiln was at yellow heat, we could see cracks opening up at nearly every joint as the bricks expanded. This allowed cold air





to enter through the walls rather than at the burner. The next kiln included this thinking in its design by building a two-layer arch so that both horizontal and vertical joints were covered at the end walls and where they met the arch, a "rabbitted" detail was made.



Two flues were placed at the opposite end from the burner port to secure more draft and make it possible to control the direction of the flame as it moved through the kiln. Fires were attempted using the cast iron burner as a louvre plate (see page 20).



After several hours at orange heat, I again resorted to the fan for draught. Even then, the fire did not seem to progress and a skin of aluminum foil was laid over the arch and around the flue pipes. At once the kiln responded and approximately five hours later, cone eleven (circa 2400°F) was melted in the kiln.



However, as a test vehicle for natural draught oil burners, this kiln seemed not adequate. Subsequent analysis suggested that the double flue did help to control the direction of the gases, but did this at the expense of draught. There was a greater surface to volume ratio than with a single flue, causing more drag and less draught. This kiln was torn down to provide material for another kiln (illustrated on pages 6 and 22).

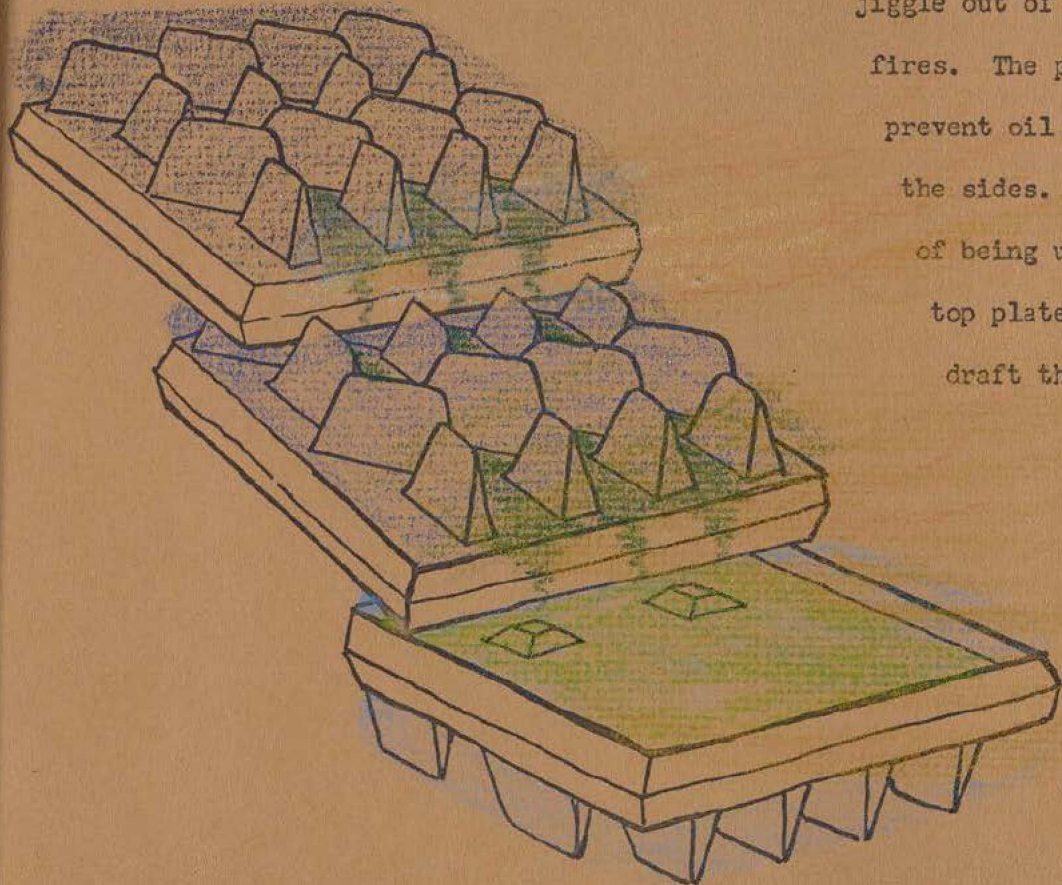
Cast Iron Plates Arranged as Louvre



Oil



Because the fins slowed the flow of oil down the plates, their pitch was increased from that of the previous louvre tests (see page 13). Due to their greater weight, these plates did not jiggle out of adjustment as in the earlier fires. The plates also had to be pitched to prevent oil from running, uncontrolled, off the sides. I was aware for the first time of being unable to get enough oil on the top plate to take advantage of the greater draft there.

