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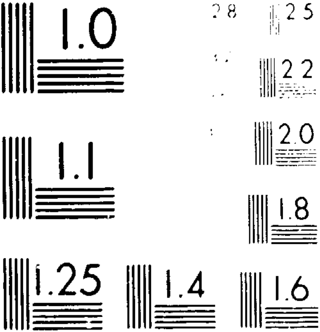

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Improvement of Steel Making Operations

at

Three Non-integrated Steel Plants

in

Arab Republic of Egypt

June, 1977

KOBE STEEL, LTD.
JAPAN
海外プロジェクト推進室
企画調査グループ

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Summary

This report concerns the present state of the steel making operations at three non-integrated steel plants in Egypt, being based on a field survey undertaken by Kobe Steel, Ltd. during the period of February-March, 1977, under contract with UNIDO.
It offers recommendations for dealing with the various problems which surfaced during the course of the survey. The results of this survey show that a number of the problems concern workshop practices rather than equipment and such problems could be overcome through a sure implementation of certain individual measures which would improve productivity and reduce costs to a considerable extent.

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1. Introduction

A Field Survey Team of six members* were despatched to Arab Republic of Egypt by Kobe Steel, Ltd. (KOBE) for the period of February/March, 1977, under the contract with UNIDO, Contract No.76/58, Project No. DP/EGY/72/016.

The contract called for the improvement of steel making operations in basic open hearth and electric arc furnaces in the following non-integrated steel plants:

The Egyptian Copper Works, Alexandria (COPPER),
The National Metal Industries Co., Cario (NATIONAL)
and The Delta Steel Mill SAE, Cario (DELTA)

The team evaluated current steel-making operations in the various steel plants from the standpoints set forth in the contract through observation at the plants and through study of data and information furnished by their counterparts. They recommended measures for improvement orally to their counterparts at the plants and demonstrated several practices of improvement measures thus recommended.

The team spent approximately two weeks at the various plants, 4 to 5 days for observations, 3 to 4 days for demonstration and 3 to 5 days for discussion and recommendations, and it centered its activities on workshop practices.

The major equipment covered by those activities was:

COPPER	Open hearth furnaces :	50t x 1, 30t x 1,
	electric-arc furnace :	5t x 1,
NATIONAL	Open hearth furnaces :	35t x 2,
DELTA	Electric-arc furnaces:	25t x 1, 18t x 1,
		3t x 2,
	(induction furnace :	1t x 1,)

including ingot making facilities for bottom poured 150/180kg ingot of reinforcing bar quality.

Top priority is to be given to improvement of certain individual steps of the work, on the floor of the workshop, through joint maneuvers of both the engineers and the workers.

Accumulation of such improved individual work would easily result in a considerable extent of increased productivity, reduced costs and improved quality.

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2. Common Problems Observed in Three Plants and Solutions Recommended

Reinforcing Bars and rods being major end products among the three steel plants, starting from almost same type of raw materials with same type of equipment and process, there exists a considerable number of similar problems commonly among these steel plants. Some of them are common among two steel plants only and some among three.

These common problems have been extracted, regardless of applicability for two or three plants, and been classified into three categories of "Major", "Others" and "Recommendation to the Management".

2.1 Major Problems

Major problems are defined as a group of problems and recommendations through which immediate improvements in terms of productivity, cost and quality can be expected without investing money and time. if performed immediately and properly.

The practices thus recommended here should be carried out by joint effort of engineers and workers in the field correctly, step by step exactly, though some resistance could be anticipated during the initial period of such practices.

2.1.1 Frequent occurrence of Steel leakage at ingot making stage

Steel leakage was observed during ingot making operation of almost every heat resulting in a lower yield or inferior quality of steel.

The prevention of such accidents is a matter of urgency and importance.

As preventitive measures, it is essential that stool brick lining, pouring tube setting and mould setting be performed correctly,step by step, with the aid of tools intended for those purposes. (Fig. 1)

In order to improve such defective practices, it is recommended as follows:

1) Stool brick lining

The recommended practices will effectively prevent steel clogging and trapping of foreign matter in the runner, as well as steel leakage.

i) Inspection of bricks: Thoroughly, especially the fitting of joint portions.

ii) Capping outlet of the runner brick with a sheet of paper for prevention of trapping foreign matters. (Photo. 1)

iii) Cleaning and inspection of breakage of the stool channel or metal adhesion.

iv) Making of a sand bedding on the bottom of the channel:
Fine, well-dried sand, free of foreign matters, should be spread so that the upper surface of the runner bricks and that of the stool are on the same level.

v) Laying the runner in the channel: The end bricks should be held firmly against the channel walls by inserting scrap bricks in the gap. Joints should be thinly mortared without overfilling mortar into the runner. (Photo. 2)

vi) Filling the gap between the runner and the channel walls with sand.

vii) Compacting sand by knocking on corners of the stool with a crowbar:

viii) Sealing the gap between the runner and the channel walls with mortar.

ix) Cleaning excess sand and mortar from the stool: Thoroughly by using a broom.

x) Removing foreign matters left in the runner completely by inserting a suction pipe through the paper capping. (Photo. 3)

2) Setting of the pouring tubes

When the pouring tubes are of separated sleeve type, it should be clamped firmly with fasteners or cotters, without leaving a gap larger than 5mm and with mortar being filled in the gap.

i) Inspection of bricks: Thoroughly, especially the joint portions.

ii) Perpendicular laying of bricks: Placing mortar thinly on the joint portion.

iii) Placing mortar around the king-brick.

iv) After complete removal of foreign matters from the bottom face, lowering pouring sleeves over the assembled bricks in perfect alignment with them. (Photo 4)

v) Mounting of funnel.

vi) Filling spaces between the bricks and the sleeves with sand and compacting it by hitting the sleeves with a hammer.

vii) Sealing the opening between the funnel and the pouring sleeves with mortar after filling it with sand. Mortar placed only in the upper portion around funnel.

Easier preparation, maintenance and lifting operations can be expected if the design of the pouring sleeves is improved as shown in Fig. 2.

It is further recommended that an anchor type slinging hook (Fig. 2) be provided, for lifting pouring tube only by crane operator without aide of ground worker.

3) Setting of mould on the stool

i) Inspection of mould: Removal of metal adhesions and foreign matters from the bottom surface.

ii) Setting the mould on the stool: Gently so as not to touch the pouring tube already set, with the outlet of the runner brick held in the center of the mould bottom and aligning the slinging hooks in the same direction.

2.1.2 Deformed hearth configuration and tap hole

Generally, due to insufficient maintenance, the hearth becomes excessively elevated and deformed and the shape of the tap hole also is distorted. The designed shape of the hearth and tap hole should be maintained. It is recommended that the repairing methods under normal and abnormal conditions be improved. Satisfactory maintenance of the hearth will bring about the following results:

1) Possible increase in furnace capacity,
2) Acceleration of the charging and melting speeds of material,
3) Longer life of refractories of furnace roof and walls,
4) Lower unit consumption of repairing materials,
5) Prevention of steel leakage from the hearth,
6) Shortening of the repair time,
7) Improvement of the quality of steel ingot.

Hearth maintenance consists mainly of two phases, hearth inspection and repair work. The main points and steps of such maintenance are described hereafter with the open hearth as the example

Tools required for the effective execution of hearth maintenance are shown in Fig. 3, 4 and Photo. 5.

Inspection of the Hearth

"Watch the hearth" is about all that can be said about this work.

1) During and after the tapping

A complete visual inspection of hearth is to be finished before all the molten steel has come out of the tap hole. Fuel shall not be cut off, even during the inspection period, in order to avoid lowering of the temperature.

When measuring the depth of any eroded part which is covered with molten steel or slag, such steel and slag should be blown off with high pressure air or oxygen, or the depth should be measured with a tool.

Carefully inspect the steel bath and the slag line during the refining (especially behind front columns), and try to discover any abnormalities, such as boiling, early. If there is boiling, throw Si-Mn into the hearth, and dolomite at the slag line, as emergency measure.

2) Irregularity of the hearth can be known by accurately comparing the molten bath surface with the sill level.

   There is another method for measuring the molten bath level, that is, in the last stage of refining period, of a heat with good slag fluidity, the molten bath surface level can be measured by a measuring tool, the figures of which are to be recorded twice a week on a check-sheet and utilized for selecting the method of repair.

3) It is possible to prevent steel leakage accidents by keeping close track of the thickness of the front wall, back wall and the gas port slopes at the level of the slag line.
   Measuring of the thickness of the front and back walls should be done visually with the aid of tools, as shown in Fig. 5.
   Measurement of the gas port slope, both thickness and height, should be done visually.

Repair Work

There are four categories of hearth repairs, repairs under normal condition, cleaning of the bed, resurfacing of bed and repairing of the tap hole.

1) Repair under normal condition

The hearth is to be repaired even when the inspection shows no sign of abnormality.
This repair should be started immediately after tapping of every heat, be carried out accurately and deliberately step by step, and be finished within 15-minutes(from the end of the tapping to the start of the charging).
The following steps should be carried out in combination with the hearth inspection practices previously mentioned.

i) The slags should be scraped off the charging door and removed from the working floor, before tapping on the other side being finished, to facilitate the repair work.

ii) Throwing of dolomite on the slag line of the exhaust sides by alternating firing directions; preferably on both sides while tapping

iii) Closing of the tap hole on completion of tapping (method to be described later under 4)

iv) Commencement of charging: quickly to lime charging stages, by loading a charging box on the machine ready to be charged.

This lime will prevent surplus or spilled dolomite from sticking to the hearth.

v) Back wall repair: dolomite casting by means of the throwing machine

vi) Front wall repair: dolomite casting with the aide of a roller guide and a paddle.

vii) Resumption of charging

2) Cleaning of hearth bed (repair under abnormal condition)

This is to be performed when the steel bath surface has risen above the standard sill level, or when the outflow of the molten steel or slag is worsened due to excessive irregularity of the hearth surface, caused by adhesion of CaO, etc.
The steps of this repair work are described below.

i) Temporary closing of tap hole after tapping, with fuel on.

ii) Spreading of mill scale and fluorspar over the raised portion of the hearth: Fluorspar is an active fluxing material and requires careful handling.

iii) Blasting off the raised portion with oxygen.

iv) Then, heating for about one hour until a metal and slag pool is formed in front of tap hole of hearth.

Addition of fluorspar, if the fluidity is found to be insufficient.

v) Opening of the tap hole, and discharging all molten steel and slag, collected in front of the tap hole.

vi) Opening the tap hole with oxygen.

3) Resurfacing of bed (repair under abnormal condition)

This is to be performed when the pool of molten steel and slag formed is deeper and wider than the designed figure, or when the entire area of the hearth has been eroded to certain extent and lowered. While carrying out this operation, give particular attention to the depth.

The steps are as follows:

i) Temporary closing of tap hole with fuel on.

ii) Spreading of fluorspar and mill scale over the ridge close to the tap hole: also spreading them over the raised portions of the hearth.

iii) Blasting open the ridge by using oxygen, fluorspar and mill scale.

iv) Blasting the foot of the front wall by using oxygen.

v) Blasting the lower portion of slag line on gas port slope by using oxygen.

vi) Heating for about one hour after preparatory steps ii) to v) to collect molten metal and slag in front of a tap hole.

vii) Opening of the tap hole upon the formation of a pool.

viii) After the discharge of molten metal and slags, blasting by air any residue on the hearth toward the tap hole.

ix) Bedding of the hearth with dolomite: up to a thickness slightly above the specified level. The dolomite thickness should not exceed 150mm. When eroded deeper than 150mm, filling it with MgO mixed with bittern. Photo 6 demonstrates way of mixing MgO with bittern as a binder for hearth material.

x) Temporary closing of tap hole, after restoring the original shape, if necessary.

xi) Sintering of the hearth until the bedded dolomite surface melts.

xii) Spreading the slag breeze over the entire hearth surface, and thorough heating, causing it to penetrate in.

xiii) Opening the tap hole and discharging excess slag.

xiv) Cooling and solidifying the hearth surface, by freely allowing in air for a few minutes with the fuel off.

xv) Closing of tap hole.

xvi) Fuel on.

xvii) Commencement of charging.

4) Repairing of the tap hole

i) Normal closing of the tap hole: by casting and stamping of dolomite from both the front and rear simultaneously.

ii) When the hole is large: lap the hole after cleaning the hole by using oxygen. Pressing bittern mixed MgO onto the bottom side of the hole, placing a pipe on it at a right angle, filling the space outside the pipe with bittern mixed MgO, and compacting it from both sides. (Photo. 7)

iii) When the hole is small: blasting around the hole with oxygen to enlarge it gradually. Since this is time consuming work, it is preferable that it be done bit by bit by every heat.

iv) When the hole is long: discarding of the elongated portion of the hole by using flourspar and oxygen and molten steel and slag be disposed outside and/or closing the hole with dolomite up to slightly inside the discarded end.

2.1.3 Careless handling of electrodes at electric arc furnaces

While electrodes are extremely expensive, they are being handled without the proper consideration. It must be pointed out that such careless handling of electrodes as submerging them into molten steel for carburization or charging large size scrap into the upper part of the furnace burden could exercise a deteriorating influence on productivity and costs, by bringing about breakage and loosening (pulling-off), tapering of the electrode body, and operation stoppage. As a consequence of such improper electrode handling, it is assumed that breakage has been occuring very frequently. This is also indicated by the pile of broken electrodes shown in Photo 8. Further, the data on unit consumption (COPPER 8kg./ton DELTA 11kg./ton) is considered to be abnormally high, compared with that of general practices. The main points of recommendations on improvement of electrode handling are as follows:

1) Storage of electrodes

The location to be selected should be free of dust and low in moisture, and the stored items should be placed on sleepers, etc.

Checks for the adhesion of dust to the socket section or breakage of threaded sections and end surfaces must be carried out most carefully. (Photo 9) Nipples should be stored in packed condition.

2) Transportation of electrodes

Electrodes should by all means be transported by using hanging pins, having perfect screw threads. If an electrode with a screwed-in nipple is to be lifted by the hanging pin, the end portion must be protected by means of some kind of floor cover, such as a straw mat, a hessian cloth, or a canvas, laid underneath. (Photo 10)

3) Connection of electrodes

Dust on sockets, nipples and electrode ends must be completely removed by air blasting. (Photo 11) Threaded portions must be screwed in very carefully to avoid breakage.

A nipple to be screwed into a connecting electrode should not be screwed in completely, being left loose. It should be screwed in completely while at the same time screwing in a lower electrode to avoid one-sided screwing.

4) Holding of electrode

The practice of holding at the point outside of yellow lines should be avoided. (Photo 12)
When the holding position is to be adjusted upwards (when the electrode is extended), electrode should be supported by a crane, or by resting the lower end on top of the materials in the furnace, to prevent it from dropping down. The holding position should be determined upon confirming the electrode length before charging the material, and should not be changed without particular need during the same heat.

5) Problems on equipment

i) A large clearance between the electrodes and the glands of the roof causes excessive flame blowouts, resulting in oxidation and reduction in the diameter of the electrodes around the furnace roof. The glands presently in use should be redesigned. (Photo 13)

ii) Faulty airtightness of furnace

If the airtightness at the contacting portion of the roof and the furnace, charging door, tap hole, etc. is not satisfactory, the electrodes within the furnace will be reduced in diameter by oxidation.

iii) Inclination of electrode holding device

Electrode breakage tends to occur, if it is not held vertical, or if the centers of the electrodes in the holders and that of the roof openings for the electrodes are not aligned. (Photo 14)

6) Operational problems

i) Charging of heavy scraps into the upper part of the furnace burden has been observed. Heavy scraps should be charged at the lower part of the furnace so as to prevent the electrode from falling and breaking by touching with such scraps.

ii) It has been observed that during automatic operation, the operator is at times absent from the control room. Even when the electrode is being positioned automatically, the operator should watch the furnace operation and the instruments constantly so as to permit him to act quickly as ,for example, manually lifting the electrode in the case of over current. Surveillance by operator (furnace condition, electrode positioning, ammeter, etc.) is most important. If no melt-down can be seen after the predetermined time has elapsed, an inspection of the furnace interior by lifting up the electrode, and , possibly, cutting of the scraps by oxygen will be necessary.

iii) Carburization by means of electrodes being submerged in molten steel.
Carburization with the electrodes in use should be discontinued. Conventional coke carburization should be employed.

iv) Non-electroconductors such as sand, wood blocks and slags contained in scraps should be removed before charging.

v) Charging should be performed rapidly with the minimum roof opening to avoid needless consumption of electrodes.

vi) Tapping should be performed after confirming that no unmelted material has been left sticking on the furnace wall.

vii) The furnace should be tilted slowly when tapping so as to protect the electrodes from any impact.

viii) Lifting the electrodes when blowing oxygen into molten bath.

2.1.4 Unstrippable ingots from the mould

Frequent difficulties have been observed with the stripping of ingots from the moulds. (Photo 15) These unstrippable ingots shorten the life of the mould and delay the ingot making operation.

A prolonged presence of ingot in the mould and the inclined stripping force are assumed to be the main reasons for these difficulties.

Ingots should be stripped within 20 - 30 minutes after pouring by lifting the mould straight up without moving the ingot and its runner.

The ingot and its runner will be lifted together with the mould, if the mould is pulled in any direction other than a perfect vertical one.

2.1.5 Insufficient temperature control of molten steel

It has been observed that the pit scrap was being thrown into the ladle to lower the molten steel temperature during the course of tapping,and that skull had formed in the ladle due to low temperature.

Such practices lead to a greater loss of heat and a higher refractory consumption in the melting stage, or to a shorter refractory life of ladle lining and a lower ingot yield in the ingot making stage.

Hence, an excessive temperature rise should be prevented both by observation of the molten steel temperature (visually and by means of an immersion pyrometer) and by strict combustion control.

If the molten steel temperature must be lowered, it is recommended that the rolled scraps be thrown into the furnace, instead of the ladle, as it is dangerous to throw pit scrap into the ladle, not to mention the damage to ladle or the increased inclusion in steel.

2.1.6 Frequent scattering of molten steel

During the tapping and pouring practices, scattering of molten steel in the ingot making yard due to ladle overflows, leakage from pouring nozzle, or splashing at top of pouring tube has been observed. Scattered molten steel results in various losses not only in the form of a lower yield of steel, but also in damage to the ladle, the mould or the pouring tube, in increased amount of pit scrap which to be disposed of, and in lack of safety. Therefore, scattering of molten steel should be minimized through the following measures.

1) The proper charging amount meeting with the ladle capacity.
2) Correction of inclined ladle holding.
3) Installation of ladle spout.
4) Increasing of ladle capacity.
5) Complete stoppage of molten steel leaking from nozzles by perfect preparation of stoppers.
6) Correct positioning of the nozzle over the pouring tube.
7) Proper instruction to crane operators.
8) Improvement of the skill of crane operators.

2.1.7 Imperfect shape of ingot making bricks

Both the shape and materials are unsatisfactory. (Photo 16)

Ill shaped bricks are the major reason for steel leakage. Such bricks should be separated and rejected by means of an acceptance inspection before they are used. Complaints and claims should be lodged against the brick manufacturers so as to force them to correct such defects.

(a joint effort among three steel plants is suggested).

Furthermore, bricks, currently poorly stored (Photo 17), should be stored under a roof with proper classification.

2.2 Other Problems

Common problems and recommendations other than "Major Problems" are dealt with in this section. These problems require the investment of a certain amount of time and money while at the same time yielding results of a lesser degree than those discussed in "Major Problems".

2.2.1 Positive utilization of oxygen

Methods of oxygen utilization, as well as problems and solutions thereof are proposed below.

<u>Application to the open hearth furnace</u>

1) Objectives

i) Acceleration of melting and decarburization through oxygen enrichment of the combustion system.

ii) Acceleration of heating by exothermic heat from direct reaction of blown oxygen with carbon in molten steel.

iii) Deterred oxidization of Mn and Cr, dehydrogation, and the bringing of non-metallic materials to the surface through high temperature refining and strong boiling.

2) Application at each stage

i) Charging stage

a) Application to main burner (Fig. 6)
oxygen pressure 6kg./cm^2,
oxygen flow rate 3 - 8 Nm^3/min.

b) Oxygen also may be used for auxiliary jet burners, roof jet burners, etc.

ii) Melting stage

a) 3 - 8 Nm^3/min. for main burner

b) In the final stage, a heap of CaO and heavy scraps are to be blasted down with oxygen by means of a lance pipe through the charging door and thereby accelerating the melting.

iii) Refining stage

a) Oxygen is blown through the lance pipes, (1 inch in diameter, 5 - 8m long) through each door into a depth of 300 - 500mm beneath the slag layer at a pressure of 9 kg/cm^2, and at flow rate of 7 - 10 Nm^3/min.

b) Oxygen can be used to accelerate the slagging of additional lime.

c) In the final stage, the flow rate and the number of lance pipes should be decreased to adjust the steel composition and temperature.

3) Problems and proposals

i) To avoid soft melting, more carbon than current practice should be charged (by means of pig iron, electrode scrap, coke, etc.)

ii) The oxygen nozzle should be cleaned at every heat to protect it from clogging.

iii) Head current preventing valves should be provided in the piping which are prone to fire.

iv) Care should be taken in setting the level and angle of the burners and lances to protect the roof from overheating.

v) Periodic cleaning should be performed since the checkers of the regenerators tend to clog due to increased dust and fumes.

vi) As the lance pipe will be rapidly consumed, it is desirable to cover its tip with ample slag, and to use calorized pipes. (Photo 18)

vii) High pressure hoses and leak free hose couplings are recommended.

Application to electric arc furnace

A method of introducing oxygen by lance pipe through the charging door is both the most economical and the easiest to operate.

There are some other methods such as roof jet or troidal burners which are available for directing jet flames towards places where melting of charged materials is difficult. However, they are neither economical nor easy to utilize.

The lance pipe method works as follows:

i) During the melting stage, oxygen is used in place of a bar to blast the heaped materials down.
(pressure: 9 kg/cm^2, flow rate: 6 - 8 $Nm^3/min.$)

ii) During the oxidation period, oxygen is used in place of iron ore and mill scale.
(pipe length: 5 - 8m, pipe diameter: 1 inch, pressure: 9 kg/cm^2, flow rate: 6 - 8 $Nm^3/min.$)
Dip the pipe into molten steel at an angle of 30^o and to a depth of 500mm.

iii) The slagging is accelerated by blasting the surface of the bath.

iv) The hearth is blasted with oxygen for cleaning or resurfacing, when repair work is performed after tapping.

2.2.2 Modification of the facilities and layout of the ingot making shop.

It is recommended that the facilities be improved and the layout be studied again in order to facilitate quick and effective performance of the ingot making operation.

1) For adopting multiple stripping and setting device of mould and multiple transfer device of ingots (Fig. 7, 8. Phot 19, 20), stools and moulds are required to be redesigned. (Fig. 9)

2) Mould cooling pit

A mould cooling pit should be provided for the storage of moulds which are carried and released from the multiple stripping and setting device as well as removal of any matters adhering to the mould. It would also be used for fixing the hanger rings, for repairing the tipped portions of mould and for other purposes. The mould interior may be coated with an appropriate protective agent, if necessary.

3) For more effective use of the indoor space, steel ingots, steel scrap and slag etc. should be transferred outdoors, for further treatment.

4) Fig. 10 gives one example of the recommended modifications of the layouts.

In case of COPPER, new device of rotatable crane hook, as shown in Fig. 10-a, is suggested to be considered, in preparation for tapping operation of 25 ton electric arc furnace, because existing crane hook is not suited to hold the ladle in the correct direction to receive molten steel.

2.2.3 Improvement of charging practices

Open-hearth furnace

1) The Mn ores should be charged at the initial stage of the charging with scrap instead of melting stage.

2) It is recommended that the amount of lime charged be increased (from 4 to 8%) thereby accelerating the dephosphorization and desulfurization.

3) Lower heaping of lime will result in soft melting, and incorrect positioning of heavy scrap trings about a longer melting time. Materials shall be charged into proper position a~ shown in Fig. 11.

4) The charging operation is left to the judgement of crane operator. The crane operator shall be instructed by one of the furnace crew who has a good view of furnace interior as to materials and positions to be charged.

Electric arc furnace

1) Frequent times of charging has been observed (3 - 4 times/heat at DELTA's 25t furnace). The ratio of the heavy scrap, pressed scrap, etc. should be reconsidered to reduce the bulk of scraps.

2) Material loading into bucket

Heavy materials should be placed at the bottom of the bucket if possible. Also, lime or limestone should not be charged separately but rather be placed at the bottom of the bucket at the time of second charging (by laying a thin iron sheet, cardboard paper, straw, etc. on the bottom).

3) The releasing position of the materials from the bucket is too high.

The bucket must be suspended as low as possible. Otherwise, there is a danger of the materials being scattered outside the furnace, and of the water supply and drainage pipes being damaged, when the materials are dropped.
Steel plates may be provided over the pipings to shield them from such damage.

4) Opening time of the roof for charging

Charging should be carried out quickly, because the effect of the charging time on heat efficiency, the life of refractories, the consumption of electrodes, etc. is considerably large.
The steps are as follows:

i) Lifting the bucket first by means of a crane ready to be charged.

ii) Lifting the electrodes and swinging open roof.

iii) Moving the bucket onto furnace along with move of the roof.

5) Insufficient check of the furnace interior after charging.

Non-electroconductive materials and protruded materials should be checked.

Non-metallic materials attached to scraps should be removed completely beforehand in scrap yard.

6) Charging and adjustment by means of a lifting magnet should be discontinued.

2.2.4 Ladle life

The ladle life seems rather short, 8 times at COPPER, 11 times at NATIONAL and 13 times at DELTA due to excessive erosion at joints.

It is essential that the brick laying method, as well as the drying of lining and pre-heating of ladles be improved, although there may be problems with the material and shape of the brick.

The main steps of the ladle brick laying are as follows.

1) Preparation of mortar.

   Remove the foreign matter, and knead the mortar with water until it becomes ralatively soft.

2) Inspection of bricks:

   Ill-shaped bricks should be used for the upper portion as much as possible.

3) Laying of bricks:

   Layer by layer, while keeping the upper surface level.

4) Use of mortar:

   A relatively thin layer of mortar shoud be used on the brick joints for the back wall. Joints should be kept to a minimum with a slight amount of mortar being applied, only if necessary. (Photo 21)

5) Tightening of bricks:

   Sufficiently by using a wooden hammer.

