OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

D03615

Distr.
LIMITED

ID/WG.110/9
11 November 1971

ENGLISH
ORIGINAL: GERMAN

United Nations Industrial Development Organization

Workshop on Creation and Transfer of Metallurgical Know-How

Jamshedpur, India, 6 - 10 December 1971

THE PLANNING OF LD STEELWORKS[1]

by

V Ö E S T

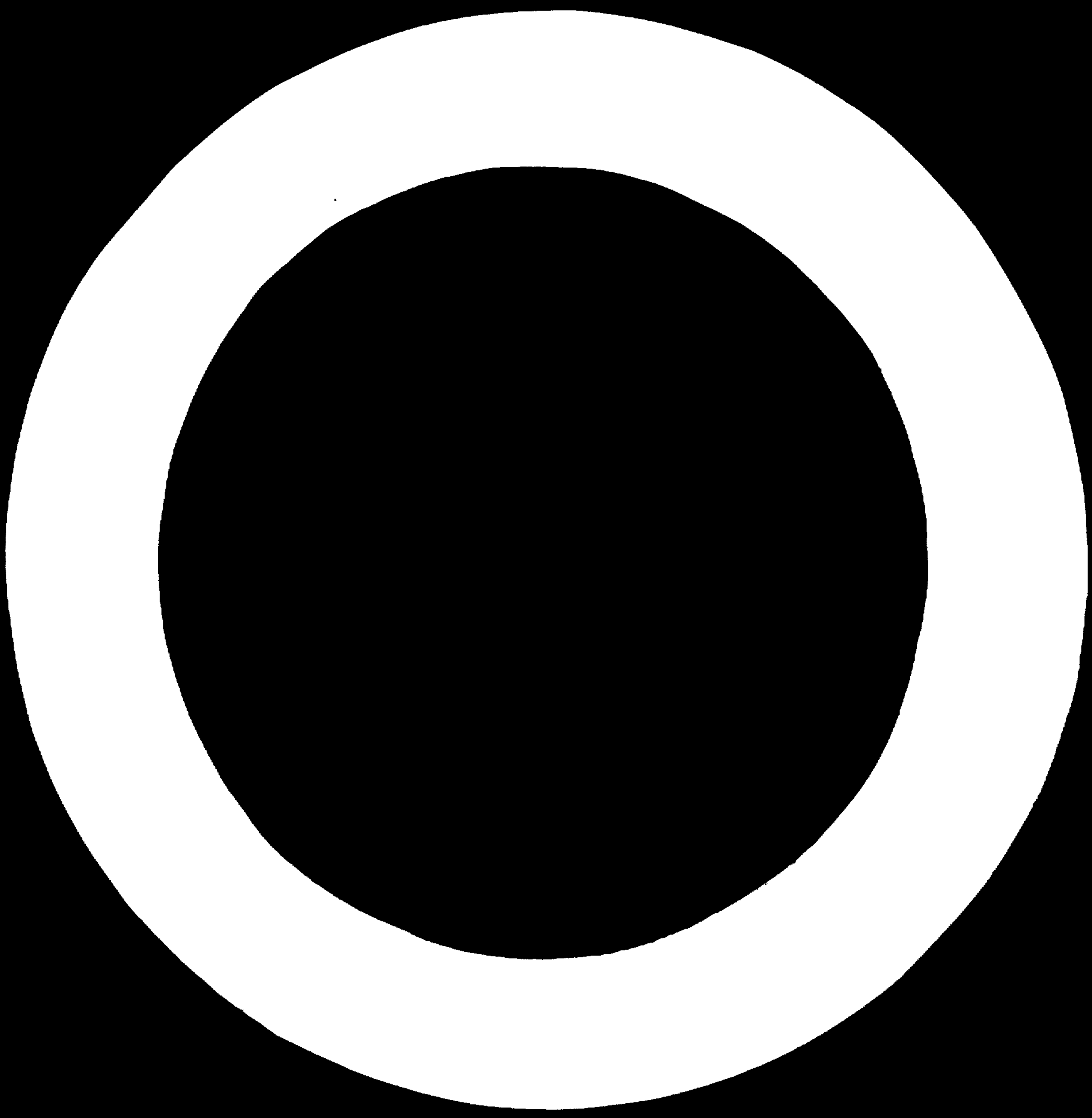
(Vereinigte Österreichische Eisen- und Stahlwerke Aktiengesellschaft)

Austria

1/ The views and opinions expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO.

id.71-8013

We regret that some of the pages in the microfiche copy of this report may not be up to the proper legibility standards, even though the best possible copy was used for preparing the master fiche.



THE PLANNING OF LD STEELWORKS

If we are to speak of the planning of LD steelworks, it is necessary to emphasize the importance of the subject, since US$20–40 million has to be invested in the construction of an LD steelworks according to its size, and in the case of misplanning many millions of dollars would be spent uselessly. Therefore, when the engineer sets about the task of planning a steelworks, various data regarding inter alia the size of the converter vessel, the ingot programme or the flow of materials within the steelworks etc., must be known if the solution is to be successful, and here the first critical considerations present themselves. Usually the customer calls for the erection of a steelworks with a specific guaranteed annual output. The formula in Figure 1 gives the theoretical vessel size; however, one would be well advised to correct this formula with a factor that takes into account climatic conditions, the experience of the operating and maintenance personnel and the rate of utilization of plants upstream and downstream. It would be easy to determine this factor in such a manner that the annual output would be achieved with a very high degree of certainty, but since in the final analysis it is the chief duty of the planning engineer to work out the most economic solution it is important to submit the above-mentioned aspects to as searching a scrutiny as possible. This factor is also time-dependent and it can be said very generally that almost everywhere output has increased in the course of operating a steelworks. It should also be considered that the certainty of achieving a given annual output is related to the number of vessels installed. As you will all certainly remember, with a few exceptions two vessels, one of which was in production, were almost always installed in the first LD steelworks. In the course of development, in which VÖest played a not inconsiderable part, it came to be accepted that even with larger vessels it is possible to keep two out of three installed vessels permanently in operation. Latest developments show, however, that in any case it is valuable to consider whether to install a single vessel of the largest possible size. On the one hand, as is known, productivity increases with the size of the vessel but, on the other hand, if only one vessel is installed, the crew is inevitably idle for at least part of the lining time, so that unproductive costs are caused. The idea also seems tempting when all the steel

STEELWORKS OUTPUT

1. **The number of converter vessels in operation is constant**
(2-and 3- vessel plant)

$$A = \frac{L \cdot t_{ch}}{n \cdot T \cdot 1440}$$

Where

L = Annual output in t of liquid steel
A = Size of charge in t of liquid steel
T = effective working days/year
t_{ch} = average tap-to-tap time
n = Number of vessels in operation

2. **The number of converter vessels in operation is variable**

$$A = \frac{L}{n \cdot H \cdot T}\left(\frac{H \cdot t_{ch}}{1440} + Z\right)$$

H = Vessel life in heats
Z = Vessel lining or change-over time in days

Figure 1

produced is cast in continuous casting installations, since it is then no longer necessary to maintain a nearly continuous supply of hot ingots to the rolling mills downstream. However, the pre-condition for this is that the discountinuous consumption of hot metal within the total flow of materials in the iron and steel works can be evened out either by other steel plants or by mixers. To revert once again to the above-mentioned safety factor, it seems obvious that, with two vessels installed, a breakdown, say, in the waste gas cooling and cleaning plant downstream has not nearly the same effect upon monthly output as in the case of a steelworks with one vessel, since here the entire repair time must in fact be counted as a loss in production time. Of course it can be objected that as a result of years of development and experience the parts of the installation auxiliary to the vessel can be reckoned to have considerably higher reliability in operation than was the case, say, at the beginning of the LD age.

It is very stimulating but not easy for the planning engineer if he is set the opposite task, namely, to achieve maximum production within a given space. This can occur if, for example, a Siemens-Martins steelworks is to be closed down and converted to LD production or if, as a result of crowding in a metallurgical plant, very little space is available for the construction of an LD steel plant. In such cases also solutions were found by VÖest, using interchangeable vessels, which finally so convinced the customer that we were awarded the contract. As an example I should like to mention here inter alia the LD-AC steelworks in Differdingen. The ground plan of this steelworks is given in Figure 1 a. So, when the decision regarding the final sise of vessel and the number of converters installed has been taken (doubtless the most importent factors in defining an LD steelworks), naturally data regarding all installations grouped around the vessel, such as steel delivery cars, slag cars, lance installations as well as their capacity are already determined on the basis of various design formulas. In addition, various other constitutuent factors such as the type and sise of the dust removing plants, the capacity of the hoppers for vessel additions and ladle additions and at least the number of ladles in circulation, the ladle lining stations, the number of any ladle tipping devices and ladle heaters must be determined. However, before the designer can begin to prepare drawings, it is essential to consider more closely the flow of materials in the metallurgical plant. Usually the flow of materials makes it possible to follow a particular basic principle in the construction of LD steelworks.

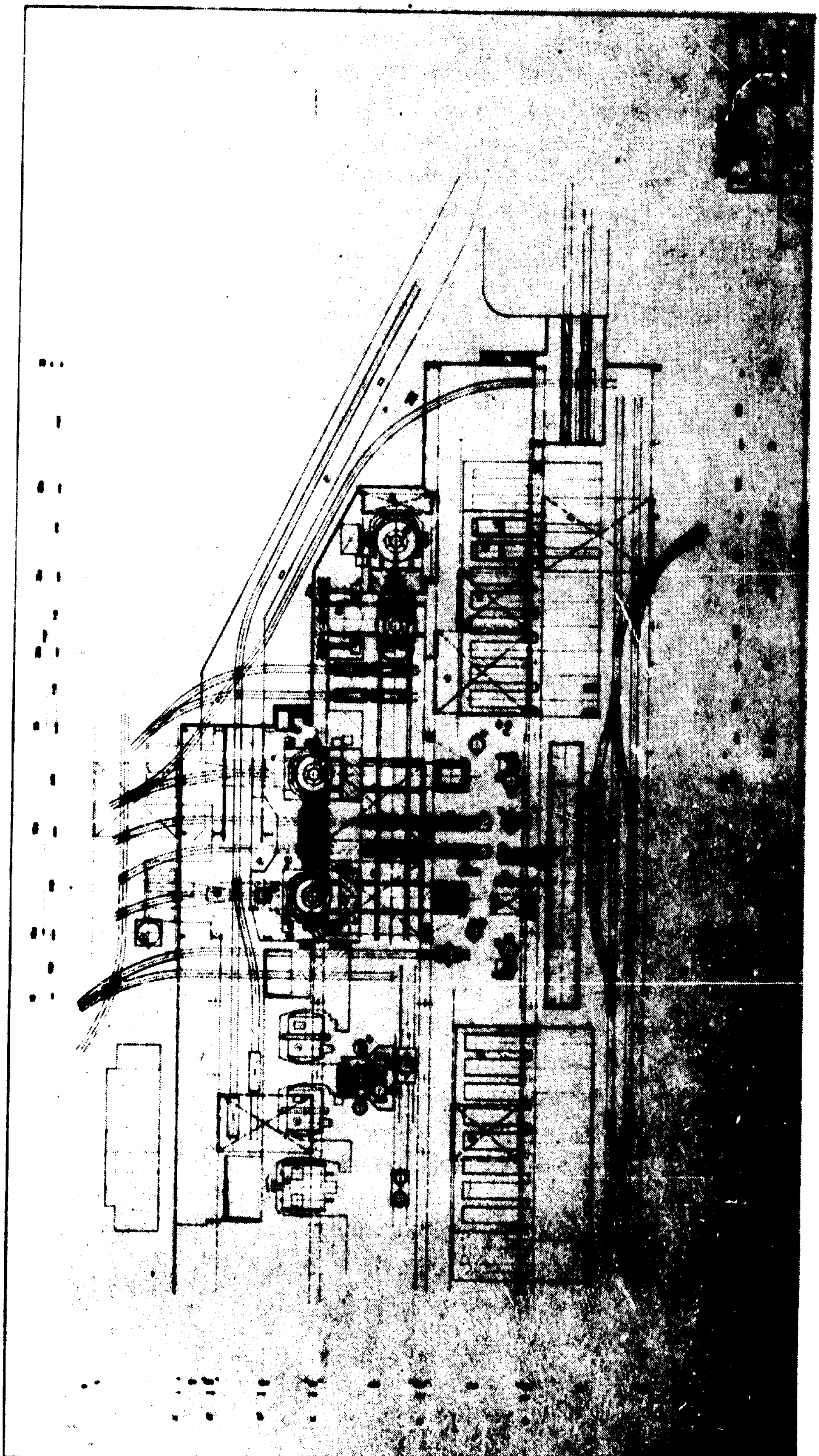


Figure 1a

As is generally known, an LD steelworks of normal construction can be divided into the three following main groups (Figure 2):

(1) A part in which all operations related to charging of the vessel are carried out. The scrap and hot metal departments are therefore housed there.

(2) A converter shop, which is also the heart of the LD steelworks and is striking if only for its height, in which the vessel installations, lance, and dust removing installations and usually all the additions section are housed. It is expedient to accommodate a large number of the electrical substations, valve rooms and pump rooms on the left and the right of the converter shop, since there is naturally a strong concentration of various facilities here. This point will be dealt with in greater detail later.

