

THE CUPOLETTE

**A Basic Guide to Construction,
Installation and Operation**

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INTRODUCTION
(from *Casting Iron* by C.W. Amens)

Before you can begin casting iron, you must have a method of melting the iron and super heating it to a temperature that is sufficiently hot and liquid enough so that you can successfully fill the mold cavities.

A cupola is a domed roof, cylindrical shaft-type blast furnace used for remelting metals (usually iron) before casting, (the cupolette is basically a small cupola with some changes that will be discussed shortly). The cupola is primarily a shaft-type furnace used to remelt pig iron and ferrous mixes in direct contact with the fuel in a continuous operation. It can be used as a batch melter (single tap) and is not solely relegated to melting cast iron; red metals, copper, brass and bronze can be readily melted in the cupola. Nevertheless, it's basic use is for melting gray iron.

Cupolas vary in size from the minibatch melter of a few hundred pounds (the cupolette even less) to those with a 50-plus-tons-per-hour melt capacity. Countless people over the years have come up with all sorts of designs, re-designs, modifications, etc. The cupola's charge consists basically of pig iron, scrap iron and scrap steel. Its purpose is to melt the charge. It is basically a vertical refractory lined stack, that you charge with alternate layers of fuel (coke) and metal, with suitable openings (tuyeres) near the bottom in which you introduce blast air for combustion. Each charge of metal is melted by the heat produced by the layer of fuel below it (when it reaches the melting zone in the stack). The fuel that melted this charge is replaced by the coke above it with its charge of metal to melt. The molten metal descends down through the coke bed below the tuyeres in the form of droplets and collects in the well. When sufficient molten metal is collected, it is removed from the well by tapping it into a ladle. If you continue to add or replace these layers from above the operation becomes (more or less) continuous, (however, the greatest difference between the cupola and cupolette - aside from the size - is that a cupolette does not possess a hole to remove accumulated slag and continual operation would not be possible).

It must be noted that this is a basic manual of construction and operation. It is assumed that anyone attempting these procedures is already familiar with general foundry operations, processes and terms.

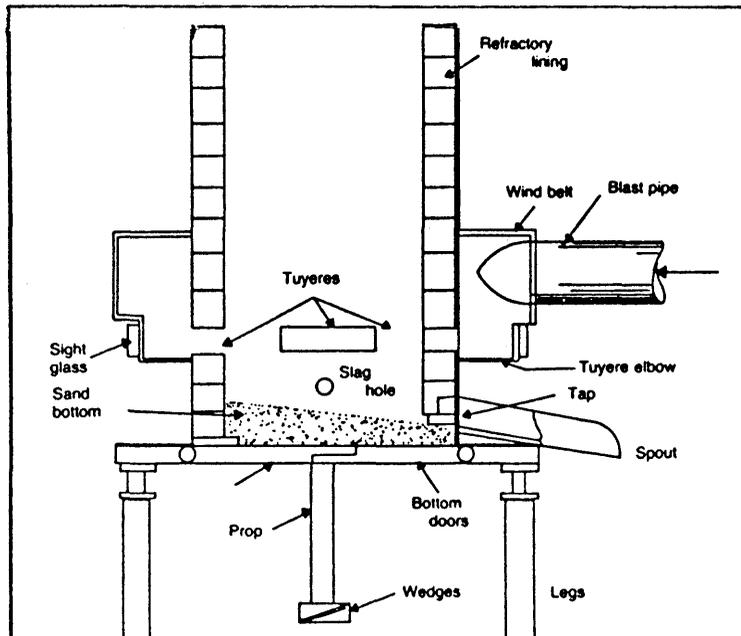


Fig. 1. C. W. Amens' Cupola, from *Casting Iron*.

CONSTRUCTION

- I. Review the construction and specification diagrams in Appendix I.
- II. This design can be considered in terms of:
 - A. The Stack, (including the top lid).
 - B. The Well, (including the wind-belt, tuyeres, blow pipe, breast and spout).
 - C. The Table, (including the drop door).
- II. With the stack and well steel shells constructed, it is time to ram in the refractory lining.
 - A. Use: AP Green "Super G Plus" refractory.
 1. Available at a foundry supply. (See Appendix IV, Resources).
 2. This design requires approximately 900 lbs.
 - B. Use secondary steel inserts to form the inside dimension of the stack and well. The refractory walls should be 3 inches thick, so with this design the outside shell diameter is 22 inches and inside diameter is 16 inches.
 - C. Considering the weight of the shells, inserts and refractory this procedure is best done on the floor. I dusted the concrete floor with silica sand to act as a separator. Secure the outside and inside shells.
 - D. For the well section, use wooden inserts to establish the tuyere dimension (3 x 3 inches) through the refractory wall. The refractory will be rammed around the wooden inserts. See Figs. 2 and 3.