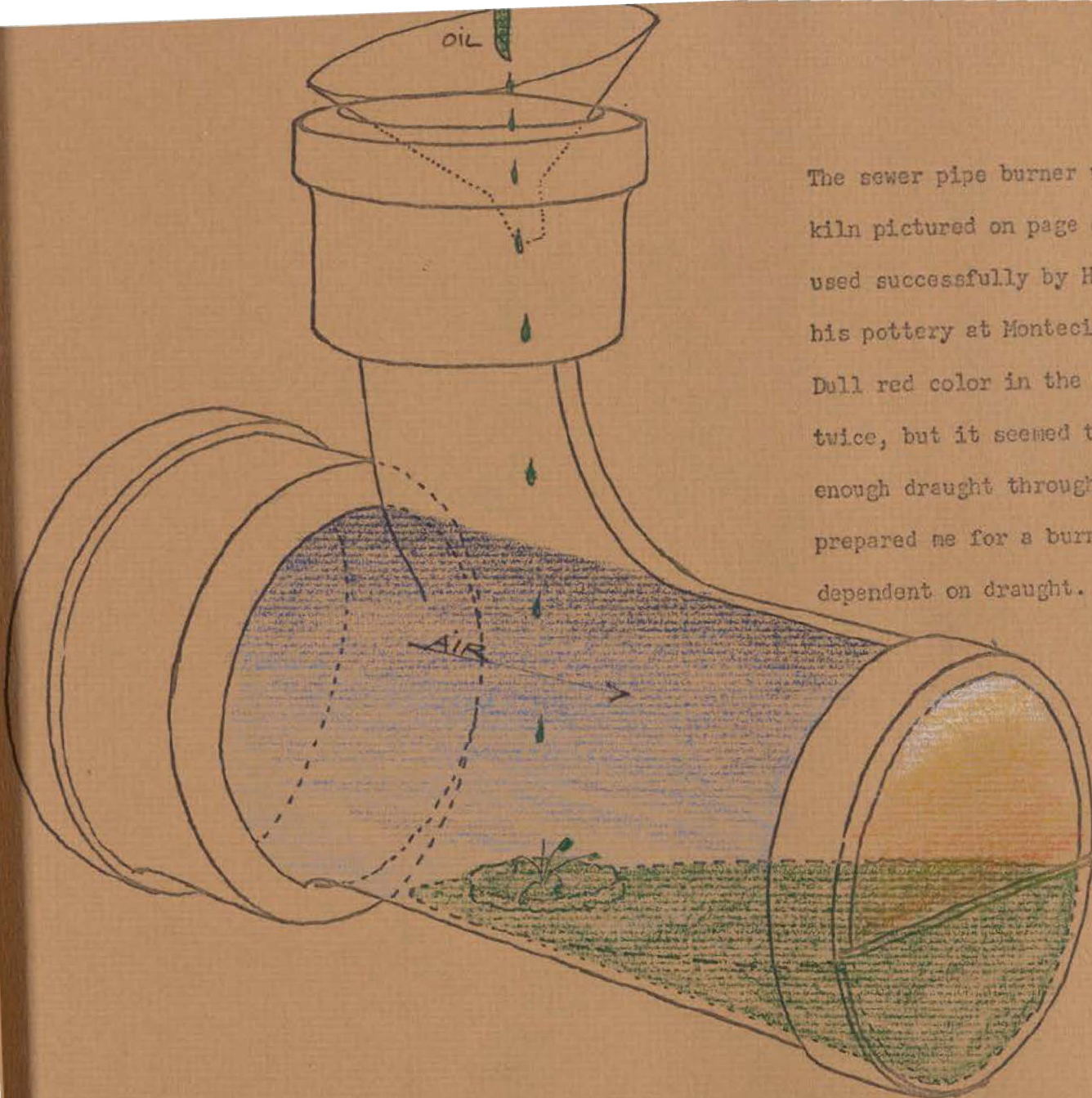


Salt Glazed Pots from the Steamboat Catenary Kiln



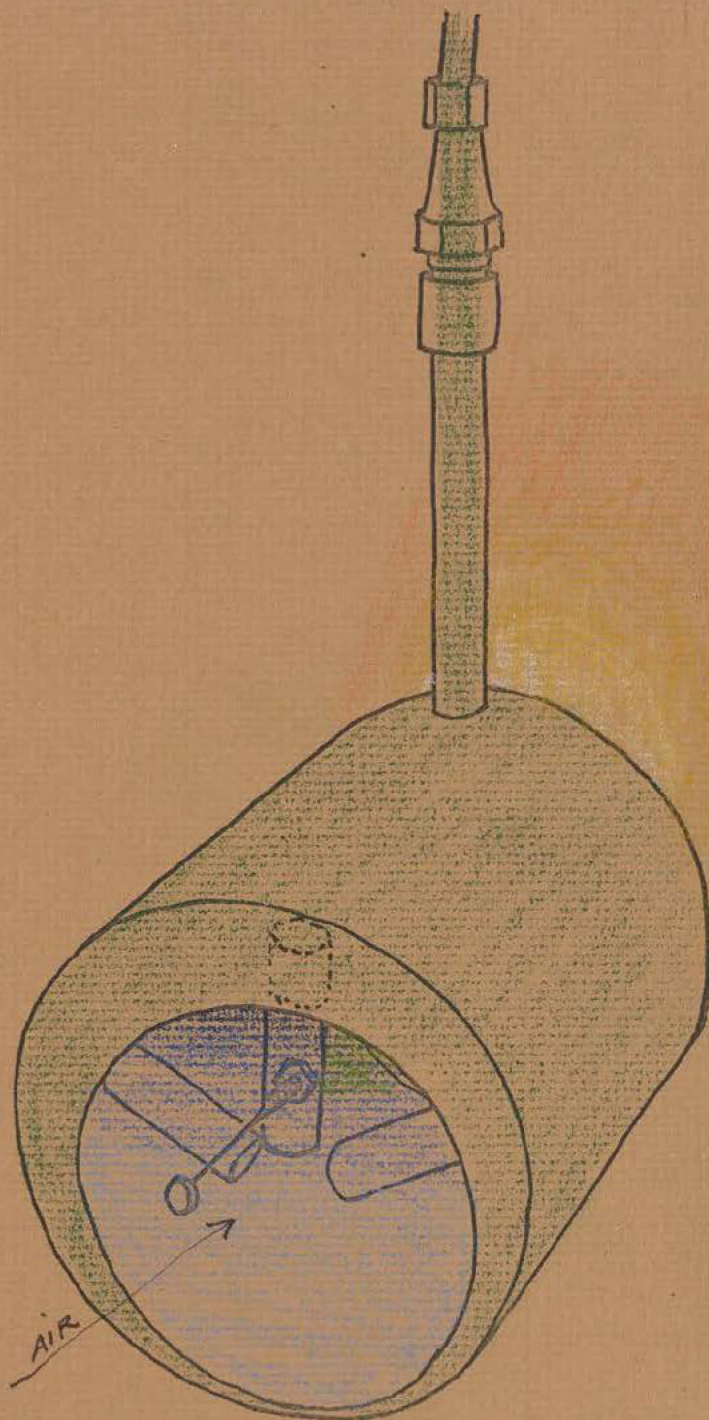
Sewer Pipe Burner





The sewer pipe burner was tried in the kiln pictured on page 6. It had been used successfully by Howard Guillard in his pottery at Montecito, California. Dull red color in the kiln was achieved twice, but it seemed there was not enough draught through the pipe. This prepared me for a burner idea not dependent on draught.