(3) The teeming bay, which is designed either for conventional casting, continuous casting or a mixed programme, and where the entire ladle section and sometimes a de-gassing plant is housed.

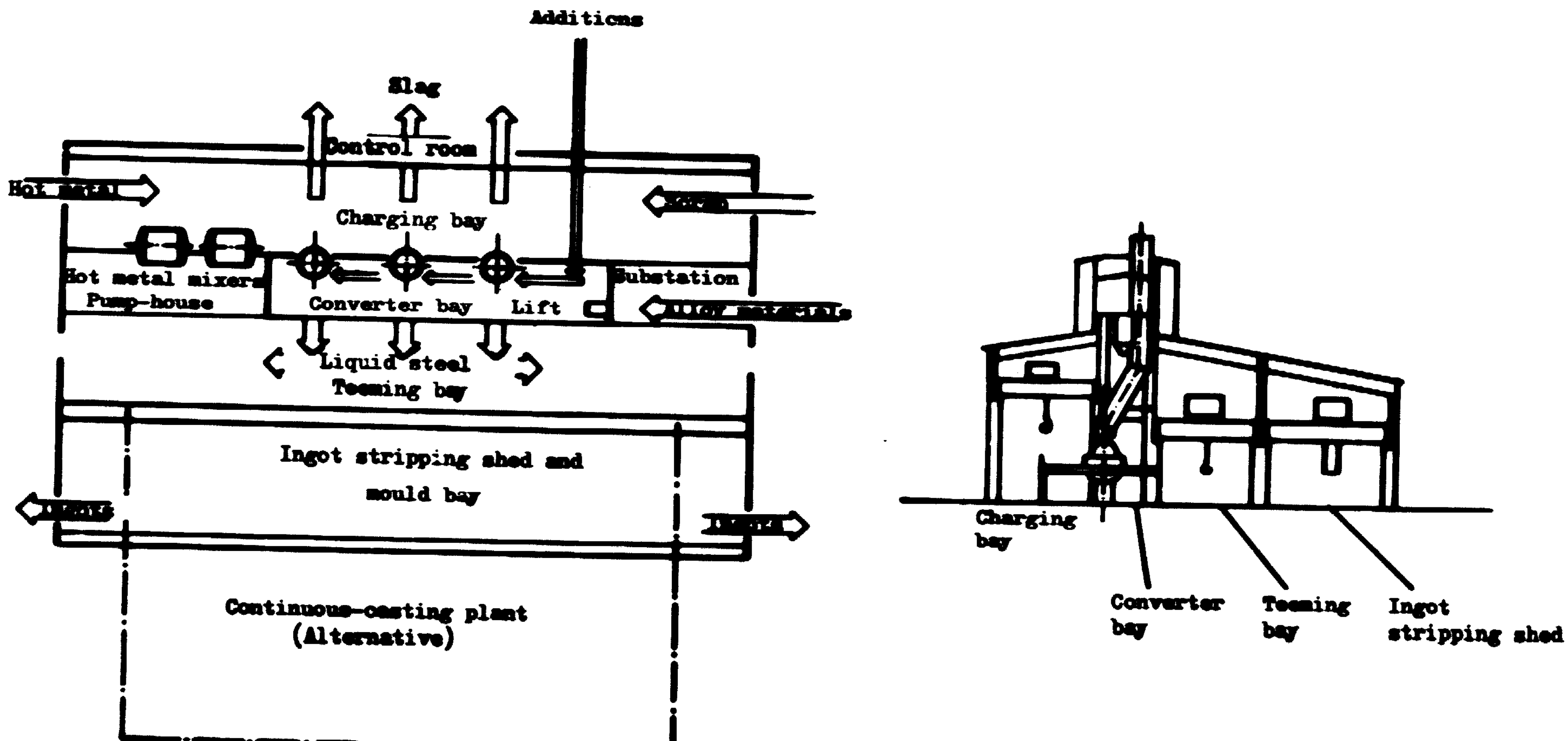
Plans providing for the converter shop as the first unit cannot be regarded as the most ideal solution, if only from the point of view of the flow of materials within the steelworks. Only when circumstances make this inevitable should such a solution be adopted.

Around the LD steelworks there are grouped, according to space conditions, a low level storage installation, perhaps a sludge treatment installation and possibly also a dolomite plant. All these installations, although only auxiliary, can under certain circumstances, however, influence the basic planning of an LD steelworks.

I should like to supplement this broad outline sketch of an LD steelworks with a few details:

(1) <u>The hot metal department</u>

From the very beginning an attempt should be made to approach as nearly as possible to ideal conditions regarding flow of materials in an LD steelworks; in other words, an LD steelworks must be integrated into the general metallurgical complex in such a way that scrap and hot metal can be supplied as favourably as possible or - if this is not the case - an attempt should be made to influence handling routes in such a manner that the most favourable possible conditions arise at the charging and casting sides.



VÖEST

Figure 2

On the assumption that a steelworks has not more than three converter vessels, the best solution is to bring in the scrap from one side of the charging bay and the hot metal from the other. Good slag removal conditions can also be achieved by this arrangement (Figure 2). In cases where space is not available for this ideal solution or where the freedom of the planner is somewhat limited through local regulations, for example, regarding the transport of hot metal an attempt should be made to organise materials handling in two planes. Whether the hot metal or the scrap is brought to the vessel installations on the "second" plane (working platform) will be decided according to local conditions; no general rule can be stated to cover this.

The design of the charging bay will be influenced to a not inconsiderable extent by the decision whether hot metal mixers should be set up within the steelworks and handling should be carried out with the aid of normal hot metal ladles or whether the hot metal is brought into the steelworks by means of torpedo ladles. As is known there have been many papers and discussions on this subject. In many cases in which our firm was entrusted with planning for LD steelworks some advance decision on this point had already been taken, that is to say that the metallurgical plant in question was already accustomed to working with torpedo ladles or it was taken for granted that mixers would be used. If one briefly recalls the most important advantages of mixer operation, namely, more constant analysis, a certain degree of constancy in temperature and the buffering effect, and the advantages of operating with torpedo ladles, namely, higher temperature of the hot metal and possibly also lower capital investment costs, it is really difficult to give a definite ruling immediately when one is completely free to plan. In such cases, the decision should be made on the basis of cost. Such a comparison of costs gives a true picture only if, after precise planning, the cost of construction of sheds, cranes, relining equipment, foundations, etc., of both versions are taken into account and operating and maintenance costs are added to the total capital investment costs.

If a decision has been made to use a hot metal mixer, the possibility should also be provided for of setting up a second mixer at the steelworks at a later time, the construction of a second mixer usually running parallel to the construction of a third vessel in the course of the expansion of a steelworks.

If mixer capacities are analysed, a clear trend towards increasing size in mixer vessels will be found, the largest mixers which VÖest has so far constructed having a capacity of 2,200 t. From the technical standpoint it is quite possible to build even larger models. However, according to Japanese reports, the limit of economy seems to lie at a capacity of approximately 2,500 t, for according to these Japanese sources the curve of the economic factor has a sharp break at this size of mixer - the cause is reported to be various difficulties with the lining - so that it has been decided to introduce 2,000 t mixers in a large Japanese metallurgical combine as a standard size.

As a result of the increasingly strict regulations regarding aerial pollution, it will be essential in future planning to provide generously designed installations for exhausting the gases that arise on emptying and charging the hot metal mixer. Conditions for effective exhausting of gas are more favourable in the case of a transfer pit, that is to say if the hot metal is brought in torpedo ladles. If the transfer station is accommodated in a subsidiary bay outside the charging bay proper, the nuisance caused in the charging bay is lowest. In most cases, the hot metal department should be supplemented with a slag removal station. Also installations for removing sulphur from the hot metal must occasionally be planned within the steelworks. It is clear that then ideal conditions regarding air pollution are not always achieved.

Whereas all steelworks in which VÖest has carried out the planning or at least played a prominent part in supplying important installations either work with mixers or torpedo ladles, cases are also known to us in which the hot metal department has a kind of hermaphrodite existence. In these steelworks the hot metal to be charged into the converter can be taken either from torpedo ladles or mixers. The managements of such works have expressed themselves very favourably regarding these two possibilities. However, from the viewpoint of capital investment costs, this is certainly not a very economical solution.

As more and more efforts are being made towards the exact quantitative assessment of materials flow in steelworks, it is essential nowadays to weigh exactly the quantities of hot metal supplied as well as the quantities charged, using platform or crane weighers, and to feed the data into a central computer.

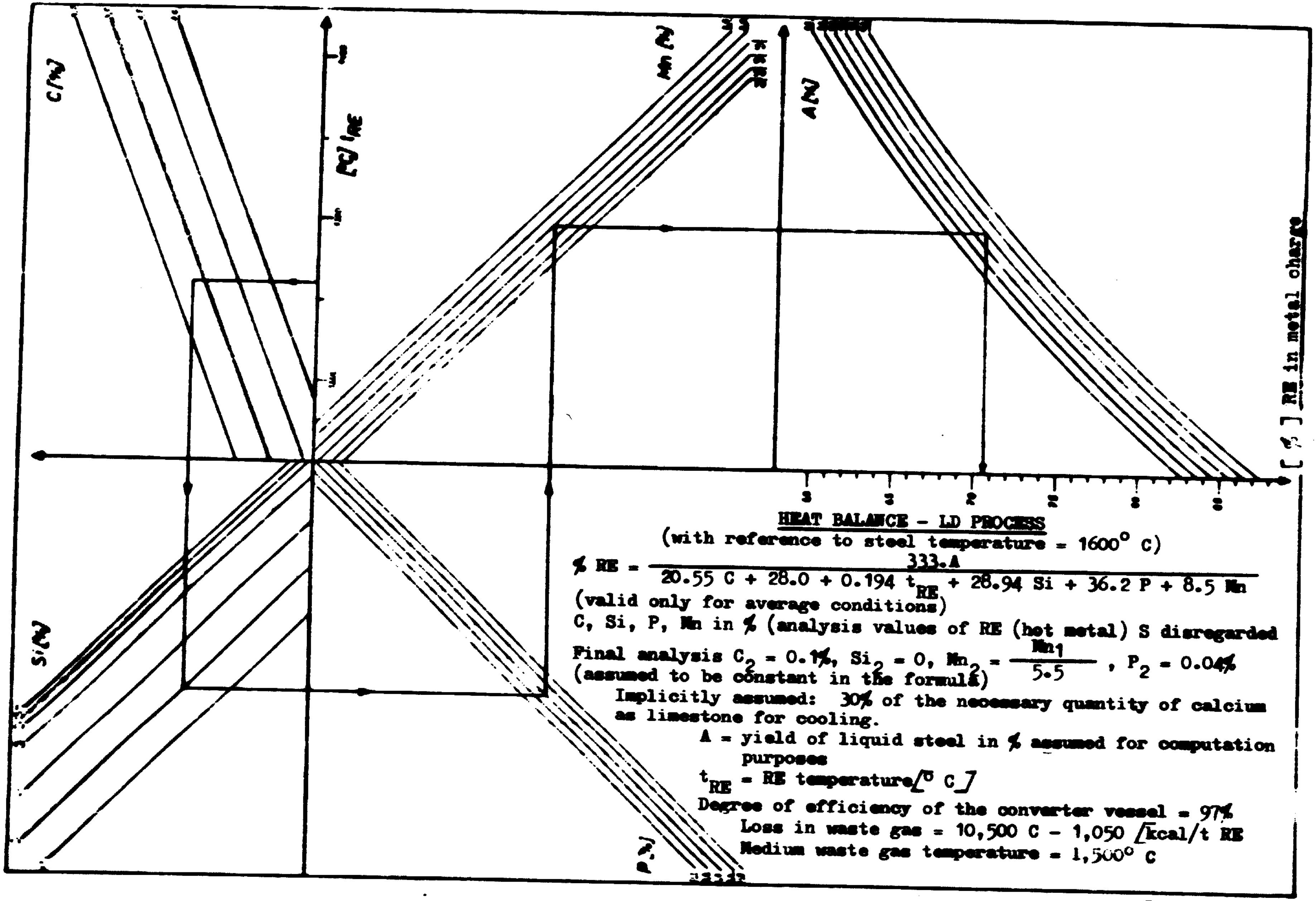
(2) The scrap department

The bases for the design of the scrap department are shown in Figure 3. Scrap handling is relatively simple if the net scrap weight of the scrap delivered within the steelworks in boxes does not have to be established subsequently. However, if the production programme includes a wide range of qualities and there are some fluctuations in the analysis of the hot metal and its temperature, it is necessary to make arrangements for finding the net weight of the scrap within the steelworks, if it is impossible to compensate with ore. This requires having some stock in hand, and the provision of weighing devices and suitably designed cranes. If therefore for various reasons some amounts of process scrap are necessary, a special scrap bay should be provided as an extension of the charging bay. If this is impossible for reasons of space, plans should provide for a scrap bay parallel to the charging bay. However, this inevitably has an influence on slag handling.