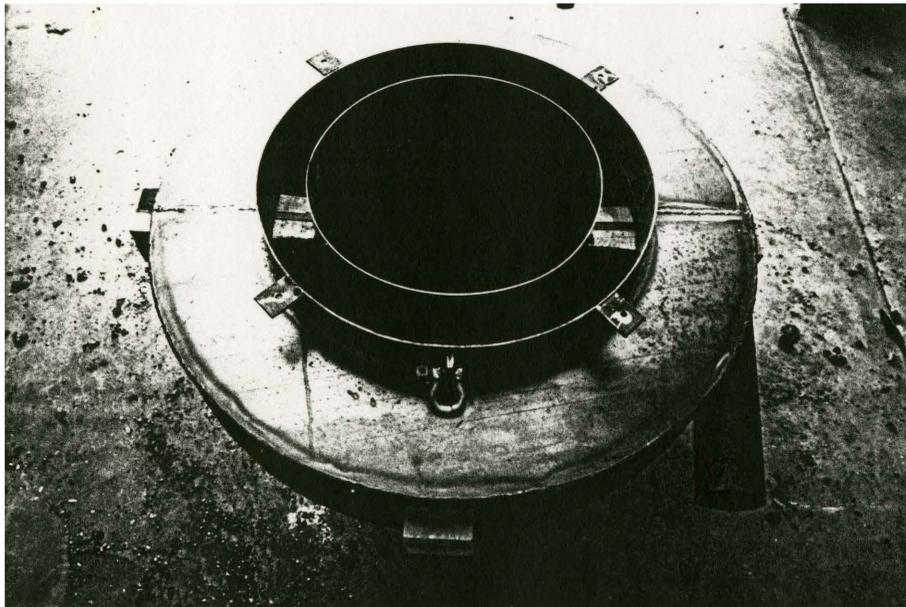


Fig. 2. The well section ready for refractory lining. Note the relation of the inside and outside steel linings and the blocks that when removed create the tuyere openings.

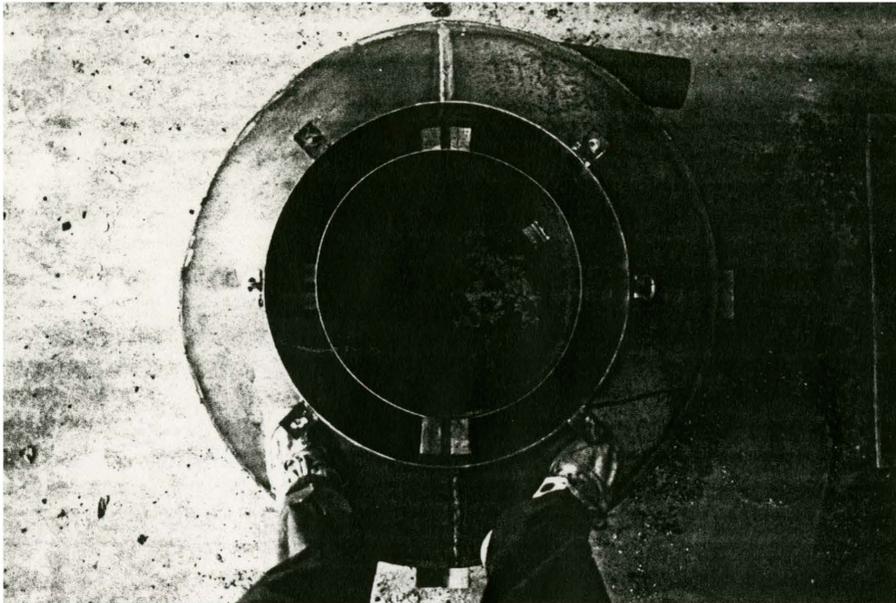


Fig. 3. The well section ready for refractory lining.
Note the use of wooden forms to establish the tuyere openings.

- E. Begin ramming procedure of the refractory.
1. Open one box of AP Green at a time, break the semi-soft blocks into smaller chunks and drop into liner area.
 2. Use two-by-fours to thoroughly compact all material.
 3. Bring just up to top of liner forms, leveling carefully. Repeat this procedure for both the well and stack sections. See Fig. 4.
- F. Allow to set 48 hours covered in plastic, then 3-4 days uncovered.