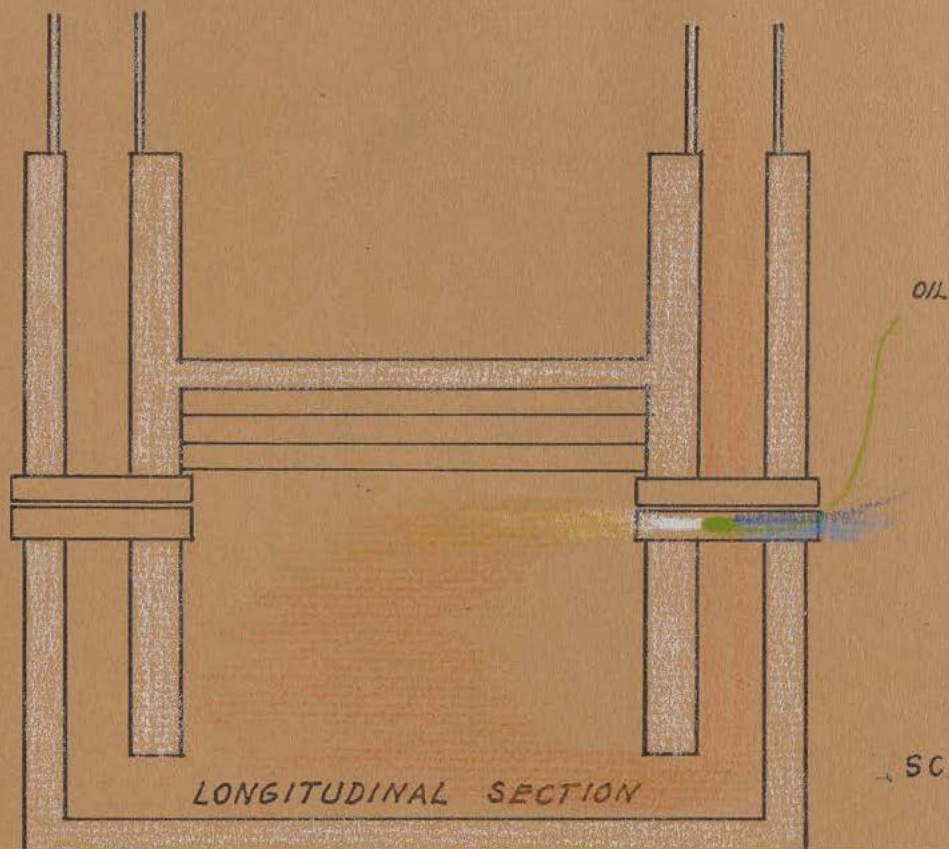




When Paul Soldner visited the pottery in the spring of 1966, he suggested trying something like a kerosene wood burner. I had one welded up from two pipes of the same length, but different diameters. Nested together with ends welded on, they formed an oil reservoir. The oil entered at the near end and was injected into the air stream through a needle valve from a model airplane engine. The fire thus heated the reservoir until all the oil was vaporized as it came out. The pressure in the fuel lines made it necessary to pressurize the oil tank to prevent vapor lock. A small air compressor was more than adequate, causing the tank ends to bulge excessively under 30 p.s.i.; I halted further tests. This burner put out a very hot flame in a matter of minutes but the accomplishment promised to be more expensive than I could underwrite at that time.



In March of 1967, Bruce Finch and I built a kiln at the Hudson ranch. Harrick Hudson had successfully developed a small natural draft burner, and we wanted to try to scale it up. The burner was located so that the hot gases passed around it on their way up the flue. In practice, we found that while the first part of the fire was very slow, when the exhaust gases were hot enough to cause the oil in the burner tubes to vaporize, the temperature rose rapidly. Building a small fire in each flue was found necessary to establish draft at the beginning. This design depended (for success) on the relation between "burner" and kiln. Some idea of the proportions may be drawn from the following pages.