If weighing the scrap in the steelworks is necessary only in the rarest cases, an expedient is to provide a scrap chute with easily opened compartments so that dosage is possible from time to time, though admittedly approximate. In certain steelworks it is usual to sort the scrap into light and heavy and charge them separately; most steelworks known to us, however, disregard this. Charging of all the scrap by chute goes a long way towards meeting the desire for the shortest possible charging times. Only such large chutes may sometimes require increased capital expenditure, and higher crane runways, etc. Sometimes the use of a scrap charging machine may become necessary in conversions or extensions of works. In order to be a valid substitute for crane charging installations, such scrap charging machines must be fitted with appropriate propulsion systems. The ideal solution is still to be able to pick up the scrap charging boxes with a crane and empty the contents direct into the vessel, the scrap being brought into the steelworks by means of suitable wagons, already in charging boxes. In some cases, scrap handling has been solved without the use of any railed vehicles whatsoever. Whether this is possible, however, in the case of very large vessels, demanding an hourly turnover of well above 100 t, can only be shown by future developments.

(3) The converter vessel installation

The converter vessel is the dominating element in an LD steelworks. I do not wish to deal with design details here, as this is outside the framework of this paper, but shall only remark that the entire planning of the steelworks



HEAT BALANCE - LD PROCESS

(with reference to steel temperature = 1600° C)

$$\% \text{ RE} = \frac{333.A}{20.55\ C + 28.0 + 0.194\ t_{RE} + 28.94\ Si + 36.2\ P + 8.5\ Mn}$$

(valid only for average conditions)

C, Si, P, Mn in % (analysis values of RE (hot metal) S disregarded

Final analysis $C_2 = 0.1\%$, $Si_2 = 0$, $Mn_2 = \frac{Mn_1}{5.5}$, $P_2 = 0.04\%$
(assumed to be constant in the formula)

Implicitly assumed: 30% of the necessary quantity of calcium as limestone for cooling.

A = yield of liquid steel in % assumed for computation purposes

t_{RE} = RE temperature [° C]

Degree of efficiency of the converter vessel = 97%

Loss in waste gas = 10,500 C - 1,050 [kcal/t RE

Medium waste gas temperature = 1,500° C

Figure 3

must be subordinated to this central element. This applies to the distance between pillars, heights of platforms and space around the converter vessel plant, etc.

In addition, care will have to be taken that the delivery and removal of all materials can proceed quickly and smoothly. Short charging times mean high productivity and thus financial profit. In addition, every effort should be made by the planning staff to ensure that re-lining also requires only a minimum of time; for example, quick delivery of the lining material, favourable storage possibilities for the brick pallets, etc.

Good accessibility in repairs through easily removable platforms, suitable arrangement of the tilting drive, and bearing housings that are easily removed and installed are further details that must definitely be borne in mind.

Also, well arranged, perhaps water-cooled slag protection installations around the vessel increase operational safety.

An important detail for the future will be the effective exhausting of the gases that are generated in charging the vessel and tapping. There has been no convincing progress so far in this area. However, we are working on the problem. We hope that here also, as in many areas of the construction of LD steelworks, we can give the lead.

(4) Waste gas cooling and cleaning plant

You certainly all remember the large waste gas cooling and cleaning installations that existed in early days of LD steelworks construction, the dust removing plant being erected outside the steelworks because of its great volume, in the case of electrostatic precipitators. The reason for the great size of these installations was the enormous excess air factors that were usual at that time. However, in spite of generous designing there were many undesirable breakdowns in these installations. A few, one can say, daring firms even decided to install a single installation down-stream of two vessels that were in operation alternately. These designs did not stand the test of pratical experience as such installations are continually in operation. If repairs become necessary then this inevitably influences production, if it is impossible to discharge gases direct into the atmosphere.

There are more examples of installations in which one waste gas cooling plant is installed per vessel and only the cleaning installation proper is common to all the vessels. As a firm planning steelworks, we have for years taken the

3. Theoretical quantity of dry gas (peak value)

Quantity of primary gas

$$Q_{Prim} = 18.6 \left(\frac{dc}{dt}\right)_{max} \cdot RE \, [Nm3/min]$$

$\left(\frac{dc}{dt}\right)_{max}$ = rate of oxidation loss of C in %/min

RE = quantity of hot metal (t)

n = air factor

Quantity of secondary gas

$$\frac{n \leq 1}{Q_{Sek}} = (18.6 + 31.4\,n)\left(\frac{dc}{dt}\right)_{max} \cdot RE \, [Nm3/min]$$

$$\frac{n \geq 1}{Q_{Sek}} = (10.1 + 39.9\,n)\left(\frac{dc}{dt}\right)_{max} \cdot RE \, [Nm3/min]$$

4. Relation between maximum O_2 flow and maximum rate of oxidation loss of C

$$O_{2\,max} = 10.25 \left(\frac{dc}{dt}\right)_{max} \cdot RE \, [Nm3/min]$$

Figure 4

view, particularly with wet scrubber installations, that a "building block" system should be preferred in any case, by which we mean an installation in which one waste gas cooling and cleaning plant is installed per vessel. The experience of many years supports us in this view.

If one considers the formula for the maximum quantities of gas produced, which in the long run determines the design of the waste gas cooling and cleaning plant, the present trend, namely, operating with as low an air factor as possible is very understandable (Figure 4). A low air factor gives small quantities of gas and consequently correspondingly smaller installations. As a further result of this approach, the steel structure of the converter shop, which accounts for a considerable portion of the costs of the steel structure of the entire steelworks is now being made lighter and therefore cheaper, owing to the lower weight of the gas cooling plant. On the other hand, owing to the high CO concentration, only wet scrubbers or wet electrostatic precipitators can be used at the moment for cleaning these waste gases. However, it is known that experiments are being carried out by various firms to use dry electrostatic precipitators for this type of waste gas. The development of wet scrubbers has now reached such a high level that they fully meet the legal provisions regarding air pollution. Looked at from the capital costs angle, wet scrubbers are more favourable than electrostatic precipitators.

To deal with the various well tried dust-removing systems would go beyond the framework of this paper, but I should like to emphasise a few outstanding features. As far as new plants are concerned, there is a constant decline in the number of waste gas cooling installations in which the physical and chemical heat of the vessel waste gases is used for the production of steam for use in the works. Also installations that exploit the CO gas produced are not very numerous. In short, it is nowadays desired to destroy or eliminate the energy inherent in the waste gas at as small expense as possible.

The part directly above the vessel, known as the hood, is naturally exposed to the greatest thermal and mechanical stress. Therefore certain repair work is absolutely essential at this point. Such repair work must be made easy to carry out as it can usually be performed only when the vessel is being lined. Formerly, most hoods were fitted with interchangeable cooling plates. Today, it can be said, however, that in the long run the tube-cooled hood causes less trouble than the former plate designs. However, it is an error in planning if arrangements are not made for the possibility of replacing the hood rapidly by another one for the purpose of large-scale repairs. In relation to this it should be borne in mind that large handling space for repairs is expensive, particularly in the vessel bays. Therefore it is more favourable to take the hood into the crane area, perhaps by means of auxiliary structures that can be erected rapidly.

It has again and again been our experience that we have had to point out even to firms highly specialized in this field that it is necessary to take into consideration not only the theoretical design data but also the fact that occasionally there may be particularly intensive oxidation loss of carbon and that these peak values, although short in duration, must be absorbed by the plant. Also we advise our customers to provide for two additional chutes in the hood. Furthermore, the possibility should also be provided of introducing not only the blast lance proper but also another lance into the vessel. I am thinking mainly of the temperature measurement lances developed by VÖest according to the VP process.

Also it is necessary to provide at the lance inlet point suitable steam or air seals that can be relied upon to prevent penetration of the flames which could badly damage the parts of the installation above. As is known, nitrogen seals are used at this point in installations with a high concentration of CO.

As has been hinted at before, the trend towards what is known as "minimum gas dust-removing plant" is not to be overlooked in new installations being erected. We ourselves have followed another way in our LD Steelworks II, as the logical consequence of the experience we have gained. Since steam was needed in our metallurgical complex, we developed further a boiler version with our No. 6 vessel that makes full use of waste gases. As can be seen from Figure 5, we shut off the stream of gas from the vessel by means of a mobile hood ring so that there can be no after-burning in the lower section of the hood. As is known, these parts are always subject to particularly strong thermal stress because of the inevitable combustion and thus particularly often require repairing. This does not apply to the solution chosen by VÖest, since the combustion of the gases occurs then in the part that is designed and predestined for the purpose, namely, in the boiler plant itself. There the combustion is strictly regulated by the controlled admission of secondary air. A valuable side-effect of this design has been shown to be a considerable increase in the yield of the vessel (over 1 per cent), since owing to correct choice of the hood diameter, spittings to a large extent run back again into the vessel.

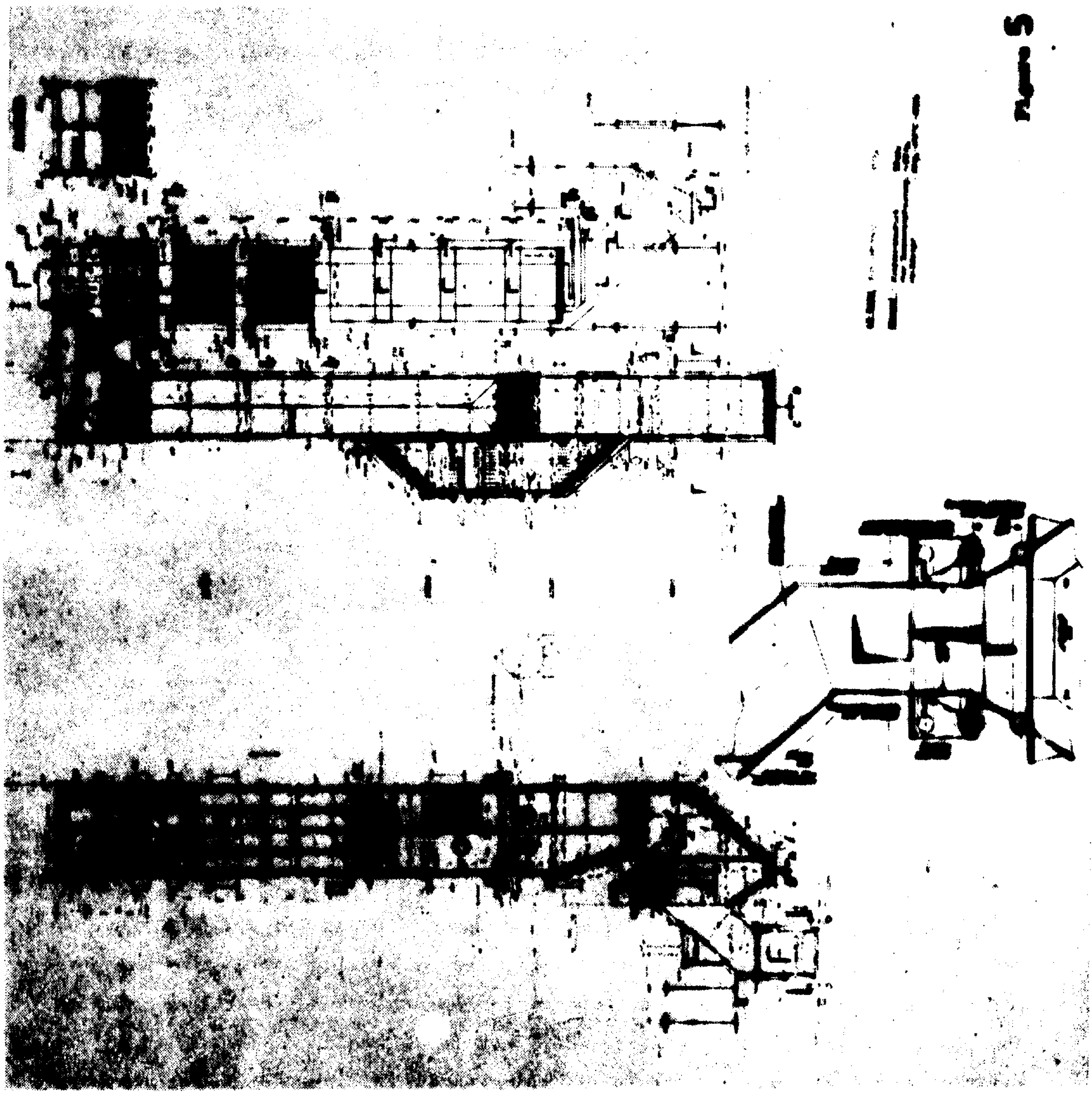


Figure 5

The mechanism for raising the closing rings has an important function - and this applies not only to the VÖest plant but also to other installations that work with closing rings. After teething troubles caused by the unfavourable conditions to which the closing mechanism is exposed, we have now been able to find suitable designs to meet these conditions, so that this problem can also be regarded as solved.

From the economic point of view, the dust produced, which can make up approximately 1.2 per cent of the metal charge - though one is well advised to take 1.5 per cent as the basis for planning - should be made use of. It suffices to recall that in a steelworks with 1 million tonnes annual output, approximately 12,000 t of dust will be produced. Research has shown that LD dust has very many uses; the scale ranges from selling to the chemical industry, re-cycling in the individual plants of the metallurgical complex, such as the steelworks, the sintering installation, etc., to its use as an infill material to obtain additional land, as has been observed in Japan.

In the vast majority of cases, the dust is conveyed to a sintering plant. However, no one has yet measured how much of this dust enters the atmosphere through the chimney of the sintering plant.

I should not forget to mention here the experiments made on using LD dust directly in steelworks, as for example in our sister works at Donawitz or, the latest example, the re-cycling planned in the new LD steelworks in Koverhar. VÖest itself has already carried out a series of experiments together with the metallurgical works in Kosice (in Czechoslovakia) on introducing LD dust into the vessel through the lance.