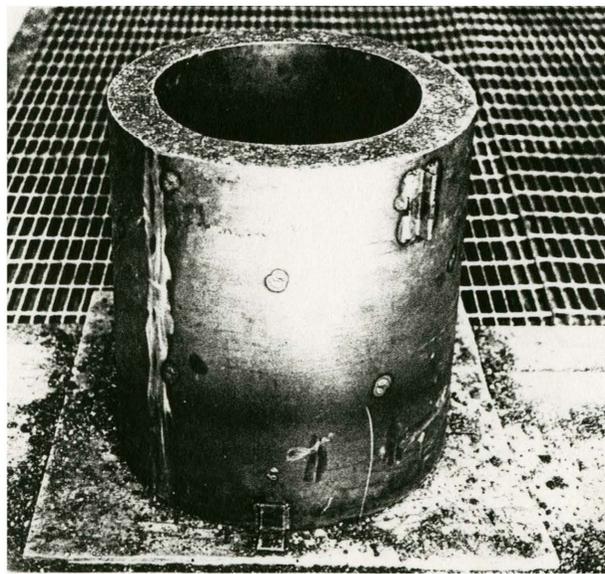


Fig. 4. Stack section properly rammed with refractory.

II. Cure the Refractory.

- A. Carefully stack both sections and lid on top of a floor furnace and ignite (with considerable caution).
- B. Candle for 4 to 6 hours.
- C. At 2 hour intervals bump up heat, total 8 hours, to a dull red glow.
- D. Shut down, brick top hole, stuff tuyeres with Kao-wool, cool slowly.

III. Stacking (installation) of cupolette.

- A. Select location carefully. Consider:
 1. ventilation: outdoors is good, though a simple overhead roof is ideal for shelter from elements.
 2. evacuation: in case of mishap, have plenty of escape room.
 3. pouring floor space, (in front of furnace) and tool space is essential.
 4. proximity to coke and material bins essential.
 5. control of blower power essential.
- B. Stacking procedure:
 1. secure, level table.
 2. use Blastpatch 85 cement as mortar between the three sections. Roll into "worms" 1 inch in diameter, dust with silica, see Fig. 6.
 3. place, level well section on table. Bolt securely through L brackets.
 4. place, level stack section on will. Bolt securely. See Fig. 5.

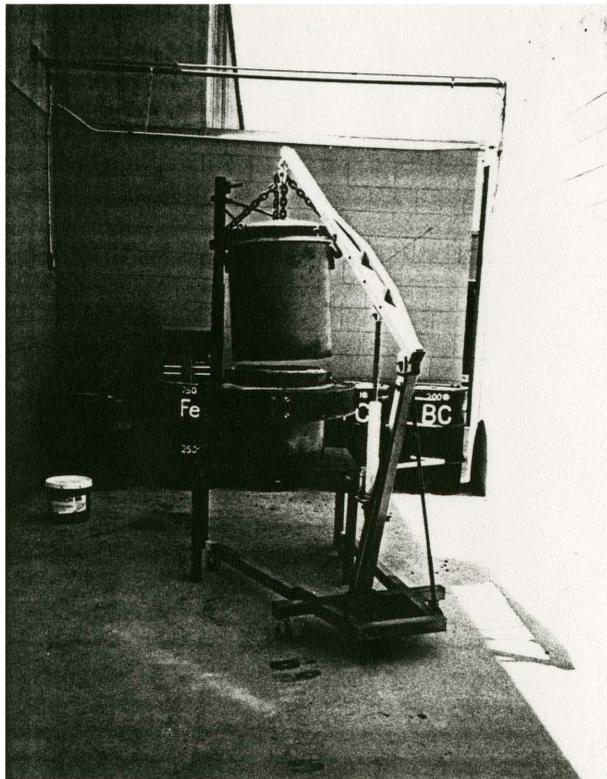


Fig. 5. Assembly of well and stack sections in "permanent" location.