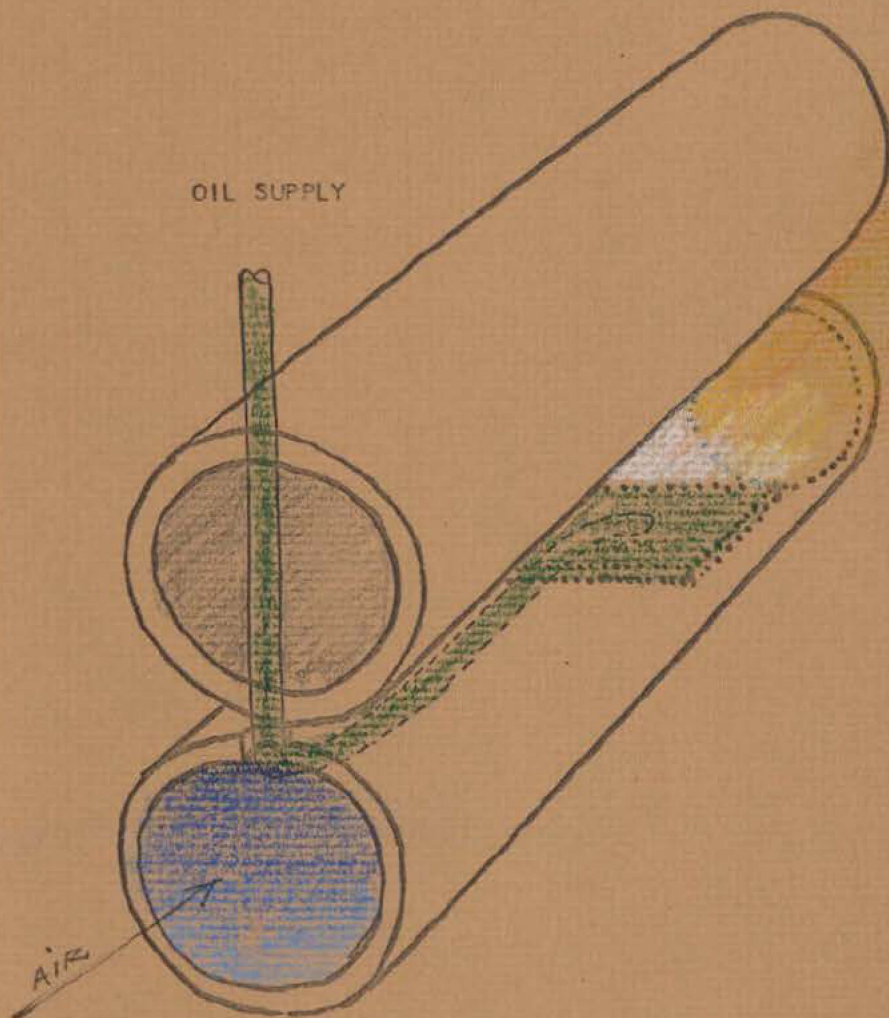
SCALE : $\frac{1}{2}" = 1'-0"$



Detail of Hudson Burner
(bricks have been removed)



OIL SUPPLY



The oil was directed to a small sponge-brick "wafer", which was placed inside the bottom tube. As the fire progressed, the wafer was moved further inside the tube to take advantage of the heating effect of the gases surrounding the tube. The upper tube was used for salting the kiln.

30.

PROJECT

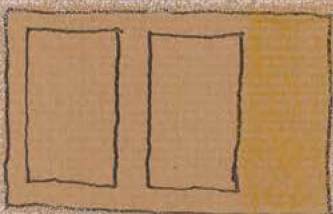
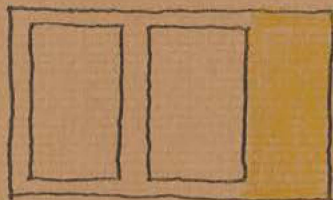
THE TERMINAL PROJECT

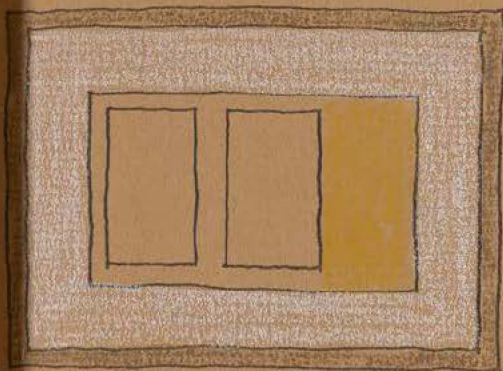
An Oil Burner for a Pottery Kiln.

At this point, resolving questions surrounding a simple oil burner became the intention of my terminal project. In each of the preceding oil fires, the kiln was potentially subject to as much experimental variation as was the burner.

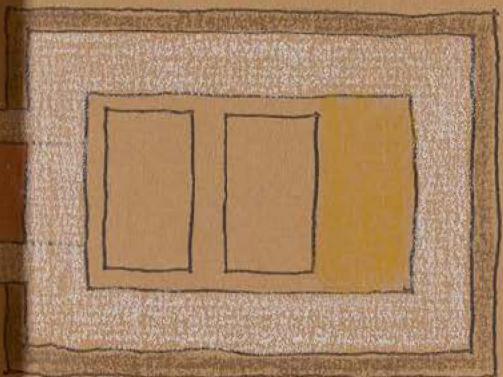
To focus my attention on the burning, I drew only the "safest" information from these kiln experiences to build the most conservative kiln I could imagine. It was proven through previous firing that only one burner idea could be tried per fire, as even a small adjustment in the design altered the basic idea. This requirement for frequent firing established that the chamber be small enough to minimize the demand for ware and loading time. A space of twelve to fifteen cubic feet in two tiers of shelving, with an additional five cubic feet for fire box, seemed suitable.

Since this amount of ware did not constitute much mass to absorb heat from the passing gases, I used nine inch, hard firebrick walls to serve as a heat sink. This was employed, like a flywheel, to moderate sudden changes in the fire.





To contain this heat, three inches of magnesia block insulation was used. This kiln is like the hummingbird, who with a high ratio of surface to volume, devours quick burning foods to stay alive; while the elephant enjoys a much slower metabolism due to his correspondingly lower ratio of surface to volume. Thus the elephant needs no feathers.