(5) <u>The additions section</u>

The additions section occupies considerable space in the converter bay, like the waste gas installation. Since large quantities have to be stored at suitable heights, the additions section accounts for much of the weight of the steel structure. If the hopper walls are used as bearing members in the steel structure, this does simplify the matter to some extent but does not bring any considerable reduction in weight. There are two schools of thought among customers regarding the principles of planning in this respect. One group is interested in storing as large as possible an amount in the converter shop; typical representatives of this view are many American steelworks. It is desired to store at least the requirements for three shifts in steelworks, refilling to be carried out in one shift minus two hours (operator's meal break and warm-up period). The other group, particularly as far as limestone is concerned, wishes to store in the converter bay only a supply of a few charges, as for example in many Japanese steelworks. We believe that the golden mean between these two extreme views is correct and therefore we adopt the following procedure. The lime requirement per charge, which is calculated according to the Marineck formula with a desired degree of basicity of 3 is converted to an hourly requirement (Figure 6).

In our view a minimum of about six hours' supply should be provided; the reason is that during this time small to medium scale repairs can quite easily be carried out on the conveyor systems leading to the additions section. Furthermore, an automatic feed device should be provided that ensures that replenishment begins immediately when a certain minimum level is reached in any hopper. As can be seen from Figure 7, relatively small sizes of lime hoppers are sufficient, so that the weight of the steel structure can be reduced and in addition savings in personnel are possible through the automatic system provided, since the worker previously responsible for filling the hoppers for the day is now no longer needed and the supply installation can quite well be supervised by the operator alone, who is also responsible for the low-level storage and transfer stations outside the steelworks. No firm rule can be given for the size of the hoppers for fluxes, ore and coke if used; the capacities generally follow from the residual space available, a hopper breadth of 1.5 m being the minimum and the height depending approximately on the height of the lime hoppers.

We have attempted to introduce some order into the multiplicity of possible solutions for the arrangement of the hoppers and the weighing containers beneath them, and in the following Figures 8, 9 and 10 we have shown three possible versions used as a basis for discussion with a customer.

It has more or less become standard practice that the additions section proper, consisting of the weighing hoppers and the delivery equipment, is automated and controlled from the central control point.

In addition it is also worth while to reflect briefly on the degree of accuracy necessary. The effect of tolerances on final temperature is shown in Figure 11. Inaccuracies in the measurement of the quantity of hot metal

5. Lime ratio

$$K = \frac{CaO}{r} \cdot 100$$

K = Quantity of lime in kg
CaO kg
r = CaO content of lime in %

LD CaO requirements

$$CaO = 1.7\,(40\Delta Si + 27.2\,\Delta P)\ [\text{kg/t hot metal}]$$

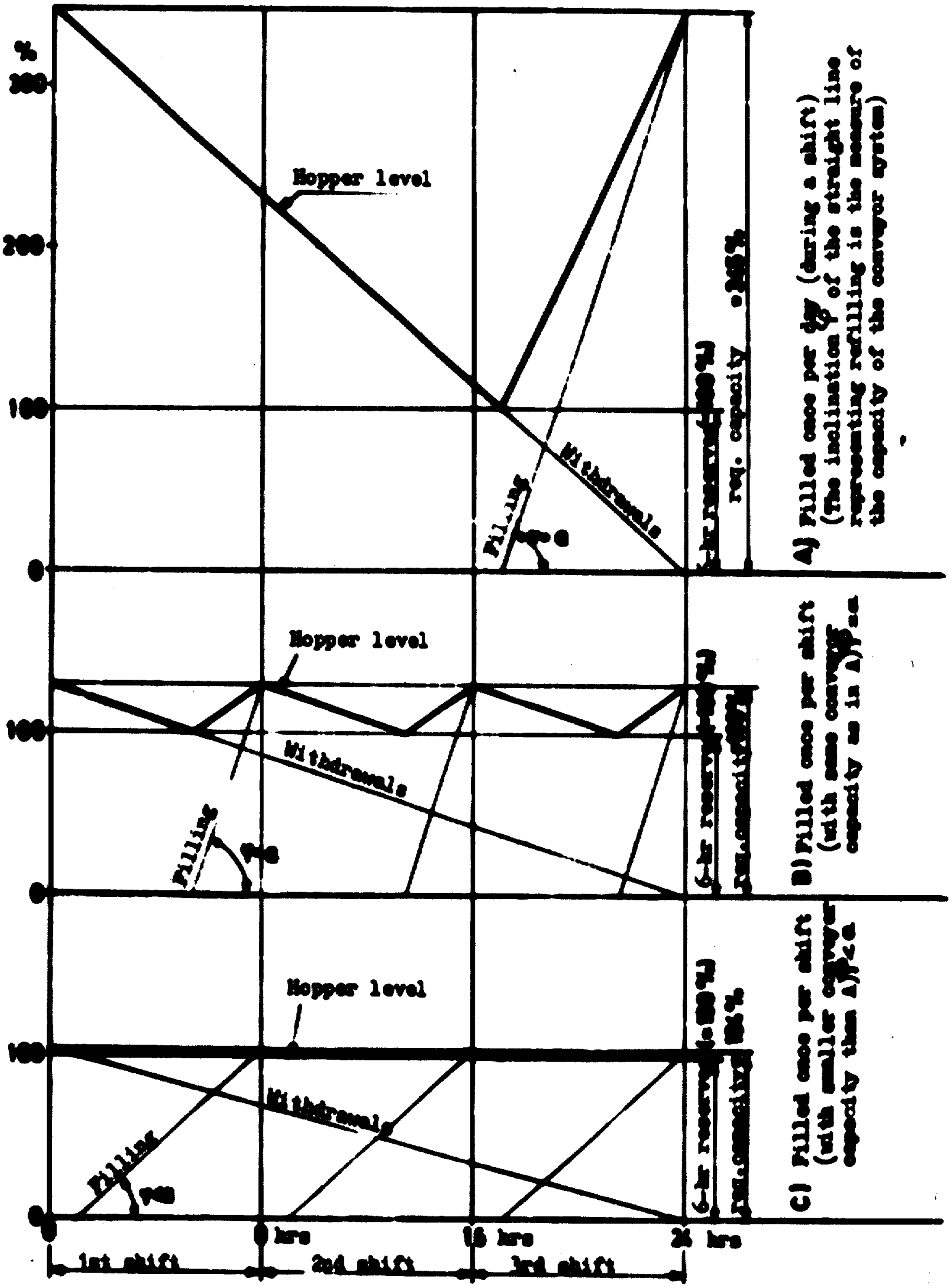
ΔSi = Oxidation loss of Si in %
ΔP = Oxidation loss of P in %

(after Marincek)

LD-AC CaO requirements (total requirements) - Re-use of second slag

$$CaO = 1.35\,(40\Delta Si + 27.2\,\Delta P)\ [\text{kg/t hot metal}]$$

Figure 6



REQUIRED CAPACITY OF ELEVATED HOPPERS

DEPENDING ON FILLING AND WITHDRAWALS

Figure 7

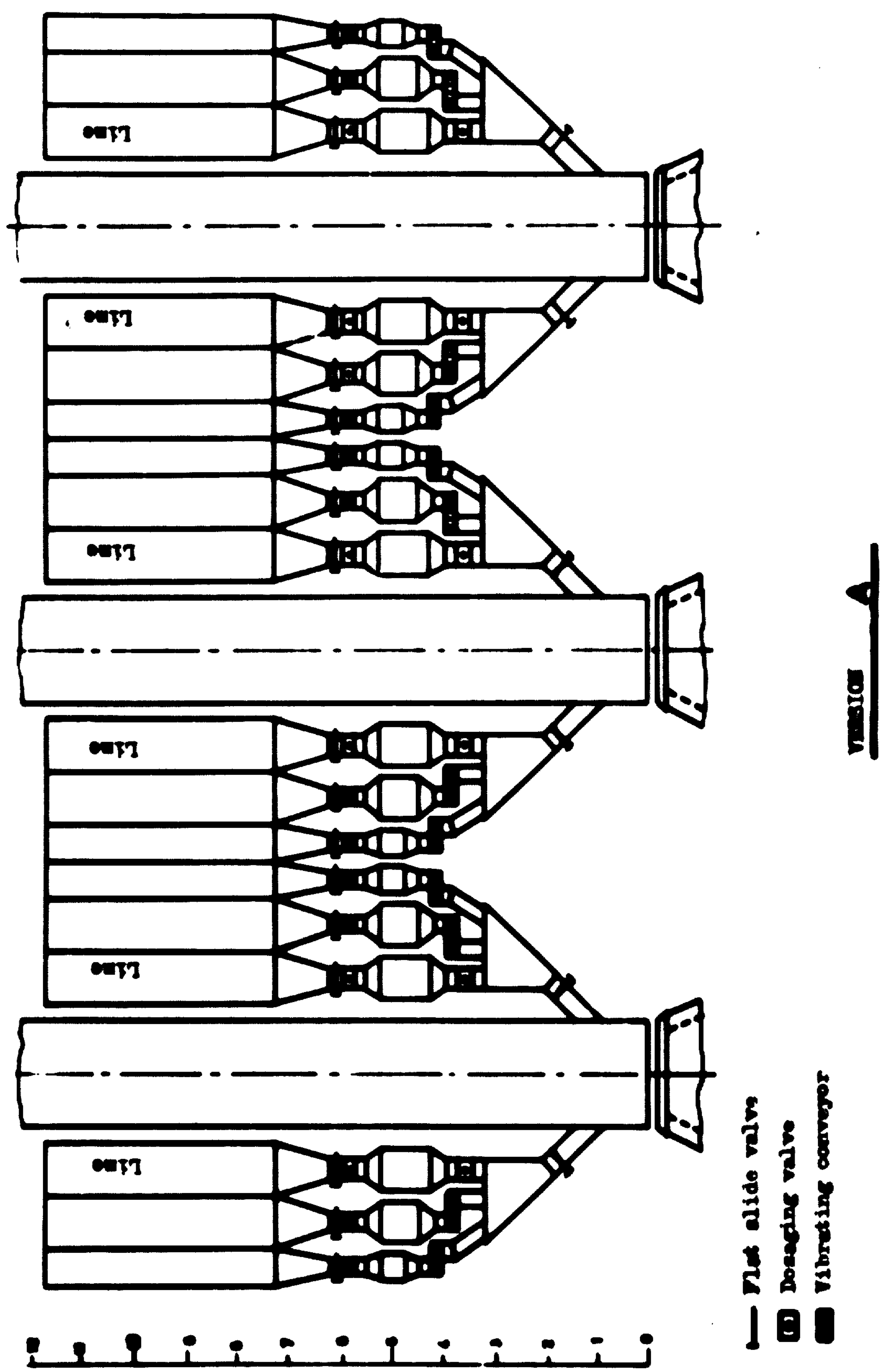
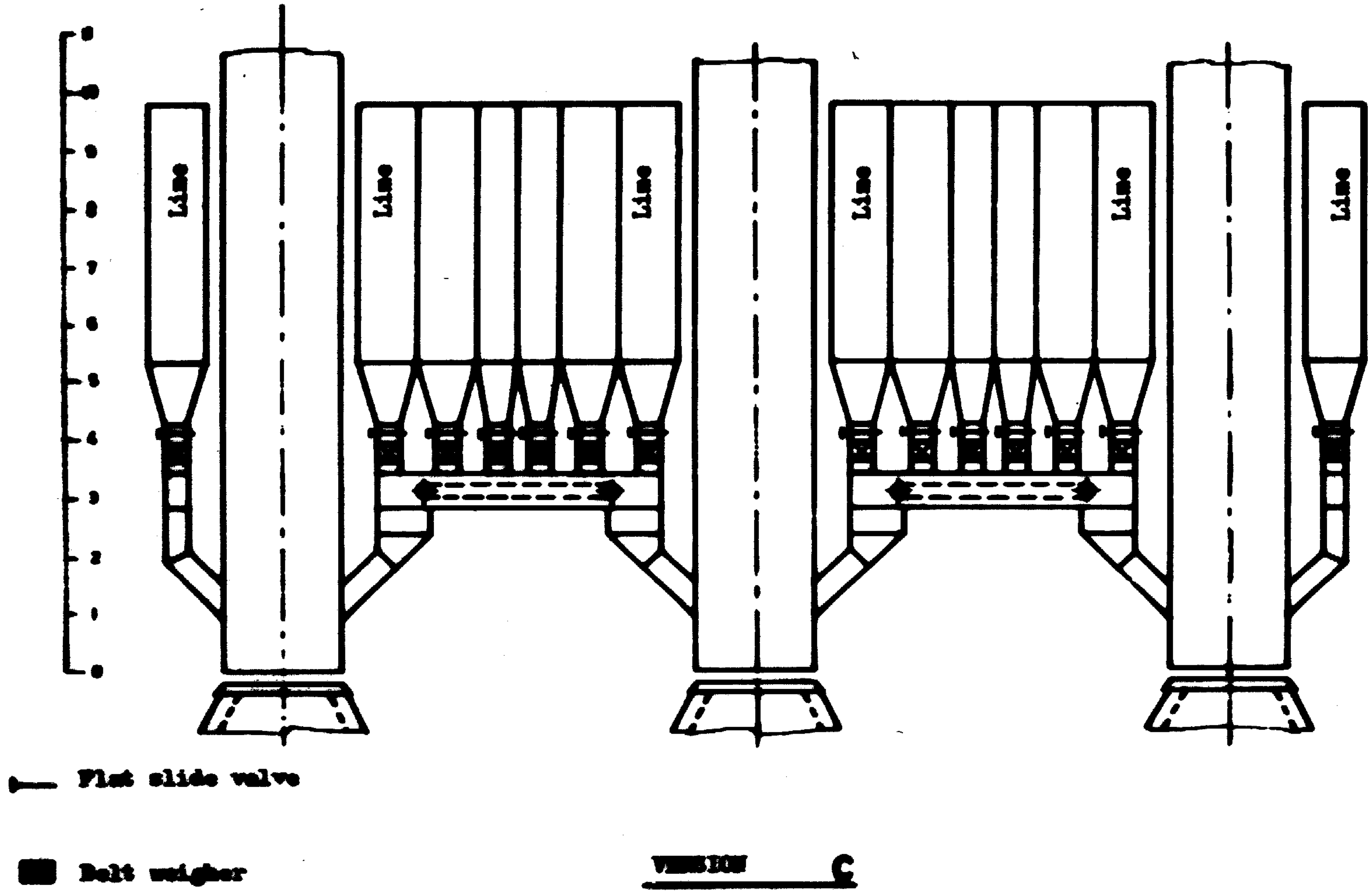
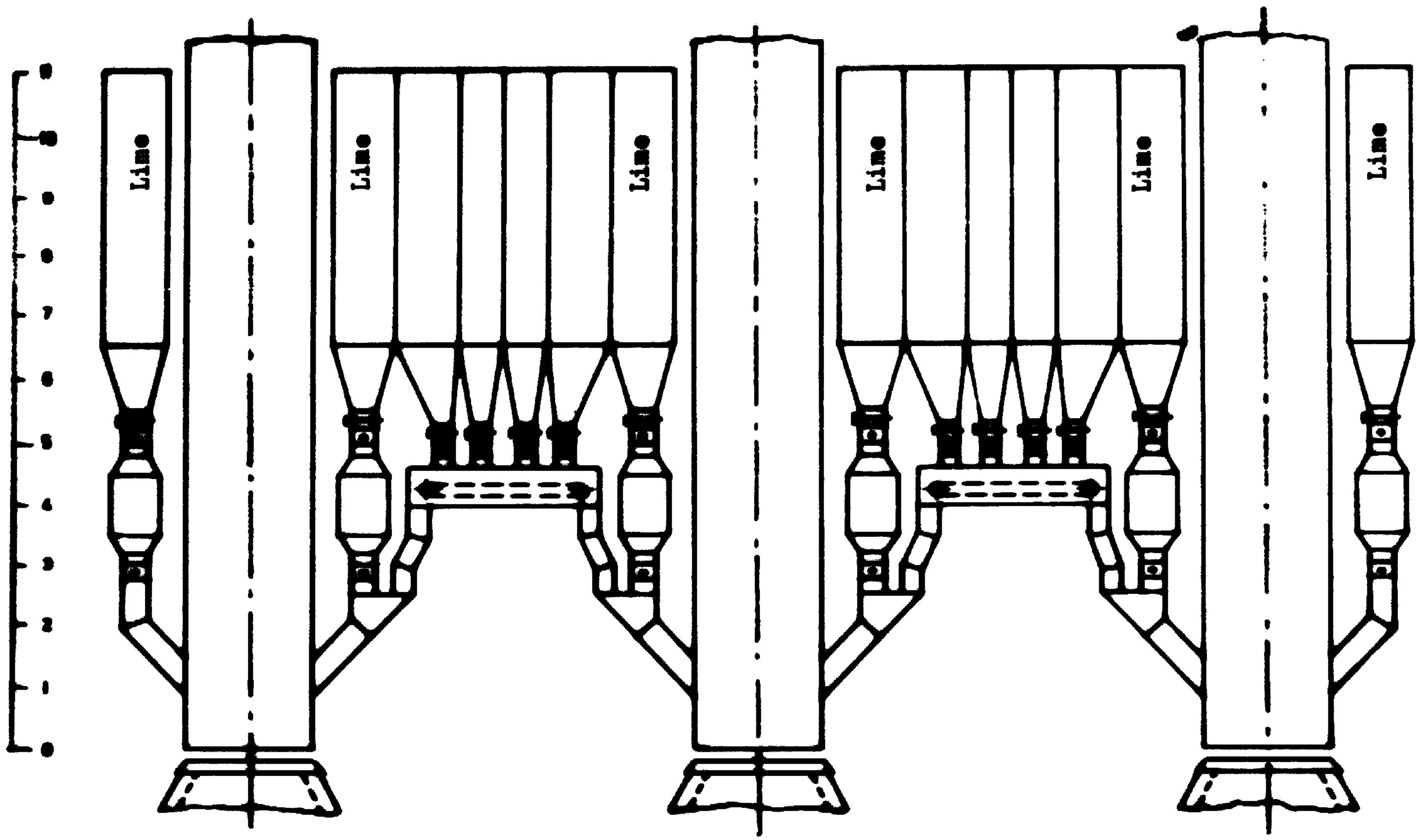