6) Laying and tightening of the last brick on each layer with a measured and shaped brick, depending on the space to be filled.

It may be possible to extend the life one or two times by plugging brick fragments or mortar into eroded joint portions while the ladle is still warm after the pouring.

2.2.5 Stopper fabrication

1) The screw threads of the stopper head were not being fastened sufficiently. Some were found screwed-in only halfway (3 - 4 threads of a total of 7 - 8 threads) into the stopper rod, due to foreign matter thereon.
This work, which if performed poorly brings about a loosening of the head during the pouring practice, is particularly important. The performance should be improved.
It is essential that the screw thread of the stopper rod be kept completely free of such deposited materials as spilt metal, mortar and rust, so that the stopper head can be fastened perfectly.

2) The stopper drying method

The stopper is an important item. However it was observed that drying was being performed improperly in front of the open-hearth furnace slag pocket, between the stools, and on the drying furnace without a cover. It is recommended a perfect drying furnace be installed in the future.

3) The straightness of the stopper rod should be checked.

One way of doing this would be to roll the rod on the surface of a stool, etc.

2.2.6 Mould handling

1) Metal adhesion to the top portion of mould is excessive.

   It is recommended that the diameter of the funnel be increased, that the ladle be kept horizontal for direct pouring and that the center of the funnels be kept in a straight line, parallel to the crane rails.

2) The swinging of mould for ingot stripping should be discontinued. If not stripped, the stripping machine should be used.

3) The metal adhering to the mould (Photo 23) should be removed each time it occurs and the hanger ring should be kept in normal shape at all times for collective stripping of ingots.

2.2.7 Combination of visual observation and scientific measurement

Reliance upon visual observation or instruments alone will result in failure in many cases as exemplified when the molten steel temperature is measured for analyzing molten steel composition or when the amount of tapped steel is estimated.

1) The device for measuring the amount of steel in ladle is shown in Fig. 12.

2) The visual tests for molten steel and slag are as follows.

   The sample case for the visual test is shown in Fig. 13.

   i) Composition

      In addition to spark observation, observation of oxidized film of the sample is also important:

      a) Mn or Cr is high, when it shows no brightness but rather exhibits an apparent viscosity.

      b) C and Mn are low, when the central portion of the solidified sample appears concave.

   ii) Temperature

      The color should be observed at the moment when the slag is peeled.

iii) Slag

Fluidity and viscosity are to be checked.

Slag in state of soft ice-cream is satisfactory.

iv) Basicity

After pouring the slag into the slag case and allowing it to cool naturally, the surface condition is to be checked. To many wrinkles indicate an excessively low basicity.

No brightness (gloss) indicates high FeO.

Cavities and many cracks indicate high basicity.

Judgement should be made based not only on i) - iv) but also on furnace interior and refining history inspection and thus integrated judgement should be made.

2.2.8 Tapping spout preparation

1) The repair of the tapping spout at every heat should be reduced to twice a week, if bittern-kneaded magnesia (MgO) is stamped on the spout.

2) A spout cover is recommended for complete drying of the passage.

2.2.9 Pipings and fittings for oxygen

Pipings and fittings should be improved as shown in Photo 24, which shows the device to be used for hearth operation. Photo 25 shows those for tapping and Photo 26 for ingot making.

2.2.10 Communication

It is recommended that some schedule board indicating the steel grade, the tapping time, charged material and amount, etc., and a siren or a bell to signal tapping commencement to the ingot making side from melting side be provided.

2.2.11 Roller guide attachment on the changing door.

A roller guide attachment should be provided on the charging door to facilitate hearth repair work. (Fig. 4)

2 2.12 The "Plan - Do - Check - Action" cycle should be established and repeated.

An example of such a cycle for the "Countermeasures for the Curtailment of Unit Consumption of Electric Power" is detailed below for guidance.

1) Selection of the themes	:	Curtailment of unit consumption of electric power (25t E.F.)
2) Meeting among the people concerned	:	About ten persons, directly engaged in the work and having a sufficient knowledge of the work.
3) Brain-storming	:	Exchange individual viewpoints freely. Refer to the attached sheet.
4) Preparation of characteristic chart	:	It is recommended that the "Brain Storming Method" for smooth movement on steps 4 and 5 be adopted. (Fig. 14)

5) Evaluation of important characteristics	:	Give priority to the following points. 1. Large heat loss 2. Long melting time 3. Insufficient furnace operating technique
6) Discussion of countermeasures	:	Example for a large heat loss: improvement of the charging door etc.
7) Implementation of the measures	:	
8) Reviewing the results	:	
9) Take any subsequent steps deemed necessary	:	Standardization, restudy, etc.

2.2.13 Data collection

Data giving clues to the solution of problems should be secured.

2.2.14 Standardization

It is recommended that a working manual, formats for directives and instructions etc. be compiled.

2.3 Recommendations to the Management

In addition to the operational, technical problems stated in preceding sections, some problems in the management field have been noticed by the field survey team, in light of the current philosophy and practices in the Japanese steel industry community.

It also should be kept in mind that such problems have been noticed by the team during a relatively short stay in Egypt, without going further into the background of problems, particularly in Egypt.

Yet, the survey team is confident that consideration of these problems by the Management and efforts for their improvement will naturally lead to an overall improvement of the steel industry in Egypt.

2.3.1 Excessive lost time

A considerably large amount of waiting time has been observed being wasted in the material preparation, charging stool preparation and stripping practices and also in the repair of equipment and shift-to-shift change. Though the capacity of melting equipment is standard, the productivity is lowered remarkably owing to such a great amount of lost time. Lost time should be reduced by the following:

1) Improving the processes of material sorting and transportation in and out of the shop,

2) Expediting the ingot making practice through improvement of equipment and layout.

3) Reinforcement of the equipment mainterance.

4) Face to face direct shift change.

2.3.2 Joint study meetings on steel making practices should be held among the three plants, there being no such place for exchanging technical information among these firms.

Although they are producing similar steel ingots, the methods for production differ according to the company. For example, different methods are being employed in mortar and sand application to pouring tubes and stools, and in setting pouring tubes. It might be worthwhile to exchange data, opinions, and studies and to make mutual plant visit tours under the auspices of C.M.R.D.I.

As regards the method for preparing the operation survey sheet of open hearth furnace and the electric arc furnace, an explanation was given to C.M.R.D.I.

2.3.3. Engineers are inclined to have sophisticated discussions which are divorced from the field (work site) and imminent actual problems.

Engineers should go down to the field and should debate and discuss problems with the workers in the field on the basis of the facts of the actual situation.

Hence, it may be recommended to have newly recruited engineers undergo a one or two year training course in a work shop.

Engineers should concentrate on such matters as the setting forth of the field problems, investigation of causes, and test trials for improvements (so as to face the field with an object-oriented mind).

Since steel making operations consist of various cause and effect relationships interwoven in a complicated way, it will be essential to take an attitude of solving problems one by one, exactly, by collecting data on each problem and solving it from an integrated, overall viewpoint.

2.3.4 Co-ordinated actions for single purpose between related departments should be emphasized.

1) During shift change time, no worker is present in the field for about one hour.
When some work which should not be interrupted is to be performed over a shift changing time, such as mould stripping or charging, the problem could be serious. Concerted action between labor department and workshop is deemed to be neccessary. Workmen should remain at work site until the succeeding shift takes over the duty at the time of the shift change (face to face shift change).

2) The persons in charge of melting and ingot making respectively should mutually exchange visits to make a close inspection of operations there (deoxidizing process, molten steel temperature and quantity of molten steel, etc.).

3) The trouble shooting engineer staff are not clearly identified. Duties should be clarified and reorganized.

2.3.5 Cleaning and safety

1) Cleaning is insufficient and extremely unsafe in the shops. Pit scraps should be taken outside of the building.

2) Workers should be outfitted with safety gear such as helmet, fatigue clothes, shoes, gloves, etc.

3) Safety passages should be provided, clearly marked and be free of any obstacles.

4) Smoking should be limited to designated spots and times.

5) From the viewpoint of safety, signals to the crane operator should be given by a single person, using a whistle, instead of by many persons as has currently been observed.

6) Protection devices should be provided at several dangerous spots. (handrails, ladders, etc.)

7) The supply of tools and materials required for the work, such as gloves, helmets, aprons, shovel, suction equipment, hammers, brooms and sand, should be maintained and kept in good order.

3. Problems Inherent to Each of the Three Steel Plants and Their Solutions

After setting forth the common problems among three plants in preceding chapters, inherent and particular problems to each plant are stated in this section. Some problems in a particular plant might be applicable to other plant.

3.1 Egyption Copper Works, Alexandria

3.1.1 Raw materials

At the raw materials yard, scraps, pit scraps, ferroalloys, lime, etc. were found scattered all over. (Photo 27)

1) It is essential that they should be classified by kind, shape, etc., and provided with appropriate fences (walls), so as to make sure that these materials are placed correctly in their designated locations. As the production of high grade steels is envisaged in the future, the above practices should be put into effect even now, in order to control alloying elements and impurities.

2) Light scraps should be pressed as far as possible.

3) Pit scraps and skulls should be disposed of as they occur, instead of accumulating them for certain length of time.

3.1.2 Auxiliary raw materials

Auxiliary raw materials for composition adjustment (Fe-Mn, Fe-Si, Coke) are too large in size.

3.1.3 Burners of open hearth furnaces

The supporting system of the burner and its angle of the open-hearth furnace is improper.
If the burner can be adjusted vertically and horizontally, it becomes possible to protect the roof and to accelerate melting efficiently. (Fig. 15)

3.1.4 Leveling of charged materials

Preferablly oxygen, or air if oxygen is unavailable, for levelling heaped-up materials or raking lime, should be used.

3.1.5 Furnace wall

As a means of reducing the unit consumption of refractories of the front and back walls, it is recommended that a water cooled box or piping be installed on open hearth furnace. (Fig. 16)
Also the brick laying shown in Fig. 17 will prevent bricks from falling down.

3.1.6 Pit scraps

It would facilitate the post-treatment of pit scraps, if the molten steel or slag, overflowing the ladles or coming directly out of the open-hearth furnace should be forced to flow into a dugout with pouring sleeve scraps being erected, instead of allowing them to spread on the ground beneath the furnace. (Phct 28)

3.1.7 Control of carbon content in electric arc furnace

In case of soft melting, it has been observed that electrodes were submerged into the bath for carbonization. However this practice should be discontinued.

1) Scraps should be properly selected

2) Carbonization materials should be added to the charge based on the estimated carbon in the materials to be charged.

3) When soft melting, add the carbonizing agent after removal of slag.

3.1.8 The hearth of the electric arc furnace

The hearth on the tap hole side is elevated and deformed (Photo 29)

Preventive measures are listed below.

1) Improve the fluidity of slag, and expedite tapping work.

2) Portions defective in shape should be blasted by oxygen and rectified. (Set the bottom portion lower around tap hole)

3) When the condition becomes worse, either reduce the amount of scrap charged, or scrape the elevated hearth with a rock drill while the furnace is shut down depending upon the extent of the slag line erosion.

3.1.9 Slag fluidity of the electric arc furnace

The following points are suggested for fluidity improvement.

1) The bottom portion of the tap hole should be lowered enough to permit any slag remaining from a preceding heat to run out of the hearth.

2) Replace CaO with $CaCO_3$.

3) Use CaF_2, and at the same time, stir it thoroughly by means of rabble.

4) Skim the slag and replace after melting down

5) Elevate voltage.

6) Oxygen blowing.

3.1.10 The roof of the electric arc furnace

Refractries wear heavily around the glands on the roof.

The glands should be enlarged and remodelled (as previously described).

Mortar should no longer be placed on the glands.

(Mortar will cause a reverse effect since no heat will be emitted).

3.1.11 Charging door of the electric arc furnace

The life of bricks around the charging door is short. (60 - 70 heats)

The life can be extended by using cooling boxes around charging door.

Photo 30 shows an example.

3.1.12 Ladle stopper

The leakage from the ladle nozzle should be stopped.

The stopper head should be installed properly.

3.1.13 Stools

The row of stools should be aligned paralles with the crane garter, always being held horizontally.

3.1.14 Ladle

Metal adhesion to the bottom of the ladle due to insufficient pre-heating was conspicuous.
The ladle should be pre-heated evenly after setting a stopper.

3.1.15 Control lever of the ladle

The control lever should be rectified whenever it deforms.

3.1.16 Oxygen at ingot making area

Oxygen should be provided at the ingot making area for re-opening of nozzel, closed due to low temperature.

3.1.17 Sand for stopping leakage

Mill scales should be mixed with sand for better stoppage.

3.1.18 Measures for increasing productivity

Measures for increasing productivity, with a 50t open-hearth furnace as an example, are shown as follows.

1) Shutting down of the 5t electric arc furnace.

2) A way of increasing the charging amount (steel output) should be devised for the 50t open-hearth furnace.

   (compensating the output of the 5t electric arc furnace)

   i) Maintain correct hearth shape for the larger hearth capacity.

   ii) Increase ladle capacity:

   Make the outer lining (permanent lining) thinner.

   Reduce the area in contact with the stream of molten metal.

3) Shortening of the operation time of the 50t open-hearth furnace should be attempted.

   i) Shortening of repair time.

   ii) Shortening of steel making time.

4) Shortening preparation time for ingot making

Anticipated results of the above for reference.

1. Premise:

   Saving of 30 hr/month on non-steel making time and 1 hr/heat on steel making time.

2. Results:

   The present output of 4,300 t/month will be increased to 6,500 t/month.

3.1.19 Equalization of technical level

The difference in the technical levels of the personnel should be minimized among furnaces and shifts.

3.1.20 Rapid counter action

Counter action and measures shoud be carried out quickly.

3.2 National Metal Industries & Company

3.2.1 The waiting time for charging

The material waiting time is too long, resulting in the charging waiting time of 51 minutes against the charging time of 110 minutes and the material waiting time of 42 minutes against the charging waiting time of 51 minutes.

Measures for eliminating the waiting time during charging are as follows.

1) Improve the arrangement of the scrap yard and improve the material preparation plan. (Photo 3i)

   i) Railways should be well maintained to eliminate the possible derailment.

   ii) Trucks (Lorries) carrying heavy cargo should be kept away from railway track.

   iii) The space between the steam crane track and railway track should be kept in good order.(Fig. 18)

   iv) The space outside the steam cranes (2 units) should be utilized as a heavy materials yard, so that the materials can be placed in the charging box and boxes can be piled-up in two layers between the steam crane track and railway track to be ready for the next charging.

2) Charging platform

i) Extend the charging platform, toward the raw material yard and provide a stopper. (Fig.19) The charging platform between No. 1 and No.2 open-hearth furnaces should be utilized fully after removing the thermometer and gun.

ii) Place nothing on the charging platform other than materials.

iii) A box for scraping inside of the charging door, boxes for FeO and MnO and the like should be kept at some place other than charging platform.

3) Pit scraps, skulls, etc.

i) Charging boxes should be placed in the pit side to collect scraps when cleaning the pit side.

ii) Appropriate pits should be prepared under the hole to receive molten steel and slags so that they can be used as material without further treatment.

4) Charging box

Method of loading materials into the charging box is unsatisfactory. (Photo 32)

It should be more compact, and the frequency of charging to the open-hearth furnace should be reduced.

Current number of 58 seems too high.

The number of boxes per heat can be used as a measure for controlling the charging materials.

5) Appoint a person responsible for charging operation.

6) Tools should be kept in good order in front of the furnace. (Photo 33)

3.2.2. Size of lime and fluorspar

Size of lime and fluorspar are too large.

For the purpose of accelerating the slagging, lump size should be limited to 100mm max. for lime and 30mm max. for fluorspar.

3.2.3. Charging amount

The charging amount (tapping amount) should be restudied in view of frequent occurrence of molten steel overflow from ladle (skull). (Photo 34)

3.2.4 Slag basicity

Slag basicity is low at the time of melting (2.0 approx.)

Increase the charging amount of lime before melting down, and stir it by air until the fluidity is improved.

Water accompanied by air may cause explosion or increased H in steel, therefore a water drainage header should be provided in the air piping. (Photo 35)

3.2.5 Visual observation of the hearth

Inspection of furnace interior is insufficient.

Not only engineers, but also those who are responsible for the furnace operation should inspect the furnace interior carefully so as to take appropriate actions.

The main points of furnace interior inspection are listed below.

1) Combustion state of heavy oil: especially the heights and the inclinations of burners of both sides and adjstment of flow rate (heavy oil, air). Provide flow meter and flow control valve at a controlling station.

2) Melting state of materials and slag fluidity.

3) The temperature and eroded state of refractories on the roof and the walls.

4) Any sign of irregularity inside the furnace: such as boiling of hearth.

5) Frequent sampling for visual checking of temperature and composition.

3.2.6 Refining

During refining, maintain Mn to about 0.2 - 0.25% to prevent excess oxidation.

3.2.7 Furnace pressure

Furnace pressure is high. Flames have been observed blowing about 300mm outside the door.

If furnace pressure is high, erosion of refractories will increase. The best would be one where the flame could be seen going in and out of the charging door. Furnace pressure of 1.5 - 2.00mm H_2O at roof center will be satisfactory.

3.2.8 Regenerators

The brick life of the regenerator is said to be short. (300 - 350 heats)

It is assumed that narrowing of air passage in the checkers due to dust or erosion of checkers due to excess combustion exist.

Our proposals are as follows.

1) Cleaning should be conducted sufficiently. Blow-off the dusts accumulated on the checkers by air. It is conceivable that a bit wider checker distance could be introduced in the future.

2) Wall bricks should be sealed completely to secure the required suction force.

3) The wicket for the radiation thermometer is too large (Photo 36) and might be remedied as shown in Fig. 19.

4) Zigzagging of upper bricks, which is considered to be caused by expansion due to excessive temperature raising, should be corrected by providing expansion allowances.

3.2.9 The hearth temperature

In order to maintain the fluidity of slag and hearth temperature, combustion should be continued even during the tapping operation.

3.2.10 Hearth shape

The hearth is generally elevated and is not shaped correctly. (Fig. 21)

3.2.11 Tap hole

The tap hole of about 2,200mm long is deformed and too long with some deflection.
Protruded dolomite on the center of back wall seems forming the upper portion of the hole.
The hole tends to deflect, because of the direction of oxygen blowing.
The hole will be straightened to right angle by the use of special joint on oxygen pipe. (Fig. 22)

3.2.12 Cleaning of the hearth before shut-down

Solidified metal and slag adhering to the hearth impede digging work of resurfacing by breakers in case of repair after shut-down. In order to avoid such difficulty, it is recommended that perfect cleaning of the hearth be performed, spreading a large amount of mill scale and fluorspar over the hearth, after the last tapping before shut-down.

3.2.13 Temperature control after shut-down repair

Frequent repair of the hearth is required during initial period after shut-down repair. It is assumed that efficient combustion after such repair tends to cause excess heating, consequently spalling of the hearth. In order to prevent such spalling, it is recommended that the temperature be controlled carefully during this period and also that perfect cleaning be performed before shut-down to eliminate residual metal and slag on the hearth.

3.2.14 Cooling box over tap hole

In order to facilitate tapping practices, it is recommended that a cooling box be installed on the upper portion of the tap hole.

3.2.15 Armor plate on back side of the furnace.

The armor plate covering the outside of the open

hearth furnaces' back walls should be removed to facilitate repairs of the back walls.
It will be effective especially when oxygen is being used.

3.2.16 Charging door

To facilitate work in the front of the furnaces, it is recommended that water cooling of the charging door be installed and that a door with wickets for peeping and sampling be provided. (Fig.23)

3.2.17 Exclusive charging box for dolomite from the viewpoint of workability and safety.

Exclusive charging box for dolomite instead of the drum should be provided in view of its workability and safety.

3.2.18 Roller guide attachment on the charging door

A roller guide attachment should be provided at the charging door to facilitate the repair work of the front wall.

3.2.19 Fuel burner

The positioning of burners should be improved to a universal type (movable vertically and horizontally and easy to change height).

3.2.20 Only mortar is being used for stool brick lining and for the assembly of the pouring tube. (Photo 37) It is recommended that sand of well dried fine grain be utilized, for improved prevention of steel leakage.

3.2.21 Pouring sleeve

Sleeves of a separate type should be fastened completely by cotter or bolt/nut, avoiding strong impact of the fastening tool.

3.2.22 Ladle brick lining

The ladle brick lining method is improper (Photo 38). In order to minimize erosion of the joint, it is recommended that the bricks be laid precisely layer by layer, making the joint with vertical lag. The last brick of each layer should be clamped securely in the lining, after measuring the size accurately to make it fit to gaps.

3.2.23 Drying ladle lining

Steam was seen evaporating out of the gap between ladle brick and shell during the pourings. Also, the top surface of steel ingot was found swollen during later stage of pouring. It is assumed that a considerable amount of gas was included in the poured steel.

Therefore it is recommended that the drying of a ladle after relining be performed for four hours as minimum (Photo 39) and that the distance between the drying burner and the ladle be shortened from 1.5m to 0.5m.

3.2.24 Ventilation holes of ladle shell

Currently, the ladle shell has no ventilation hole for steam.

Fifty holes of approx. 5mm dia. should be provided for sufficient drying.

3.2.25 Life of ladle

It seems that the degree of ladle refractory erosion is not being checked correctly.

With complete check of such erosion, together with a record of the number of heats through which a particular ladle has gone, it would be possible to find some ladles which could be used for further heats.

3.2.26 Pre-heating of ladle

Skull has been seen adhering frequently to the bottom of ladles.

The ladle should be pre-heated for 2 hours before the tapping, in addition to the temperature control of molten steel.

3.2.27 Charging box for pit scrap

It is suggested that charging boxes for pit scrap (runner, shorts, etc) be placed in the ingot making area for smooth treatment and cleaning of such scraps. (Photo 40)

3.2.28 Spout of ladle

Molten steel and slag was seen overflowing at several points of ladle during tapping operation. It is recommended that a stopper and spout be provided at the top edge of the ladle for single outflow of slag.

Metal adhesion on the ladle should be removed as it occurs for keeping ladle in leveled position. (Photo 41)

3.2.29 Deoxidation at ingot making shop

Pieces of aluminum rods should be provided in the ingot making area, too, for enabling killing actions when deoxidation is insufficient during refining stage.

3.2.30 Leakage of compressed air

Compressed air has been seen leaking from several points in the piping, resulting in lower pressure. Thorough inspection of the piping and couplings should be performed constantly.

3.2.31 Safety measures

Several dangerous spots have been noticed, and urgent remodelling or repairs are recommended, such as of the hand rail on the deck behind the furnace (preferably removal type for free passage, and of the stoppers for the charging boxes on the platform facing the scrap yard.

3.2.32 Preventative measures rather than post-disposal

Although recommendations or suggestions on disposal of pit scraps, ingot shorts and metal adhesion on top of moulds have been described hereabove, it shall be stressed that measures to prevent occurrence of such problems precede those of disposal after occurrence.

3.3 The Delta Steel Mill SAE, Cairo

3.3.1 Scrap yard

The scrap is neither sorted nor controlled properly. Classification and assortment of scraps are not in order.

Scraps should be classified by grade, type, shape, etc., and assorted neatly in assigned areas.

3.3.2 Sizes of auxiliary materials

Generally, sizing of ferroalloy, lime and fluorspar are not proper. Fe-Mn & Fe-Si should be 70mm maximum instead of in the 200mm lumps as is the current practice. Lime of 25 - 35 mm, flourspar of 5 - 10 mm are also recommended.

3.3.3 Skimming at the end of the oxidation stage

Skimming at the end of the oxidation stage is not performed sufficiently. It should be performed perfectly before producing fresh slag for reducing stage, thereby shortening the time for the fresh slag forming and accelerating the desulphurization.

Since the skimming causes remarkable heat loss, it should be carried out quickly (within approximately 5 minutes).

For the purpose of quick skimming, a skimmer with round wooden bar at the end, instead of steel plate, it being lighter in weight and with which metal adhesion is easily avoidable, is recommended instead of rabble.

3.3.4 Points of slag forming for reducing stage

1) The temperature prior to skimming at the end of the oxidation stage should be set at above 1,650°C, for acceleration of the fresh slag forming for reducing stage.

2) The furnace should be kept completely airtight

(The refining with the charging doors being left open should be discontinued.)

3) Stir the slag well with rabble to activate the reaction between slag and molten steel.

3.3.5 Points before tapping

Immediately before tapping, the fluidity of slag should be improved for the purpose of hearth maintenance, and molten steel should be stirred well to obtain the uniformity of composition and temperature.

3.3.6 Remodelling of charging door

The present method of repairing the hearth from the top of furnace by opening the roof is not appropriate for the dolomite sticking to the slag line, some of which falls on the hearth, causing irregularity of the hearth. Accordingly, the charging door should be remodeled so as to allow perfect repairs be performed from the front. (Fig. 24)

Repairing of both sides of the charging door should be done by means of a paddle with bent sides from the front.

3.3.7 The tapping hole

The hole for tapping is lengthy and highly positioned. On account of poor maintenance, the bottom of the tapping hole is raised, causing adhesion of redisual slag, which results in prolonged time for tap hole opening, furthermore, prolonged time for tapping due to narrowed passage. Hence, the tap hole should be improved.

3.3.8 Holders of electrodes

When adjusting the position of electrode holder, the electrodes are pressed down with a lifting magnet, or pieces of steel strip are used in place of liners, due to malfunction of the holders. Periodic overhauling and maintenance should be performed on holders and cylinders.

3.3.9 Charging door

The charging door is not closed perfectly, (Photo 42) being opened so frequently. Such practices should be discontinued.

3.3.10 Tapping spout

The tapping spout position is high and lengthy.

For easier tapping practice of the worker, it should be improved.

It is also recommended to install a deck for easier spout preparation.