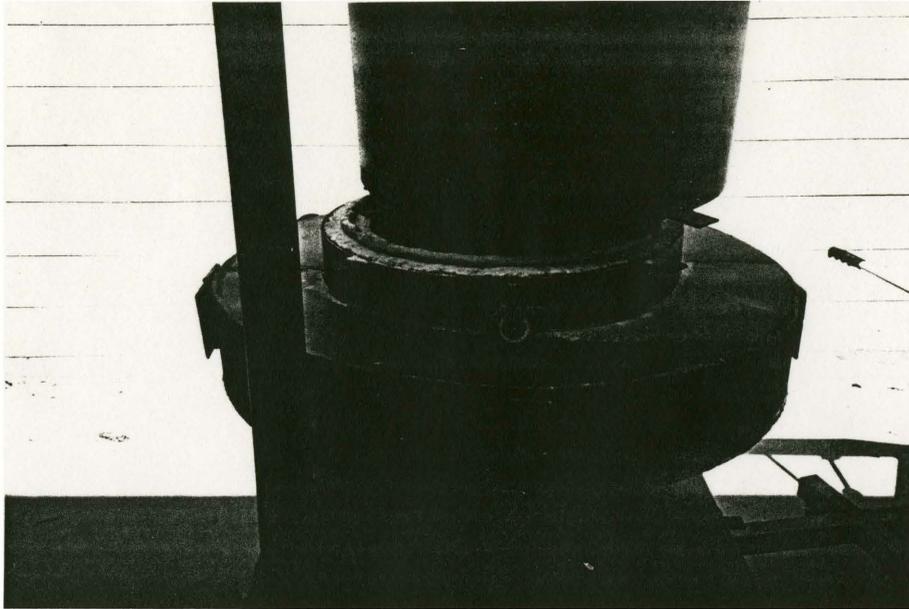


Fig. 6. Connecting stack and well sections.
Note crane hooks, "L" bracket bolting tabs,
and Blastpatch 85 "worms" for mortar between sections.

IV. Blower Assembly.

- A. Requirements, (minimum):
1. 2 horsepower electric motor with on-off switch near furnace.
 2. 3500 rpm.
 3. 600 cubic feet per minute.
 4. 4 inch flexible steel hose from blower to furnace, (8 to 20 feet long).
- B. Intake at blower should be adjustable for proper mixture.
- C. Blower hose connected to cupolette and blower by steel gear clamps.

PREPARATION FOR IGNITION

- I. Review the "List of Tools" and "Preparation Schedule" in Appendix II.
 - A. Place, prepare:
 1. tools.
 2. attach blower hose.
 3. dump "protective" sand under furnace, spout and around table legs.
 4. Bed Coke (softball size coke).
 5. Fuel Coke (briquette size), store in buckets.
 6. weigh 100 # batches of crushed iron, store in buckets.
 - II. Prepare Cupolette Bed, (Review "Recipes" in Appendix III.)
 - A. Close, secure and wedge bottom door.
 - B. Drop sand mixture in from top, careful not to disturb door.
 - C. Tamp with wooden tool to form shape and slope:
 1. when looking through the breast hole the bed should begin at bottom edge of hole and taper upward at an angle which sites a level line from the top of the hole to the back inside wall of the furnace.
 2. with fingers, through breast hole, carefully make an indentation in the bed sand. This depression will hold and show the first drops of molten iron before the breast hole is botted and keep the breast warm between heats. It should contain approximately 1/4 cup.
 3. pack bed sand to firm and smooth. See Figs. 7 and 8.

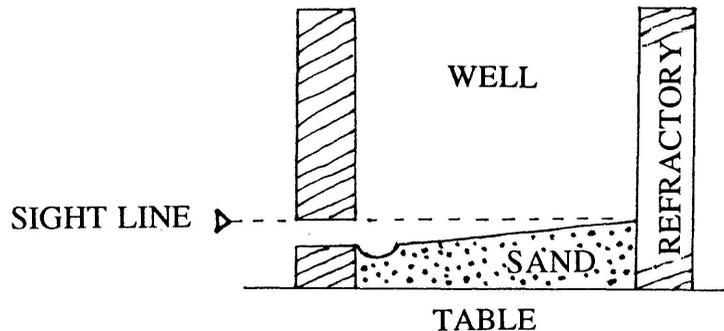


Fig. 7. Slope of Bed, note "site" lines.

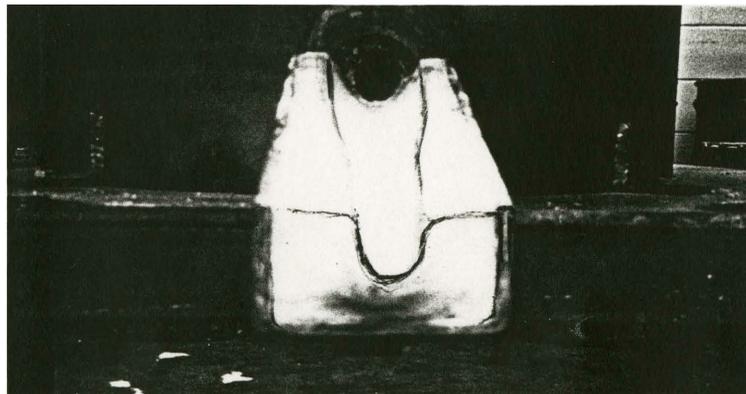


Fig. 8. Spout, Breast Hole and Bed relationship. Note site to rear wall.

III. Set Bed Coke:

- A. Place a board (1 x 6 x 14 inches) on bed, from breast hole to back wall, this will protect the fresh bed during burn-in.
- B. Make a "tunnel" of Bed Coke (3-4 pieces each side, 6-8 on top and 1 or 2 against back wall) around and over board. This tunnel will encourage proper and thorough ignition, see Fig. 9.
- C. Add rest of bed coke to long gauge height or 18 inches from top of stack.