Lime
Lime
Lime
Lime
Lime
Lime
VERSION A
Flat slide valve
Dosaging valve
Vibrating conveyor

Figure 8



VERSION C

Figure 9



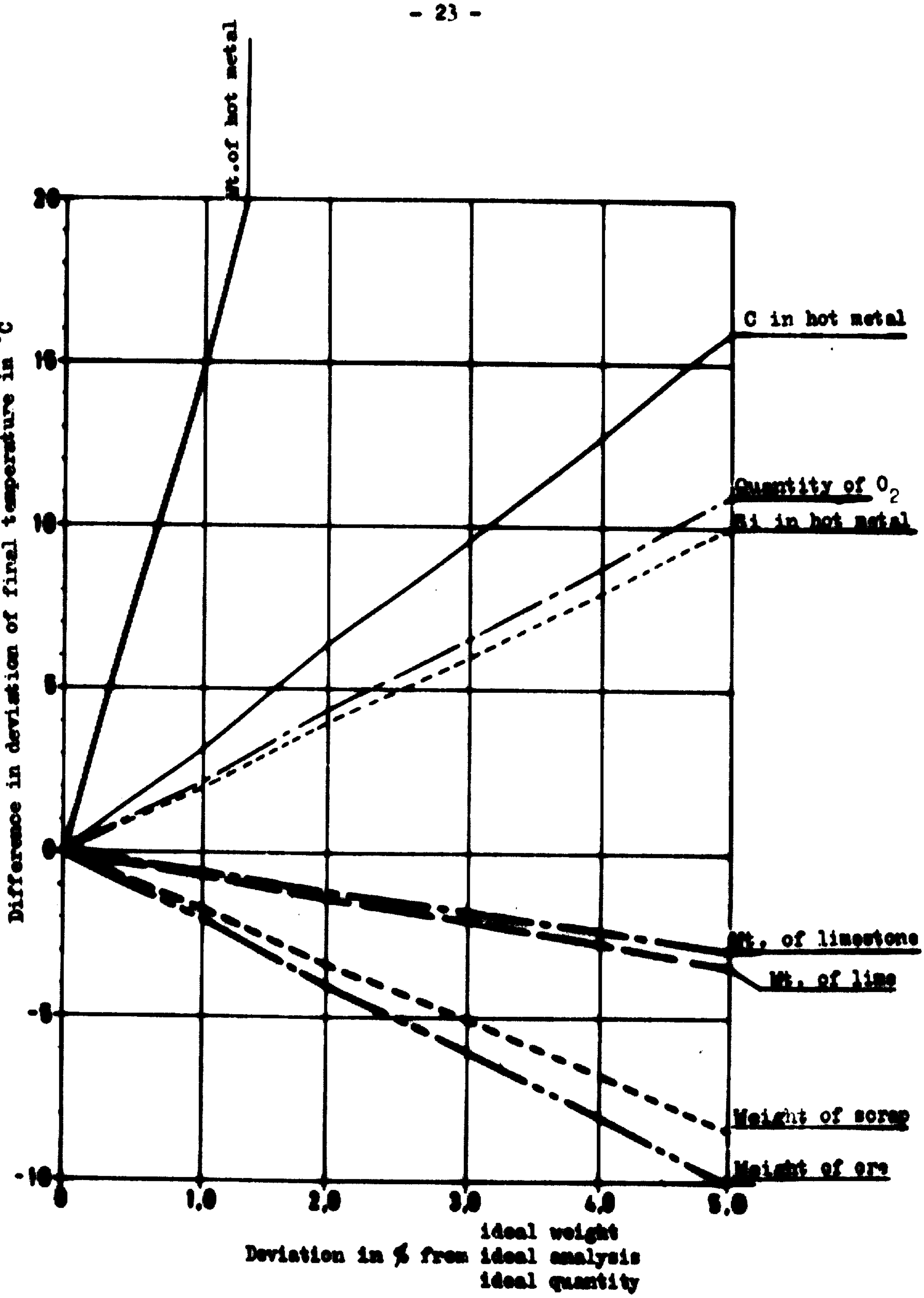
Flat slide valve

Dosaging valve

Belt weigher

VERSION D

Figure 10



THE EFFECT ON FINAL TEMPERATURE OF INACCURACIES IN THE WEIGHING OF THE CHARGE, O_2 MEASUREMENT AND ANALYSIS

(after O. Hartmann and R. Bruch, supplemented)

Figure 11

and the C content have the greatest influence on temperature, while inaccuracies in weighing the quantity of lime have a very insignificant influence, and the diagram clearly shows that accuracy in weighing to approximately 1 per cent is quite tolerable; therefore it would be quite satisfactory to use belt weighers. If it is also considered that providing for approximately 0.2 per cent accuracy in weighing results in a sharp rise in capital investment costs for this portion of the structure, it will be clearly seen that exaggerated accuracy is not always required.

Since regulations regarding air pollution at the place of work are becoming more and more strict and since dust always occurs in the additions section, only those designs are suitable that are certain to prevent the escape of dust, for example from the delivery organs. Also, much greater efforts are made nowadays than a few years ago to keep the air pure around the drop point above the hoppers. However, this requires a not inconsiderable increase in expenditure and equipment.

In planning the converter bay, it is necessary to consider not only the vessel additions but also the ladle additions. Sometimes, particularly with smaller vessel plants, it will suffice to have hoppers on the working platform. However, if the capacity of the steelworks and the programme calls for a greater turnover, it is better to accommodate the hoppers on the level above the working platform. Many steelworks planners see an advantage in regarding the ladle additions as an integral part of the vessel additions. We do not regard this as a very favourable solution, for there is little sense in transporting additions to a height of 40-44 m when they are in the end to be used a few metres above floor level. In addition, a separate conveyor system for the ladle additions is certainly more practical, and the hoppers for the ladle additions will be arranged at no more than the necessary height in the converter bay. There is no need to emphasise the fact that suitable weighing devices should also be included in the system.

(6) <u>The lance installation</u>

Fortunately, the days are past when the designer was compelled so to speak to design the lance equipment into a cramped given space. The lesson has indeed been learned that the lance equipment must be given suitable space, since, if for example interchange of lances demands too much trouble or time, a loss in production is inevitable. That was also one reason why the practice was very soon adopted of fitting the lance equipment with two lances, so that change-over from one lance to the other could be carried out even by remote control. The decisive factor with lance equipment is the maximum throughput of oxygen, which follows from the formula in Figure 4. The largest lance equipment constructed by VÖest was designed for a maximum flow of oxygen of 750 Nm3/min. In any case, care should be taken to ensure that the lances can be easily removed from the converter bay. The most favourable solution is to provide a vast slot throughout the entire length of the converter shop. However, such a slot, which is very useful for removing the lances, makes it necessary to take certain precautions with regard to the statics of the steel structure.

At this point I should like to draw attention to the measurement lances already mentioned, which have been developed by VÖest; we advise making provisions when planning new works for the possibility of introducing a measurement lance into the vessel in addition to the oxygen lance. If it is furthermore also intended to pre-heat scrap in the vessels from time to time, it is practical to supplement the lance equipment with a heating lance. The result of consistent further development of these ideas has been that we are supplying for the Hattingen steelworks in the Ruhr lance equipment with five lances, namely, two oxygen lances (one stand-by) two measurement lances (also one stand-by) and one scrap pre-heating lance.

(7) Central facilities

Since the converter vessel bay, as was indicated at the outset, represents a concentration of facilities - one could speak of a kind of energy key point - an attempt should be made to bring the electric substations and various valve and pump rooms as near as possible to this key point. Since the converter bay proper is not usually longer than two to three spans while the other bays in the steelworks have a larger number of spans, the spaces to the left and the right of the converter vessel bay can be used to house the electrical sub-stations and the pumping and valve room that cannot be accommodated directly in the converter bays. The same applies to the works offices, and perhaps the laboratories for on-the-spot testing and the computer installation, if this cannot be set up in the immediate vicinity of the central control room. Here I should like to remind you again of Figure 2, which illustrated an ideal steelworks.

Whether and to what extent any continuous casting installation is supplied with energy from that centre or whether the continuous casting installation is dependent in this respect will depend on local conditions.