3.3.11 Dust on the furnace roof

Considerable amount of dust accumulates on the roof, which should be blasted off by compressed

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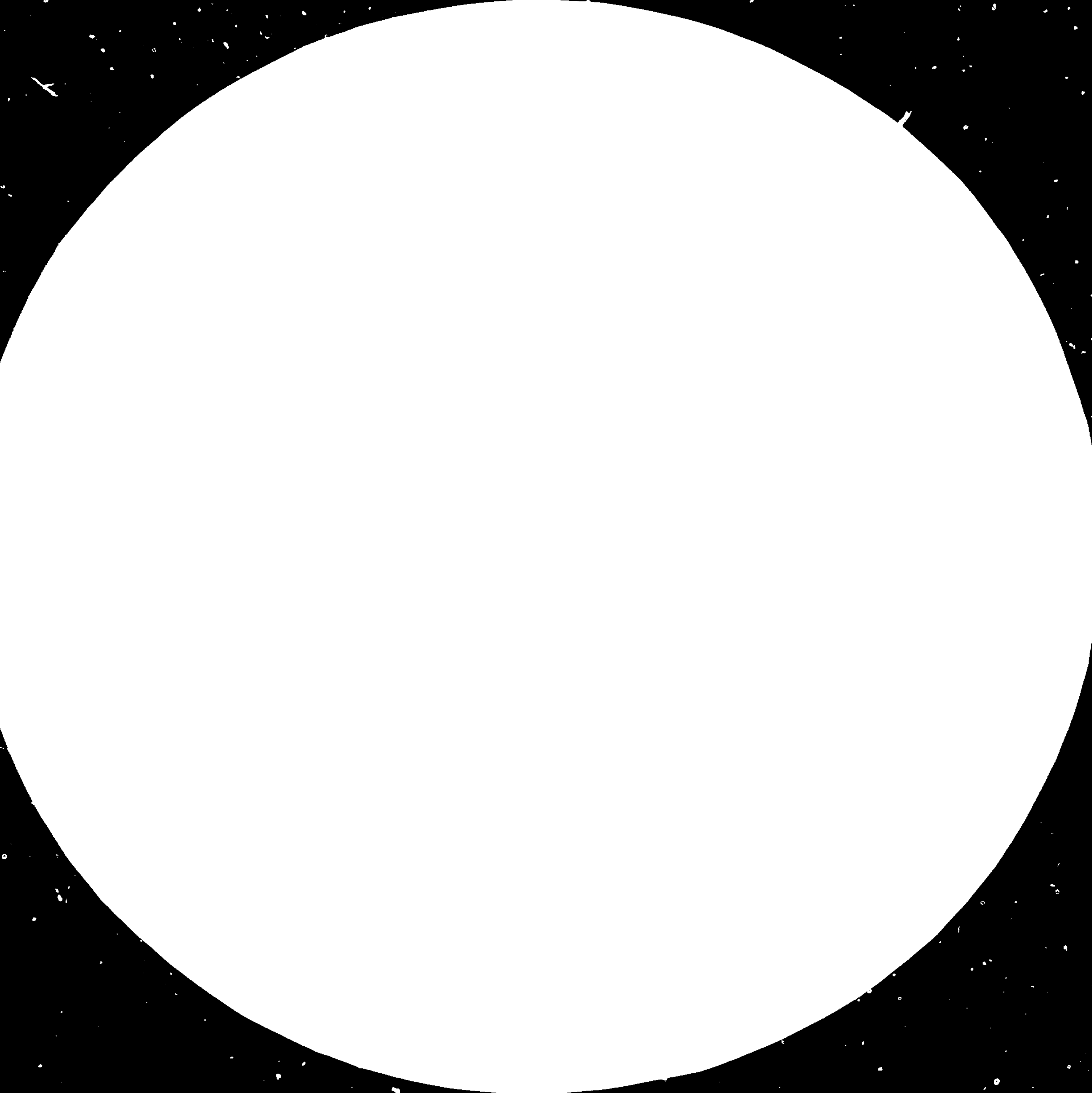

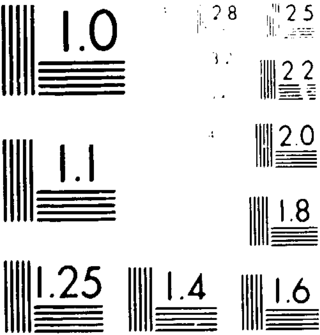
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air for heat radiation and minimize refractory erosions.

Furthermore dust accumulated on the holders and arms should also be blasted off with air. Otherwise, cracking caused by insufficient heat radiation or sparking caused by poor insulation are liable to occur. It is also recommended to provide a guard frame on the bottom side of the holder. (Photo 43)

3.3.12 Transfer between the floors

The method with which lifting magnets, moulds, etc. are transferred between melting floor and ingot making floor should be improved. (Fig. 25)

3.3.13 Limit switch at the bottom of Ram

For alignment of roof swinging ram with the ram hole attached to the furnace roof, limit switch at the bottom of ram should be provided (Fig. 26) so that one worker in charge of tilting the furnace is also able to perform such alignment, instead of having another worker standing by the ram, signaling right alignment to the other through visual adjustment.

3.3.14 Cooling box

It is recommended to install water cooling boxes for the purpose of preventing erosion of the wall refractories.
(Fig. 27, Photo 44)

3.3.15 Charging device of ferroalloys into ladle

It is recommended that a charging device for the addition of ferroalloys be installed for tapping practices.

3.3.16 Simple charging device

It would be a help if a simple charging device for lime, ferroalloys and rolled scrap is used.
(Fig. 28)

3.3.17 Steel leakage from pouring tubes

1) Pouring sleeves are not coupled well, due to ill shape and ill location of fastner holes, leaving a gap of 30mm. (Photo 45)
   They must be fabricated correctly, even if made for self-use.

2) Each pouring sleeve should be clamped completely by cotter or bolts/nuts, without leaving a gap of over 5mm within joints. (Photo 46)

3) Metal adhesion on the upper portion of pouring tube should be removed as it occurs. Excessively eroded sleeves should be discarded. (Photo 47)

3.3.18 Setting of ingot moulds

Two different types of mould (purchased, and self-made) are being used.
Moulds of the same shape should be set on one stool without mixing the two. (Photo 48)

3.3.19 Unit consumption of mould

The unit consumption of mould is extremely large (125 kg/t). The moulds should be handled very carefully. The proposed improvements are as follows.

1) The samples of self-made and purchased moulds were analysed by the team as shown below.

	C	Si	Mn	P	S	Cu	Ni	Cr	Sn
Self-made	3.04	3.39	0.52	0.220	0.065	0.30	0.07	0.10	0.046
Pur-chases	3.38	3.37	0.86	0.083	0.043	0.05	0.02	0.03	0.001

Judging from the records of corresponding moulds in Japan, toughness shall be improved by adopting the following chemical composition:

C: 3.6 - 3.8%, Si: 1.2 - 1.5%, P: 0.150 or less.

Regarding the self-made moulds, Cu, Cr and Sn should be lowered, if possible.

2) Wall thickness shall be increased up to 70mm from current 40mm in the lower portion, ranging up to 150 to 200mm from the bottom.

3) The unit consumption of mould will be reduced drastically by simply starting the mould stripping practices earlier and doing it vertically.

3.3.20 The cover for ladle drying should be modified.

The existing one covers only half, and it should be replaced by a larger one. (Photo 49)

3.3.21 The stopper drying furnace should be repaired and utilized as soon as possible.

3.3.22 Another slinging hook be added on the opposite side of the ladle for a complete removal of slag and molten steel out of the ladle. (Fig. 28)

3.3.23 A single person should be assigned to send signals to the crane operator. The man thus assigned should signal alone by using a whistle.

3.3.24 Stool brick laying should performed inside of the pit, not outside. (Photo 50)
(to hold the stool level)

3.3.25 Containers should be provided in the ingot making yard for collecting the pit scraps. When filled, they should be transfered to the charging bucket. (Photo 51)

3.3.26 Control lever of the ladle should be shortened.
The pit wall should be repaired neatly.
(Photo 52)

3.3.27 Cleaning and maintenance practices are unsatisfactory, especially around the ingot making yard.

Dangerous spots require urgent remodelling or repair, for example, the hand rail of 25t electric arc furnace and the surrounding wall of ingot making pit. (Photo 53)

3.3.28 The water main is seen running through the ingot making yard.

Either heavy loads should be not placed over it or it should be relocated.

3.3.29 Melting of 13 percent Cromium steel

Demonstration of melting 13%-Cr Steel with high-carbon Fe-Cr by the 3t electric arc furnace was not carried out by field survey team, owing to insufficient preparation in terms of furnace condition (hearth), material (oxygen) and device (screen).

Hence, the main points of the practices are described below.

1) Main points of melting

i) Furnace condition

a) As the molten bath temperature rises over 1,900°C, the hearth, slag line, furnace wall and roof are required in suitable conditions for the purpose intended.

b) While dephosphorizing is impossible and, on the other hand, the picking up of phosphorous is inevitable, sufficient hearth cleaning should be performed after tapping the previous heat.

c) Picking up of carbon tends to occur during and after the ending stage of the oxidation. Low carbon steel (C: 0.30% max.) should be melted in preceding heat, for cleaning high carbon steel adhesion off the hearth, the wall and the roof before melting of 13%-Cr steel.

ii) Material

a) Use only those materials whose compositions of which are already known.
(especially in terms of Phosphorus (P), Sulphur(S), Carbon(C) and Chromium(Cr))

b) In consideration of picking up of P, a lower P content in the charging material should be aimed for (rate of picking up differs by P content of refractories, lime, etc.).

iii) Charging

The amount to be charged before melting down should be about 85% of the total quantity, excluding the rest as coolant.

iv) Melting

a) To prevent loss of Cr due to oxidation, it is desirable to minimize openings of the furnace, such as charging door, and to accelerate melting.

The percentage of Silicon(Si) to be charged should be about 1.00%, thereby minimizing the loss of Cr during the melting.

b) Slag line in the furnace will be eroded even more by slag of abundant SiO_2 caused by oxidation of Si.

20kg. of CaO should be charged to prevent such erosion.

c) After melt down, sufficient stirring of molten bath should be done by rabble for uniformity of composition and then make sampling for chemical analysis.

d) Remove about 80% of SiO_2 rich slag, and then charge additional 20kg. of CaO.

v) Oxidation

a) Start oxygen blowing after raising bath temperature up to about 1,620°C.

b) The high temperature should be attained quickly, in order to minimize the loss of Cr during oxygen blowing.

c) At the end of oxidation period, C should be about 0.10%, in fear of the possible C pick up in the reducing period.

d) The decarburization efficiency of oxygen is estimated to be about 20 - 45%.
It is recommended to establish a standard oxygen blowing time against decarburization based on data of steel bath specimens taken at every two minutes.

vi) Reduction

a) Cold charge and Si-Cr should be added for the purpose of protecting the lining and accelerating the reduction of Cr contained in slag. (Cold charge shall be 10% of total charging quantity, while Si-Cr about 3% of the same.)

b) Then, deoxidazation by casting Al and Cr reduction to be accelerated by casting CaO and Ca-Si.

c) Due to difficulty in forming sufficient reducing slag, about 80% of slag should be removed when 70 - 80% of Cr reduction has been finished. Then, add CaO and Ca-Si for further deoxidation and desulfurization.

d) After formation of the reducing slag, adjustment of the composition should be made.

vii) Tapping

a) Open the tap hole sufficiently to permit continuous out-flow.

The above mentioned steps are summarized in Table 1.

2) Jigs to be made available (Photo 54)

i) Screen: for prevention from heat and accidents

ii) Rabble, 10 : for stirring steel bath and slag thoroughly.

iii) Slag skimmer, 5: (with a round log on its end)

iv) Lance pipe guide: for maintaining pipe angle constant.

v) Coupling for lance pipe: for easy replacement of lance.

3) Others

i) The P and C contents (%), contained in materials such as brick, lime and ferroalloy, should be checked fully. Try to use materials of low P and C contents (%) as much as possible.

ii) Prolonged operating time damages the hearth and slag line. Hence, the analysis during melting should be performed quickly.

iii) For the control of molten metal amount, all the charging materials into the furnace should be weighed accurately.

iv) Since Cr pick up is inevitable after the melting of 13% Cr steel, subsequent 3 heats shall be with steel containing 1% Cr or more.

v) In order to avoid carbon pick up from the ladle, one or two heat preceding 13% Cr-steel shall be low carbon steel with 0.3C or less.

vi) The ladle stopper should be of higher refractoriness as it is accident-prone.

3.4 Problems with Induction Furnace (DELTA)

Short life of lining, 8 to 15 heats, is pointed out as first and fatal problem in Induction Furnace operation.

Upon observation, several problems, in operation, construction of furnace and sintering surfaced. Recommended solutions are detailed below.

3.4.1 Operation

1) Insufficient slag removal

Judged from the state of erosion of lining being conspicuous (Fig. 30), thorough removal of slag is imperative after melt down and tapping, even though the counterpart appeared to believe slag removal was being performed completely.

The practice of slag removal is described below.

i) Slag removal after melt down

The slag sticking to the furnace wall below the metal surface should be floated up by stirring the bath with a steel rabble. Then, remove the slag on the bath surface by means of a spoon.

ii) Slag removal after tapping

Immediately before tapping, the edges of slag in contact with the furnace wall should be cut off, and then tapping should be conducted without delay, leaving no slag in the furnace. Soon after the tapping, slag sticking to the furnace wall should be removed by scraping.

2) No lime charging on the bottom.

Lime stuck to the bottom hampers discovery of damage of bottom lining. Lime should be added after slag removal at the time of melting down. Otherwise, the furnace capacity will be decreased and the productivity will be lowered.

3) Lining should be kept warm at the time of furnace stoppage.

Lining will crack when cooled rapidly at the time of furnace stoppage. A simple furnace cover should be provided for keeping warmth.

4) Additional materials should be charged, bit by bit, at earlier stage.

If a large quantity of additional materials are charged after melt down, the molten bath surface will solidify again, causing slag to adhere to furnace wall remaining under molten bath surface. Consequently, erosion of slag line will be accelerated. Therefore, charge it, bit by bit, gradually prior to complete melt down.

3.4.2. The furnace construction

1) The water in lining material is excessive.

Water content shall be about 3 - 5%. If the water content is high, it will make the drying and sintering the more difficult.

2) Insufficient hardness of lining material

It should be stamped to such a hardness that a nail cannot be driven in (pneumatic rammer should be used).

3) Plaster should be coated inside of the coil.

At DELTA, as plaster was being coated outside, the cooling water went up to 60^{o}C, due to high temperature of the coil.

Coil should be left exposed to the outside permitting easy heat emission to increase the cooling effect of the lining.

3.4.3 Sintering

Currently, steel core is left in the furnace and scraps are charged therein and sintering is performed in 18 hours, after relining of furnace.

1) Steel core should be withdrawn for the water contained in the lining escapes easily.

2) Melting shall be resumed after sintering of four hours by utilizing a electrode.
   The steps are as below.

   i) Upon completion of stamping, the core is lifted gently (about 50mm) by jacks (2 units) and pulled off by the crane.

   ii) Two layer of fire bricks shall be laid on the center of the bottom.

   iii) A used electrode shall be errected on fire bricks.

   iv) Sintering is performed for four hours by applying.
   50KW x 1 hr - 70KW x 1 hr - 100KW x 1 hr - 120KW x 1 hr

v) An electrode and fire bricks are taken out of the furnace. then inspect the interior. (to be repaired if there is any damage.)

vi) Resume melting

The lining life will be extended several times more, if the major points described above should be implemented.

3.4.4 Others

In addition to the above, there are some other problems to be solved as shown below.

1) Many troubles in the electric system and hydraulic cylinder.
   Over 30 hours of furnace stoppage was observed. Inspection and maintenance should be carried out at the time of scheduled furnace repair.

2) During the melting stage, a thick oxidized film was seen forming on the bath surface, and it is discharged together with large amount of molten metal after melt down. The furnace should be covered with insulating cover like asbesto sheet.

3) Control of the charging amount is not performed properly, resulting in excess metal being disposed of on the ground floor. Accurate measurement of material and control of molten metal should be performed.

4) Tapping was performed with the spout being not dried completely after repair. It should be dried thoroughly, as the quality of steel deteriolates with H_2 absorption.

4. Demonstrations

The following demonstrations were conducted during the field survey of the team.

4.1 COPPER

1. Normal repair of open hearth furnace
2. Lining of stool bricks
3. Setting of pouring tubes
4. Setting of moulds
5. Lining of ladle bricks
6. Fabrication of stopper

4.2 NATIONAL

1. Repair under abnormal condition of open hearth furnace
2. Lining of stool bricks
3. Setting of pouring tubes
4. Linihg of ladle bricks

4.3 DELTA

1. Utilization of oxygen on the electric arc furnace
2. Lining of stool bricks
3. Setting of pouring tubes
4. Setting of moulds
5. Mould stripping

5. Postscript

At the end of this report on steel making operations in three non-integrated steel plants in Egypt, we would like to emphasize again and anew that there exist good possibilities for improvements in terms of productivity, cost, quality and safety in these steel making operations if the individual field work steps are performed carefully and deliberately after giving due consideration to the recommendations made here.

Kobe Steel, Ltd., Japan, sincerely hopes this report will be of assistance to the three steel plants and that it might help lead toward immediate improvement of their steel making operations, and consequently of the steel industry in Egypt, while at the same time involving a minimum of money and time.

We at Kobe Steel would like to express our heartfelt appreciation and gratitude for the assistance and cooperation extended to our Field Survey Team by UNIDO, Vienna and Cairo, UNDP, Cairo, C.M.R.D.I., Cairo and the Management and staff of the three steel plants in Egypt.

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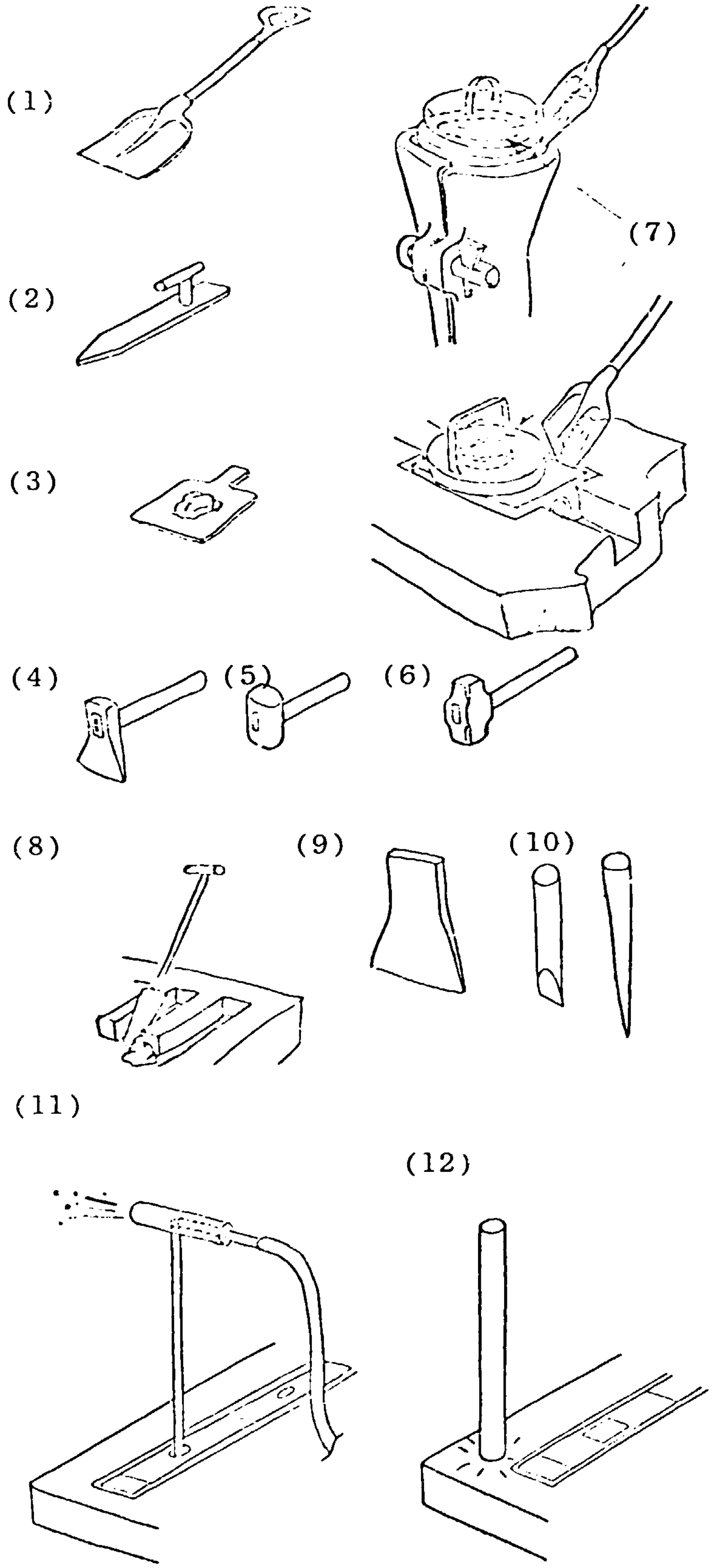


(1) Scoop

(2) Trowel

(3) Plate for mortar

(4) Hammer for brick cutting

(5) Wooden hammer for ladle brick lining

(6) Hammer

(7) Cap

(8) Tool for channel cleaning

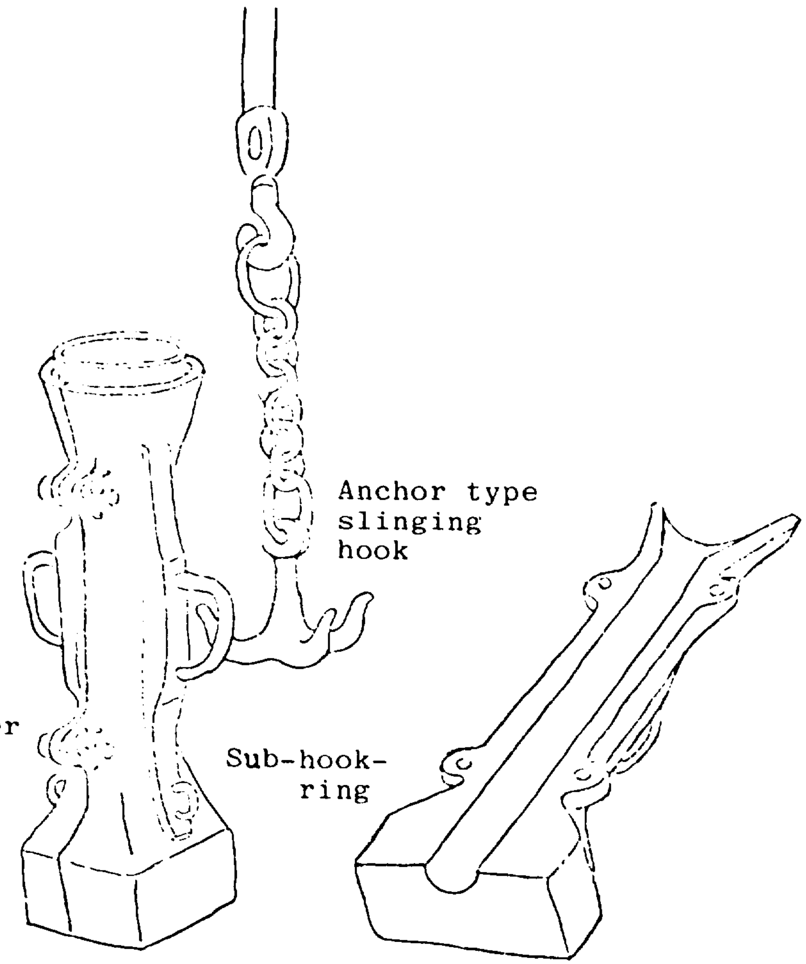
(9) Brick cutter

(10) Chisel

(11) Suction pipe

(12) Steel bar (clawbar)