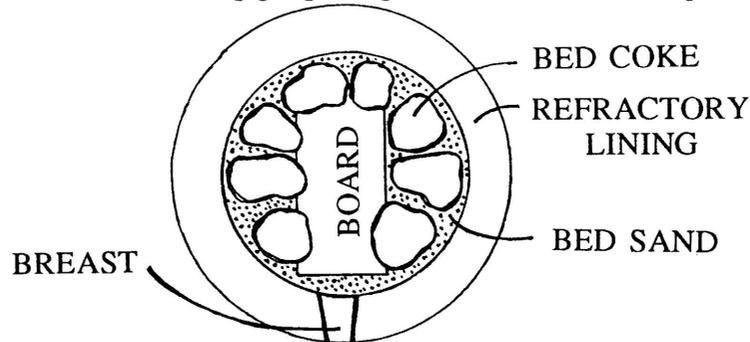


Fig. 9. Bed Coke board and "tunnel"

IV. Ignition of Bed, (approximately 2 hours prior to pour time)

- A. Check condition of bed and tunnel through breast hole.
- B. Open all tuyeres.
- C. Place lighted propane torch on stand and just inside breast hole, (time: 10:50am) begin with propane on low, advance to high in 30 minutes, see Fig. 10.
- D. Periodically check advancement of coke ignition:
 1. coke will begin to glow and burn.
 2. check at breast hole, (breast will turn orange in approx. 1 1/2 hour).
 3. check at tuyeres, open tuyere if hot spot develops, or close if cold spot develops.
 4. check back, outside wall of furnace for excessive heat.
 5. proper burn-in is achieved when top bed coke is evenly lighted and breast hole glowing. This assures quick, even melt and pour.
- E. Combustion of coke under blower power:
 1. remove propane, close lid, tuyeres and turn on blower for 15 minutes.
 2. open lid, fill stack with fuel coke, close and turn blower on again, burn fuel coke down to short gauge level (14") this assures coke ignition.

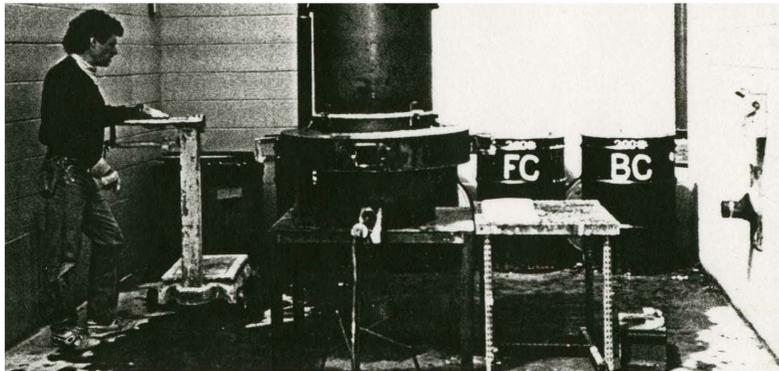


Fig. 10. Propane torch burn-in. Note open tuyeres, "charging" deck, scale for weighing charges, barrels of bed coke, fuel coke and iron.

CUPOLETTE OPERATION

I. Charging the Furnace, (time: 12:45):

- A. Turn blower off, open lid and check fuel coke height, add if necessary.
- B. Add first 100# iron charge, level out, see Fig. 11.
- C. Close lid, turn blower on, (time: 1:50).

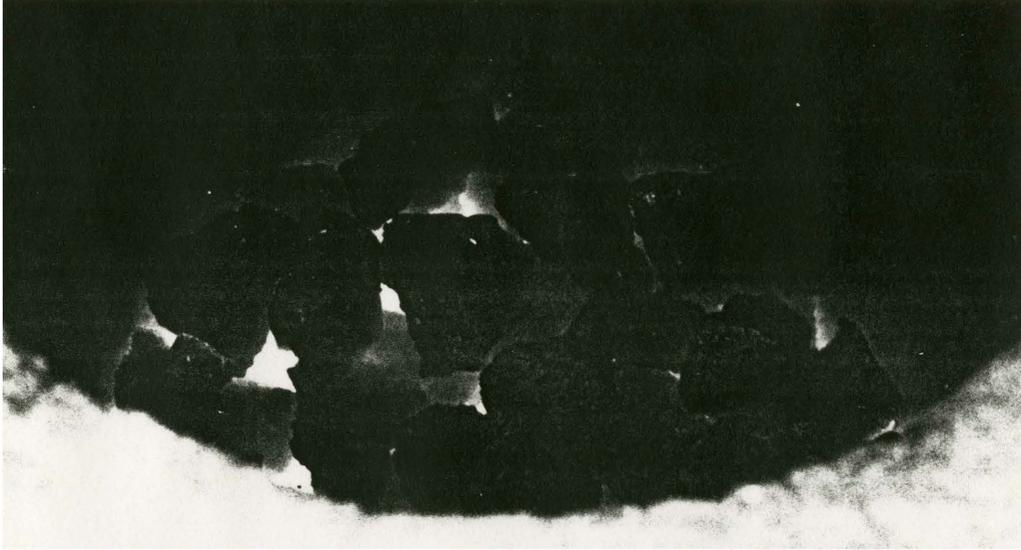


Fig. 11. First iron charge.