(8) The handling of slag

Because of given conditions in an LD steelworks, slag can be removed in two directions, namely, either towards the side from which steel is brought in or in the opposite direction. Doubtless, the best solution is the one that makes possible the removal of slag from the steelworks with the smallest possible amount of equipment and expenditure. While it is best to operate with a remote-controlled vehicle on which the slag bucket rests, as far as the area underneath the vessel is concerned, it will depend on local conditions whether slag is removed from the steelworks by railed or non-railed vehicles. A very cheap solution is to empty the slag within the steelworks directly into a slag pit with the help of a crane and then to transport it away by means of tractor shovel, but some degree of smoke nuisance and heat generation is unavoidable. Extreme solutions such as slag handling directly in the pit underneath the vessel have not proved satisfactory and in our opinion will finally be discontinued. A basic rule to which little importance was formerly attached should, however, be adhered to in any case if it is at all possible: the slag should be tapped on the side from which the scrap is charged into the vessel.

The skin of slag formed in tapping slag gives the lining not inconsiderable protection from scrap dropped in during charging. Comparative tests distinctly show much better service life of the linings. In addition to weighing the main materials involved in steel-making, such as hot metal, scrap and steel, it is felt desirable, precisely with LD - AC steelworks, to weigh also the quantity of slag tapped. This can quite well be fulfilled by the designer and certainly cannot be rejected in individual cases in view of the ever-increasing accuracy practised in data acquisition in steelworks.

(9) Casting

In the development of the LD process the engineer had to tread new paths in the steel-making units and the charging devices. As regards casting, on the other hand, it was possible to retain conventional methods until continuous casting plants were developed; however, it has to be remembered that in view of the very high hourly output of LD vessels particular attention should be devoted to the casting section. It is true that the necessary size of the individual units such as the longitudinal or transverse casting pits, the surfaces for depositing ingot moulds and the subsidiary installations, for example dry heaters for ladles, ladle-bricking pits, etc., can easily be calculated. Experience shows, however, that very often casting is the bottle-neck in production and one is well advised not to be over-economical, precisely with the casting section, in order to be able to cope with any eventualities in operation. In this connexion I should mention a new development by Vöest that aims at achieving a high output in as small a space as possible (Figure 13, revolving casting station LD-II); through the establishment of this revolving casting station our LD-II steelworks has achieved record performance in steel output per m^2 of teeming bay area.

No genuine revolution of casting was brought about until the development of continuous casting. Since this subject will be specially dealt with in the next paper I should not like to anticipate here.

(10) <u>Cranes</u>

Planners must also devote some attention to cranes. In no other part of a metallurgical plant are cranes so intimately connected with production as in the steel-making plant. Therefore the following points should be given particular attention:

- Absolute reliability in operation, which for example in extreme cases culminates in the decision not to install a scrap charging and a hot metal crane in a charging bay but rather two hot metal cranes, each of which can also charge scrap. This capital investment brings full effect only if suitable servicing areas are available in case a crane should require repair. This usually calls for at least one additional span in the charging bay so that the other crane can supply the entire working area. It is precisely the endeavour to achieve 100 per cent reliability of operation that has prevented the theoretical notion of a steelworks without cranes from being translated into reality.
- Suitable protective measures against the effects of heat. In this respect also many bitter lessons have been learnt.
- Usually it is desired to have greater rail dimensions than usual on the converter vessel side and various heights of lift so that under certain circumstances special designs of crabs are necessary. Experience shows that this point raises problems in the conversion of Siemens-Martins works, but these have always been solved so far.

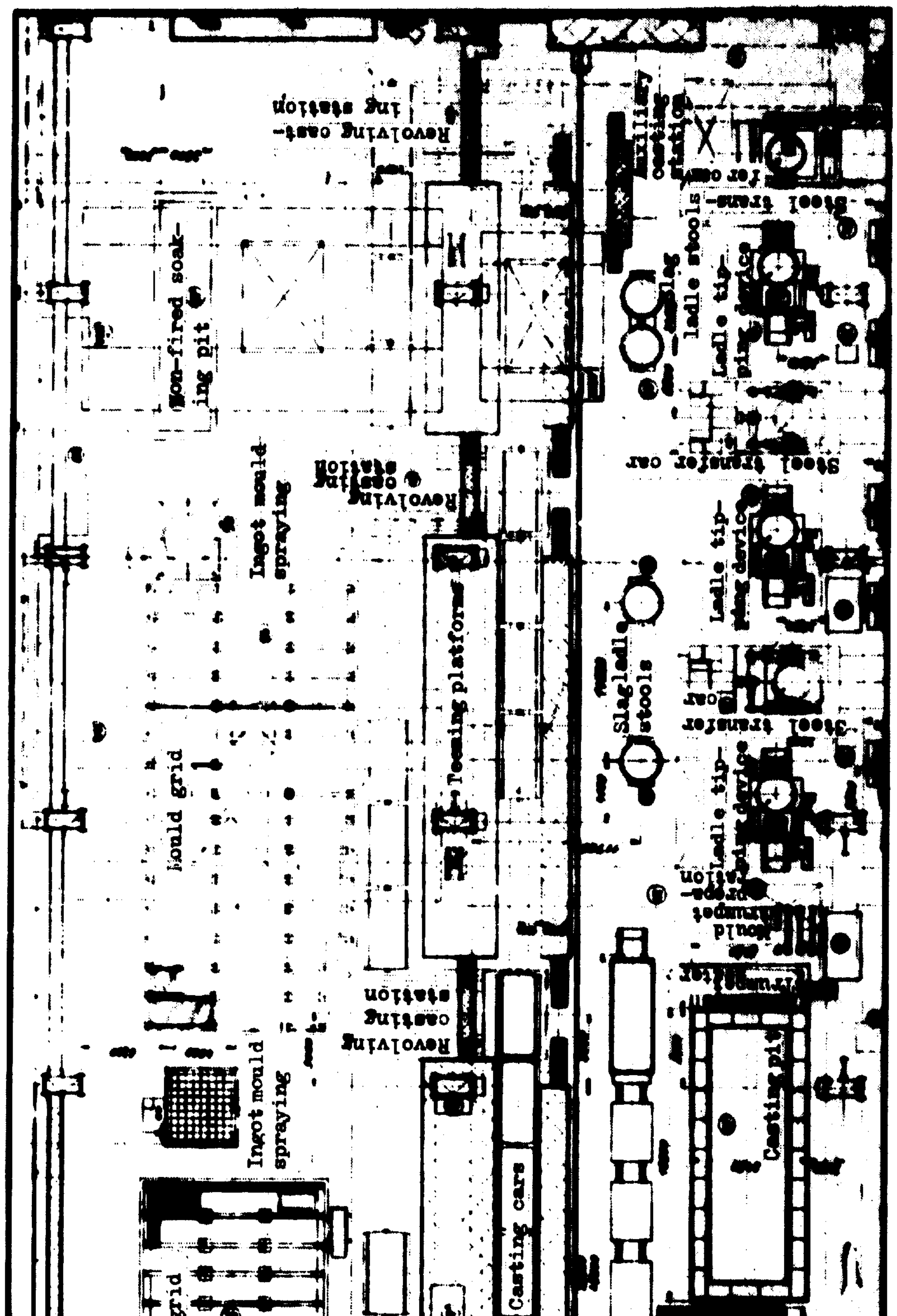

Revolving casting station
Non-fired soaking pit
Ingot mould spraying
Mould grid
Teeming platform
Casting cars
Slag ladle stools
Ladle tipping device
Steel transfer car
Casting pit
Auxiliary casting station
Exothermic station
Hopper

Figure 13

- In future more attention will have to be devoted to remote control and the transfer of measurement values, for example weighing data.

  Air conditioning of the main cranes in the steelworks is fortunately no longer a problem.

(11) Special cases

In our remarks so far we have included only those steelworks in which the converter vessel installation was fixed in location. However, there is no lack of examples in which it has been essential, mainly because of lack of space, to design the converter vessel installation in such a way that the vessel is interchangeable, so that apart from the short interchange period the plant can be operated continuously and lining times do not influence production times. I would remind you of the ground plan of the Differdingen steelworks. We think that we can truly say in this respect that VÖest has done pioneering work in this field. When this development began, two paths were followed. The first can be briefly described as follows:

The construction of a horse-shoe shaped carrying ring. After lifting off one part of the working platform and loosening the trunnion connexion between the vessel and the carrying ring, the vessel is withdrawn with the help of a suitable truck.

Transfer of the vessel to and from the lining position or the service area with the aid of two cranes having a common girder. For such transfer the vessels must be fitted with lifting lugs (see Figure 14).

Second solution:

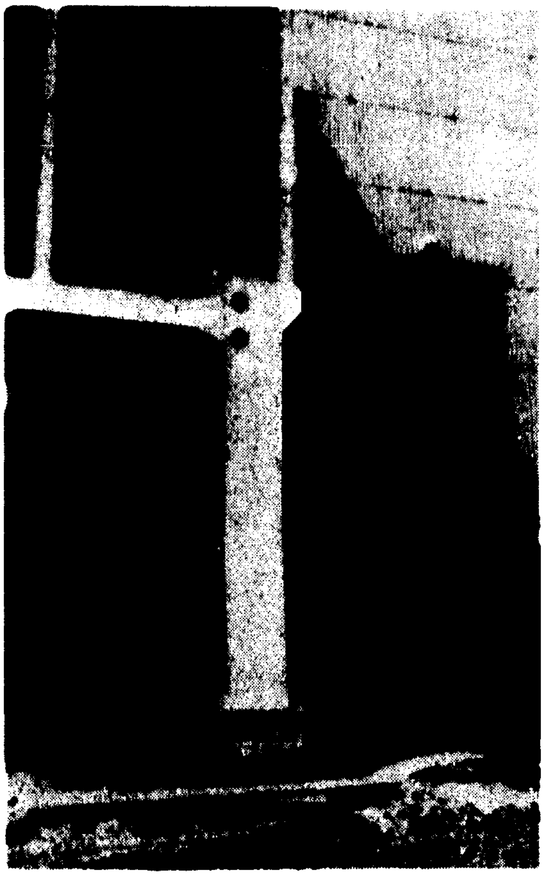
The vessel has a closed carrying ring. After loosening the claw connexion and turning the vessel, the vessel is lowered and conveyed to the clearing or servicing area with the aid of a vessel-lifting car.

The last plant constructed by us, namely, Clabecq in Belgium, is a combination of the two possibilities, namely horse-shoe shaped carrying rings and conveyance with the aid of a vessel lifting car (Figure 15). A film is now being shot on this plant and we hope that we shall soon be able to show it to you.

The next theoretical step in development would be to move the vessel to various places within the steelworks not only after each such transfer but for the individual phases of the process, such as charging, blowing and tapping.

Figure 14

Figure 15



I mention this solution here only for the sake of completeness. For the moment it exists only on paper in patent literature since so far no customer has had the courage to have such a plant set up, even as an experimental installation.

(12) Central control

In older steelworks, the vessel and the lance were controlled from a command post near the vessel, the additions section and the dust removing plant having their separate control desks or positions. In present planning, strengthened by the positive experience we have already gained, we now as far as possible provide for a central control room which includes not only the controls of the lance and additions for all vessels installed but also the control desks for the entire additions section and the waste gas cooling and cleaning plant. The only controls remaining near the vessel are those for the tilting drive, the steel transfer car and the slag car. It is an attendant consequence of the ever-increasing demands made regarding control, regulation and automation that the space requirements for the instruments in the central control room become greater and greater, and it is often a problem to provide the necessary space in the proper place. We found a particularly elegant solution of this problem in the Sidmar steelworks and I hope that the following pictures will illustrate this better than I can describe it in words (Figures 16 and 17). Also an attempt will be made to set up the computer within the steelworks as close as possible to the central control room, and only if the strict regulations regarding air-conditioning and freedom from vibration cannot be met will the computer have to be set up outside the steelworks building.

(13) Maximum sizes

The fact that the larger the unit the more favourable the economic factor, confronts the planning engineer with the question where the limit of maximum production units lies. The largest vessels supplied by us and successfully operated have a capacity of 300 t. Our investigations so far show that from the point of view of the mechanical engineer it is quite possible to manufacture vessels between 400 and 500 t. The heavy cranes necessary for these vessels can also be manufactured. The metallurgical question whether the refining process should then be carried out with several lances still remains to be answered, however. But here we are already looking into the future and

Figure 16

Figure 17

immediately the further question arises whether the dream of controlled continuous steel production will soon come true, so that continuous refining can be integrated with continuous casting. If one considers that developments so far towards large units have led to hourly outputs of between 400 and 500 t per vessel and that with two vessels of this size working simultaneously in a steelworks it is quite possible to produce about 1,000 t of steel per hour, one can imagine that all other new processes will have very great difficulty in gaining a foothold in view of this advance of the LD process.

(14) Concluding remarks

In what I have just said I have briefly outlined the principles we adopt in planning LD steelworks.

To sum up it can be said that special planning is necessary for each LD steelworks to be constructed - apart from a few basic rules and principles. Since we have by now delivered eighty vessel installations to twenty-one countries throughout the world and in addition have supplied many steelworks on the turnkey principle, we believe that we are justified in saying:

Apply to us if you have any problems regarding the planning and construction of LD steelworks; we shall certainly be able to help you.