1. Jigs for stool brick lining, pouring tube setting and mould setting. (KOBE)



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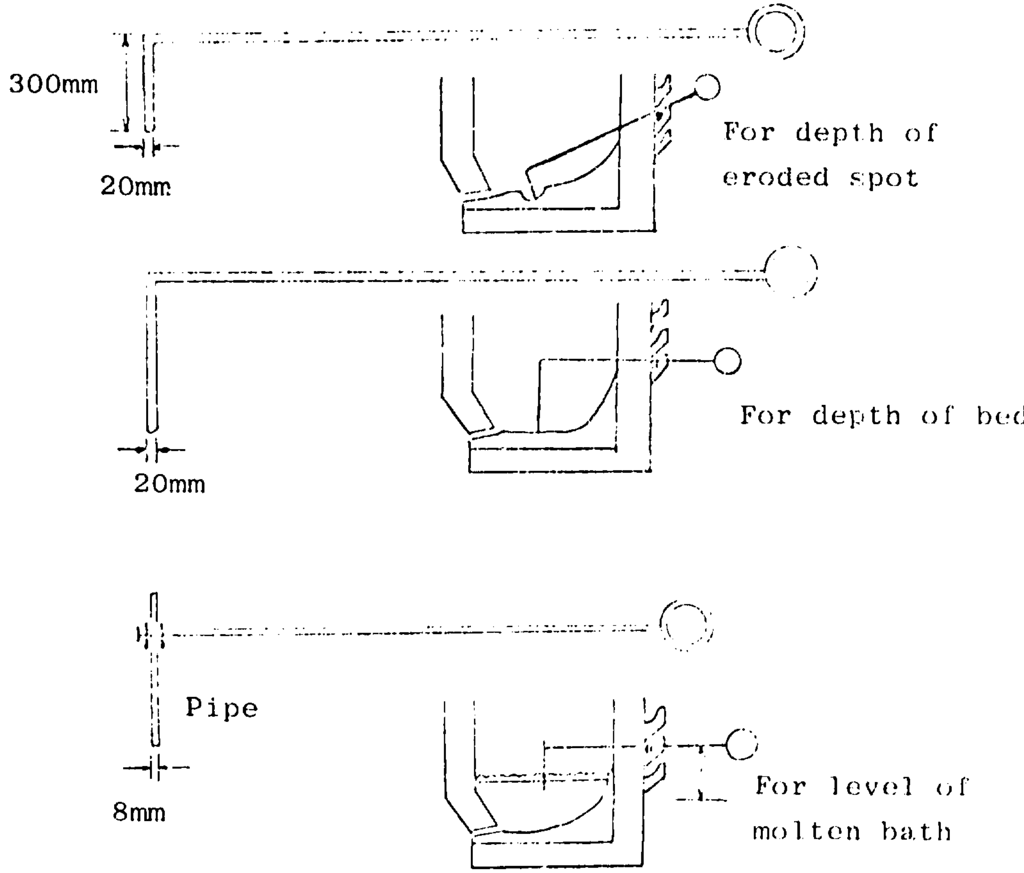
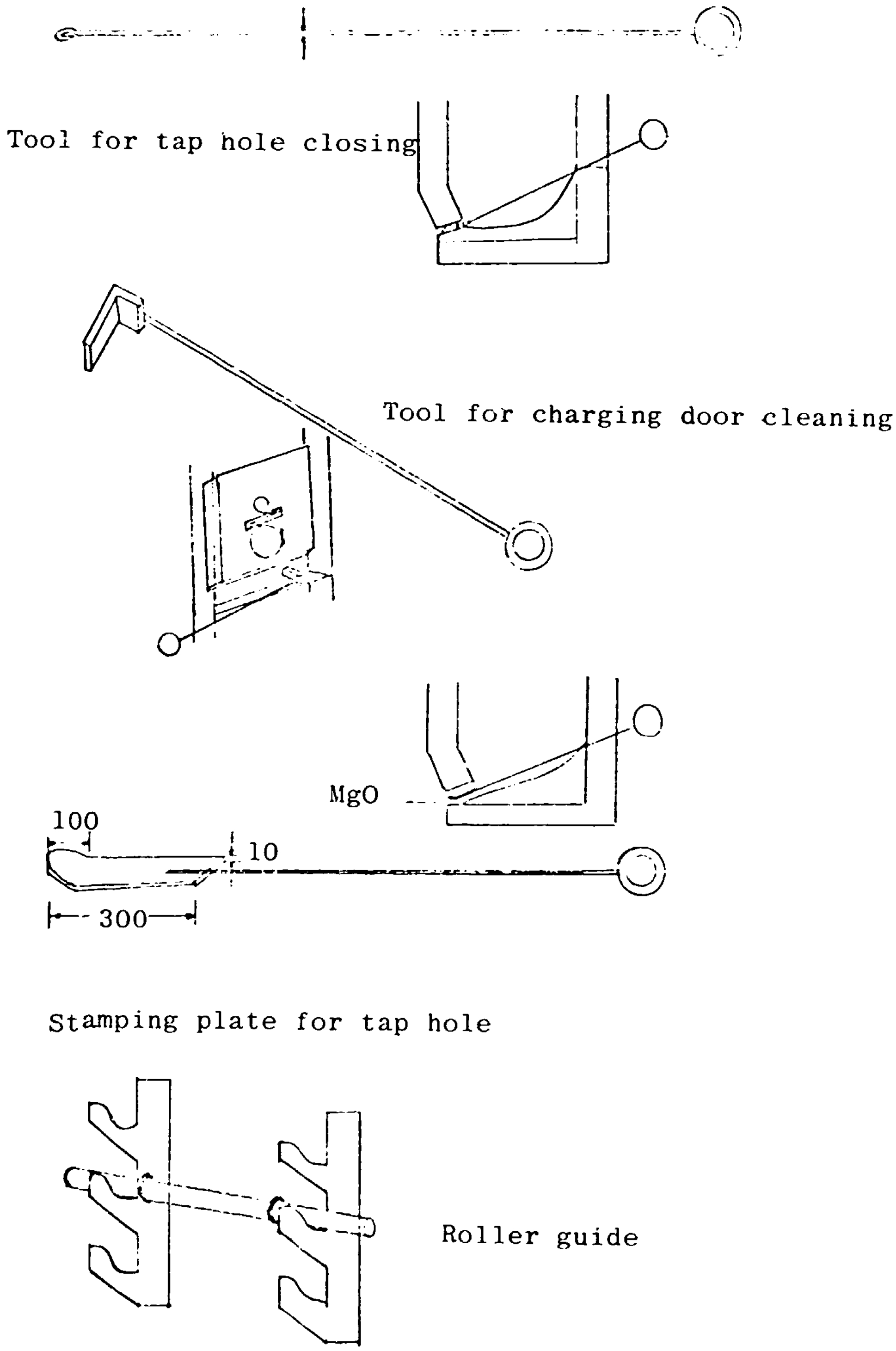
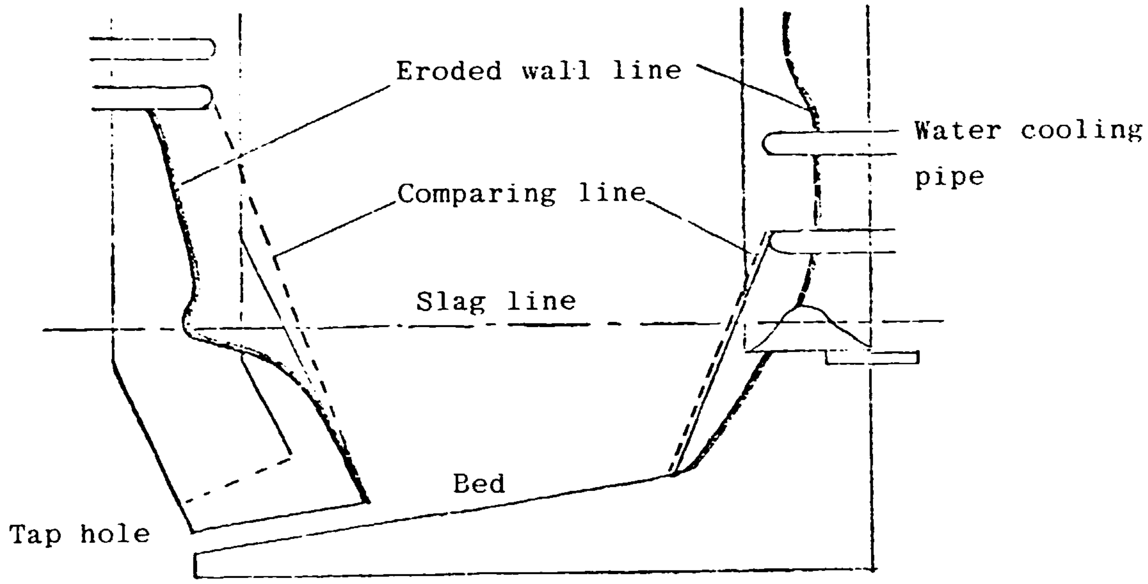


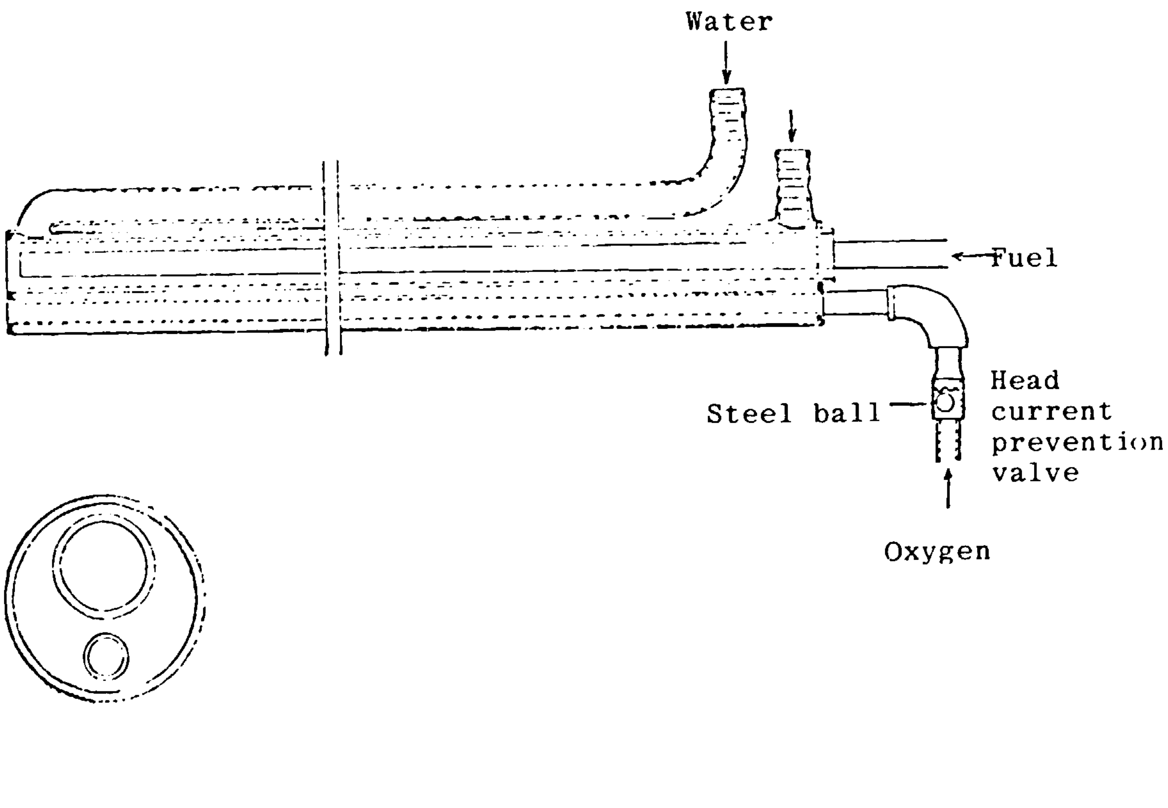
3. Devices for hearth inspection (KOBE)



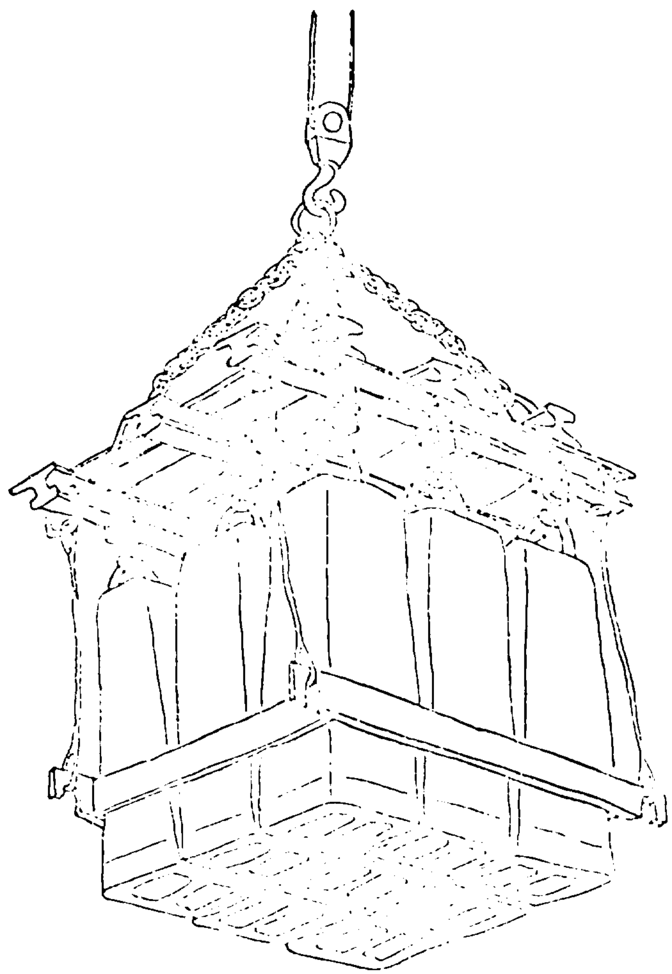
4. Devices for hearth repairing (KOBE)



5. Measuring of wall thickness of front and back walls of open hearth furnace. (KOBE)



6. Main burner with oxygen piping for open hearth furnace. (KOBE)



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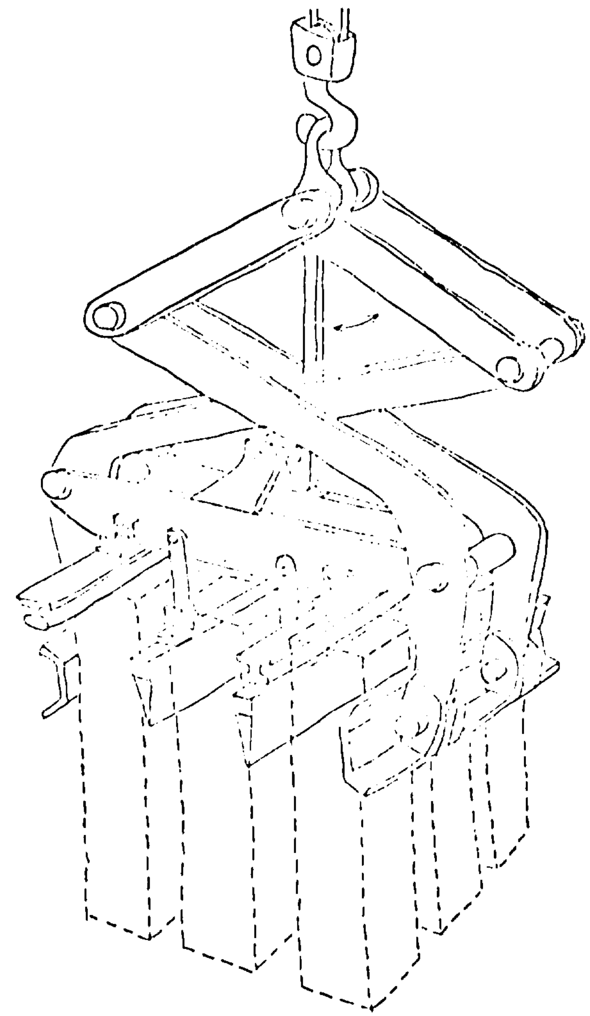

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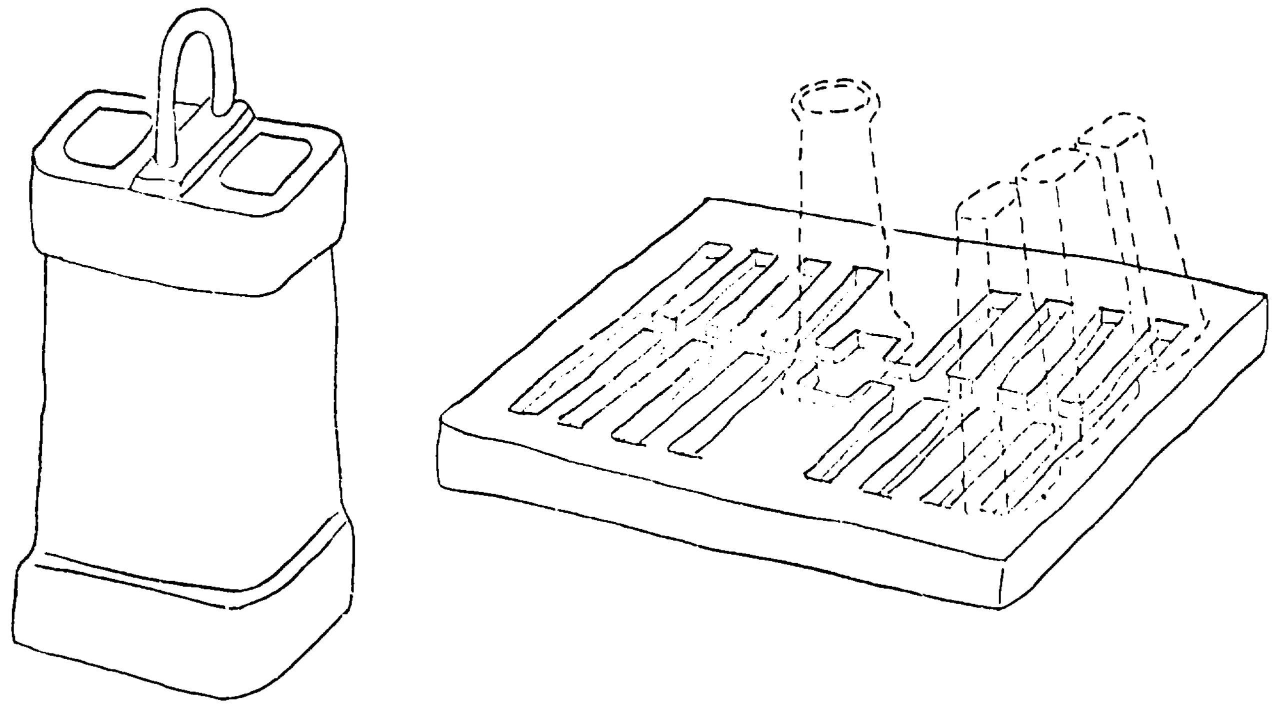
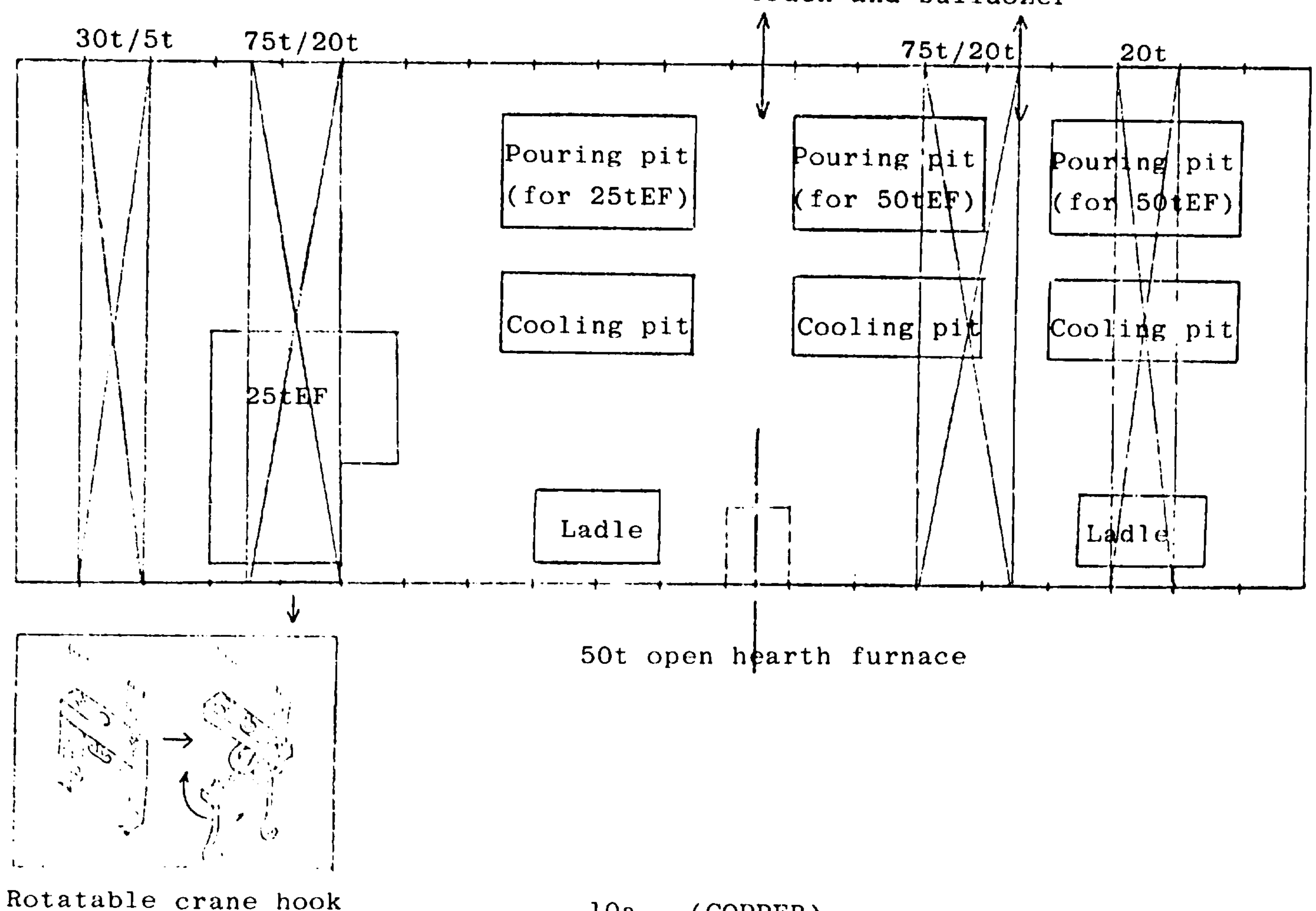
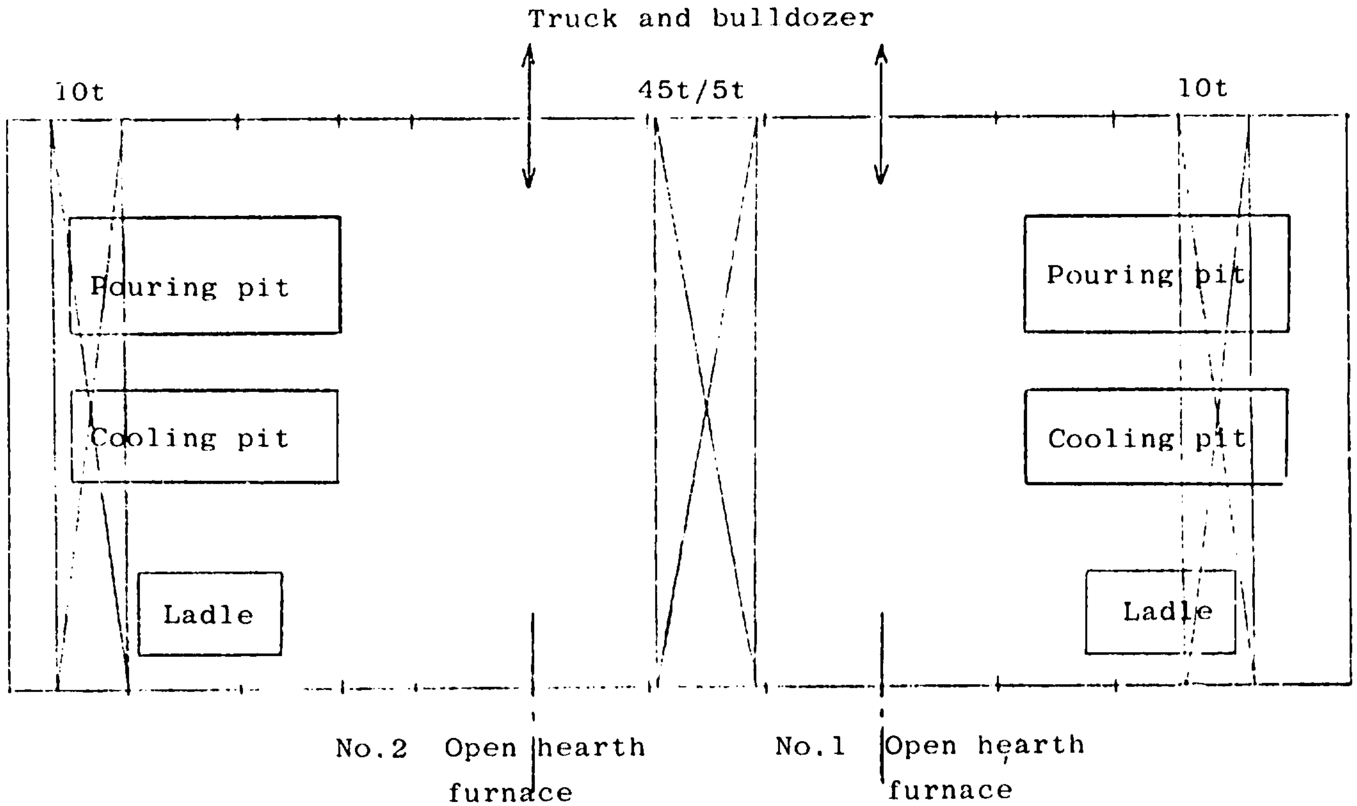


9. Twin type mould and stool. (KOBE)



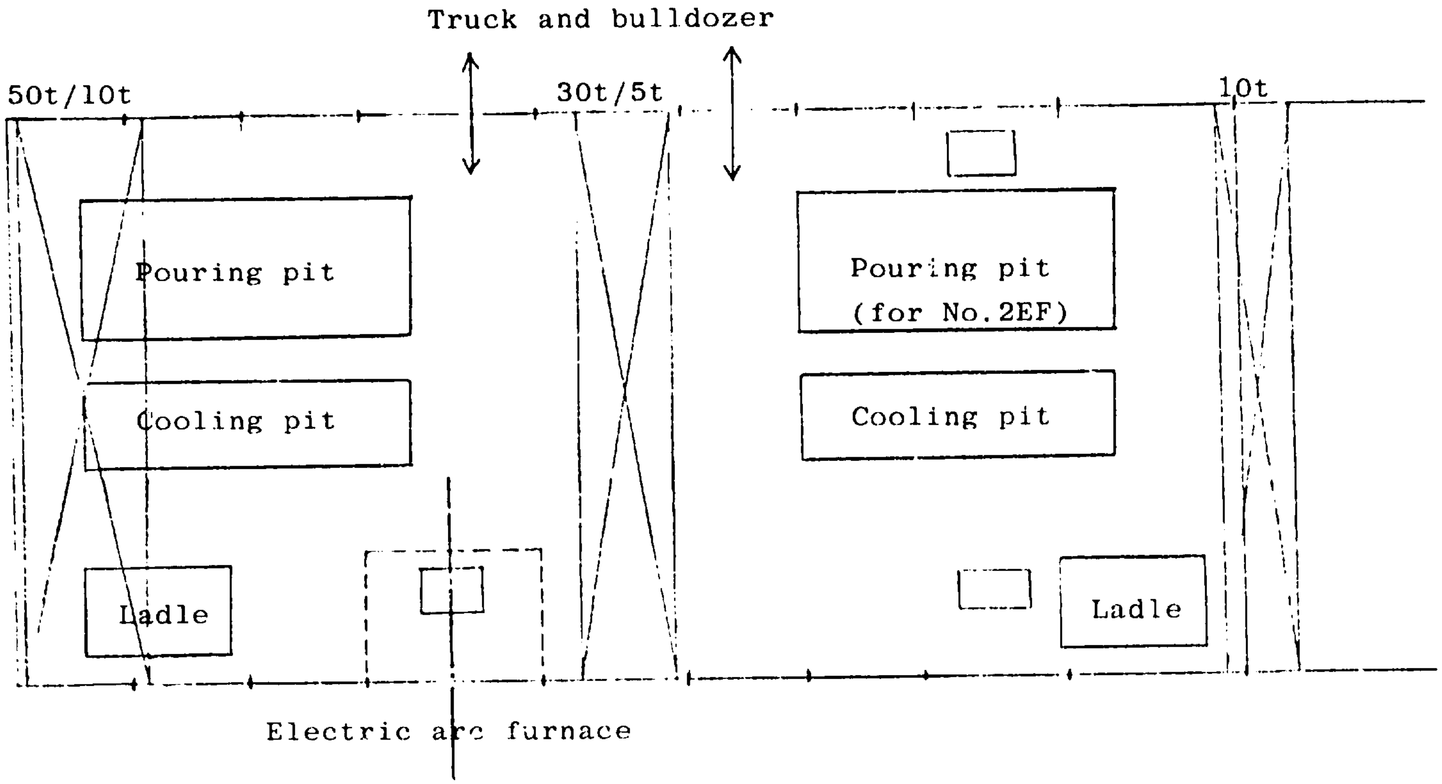
10a. (COPPER)