II. Molten Metal:

- A. Through tuyeres, watch for first drops, (time: 1:51).
- B. Through tuyeres, watch for fast drops, (time: 1:52).
- C. At breast hole, watch for metal to gather in mini-well, and for first stream, (time: 1:52:30), see Fig. 12.
- D. Bott breast hole to seal well, see Fig. 13.
 1. with bott on sick, press into breast firmly and "twist" off.

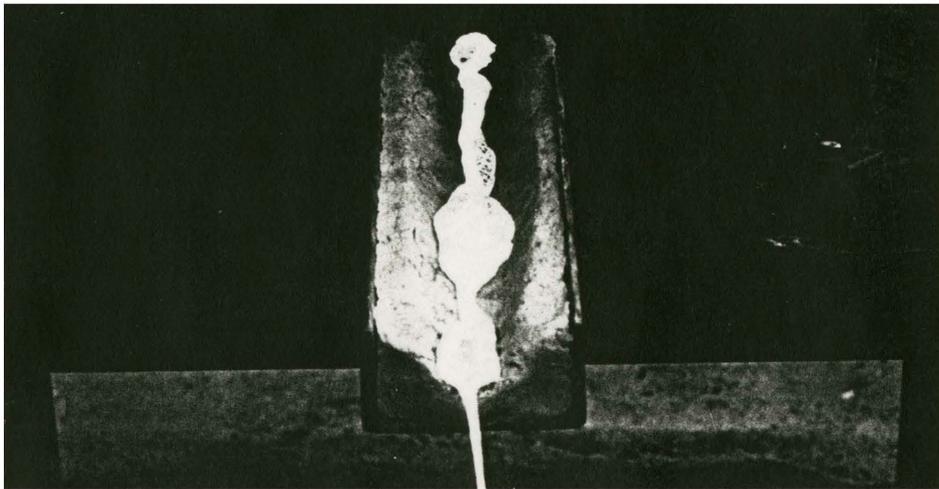


Fig. 12. Gather and first stream from well.



Fig. 13. Botting breast hole.

III. The Working Cupolette.

- A. The ETA to tap is short, have ready:
 - 1. molds to be filled.
 - 2. ladle preheated and standing by spout.
 - 3. workers suited and ready.
- B. Constantly watch molten droplets through tuyeres percolate downward.
- C. Occasionally open a tuyere and push coagulated metal away from opening, adjust coke at these openings.
- D. When drops slow the furnace is ready for tapping, (time: 2:08).

IV. Tapping the Cupolette

- A. Turn off blower.
- B. Open one tuyere to prevent CO₂ build-up and possible explosion.
- C. With poker, smartly break out bott and gently ream breast hole to assure even and thorough flow down spout and into preheated ladle, see Fig. 14.
- D. Re-bott when iron fast flow stops and slag appears.
- E. Deliver iron to molds.

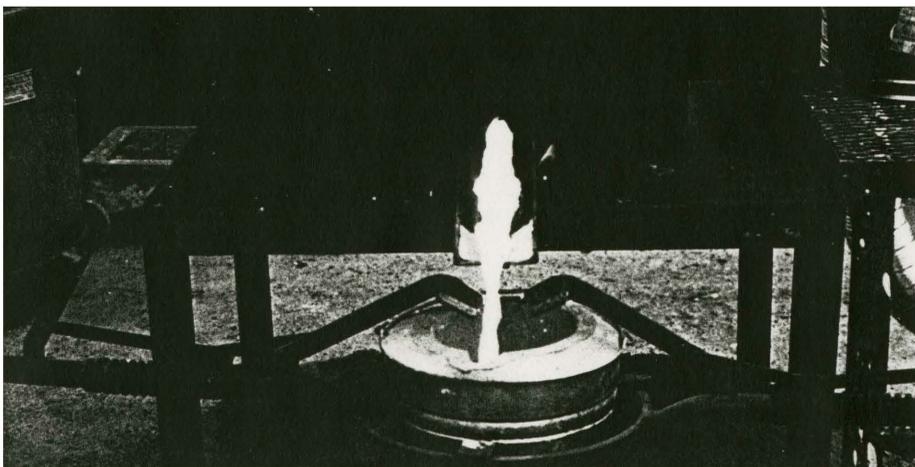


Fig. 14. Bott removed and iron flowing down spout.