LIST OF ILLUSTRATIONS

A. Figures illustrating the text

Figure	
1	Design formulae for steelworks output
1a	Floor plan of the projected Differdingen steelworks
2	Floor plan and cross section of an ideal steelworks
3	The bases for determining the charge of scrap and hot metal
4	Formulae for the quantity of gas and maximum oxygen flow
5	The LD-II waste gas cooling and cleaning plant, Vessel No. 6
6	The lime ratio formula
7	The basis for determining the capacity of lime hoppers
8) 9) 10)	A diagrammatic representation of three versions of the additions supply system
11	The effect on final termerature of inaccuracies in the weighing of charge materials, O_2 measurement and analysis
12	= Figure 4 (maximum oxygen flow)
13	LD-II revolving casting stations
14	Vessel with lifting lugs (Lysaght's)
15	Vessel lifting car at the servicing area (Clabecq)
16) 17)	An example of a central control room, Sidmar

B. Illustrations shown after reading of the paper

Figure	
18	Cross-section of the Lipesk steelworks An example of hot-metal handling on the second level
19	A view of the Lipesk charging bay, hot metal handling on the working platform
20	The Taranto vessel plant during erection (one of the largest vessels built by VÖest)
21	An example of successful integration into an existing Siemens-Martin steelworks

B. <u>Illustrations shown after reading of the paper</u> (cont'd)

Figure

22 An example of a completely tube-cooled waste gas hood with natural circulation and a view of a suitably reinforced mouth of a converter vessel