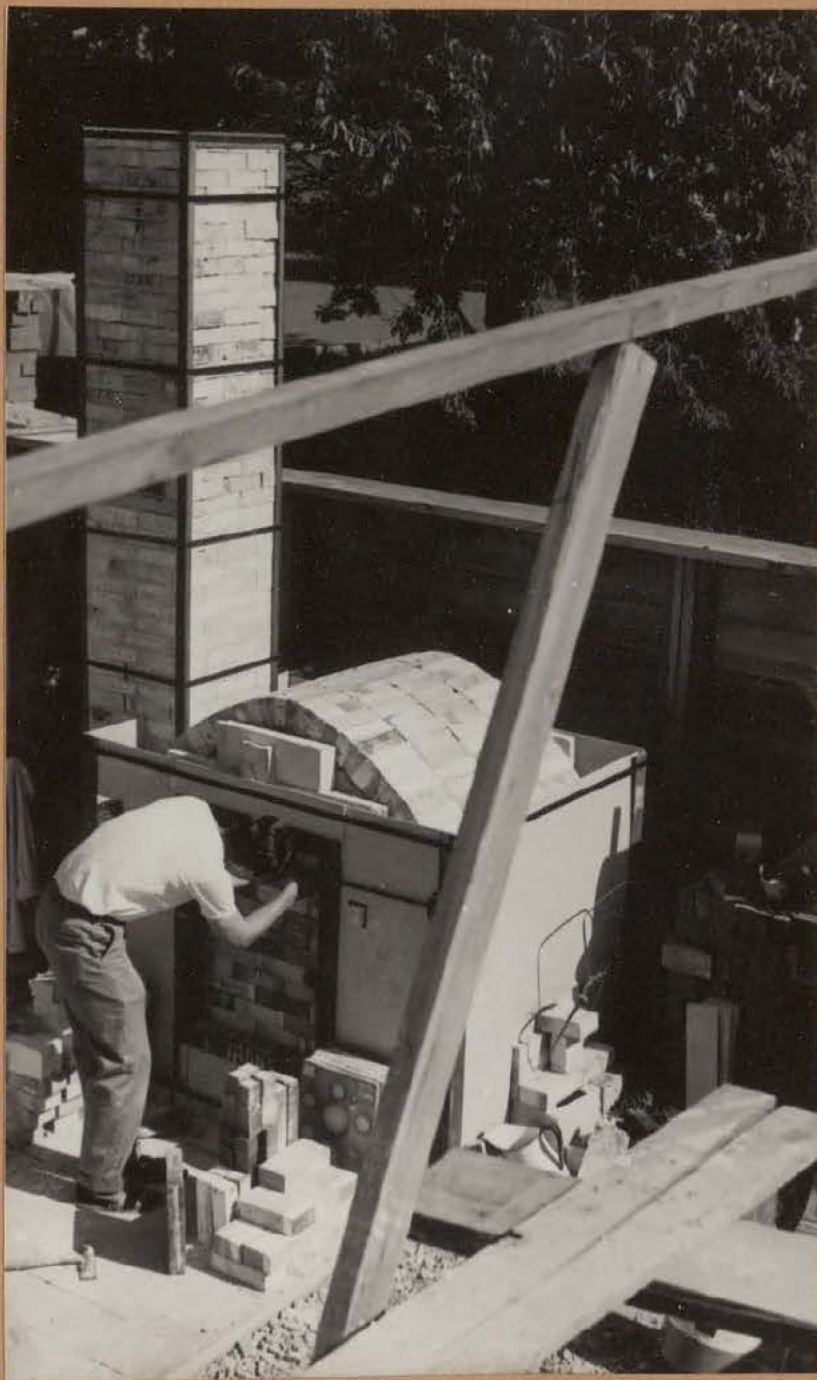


In all kilns made of brick, unit size is a factor in determining overall dimensions. Given standard firebrick, the possible variations in proportion become fewer as the kiln gets smaller. So I rented a brick saw to control the size of the brick, a particular necessity in the construction of the flue. 120 square inches was decided for the flue area, which could not be built square unless bricks were cut. A rectangular form was considered as a possible alternative, but was discarded because it would have a greater surface to volume ratio, and consequently more drag on the escaping flue gases. There was also a gain in the precision afforded by cutting, rather than breaking, the brick.

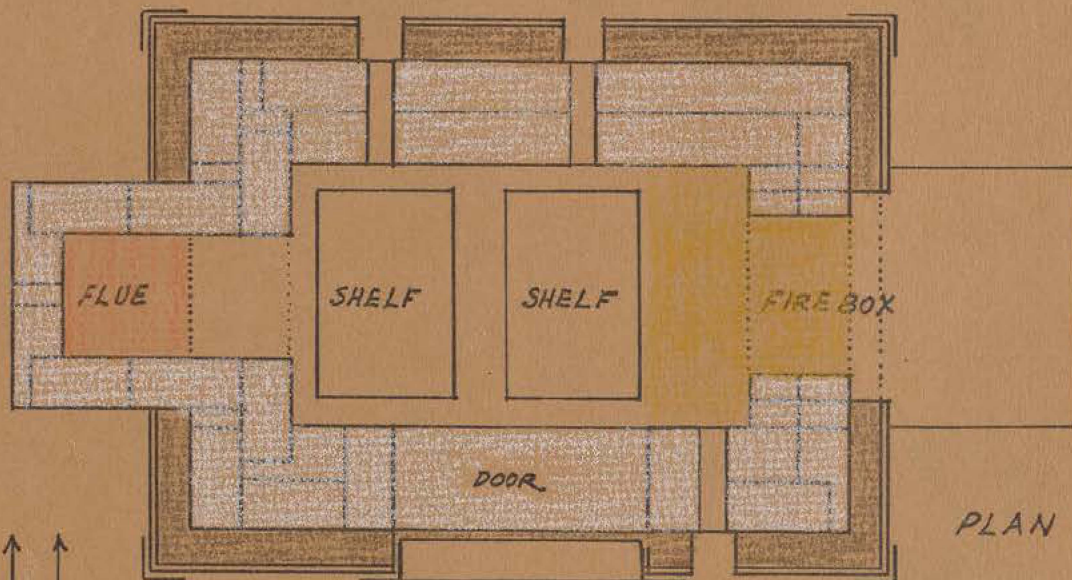
To control the movement and content (relative amounts) of the gases as they move from burner to flue, it is vital in the construction of kilns to block extraneous circulation through the walls. To do this, I lapped all vertical joints, made clean cuts with the saw, insulated with block type material, and covered all except the door with one fourth inch sheets of transite held in place by a three inch angle iron cage. These conservative measures, by concentrating the draft, permitted a closer relationship between the kiln and the burner. Then the door remained the only source of leaks, probably accounting for the fact that in early firings, this side of the kiln lagged two to three hundred degrees behind the other parts of the kiln, even when a third layer of brick was added to the door. For me, the experience has validated the concept that twenty, 5 % improvements make one hundred per cent.