10. Recommended modifications of the layout of ingot making yard



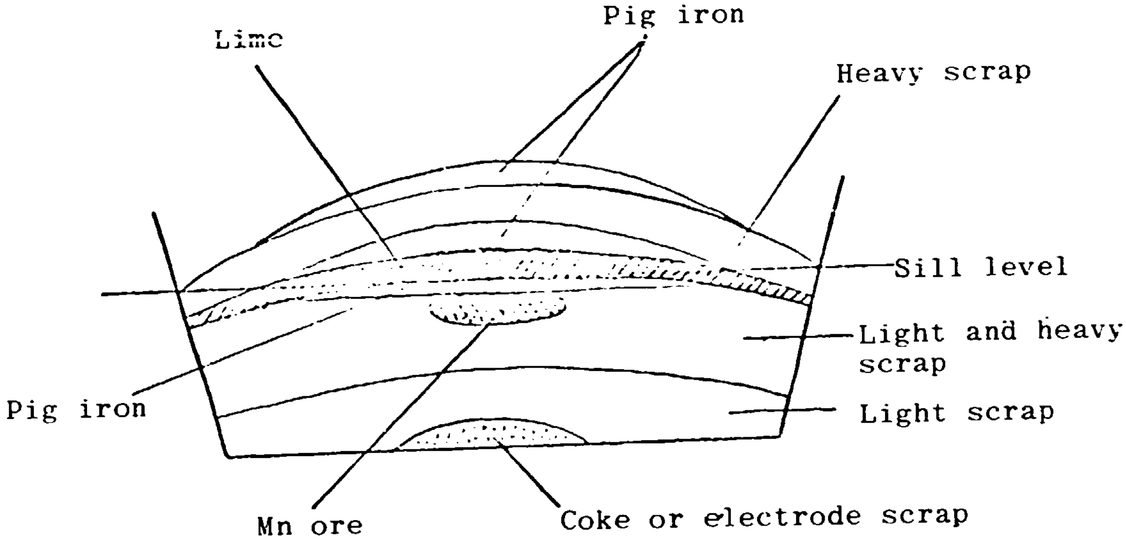
10b. (NATIONAL)

10. Recommended modifications of the layout of ingot making yrad

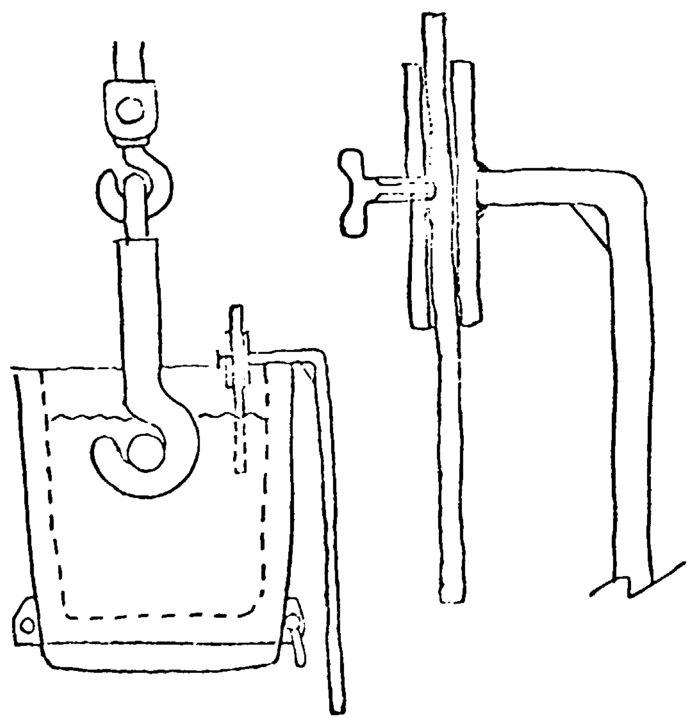


10c. (DELTA)

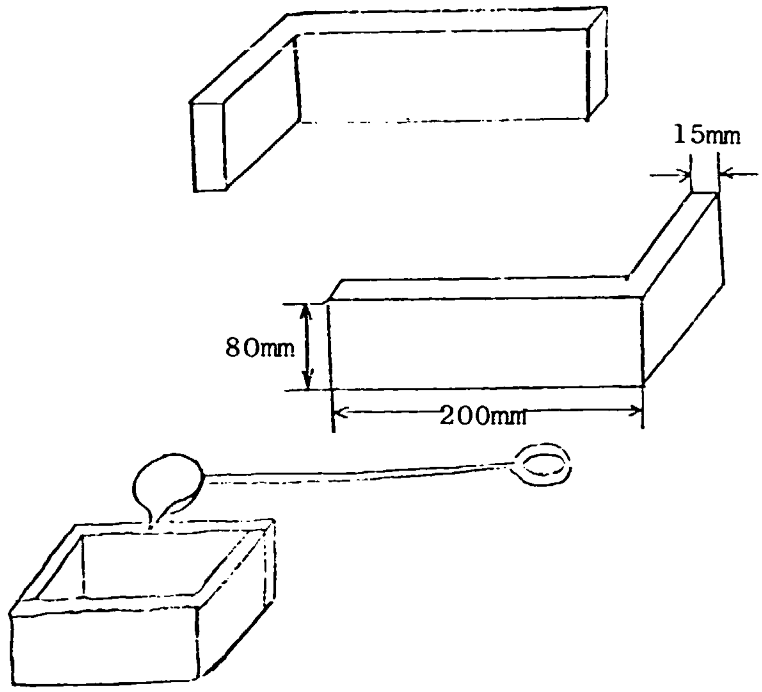
10. Recommended modifications of the layout of ingot making yard



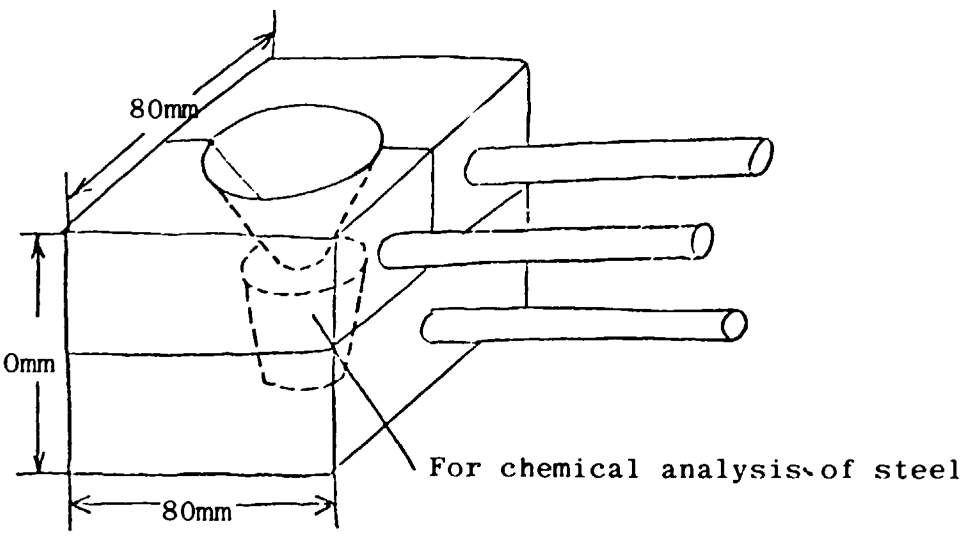
11. Correct positioning of charged materials in open hearth furnace. (KOBE)



12. Device for measuring the amount of steel in ladle (KOBE)

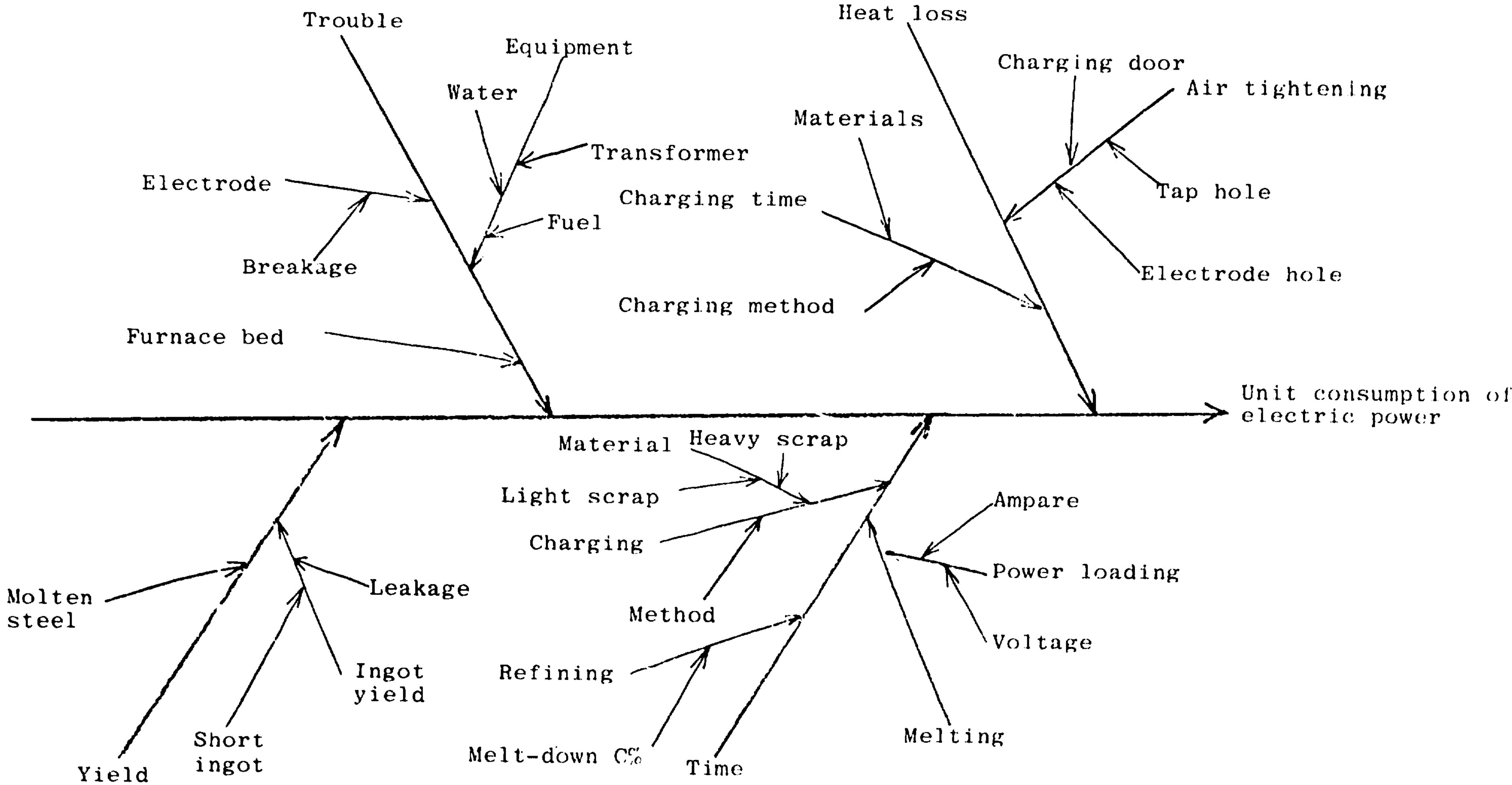


For steel

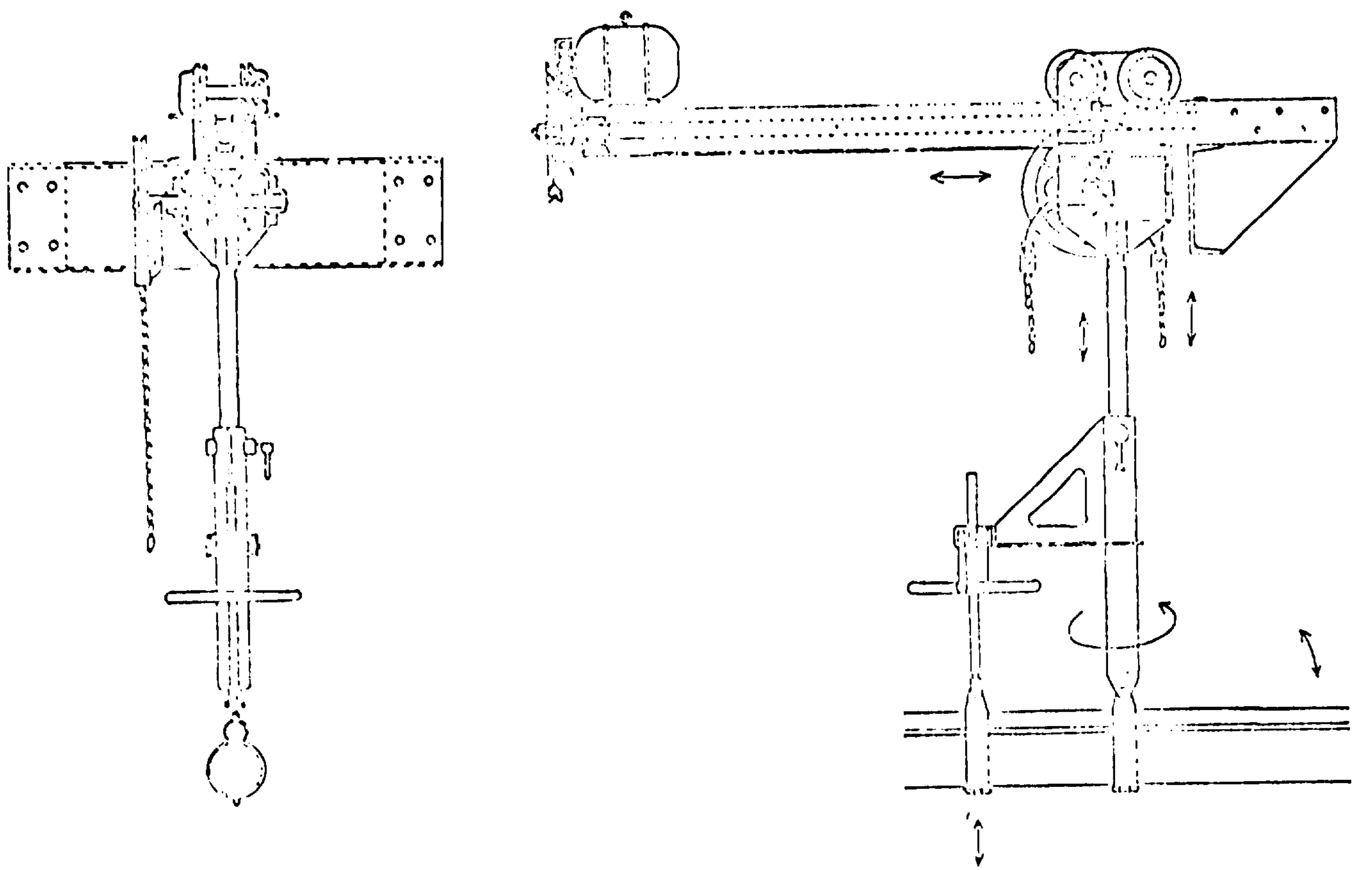


For slag (usable for chemical analysis of steel)

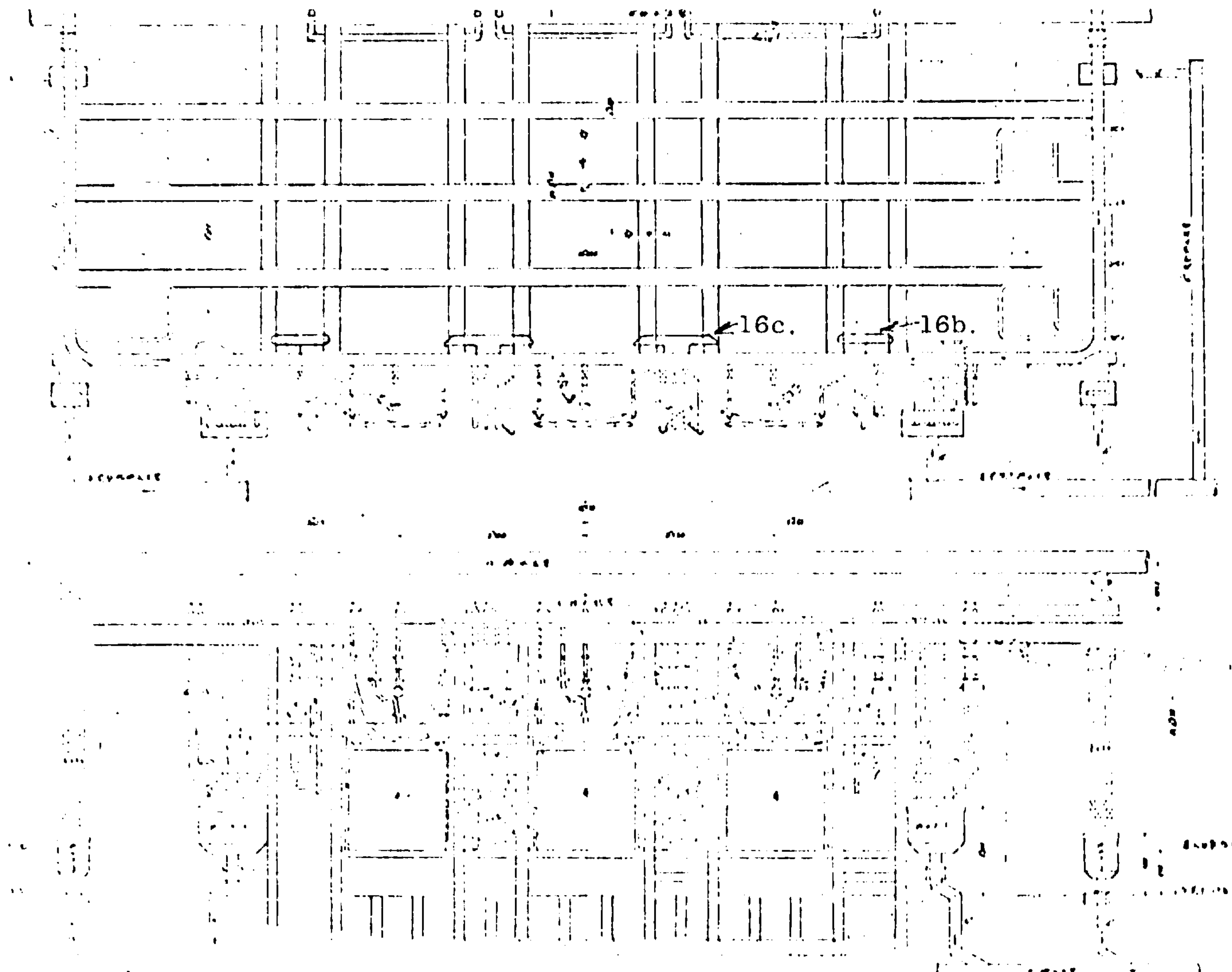
13. Sample cases for visual test. (KOBE)



14. An example of characteristics chart for "Plan-Do-Check-Action" cycle

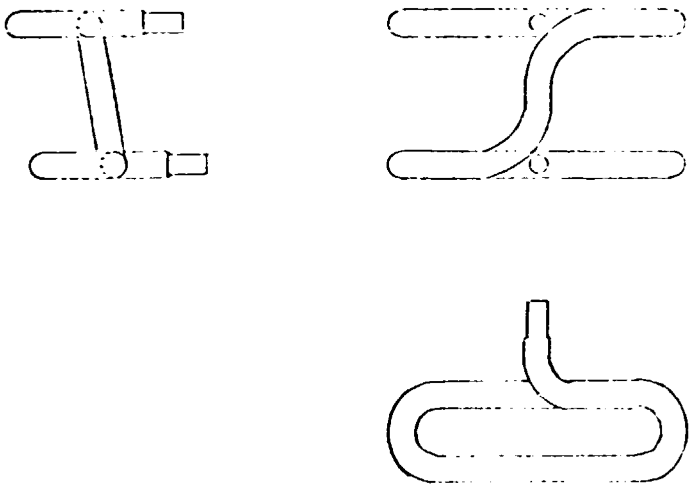


15. Universal type burner for open hearth furnace (KOBE)

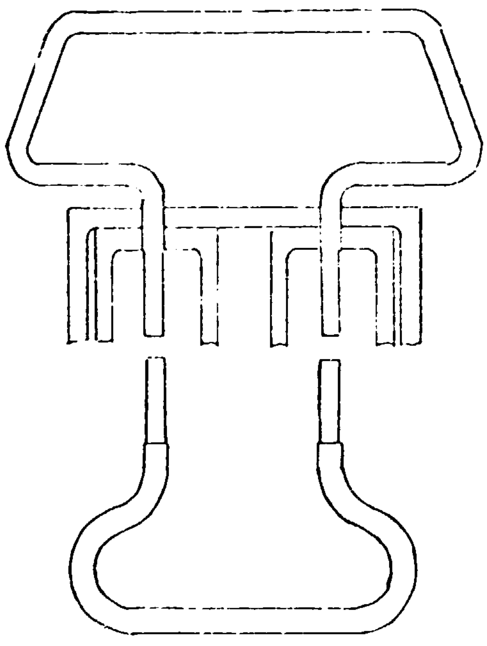


16a. General layout of water cooling piping

16. Water cooling piping for open hearth furnace (KOBE)

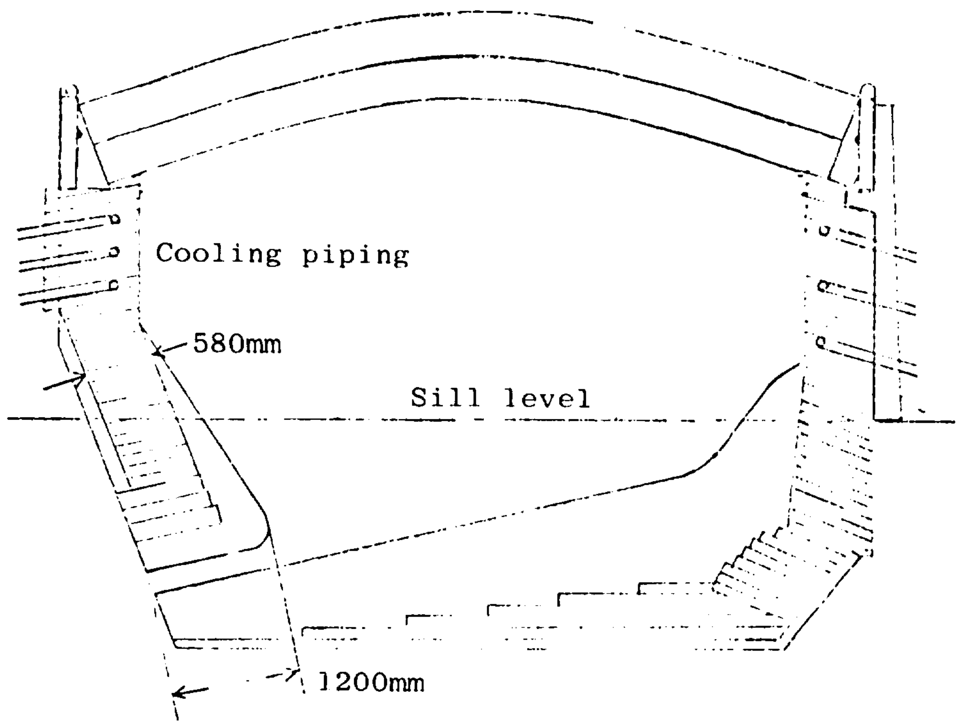


16b. Enlarged drawing of front wall piping - 1.

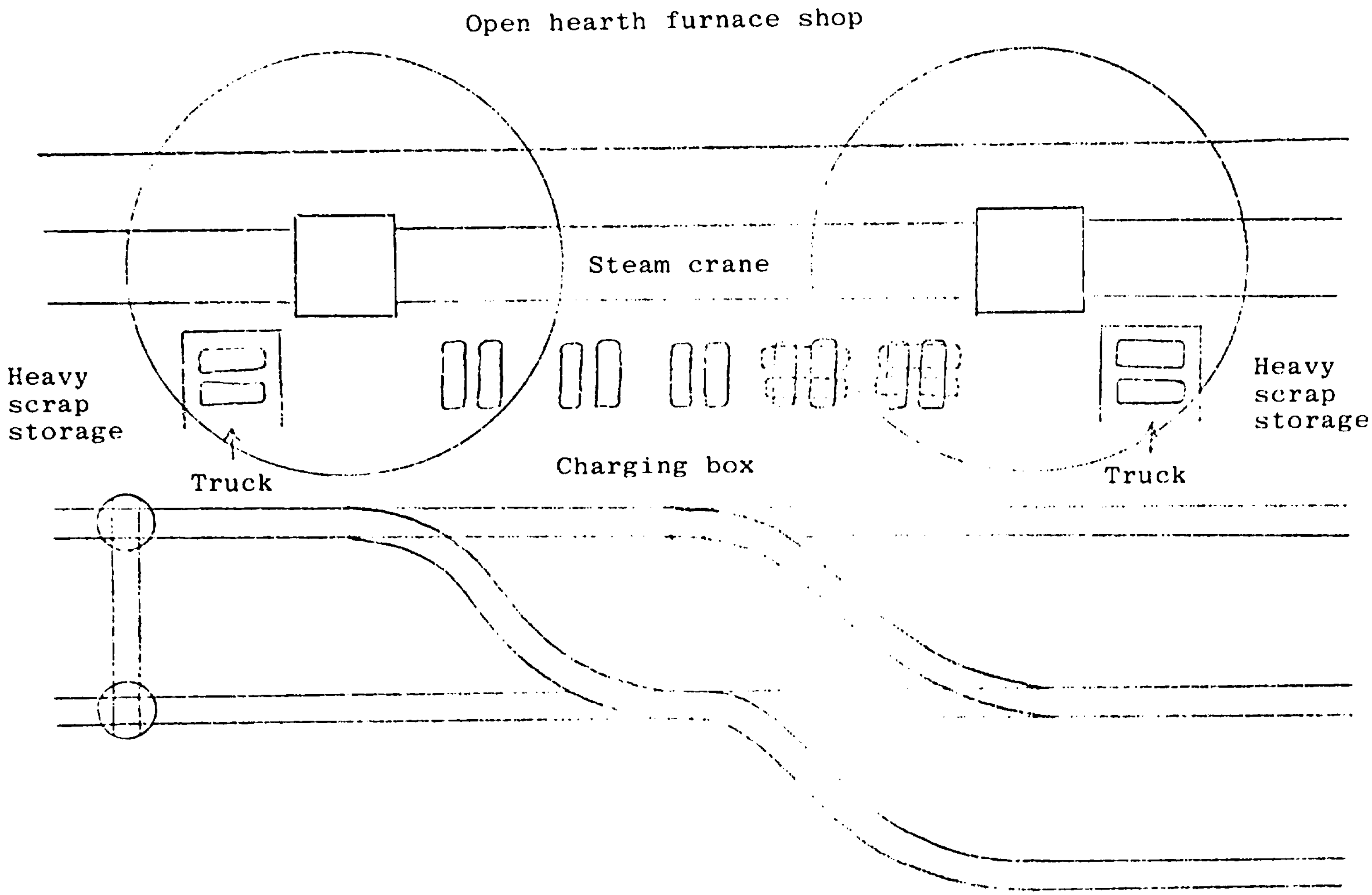


16c. Enlarged drawing of front wall piping - 2.