- V. Drafting (coasting) the Cupolette while ladle is being poured:
- A. Keep blower off.
 - B. Keep 1 tuyere open.
 - C. Keep lid closed.
 - D. Adjust level of fuel coke with gauge.
 1. the cupolette can remain in this state for an hour if necessary.
- VI. Recharging for Second Tap:
- A. Open lid, adjust fuel coke to proper height, level out.
 - B. Add iron charge, level out.
 - C. Close lid.
 - D. Close tuyere.
 - E. Turn on blower, mark time and proceed as before.
 1. note: bott is already in breast hole from the end of last tap, watch clock and fast drops for ETA.
 - F. If pour involves more than 6 taps, slag build up might be an issue after 5 taps.
 1. watch for excessive slag raising to tuyere level.
 2. after 5th tap, draw out slag with poker, re-bott and proceed.
- VII. Ending the Pour:
- A. Pour last tap, (total weight poured: 500 #).
 - B. Draft cupolette.
 - C. Do not re-bott as described above, instead draw out as much slag as possible.
 - D. Open bottom door, (time: 3:45pm)
 - E. Use pick axe to drop bed and contents of furnace, see Fig. 15.
 - F. Cool door and dropped furnace contents with water.
 - G. Close tuyeres, brick lid and cool furnace slowly.



Fig. 15. Dropping the Bed at the end of the pour.

CLEAN-UP AND INSPECTION

- I. Check Condition of Furnace, (when cupolette has cooled):
 - A. Lining:
 1. no "hot-spots" as seen during heats as glowing patches in exterior shell.
 2. no large cracks in refractory.
 3. consistent "melt-zone" wear in refractory.
 - B. Bed Seal:
 1. no "leaks" downward around sand bed to door.
- II. Check Condition and Quality of Iron:
 - A. Cut into a pouring cup, check:
 1. consistent texture.
 2. not excessively porous or gassy.
 3. consistent color (temperature).
 - B. Check slag:
 1. should be evenly grey, with little pockets.
 2. glossy black = oxidization (too much blower air).
 - C. Recycle dry coke as fuel coke only (never bed coke).

TROUBLE-SHOOTING

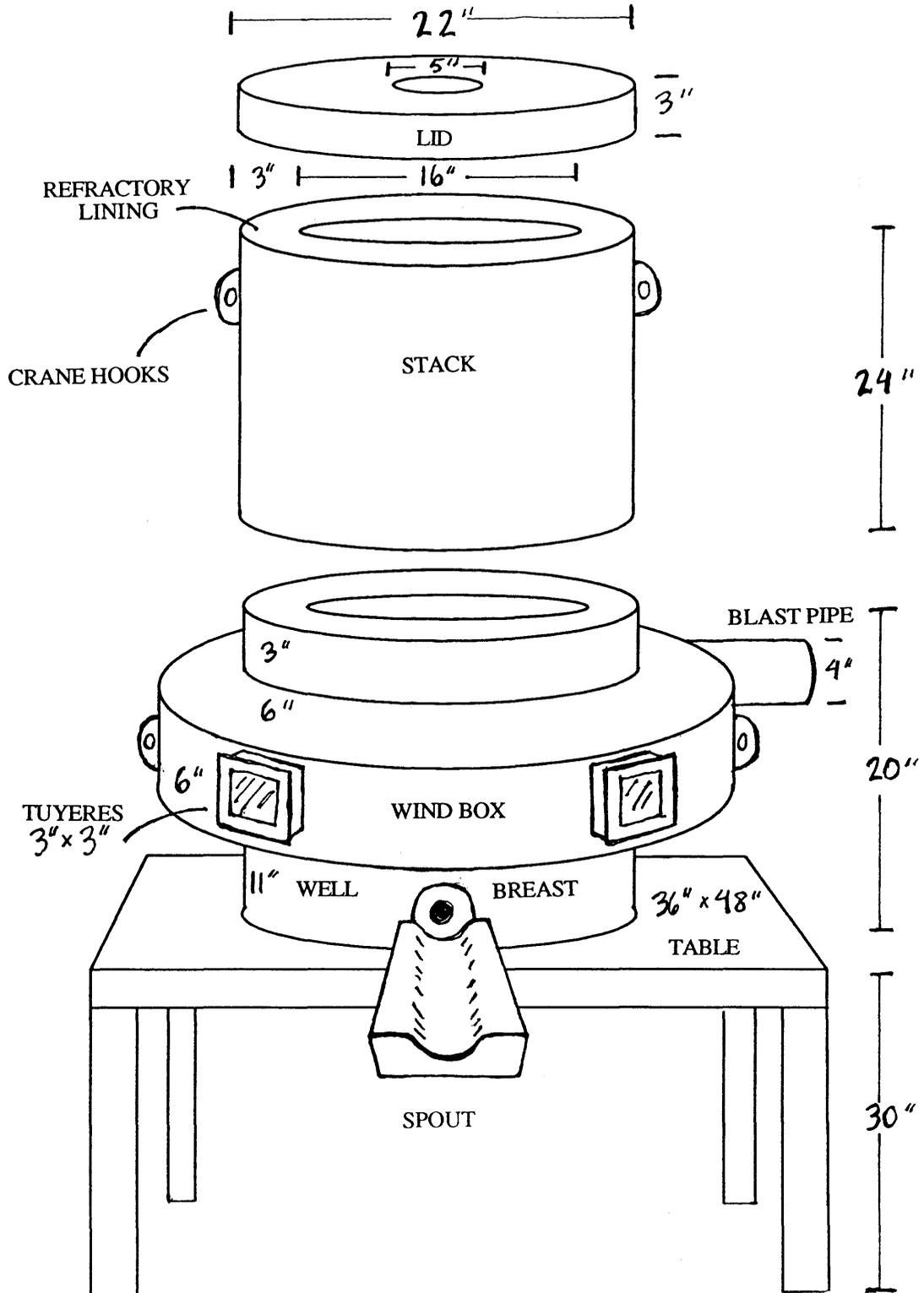
- I. Clogged Breast Hole (chilled)
 - A. Oxy-lance: a 4 foot steel pipe fitted on the end of a welding torch, connected to an oxygen cylinder (set at 20 lbs. pressure).
 1. draft cupolette.
 2. turn on oxygen.
 3. insert briskly into breast hole, "ream" chilled metal and slag, see Fig. 16