The kiln was constructed in the "Pottee" (a fenced yard), across the Millrace from the Science Building.

Stacking the door of
the "Pottee" kiln

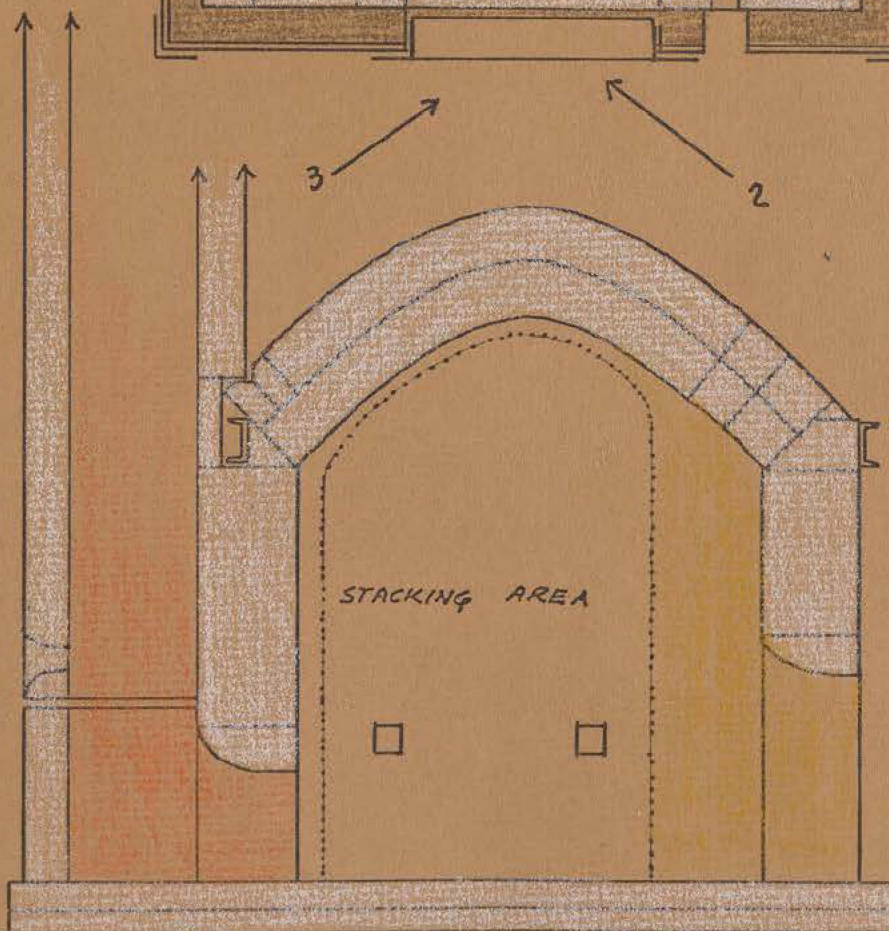


1 →



← 4

PLAN VIEW



LONGITUDINAL SECTION

SCALE : $\frac{3}{4}" = 1'-0"$

FOLLOWING THE PLAN ON THE PREVIOUS PAGE:



View One shows the 3/8" steel damper which slides in and out to control the exit of gases. Just above it is the hole for mounting a small propane burner for preheating the flue.



View Two is looking toward the flue opening from the door side of the chamber. An alumina shelf, used to support the ware, is visible just below the peephole.



View Three is taken from the same position, but looking toward the firebox. The white brick, set in at angles, diffuse the incoming gases.