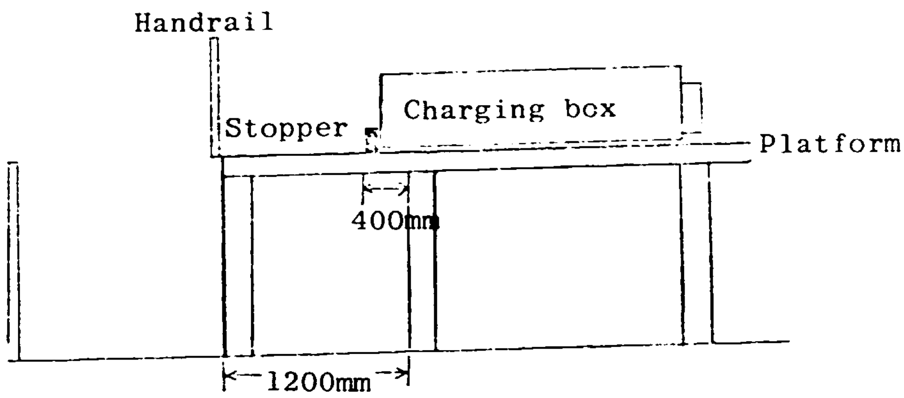
16. Water cooling piping for open hearth furnace (KOBE)



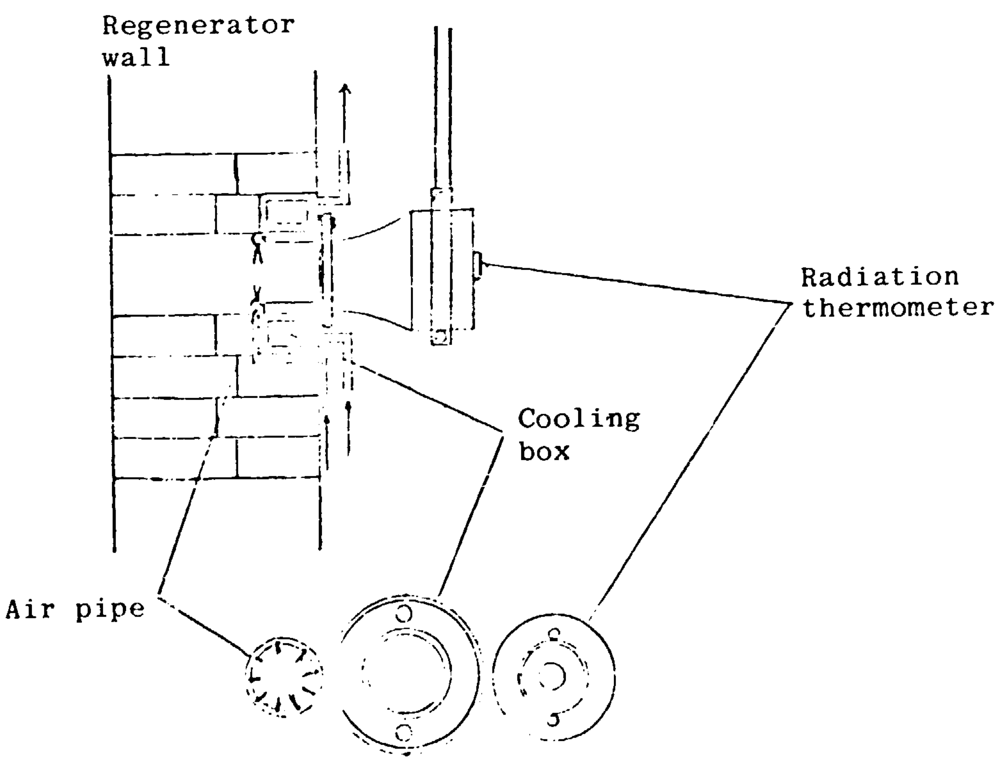
17. Brick laying preventing the brick falling from the frunace wall. (KOBE)



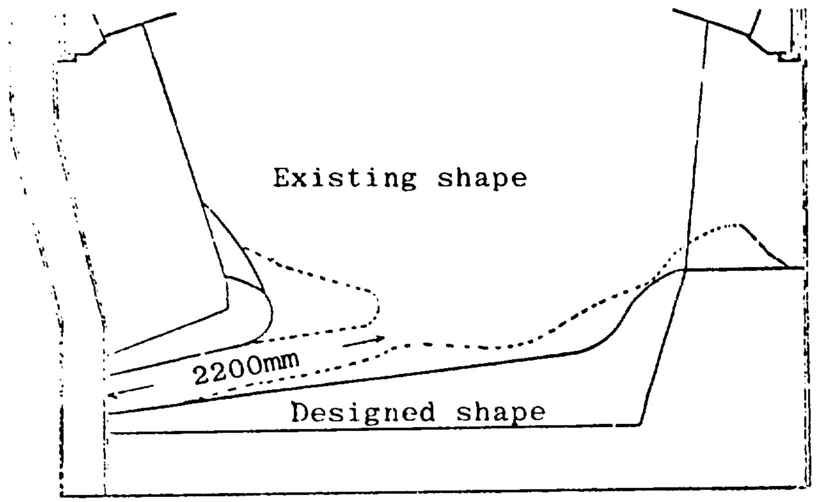
18. Recommended arrangement between steam crane track and railway track



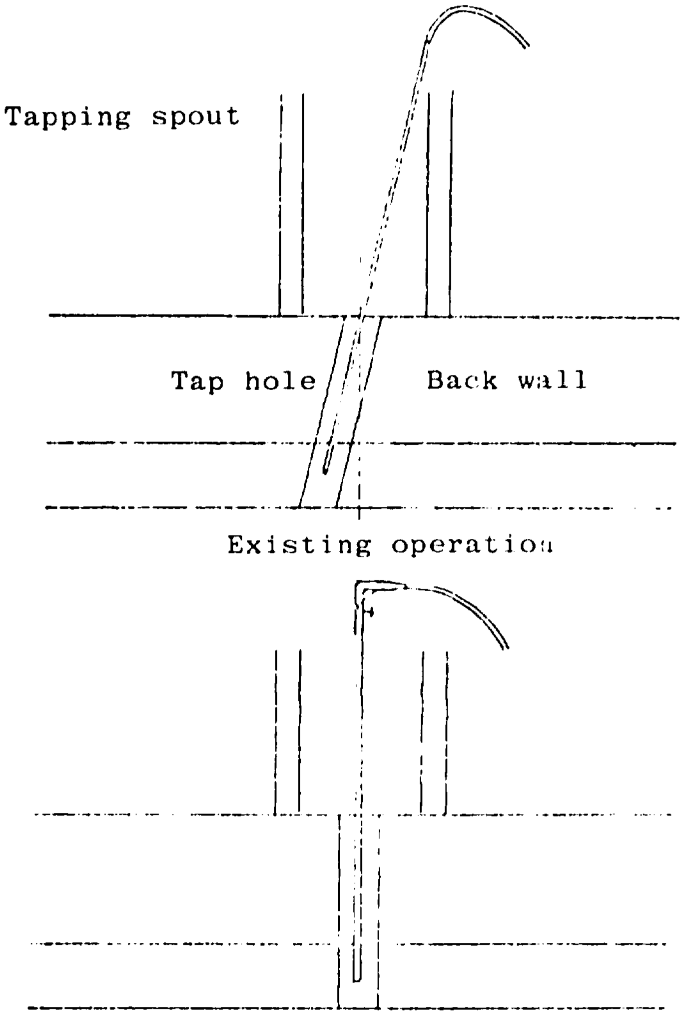
19. Recommended modification of charging platform with stopper.



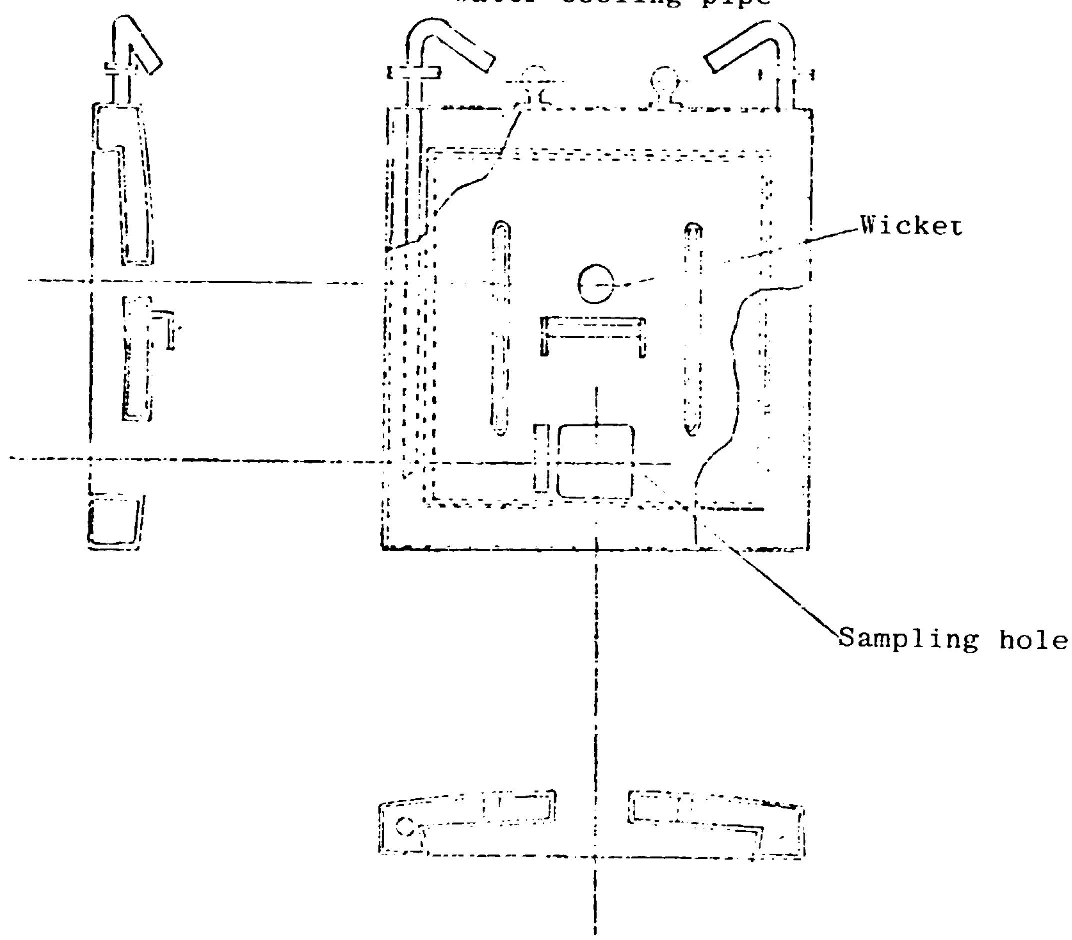
20. An improved wicket for radiation thermometer (KOBE)



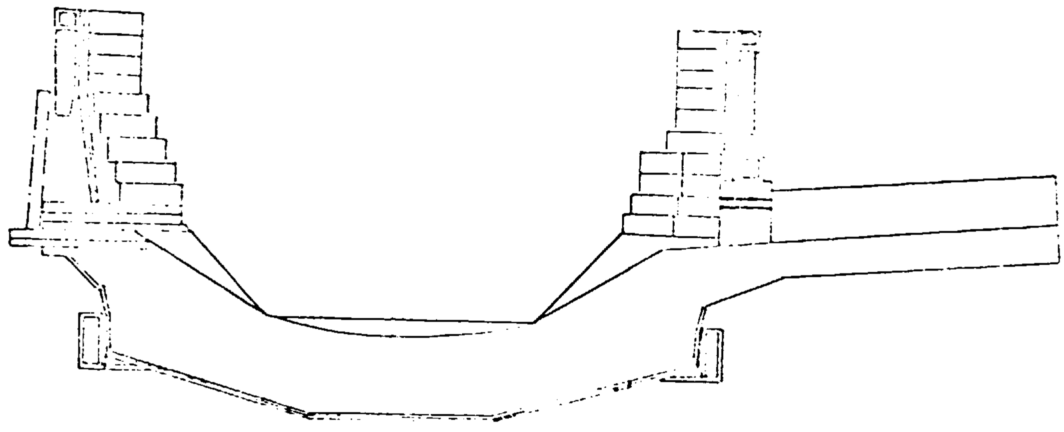
21. Irregular hearth shape, deviating from the original design (NATIONAL)



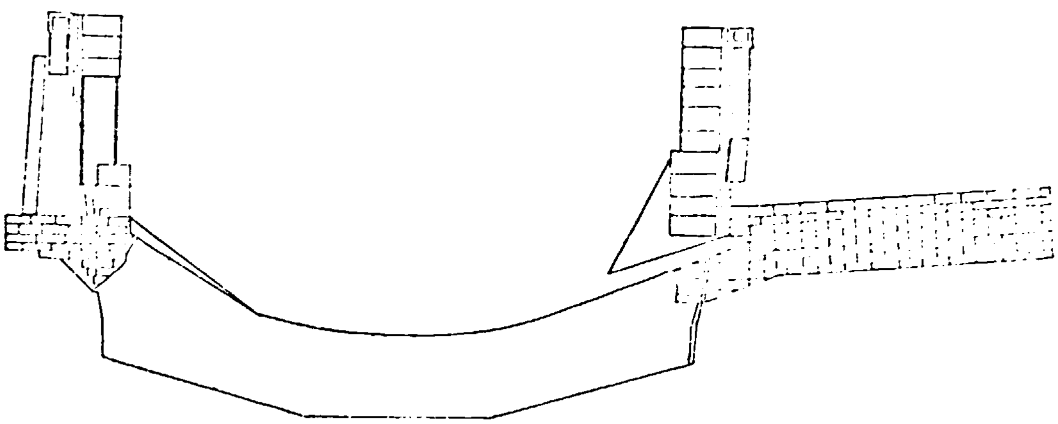
22. Coupling and elbow for oxygen piping correct tap hole opening. (NATIONAL)



23. Water cooled charging door for open hearth furnace (KOBE)

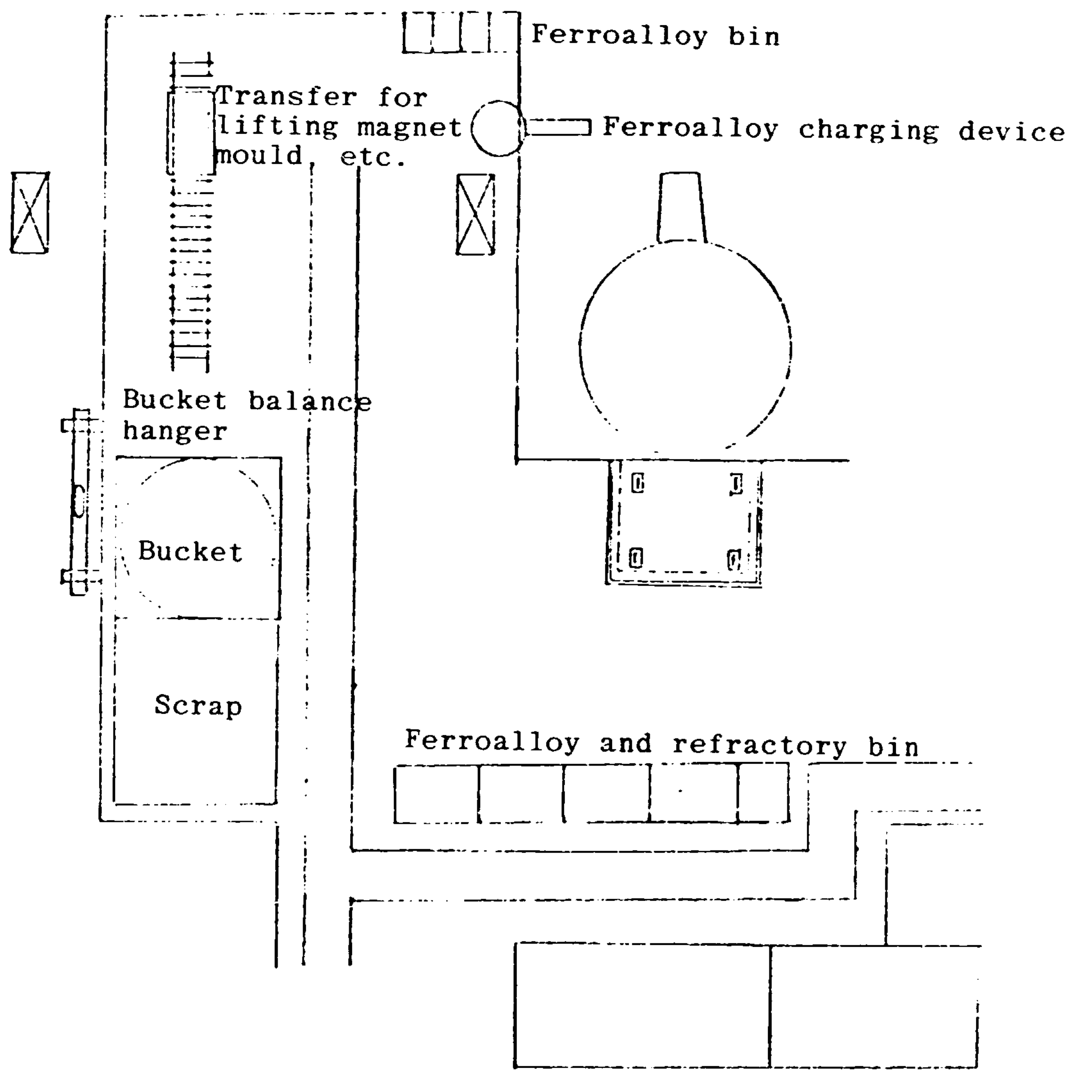


Existing design

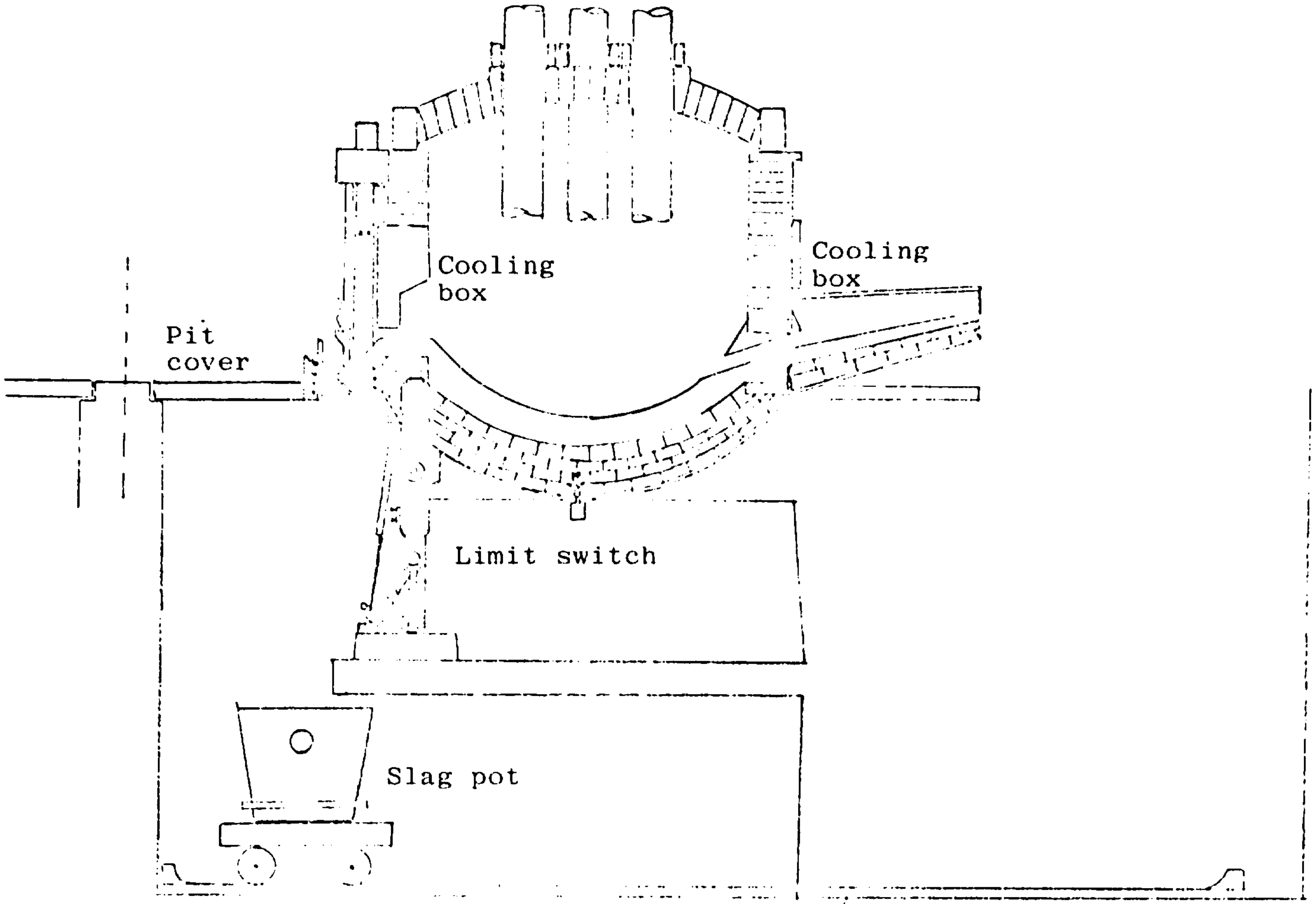


Recommended design

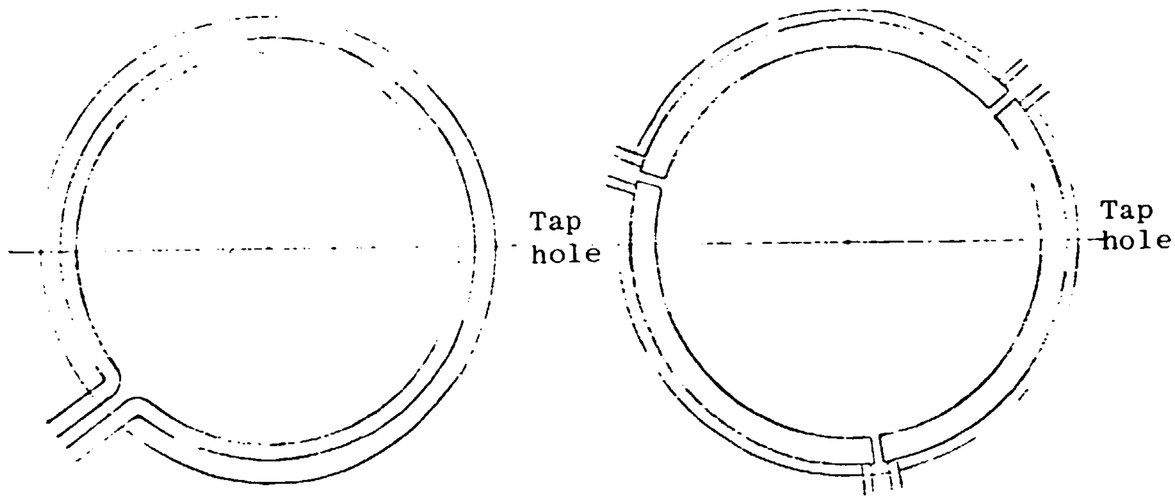
24. Recommended modification of charging door and tap hole of 25t Electric arc furnace (DELTA)



25. Recommended modification of melting floor of 25t electric arc furnace (DELTA)



26. Limit switch for alignment of ram and ramhole of electric arc furnace (KOBE)

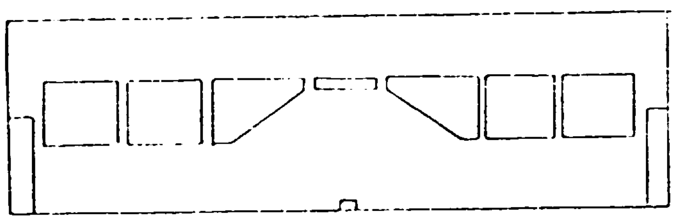


Cooling pipe   Cooling box

Pipe thickness : 13mm

Pipe inside dia.:47mm

For top portion of wall



Development

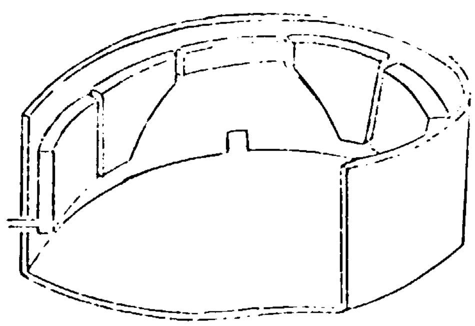
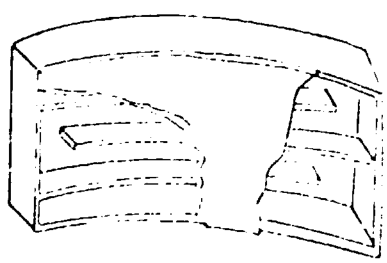