Fig. 16. Use of oxy-lance for reaming chilled breast hole.

APPENDIX I

THE CUPOLETTE
SCEMATICS AND DIMENSIONS



APPENDIX II

TOOLS

Crushed iron (3/8 x 2 x 2" maximum)
Bed coke (softball size)
Fuel coke (tennis ball size)
Buckets for iron, fuel coke, bed coke.
Scale for weighing 50# charges.
Ladles, shank, warmer and stand.
Propane tank, torch, striker, stand.
Poker.
3 bott sicks.
Charge gauge.
Skimmer.
Charging platform.
Shovels and sand.
Oxy-lance, hose, cylinder.
Bed sand mixture and stick.
Bott mixture.
Plumbago.
Pick axe.
Miscellaneous tools: pliers, hammer,
screwdriver, hatchet, tongs.
Sair-set for emergency repair.
Foundry protective wear.
Pour timing sheets, clock.
Molds to be poured.

PREPARATION SCHEDULE

1. 2 Weeks Prior: Line spout with Blast-patch.
2. 1 Day Prior: Mix and age (cover) Bed sand.
Mix and age Bott compound.
Break Bed coke to size (grapefruit).
Break Fuel coke to size (tennis ball).
Break Iron to size (3/8 x 2 x 2").
3. Morning of Pour Day: Fuel coke in buckets.
Iron in buckets weighed to charge (35# or 50#).
Prep tools and furnace as stated above.

APPENDIX III

MIXTURE FORMULAS

Bed Sand:

50# silica sand
1# bentonite, (2% sand weight)
2pints vermiculite
1pint water

This mixture is basically a weak green sand.
More bentonite would equal green sand.
Mix ahead, day before the pour, set covered overnight.
This amount is suitable for one bed.

Bott Mixture:

1pint No. 5 screened wood flour (saw dust)
1pint silica sand
1pint fireclay

Mix dry with enough water to form a wet clay consistency.
Mix ahead and allow to sit 2-5 days before pour.
Pack into cones (approx. 2 x 2 inches),
place on bott sticks, dust with plumbago.
This amount is suitable for approximately 5 taps.

Pour Spout:

Use Blastpatch 85, 1 inch thick and tapered.
Can be lined immediately following last pour,
and should be allowed to dry approx. 2 weeks before pour.
Use Sair-set for quick repairs and emergencies.

APPENDIX IV

TIME CHART

Course: _____

Date: _____

TAP	TIME	CHARGE WEIGHT	ETA	TAP TIME	ACTUAL TIME	TEMP	COMMENTS
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

Fire Lit: _____

Bed Dropped: _____

Bed Burned In: _____

Total Weight Poured: _____

First Charge: _____

Comments:

First Drops: _____

Fast Drops: _____

Botted Up: _____