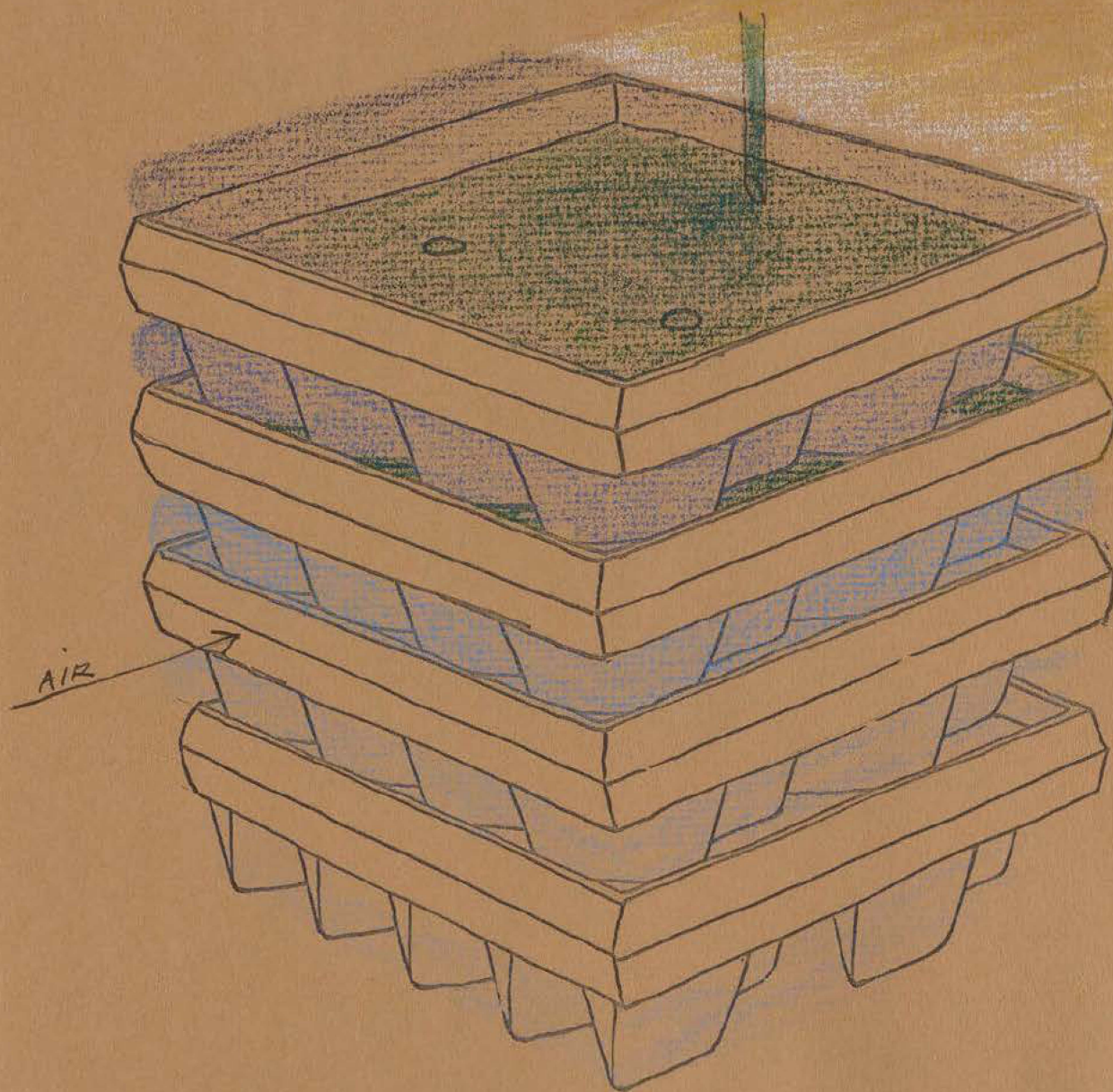
View Four records the burner area as set up for the burner on pages 38, 39, and 40. The syringe is used to affect the heat transfer described on page 6. The hole above the burner was also used as a salting port.

Revised Stack (see page 15) of
Burner Plates



oil

38.



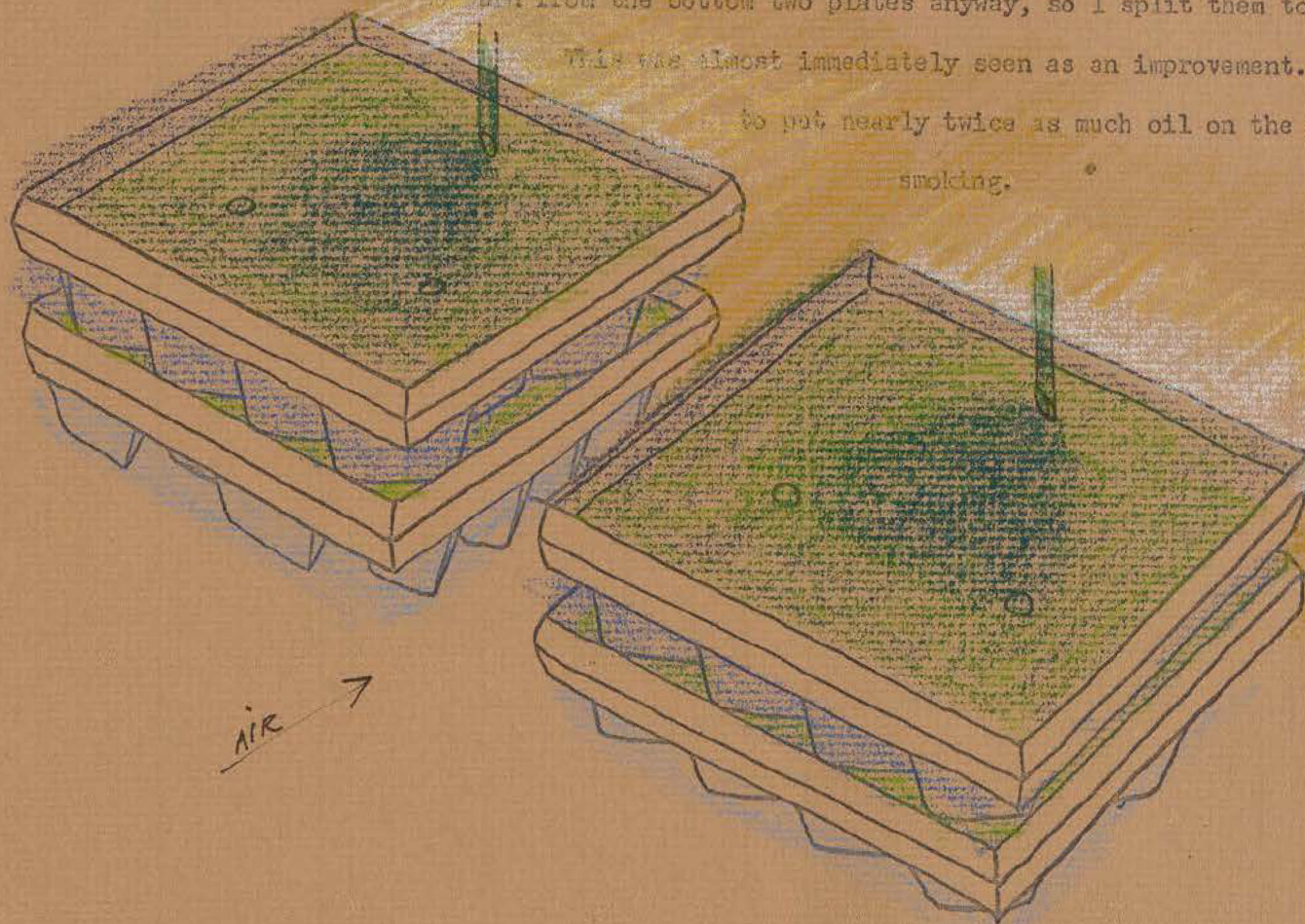
This drawing shows how the original plates (see page 15) were modified. The lugs were removed and larger holes were drilled. This burner arrangement was fired to about 2000°F. The oil burned clean when only two plates were full. As the flow of oil was increased to three or four plates, the fire became smoky. This suggested the changes as seen in the next drawing.