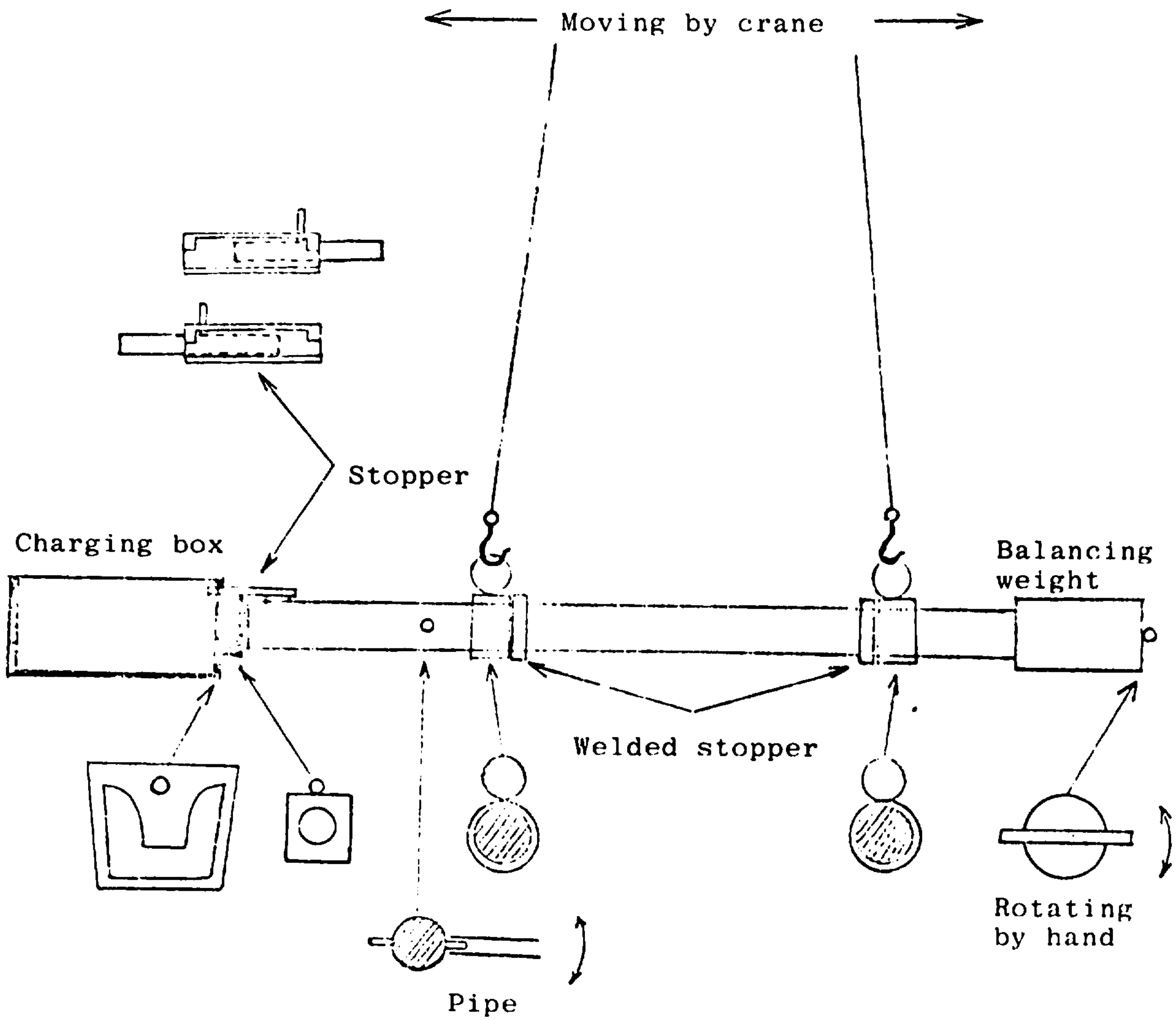
Plate thickness· 12mm

Water pressure : 5kg/sq.cm

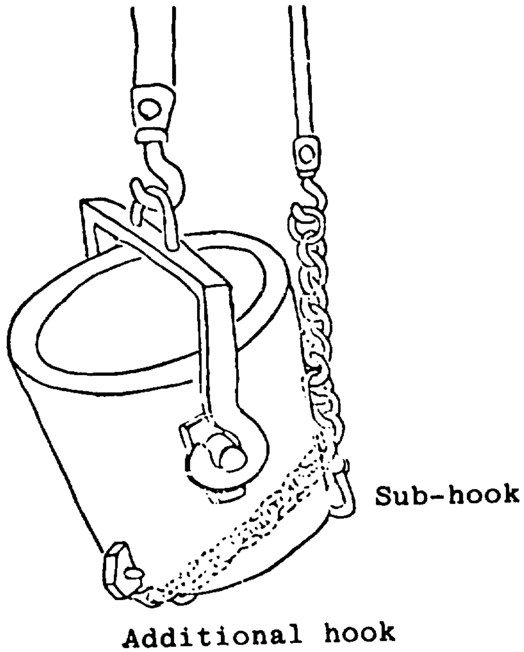


For wall

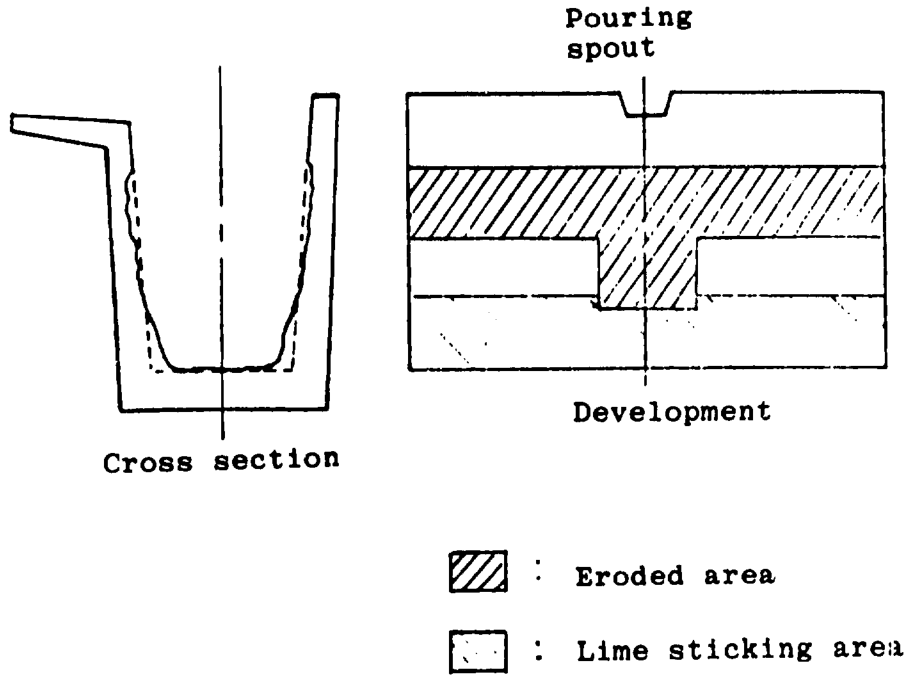
27. Water cooling box and piping of electric arc furnace
(KOBE)



28. Simple charging device for additives into ladle (KOBE)



29. Additional slinging hook on ladle (KOBE)



30. Observed eroded hearth condition of induction furnace eight heats after relining (DELTA)

Table 1. Recommended operational procedure for making 13%Cr steel in 3t electric-arc furnace.

Period	Operational procedure	C	Si	Mn	P	S	Cr	Temperature
Charging	1st charging							
	*steel scrap; 2.200 kg *Fe-Cr(H.C.); 550 kg *Fe-Si;( )kg	1.70	1.00	( )	0.03	( )	14.00	
Melting period	power on							
	2nd charging							
	CaO; 60 kg							
	melting down							
Oxidizing period	(P1) (T) slag-off(80%)	1.70	0.50	( )	0.03	( )	14.00	1600C
	CaO, 60 kg							
	(T)							1620C
	(P2) oxygen blowing +pressure; 10 kg/sq.cm +lance pipe; 19 mm dia.	( )	( )	( )	( )	( )	( )	(1700C)
	(P3)	( )	( )	( )	( )	( )	( )	
	(P4)	0.30	( )	( )	( )	( )	( )	(1900C)
	(P5)	0.10	0.10	( )	( )	( )	12.00	
	*steel scrap (L.C.); 300 kg *Si-Cr; ( )kg							
Refining period	Al ; 1.5 kg CaO ; 40 kg CaF2 ; 5 kg Ca-Si ; 5 kg							
	(P6) (T) slag-off(80%)	0.11	0.15	( )	( )	( )	12.75	1670C
	CaO ; 60 kg CaF_2 ; 5 kg Ca-Si; 5 kg							
	*Fe-Mn							
	*Fe-Si							
	(P7)	0.13	0.40	0.70	0.038	0.015	12.75	
	(T)							1650C
	tapping							

P( ); sampling and chemical analysis.

T ; taking temperature.

List of Photos

1. Capping of runner brick outlet with a piece of paper (COPPER)

2. Stool brick lining (COPPER)

3. Removing foreign matter, left in runner brick, by suction pipe (COPPER)

4. Setting of pouring tube (DELTA)

5. Repair tools for tap hole (KOBE)

6. Mixing of Magnesite with bittern (KOBE)

   6a. Bittern powder, $MgCl_2$: 46% min., NaCl : 1.5% max.

   6b. Mixing bittern with water by air-blowing

   6c. Bittern solution before mixing, 30 Baume's degree of specific gravity

   6d. Magnesite powder (MgO)

   6e. Mixing Magnesite with Bittern

7. Repairing enlarged tap hole (KOBE)

   7a. Enlarged tap hole before repair

   7b. A pipe placed on bittern mixed MgO

   7c. Compacted bittern mixed MgO around the pipe

8. A pile of broken electrodes (COPPER)

9. Stored condition of electrodes

   9a. (DELTA)

   9b. (KOBE)

10. Careful handling of electrodes, protecting the end with strawmat (KOBE)

11. Removing dust from an electrode joint by compressed air (KOBE)

    11a. Inside the joint before screwing nipple

    11b. Around the face of the joint before final fastening

12. Holding position of electrodes (KOBE)

    12a. Incorrect

    12b. Proper

13. A recommended gland with water cooling

14. Inclined electrodes (DELTA)

15. Unstrippable ingots out of moulds (COPPER)

16. Imperfect shape of ingot making bricks

    16a.

    16b.

    16c.

17. Improper outdoor storage of bricks

    17a. (COPPER)

    17b. (DELTA)

    17c. (NATIONAL)

18. Carolized pipe, dull portion showing carolizing

19. A multiple setting and stripping device of mould (KOBE)

20. A multiple transfer device of stripped ingots (KOBE)

21. Recommended ladle bricks joints with minimum of mortar (KOBE)

22. Stopper drying furnace without a cover (COPPER)

23. Steel adhesion on the mould (COPPER)

24. Coupling of oxygen pipe with rubber packing (KOBE)

    24a. Disassembled parts
    24b. Being assembled
    24c. Assembled

25. Coupling and elbow of oxygen pipe for tap hole (KOBE)

26. Coupling of oxygen pipe for ingot making operation (KOBE)

27. Raw material yard

    27a. (COPPER)
    27b. (KOBE)

28. Pit scraps, solidified in the dugout for easy handling (KOBE)

29. Elevated and deformed hearth on tap hole side (COPPER)

30. Water cooling box around the charging door (KOBE)

    30a. Viewed from outside
    30b. Viewed from inside

31. Improper classification and assortment of scraps (NATIONAL)

32. Improper loading of scraps into charging boxes (NATIONAL)

33. Arrangement in front of furnace

    33a. (NATIONAL)
    33b. (KOBE)

34. Frequent occurrence of skull (NATIONAL)

35. Water drainage header in compressed air piping (KOBE)

36. Oversized wicket for radiation thermometer (NATIONAL)

37. Assembling of pouring tube with mortar alone (NATIONAL)

38. Improper ladle brick lining, not layer by layer (NATIONAL)

39. Sufficient heating of ladle brick lining after relining (KOBE)

40. Dumped pit scraps and short ingots, not disposed into charging box (NATIONAL)

41. Steel adhesion on ladle (NATIONAL)

42. Imperfect closing of charging door (DELTA)

43. Guard frame on bottom side of electrode holder (KOBE)

44. Water cooling box and piping (KOBE)

    44a. Water cooling box

    44b. Water cooling pipe

45. Gap between pouring sleeves (DELTA)

46. Fastening of pouring sleeves (DELTA)

47. Steel adhesion on pouring tube (DELTA)

48. Two kinds of moulds on the same stool (DELTA)

49. Complete cover for ladle drying (KOBE)

59. Stool brick lining outside of pit (DELTA)

51. Scattered pit scraps and short ingots in ingot making shop (DELTA)

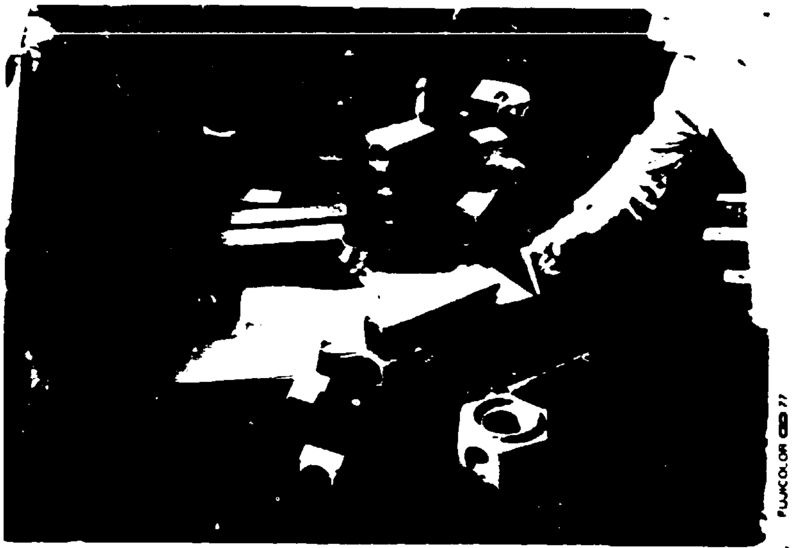
52. Collapsed wall of pit (DELTA)

53. Handrail on tap hole side deck (KOBE)

54. Jigs for electric arc furnace operation (KOBE)

    54a. Screen

    54b. Skimmer with log and rabble



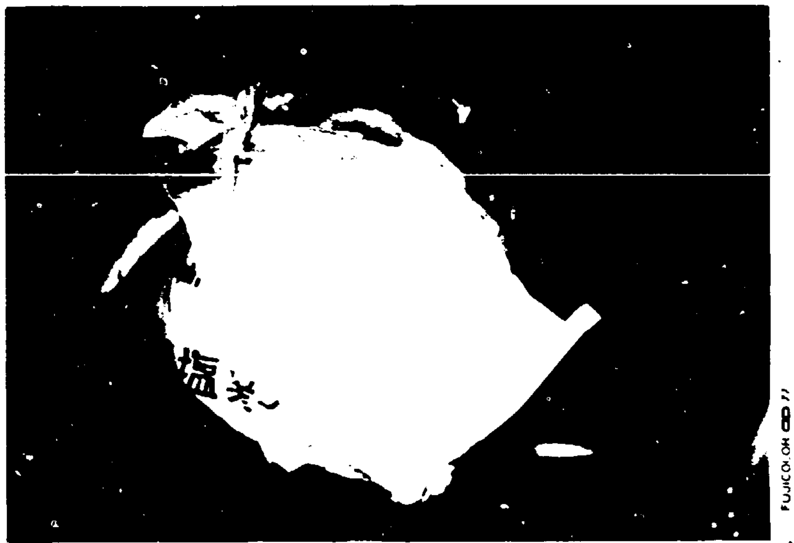
1. Capping of runner brick outlet with a piece of paper (COPPER)

2. Stool brick lining (COPPER)

3. Removing foreign matter, left in runner brick, by suction pipe (COPPER)

4. Setting of pouring tube (DELTA)

5. Repair tools for tap hole (KOBE)



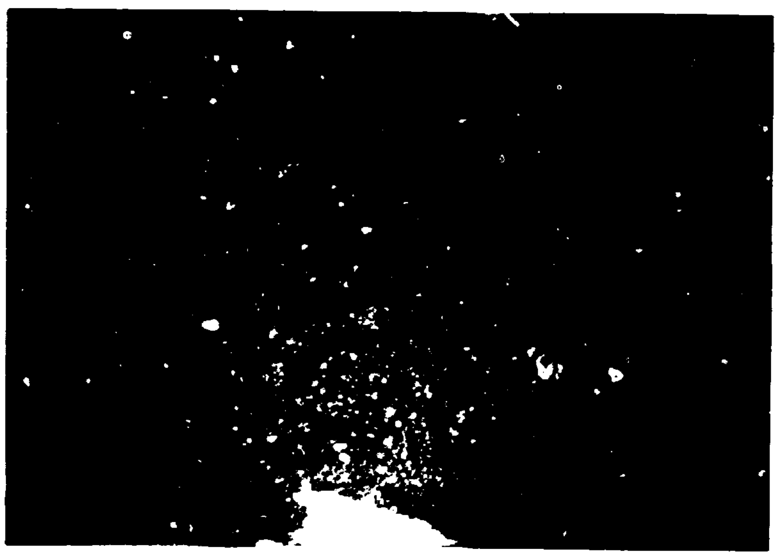
6a.
Bittern powder.
$MgCl_2$: 46% min.,
NaCl : 1.5% max.

6b.
Mixing bittern with water by air-blowing

6c.
Bittern solution before mixing, 30 Baume's degree of specific gravity

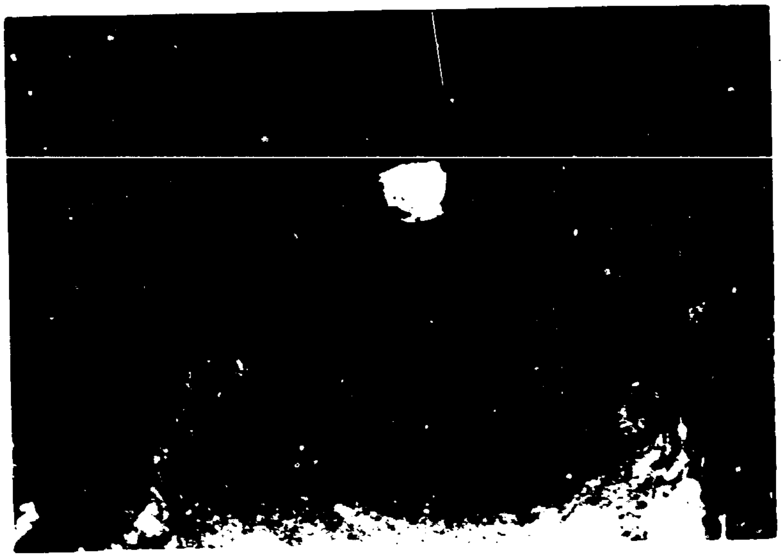
6. Mixing of Magnesite with bittern (KOBE)

6d.
Magnesite powder
(MgO)



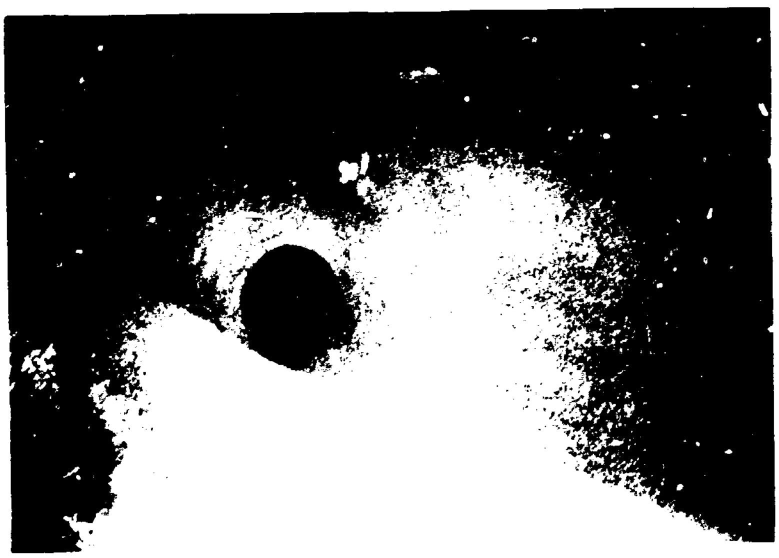
3e.
Mixing Magnesite
with Bittern

6. Mixing of Magnesite with bittern (KOBE)



7a.
Enlarged tap hole
before repair

7b.
A pipe placed on
bittern mixed MgO

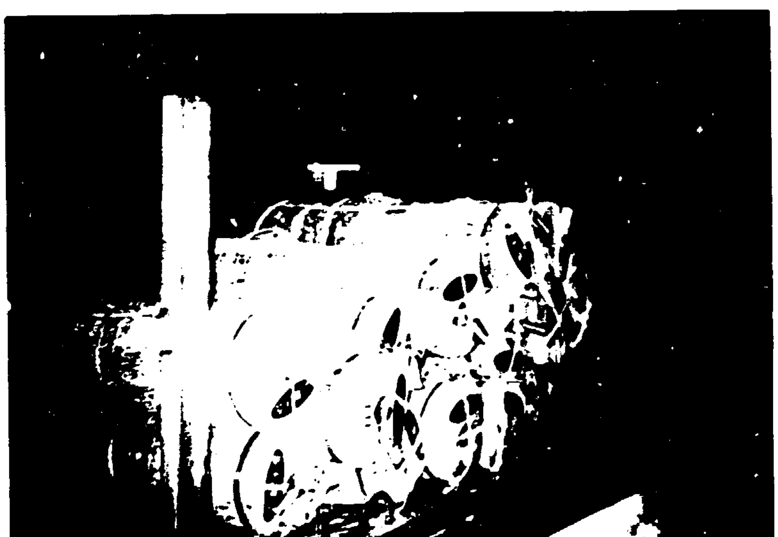


7c.
Compacted bittern
mixed MgO around
the pipe

7. Repairing enlarged tap hole (KOBE)

8. A pile of broken electrodes (COPPER)

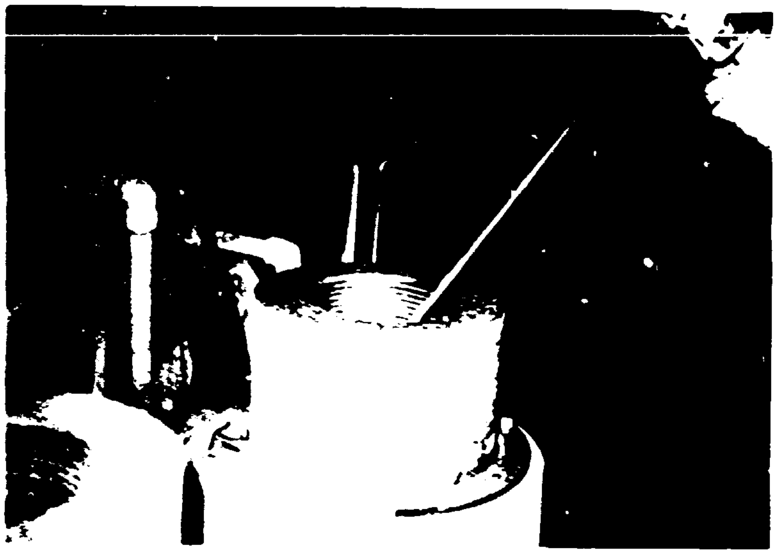
9a. (DELTA)



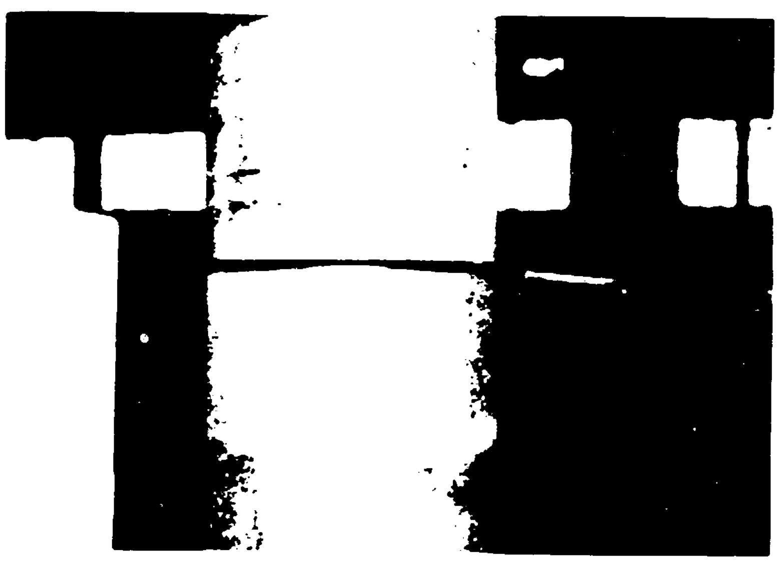
9b. (KOBE)

9. Stored condition of electrodes

10. Careful handling of electrodes, protecting the end with strawmat (KOBE)



11a. Inside the joint before screwing nipple



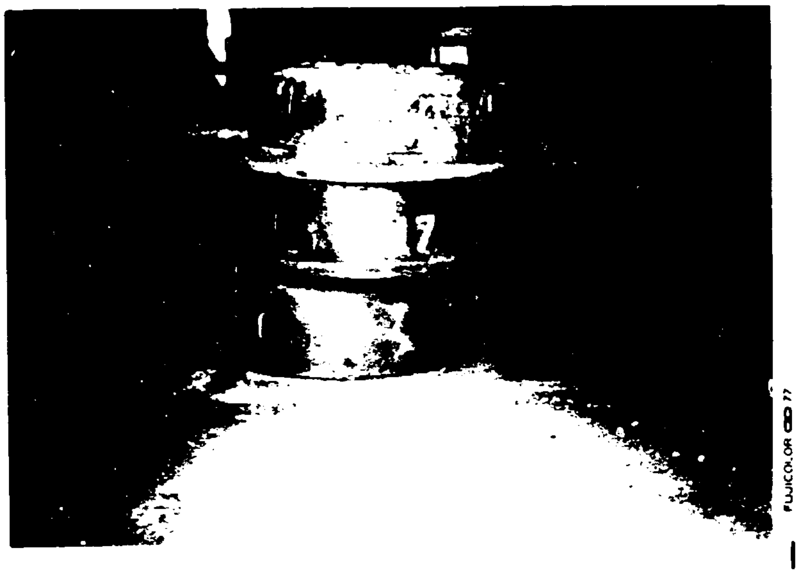
11b. Around the face of the joint before final fastening