Tandem Stack of Plates



I decided to try to distribute the draught over more burning oil by making the assembly lower and wider. In the last try (see page 38) I couldn't get the oil to burn from the bottom two plates anyway, so I split them to make two burners.

This was almost immediately seen as an improvement. It was possible to put nearly twice as much oil on the plates without smoking.



AIR →

41.



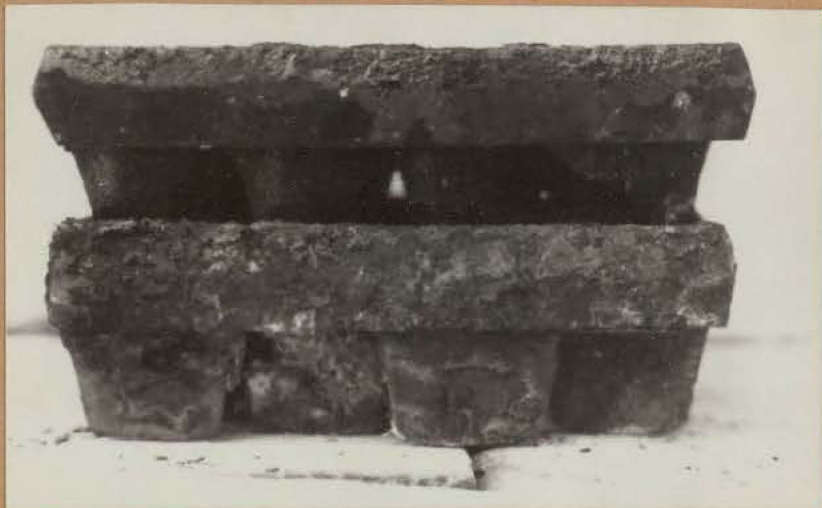
This view of the burner on the previous page shows the use of firebrick wedges to concentrate the draught at the supply of oil.



Some ware from one of the firings.



The conservative design of the kiln allowed a very long cooling cycle, which probably accounts for the growth of these crystals.



When the ribs of the bottom plate are turned this way, the incoming air is directed to the top plate, where most of the oil is.



When turned 90°, the bottom plate's fins let the air through, relieving draught at the top plate.



The pyrometer records changes in the flue temperature for more accurate information in appraising the effect of adjustments at the burner.



The salt glaze on this cup thins out at the foot, where the vapor could not reach the clay.



Three pots from a successful salt firing. This plate reveals the flame path of this kiln. In anticipating a heavier deposit of salt on the side facing the burner, the kiln and its burner may become part of the potter's "palette".



IN SUMMATION:

44.

The development of such a conservative kiln with its consequent draft has permitted me to see into the relatedness of its tools, construction, materials, proportions, valves, and burners. As any of these are adjusted, the performance will change. The natural draft kiln and its fuel distribution system must respond to each other as a unified process to reach elevated temperatures. Recognizing this integrity, and then assimilating it, by making it work, is an exercise likely to have continuing value for me.

The real fruits of my studies



are the questions which remain.

CHRONOLOGICAL SUMMARY

<u>Date</u>	<u>Location</u>	<u>Type</u>	<u>Burner</u>	<u>Page no.</u>
January 1964 . . .	Venice Potshop	small test kiln . . .	gas/wood	11
March 1964	Venice Potshop	large stoneware . . .	gas.	11
December 1964 . .	Pacific Palisades, L.A. . . .	medium stoneware . .	gas (hero tube)	12
January 1965 . . .	U of O Pottery	small test kiln . . .	oil (louvre) . .	13
May 1965	U of O Sculpture Bubble . . .	salt kin	oil (cast plates)	16
July 1965	U of O Pottery	"steamboat" kiln . .	oil (cast plates)	17
October 1965 . . .	U of O Pottery	salt kiln propane . .	oil (sewer pipe)	22
April 1966	U of O Pottery		oil (pressure type)	24
March 1967	Hudson Ranch	salt kiln	Hudson burner .	26
March 1967	U of O "Potteeo"	oil/salt kiln	stack of plates	37
			tanden stack . .	39
			air change . . .	42
June 1967			Summation . . .	44

Thanks to Verne and Dick for their
help in the "Pottee". Bob and David
for the opportunity, and the coaching.
And to Mona and Bev, thanks.