11. Removing dust from an electrode joint by compressed air (KOBE)

12a. Incorrect

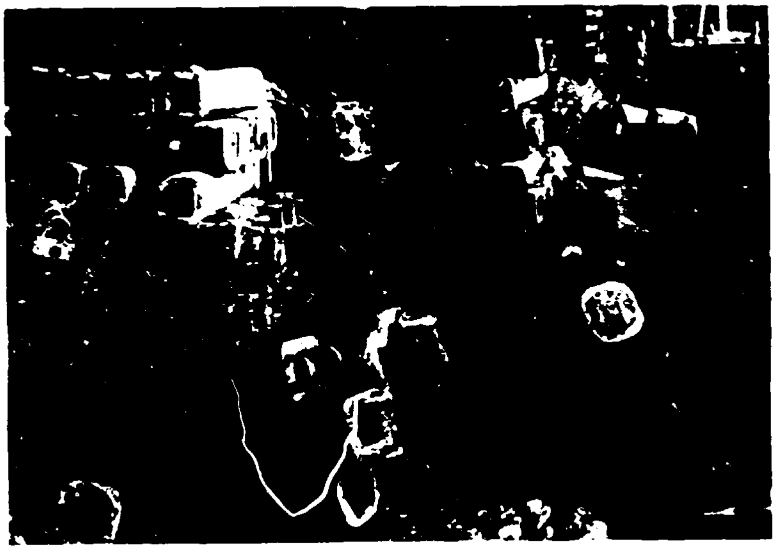
12b. Proper

12. Holding position of electrodes (KOBE)



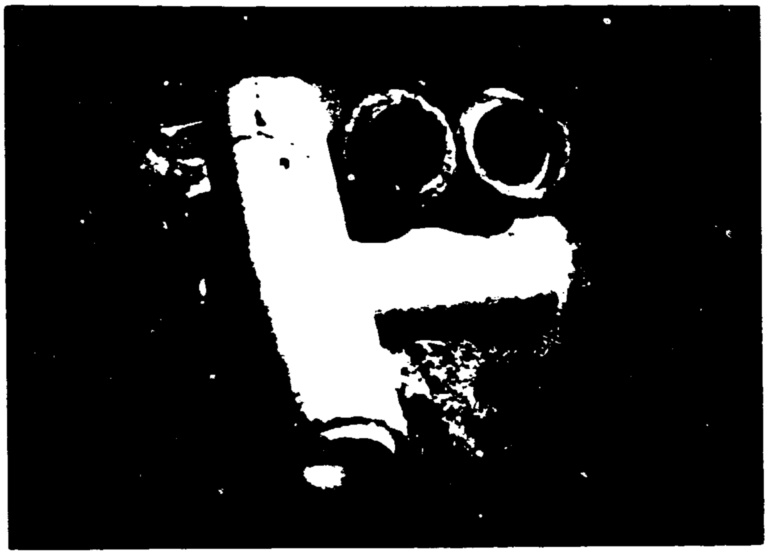
13. A recommended gland with water cooling

14. Inclined electrodes (DELTA)

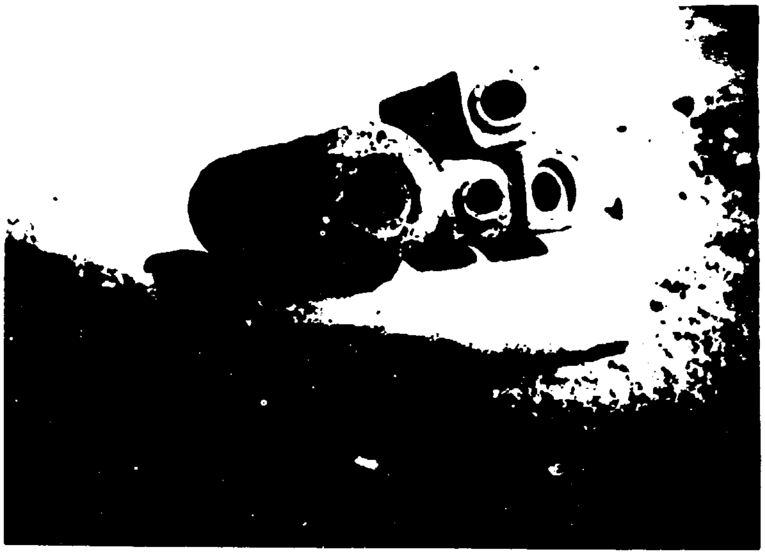


15. Unstrippable ingots out of molds (COPPER)

16a.



16b.

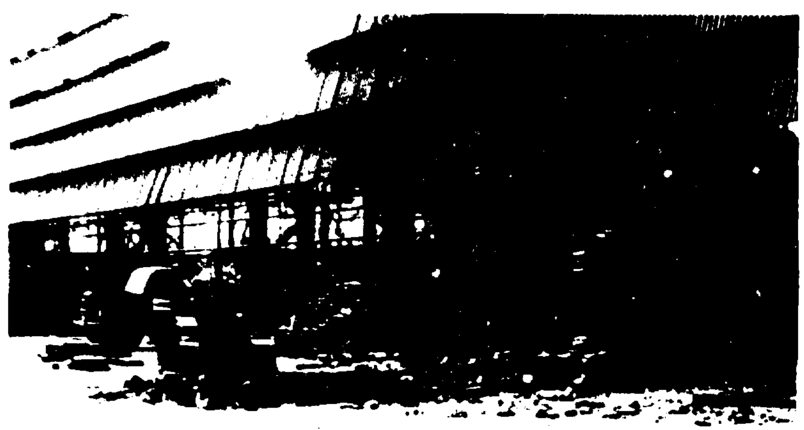


16c.

16. Imperfect shape of ingot making bricks

17a.

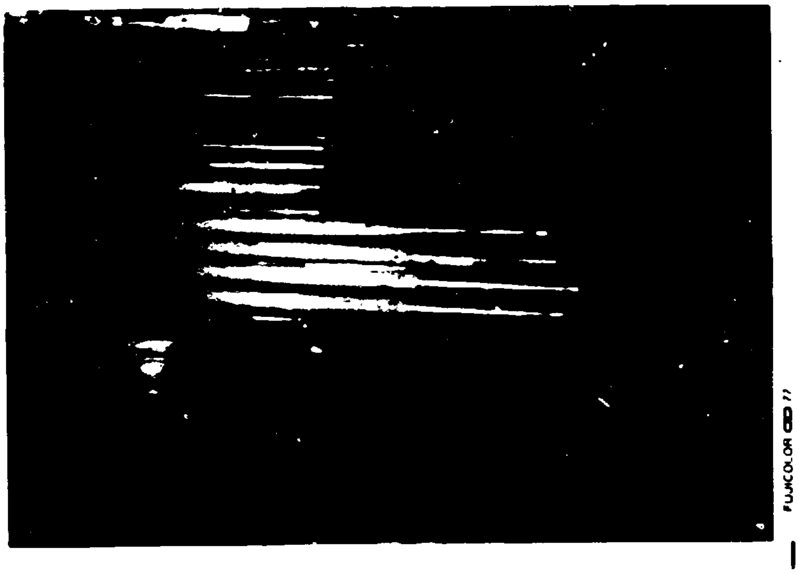
17b.



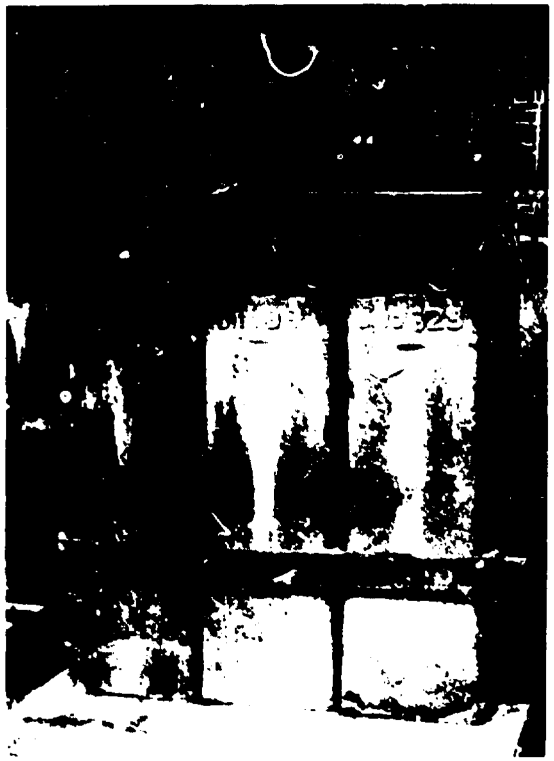
17c.

17a. (COPPER)
17b. (DELTA)
17c. (NATIONAL)

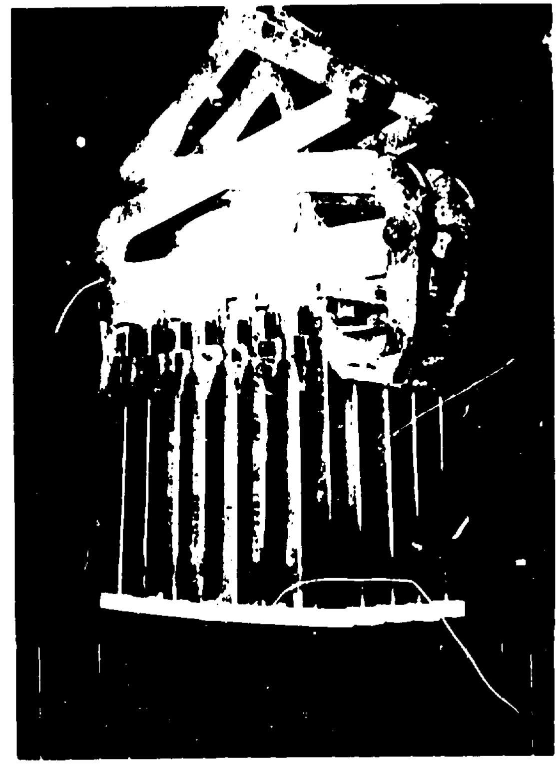
17. Improper outdoor storage of bricks



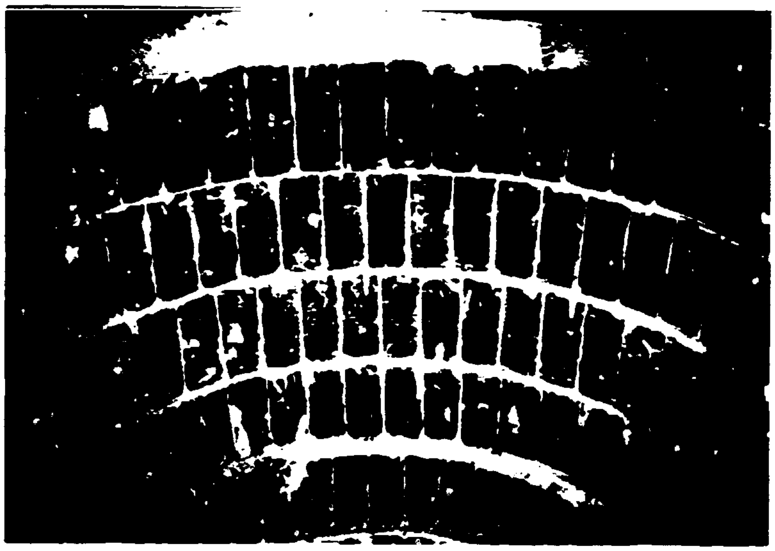
18. Carolized pipe, dull portion showing carolizing



19. A multiple setting and stripping device of moulds (KOBE)

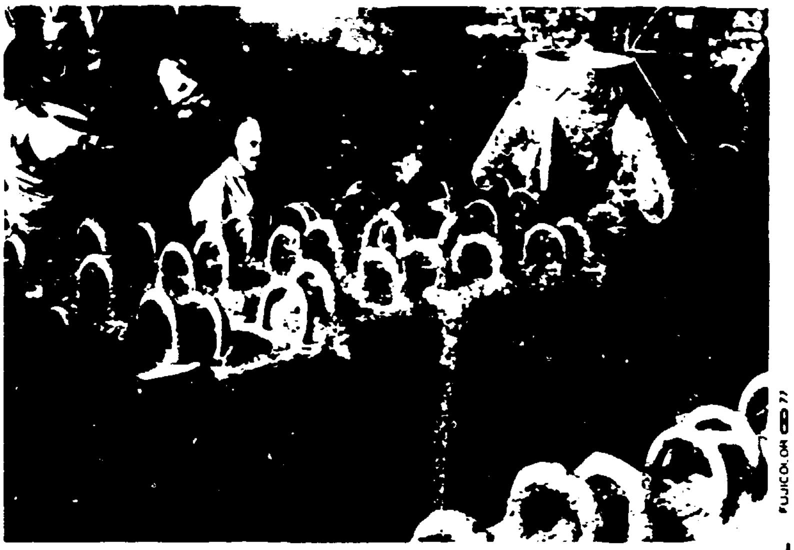


20. A multiple transfer device of stripped ingots (KOBE)

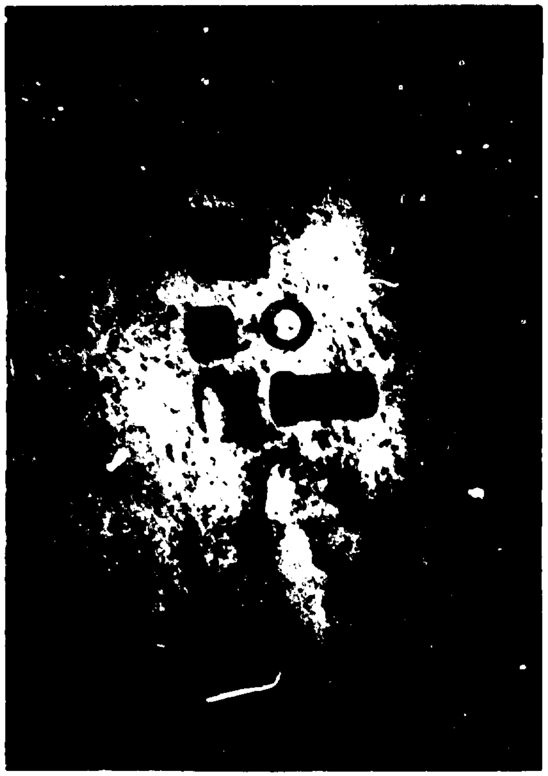


21. Recommended ladle bricks joints with minimum of motar (KOBE)

22. Stopper drying furnace without a cover (COPPER)



23. Steel adhesion on the mould (COPPER)



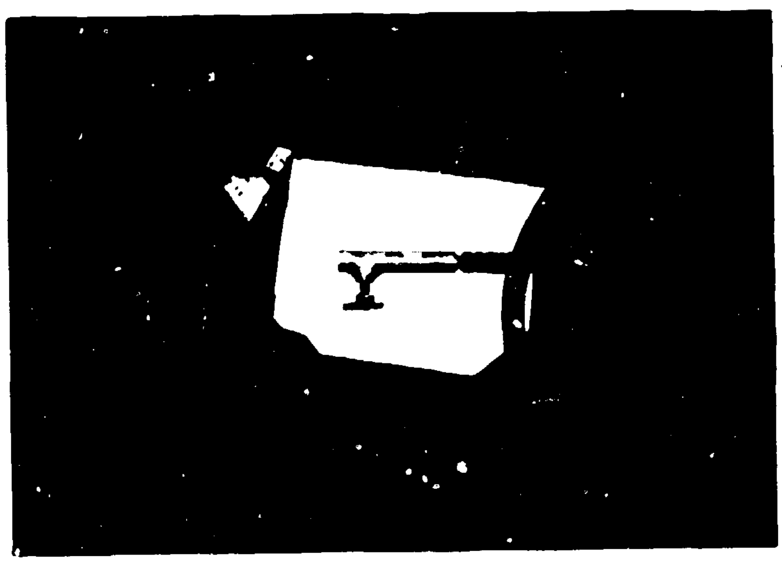
24a.
Disassembled parts

24b.
Being assembled

24c.
Assembled

24. Coupling of oxygen pipe with rubber packing (KOBE)

25. Coupling and elbow of oxygen pipe for tap hole (KOBE)



26. Coupling of oxygen pipe for ingot making operation (KOBE)

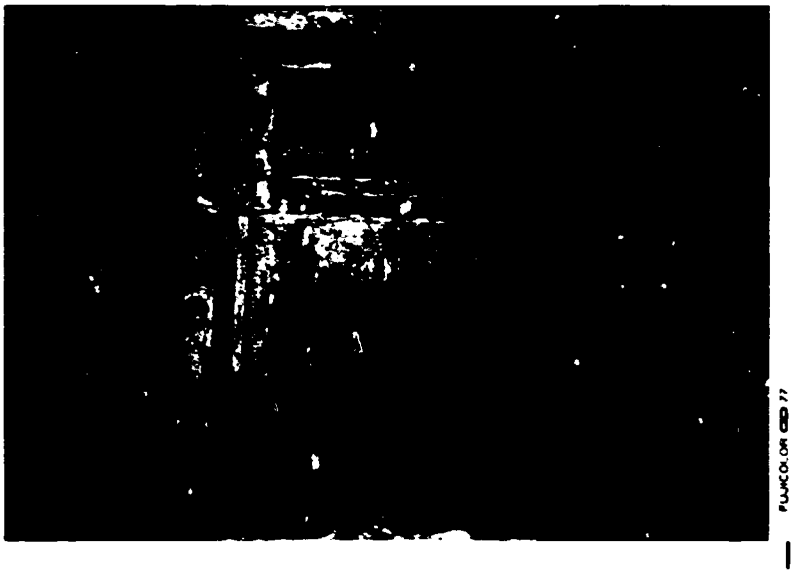
27a. (COPPER)

27b. (KOBE)

27. Raw material yard

28. Pit scraps, solidified in the dugout for easy handling (KOBE)

29. Elevated and deformed hearth on tap hole side (COPPER)



30a. Viewed from outside

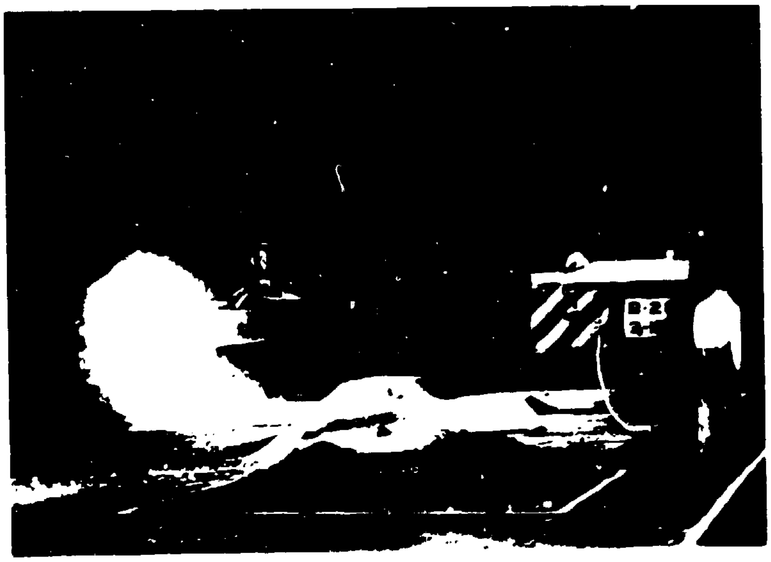
30b. Viewed from inside

30. Water cooling box around the charging door (KOBE)

31. Improper classification and assortment of scraps (NATIONAL)

32. Improper loading of scraps into charging boxes (NATIONAL)

33a. (NATIONAL)

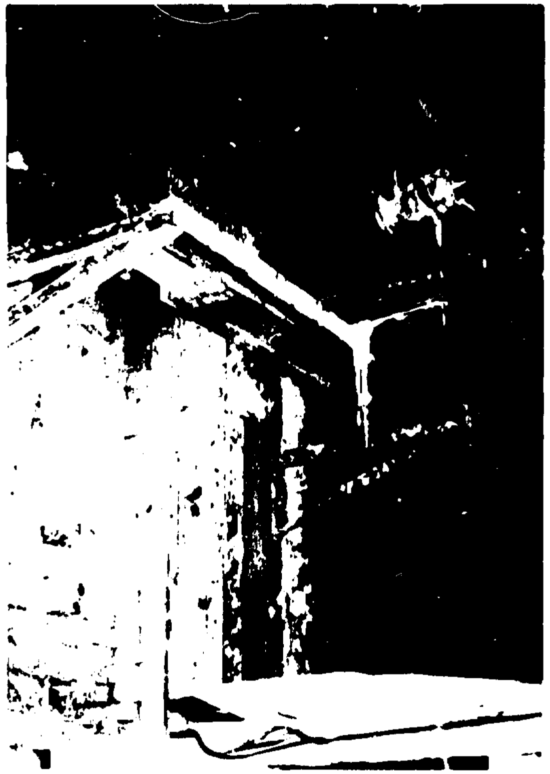


33b. (KOBE)

33. Arrangement in front of furnace

34. Frequent occurrence of skull (NATIONAL)

35. Water drainage header in compressed air piping (KOBE)



36. Oversized wicket for radiation thermometer (NATIONAL)

37. Assembling of pouring tube with mortar alone (NATIONAL)

38. Improper ladle brick lining, not layer by layer (NATIONAL)

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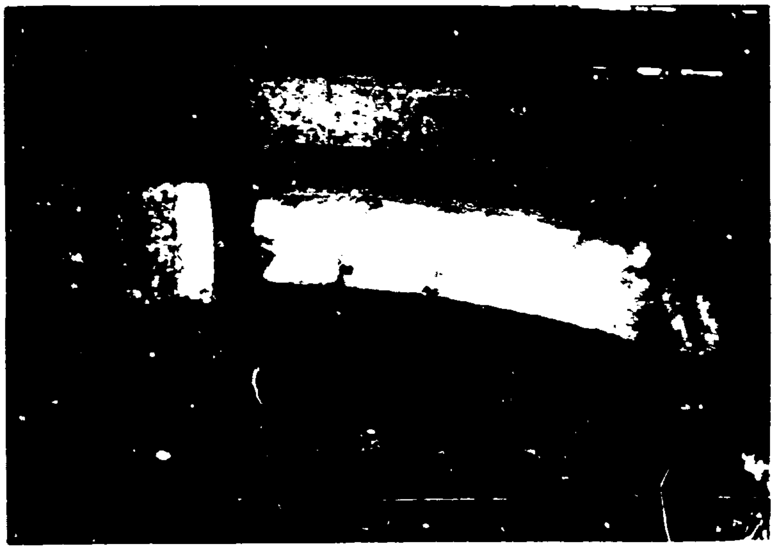
43. Guard frame on bottom side of electrode holder (KOBE)



44a. Water cooling box

44b. Water cooling pipe

44. Water cooling box and piping (KOBE)

45. Cap between pouring sleeves (DELTA)

46. Fastening of pouring sleeves (DELTA)

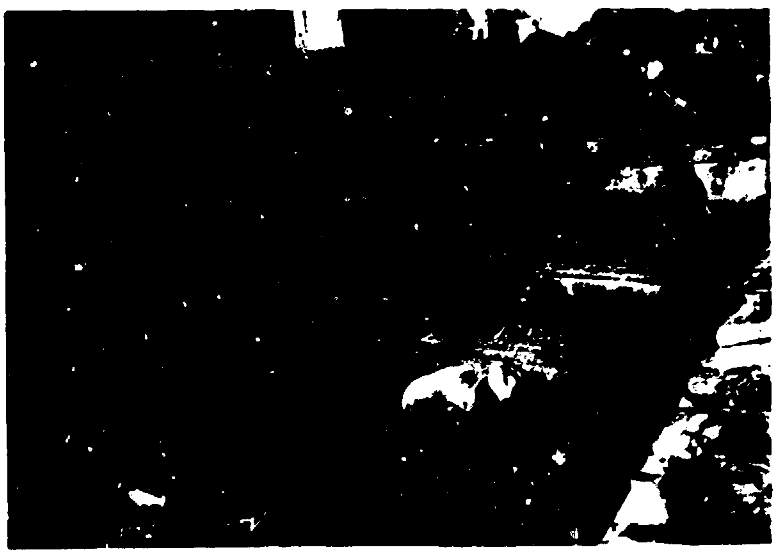
47. Steel adhesion on puring tube (DELTA)

48. Two kinds of moulds on the same stool (DELTA)

49. Complete cover for ladle drying (KOBE)

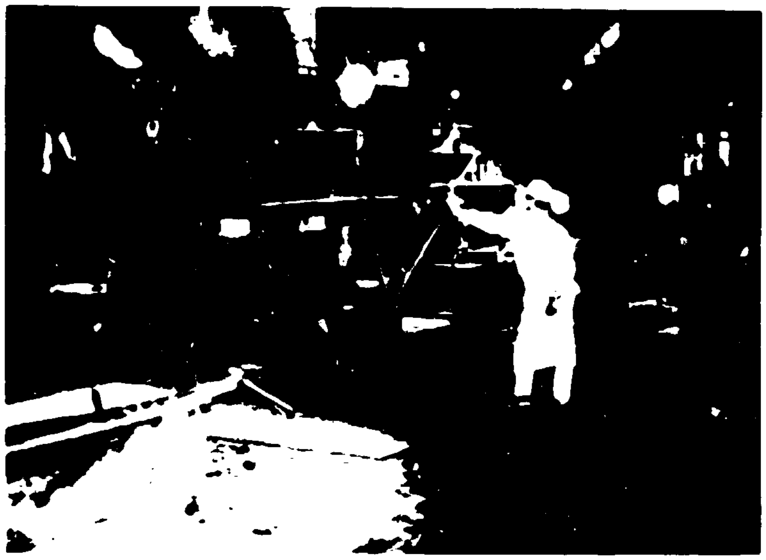
50. Stool brick lining outside of pit (DELTA)

51. Scattered pit scraps and short ingots in ingot making shop (DELTA)



52. Collapsed wall of pit (DELTA)

53. Handrail on tap hole side deck (KOBE)



54a. Screen

54b. Skimmer with log and rabble

54. Jigs for electric arc furnace operation (KOBE)