23 Cross section through the Sidmar LD steelworks (generous planning)

24 Converter vessel installation (Sidmar)

25 Charging hot metal (Sidmar)

26 Charging scrap (Sidmar)

27 A view of the teeming bay and ingot stripping shed (Sidmar)

28 Floor plan of the Hainaut Sambre steelworks (compact construction)

29 Cross-section of the Hainaut Sambre steelworks

30 Mixer installation, pouring back slag (Hainaut Sambre)

31 Emptying slag buckets (Hainaut Sambre)

32 A view of the teeming bay (Hainaut Sambre)

33 The conveyor system for vessel additions

34 Erection of the steel structure (Hainaut Sambre)

35 General view of the Hainaut Sambre steelworks

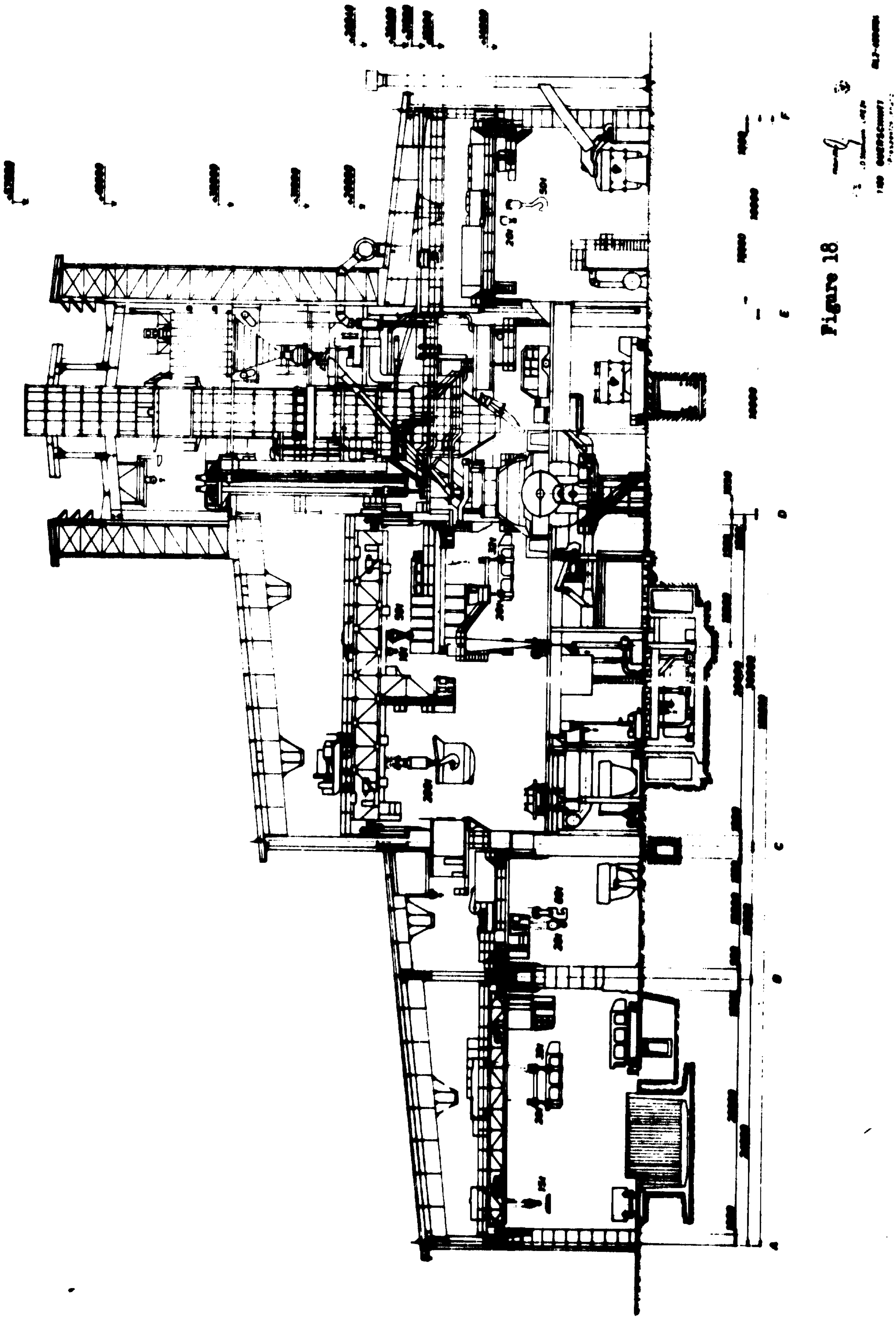


Figure 18

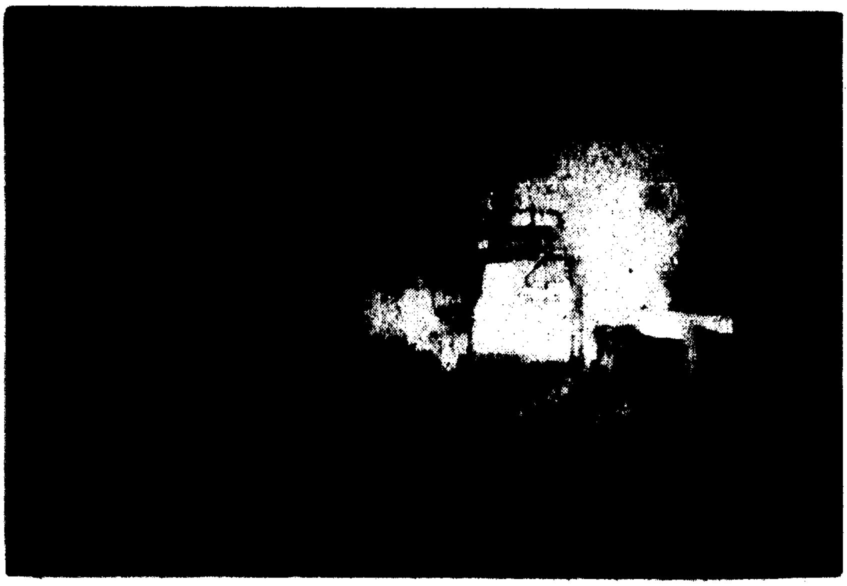


Figure 19

Figure 20

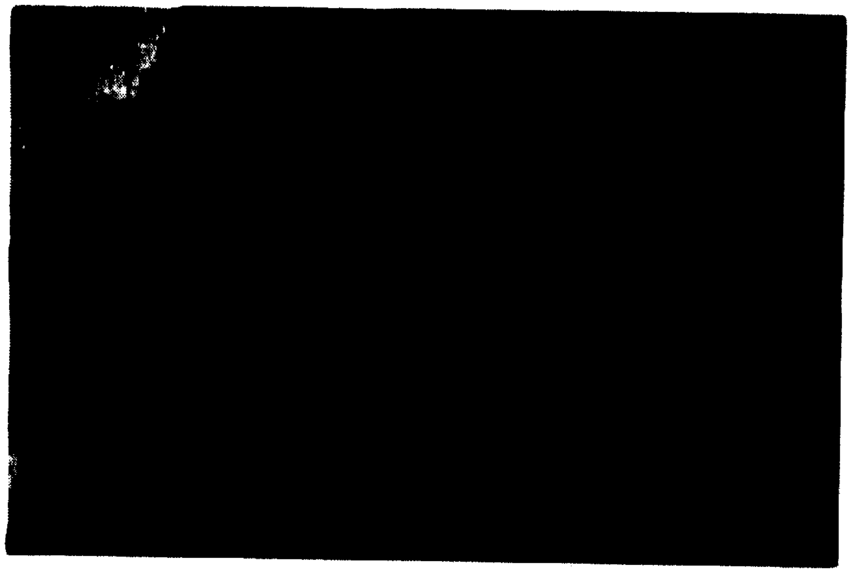


Figure 21

Figure 22

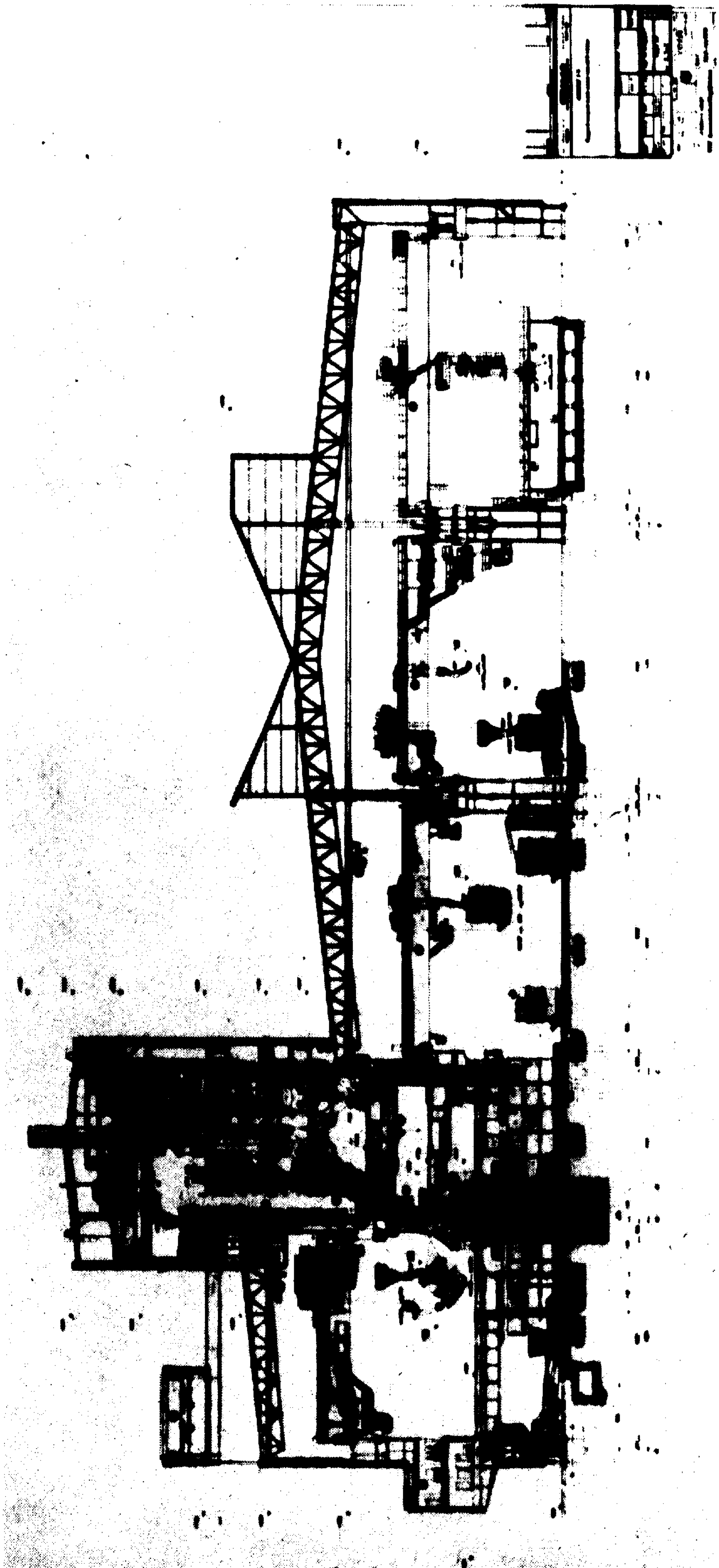


Figure 23

Figure 24

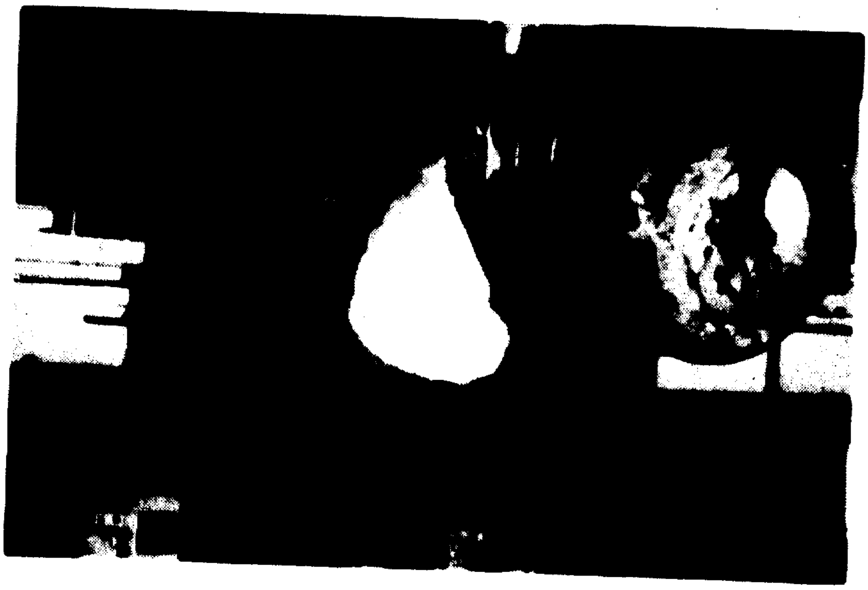


Figure 25

Figure 26

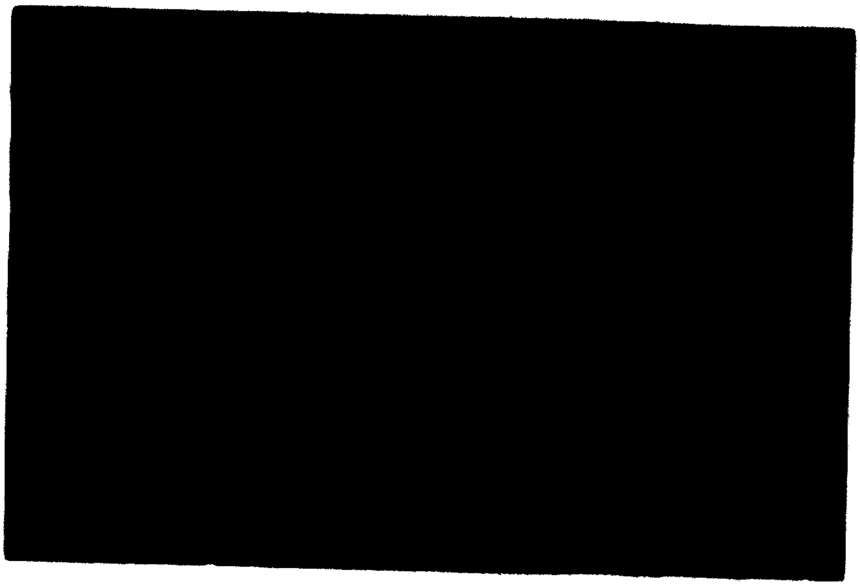


Figure 27

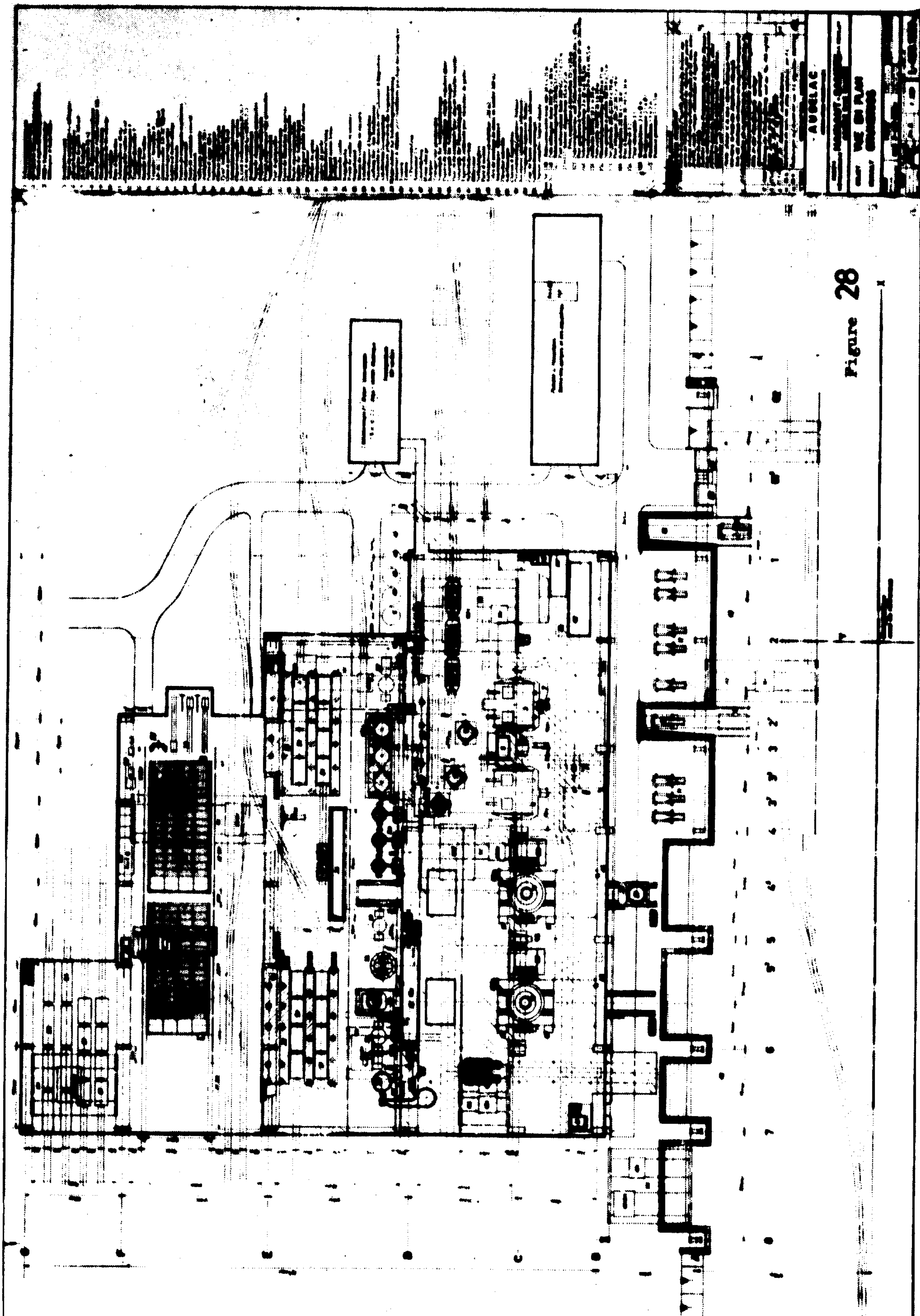


Figure 28

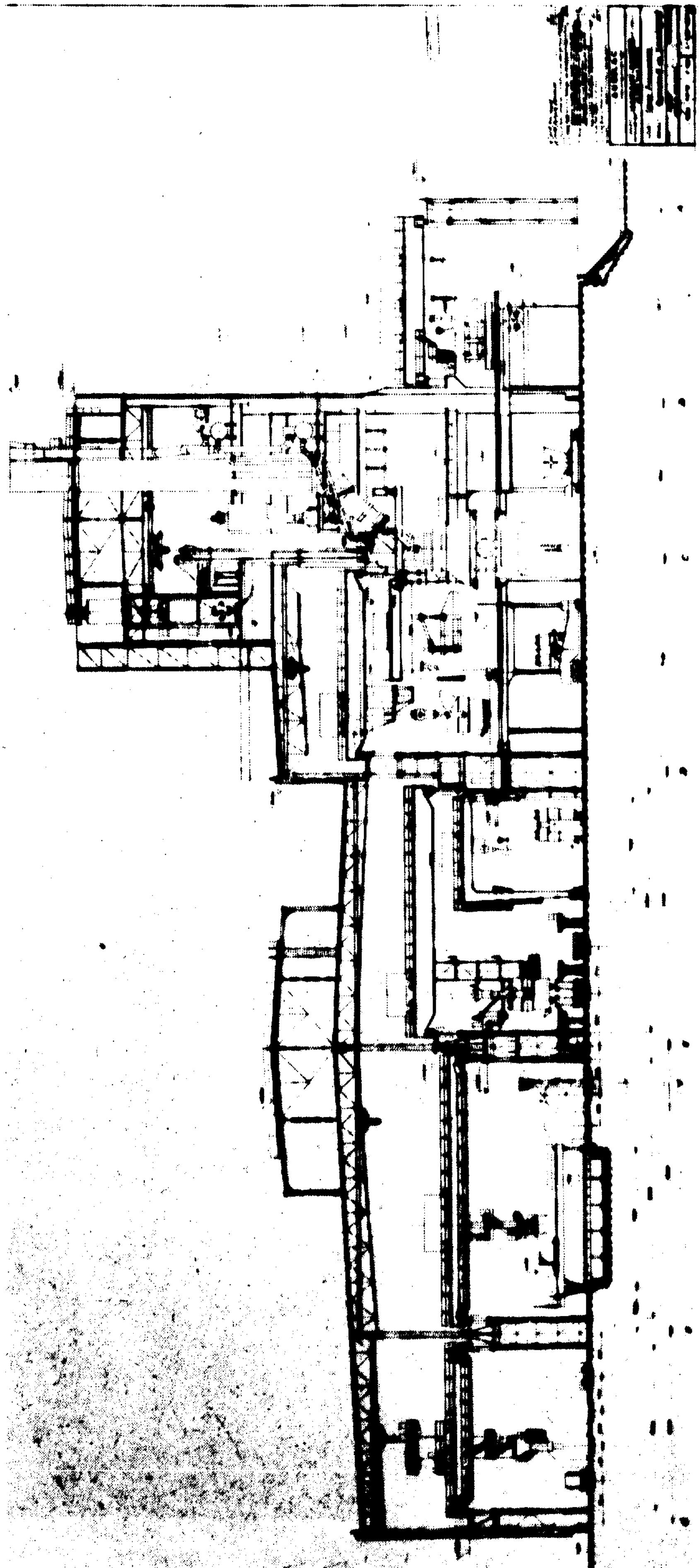


Figure 29

Figure 30

Figure 31

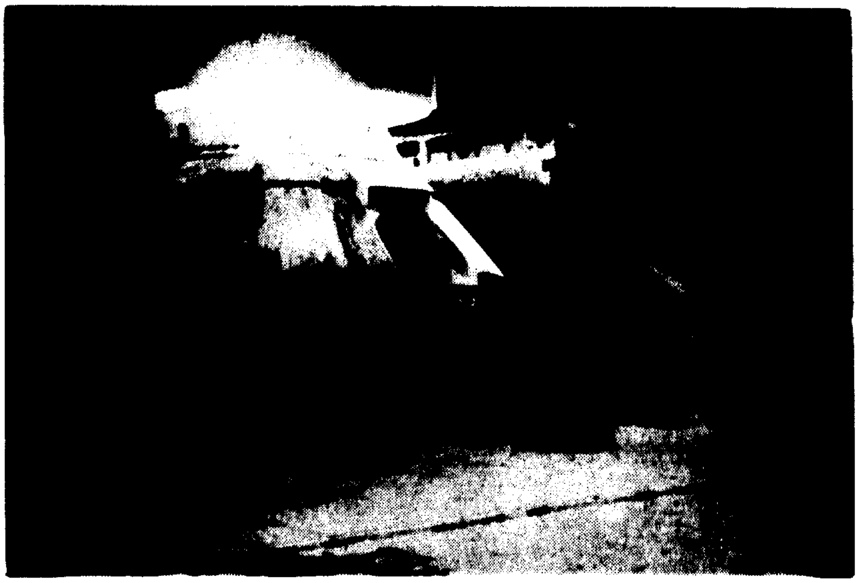


Figure 32

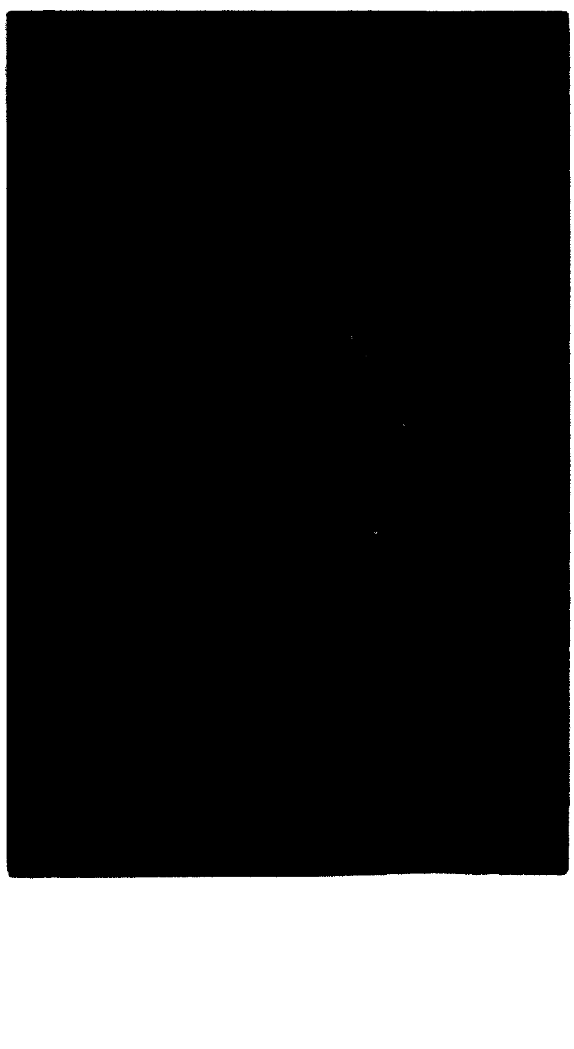


Figure 33

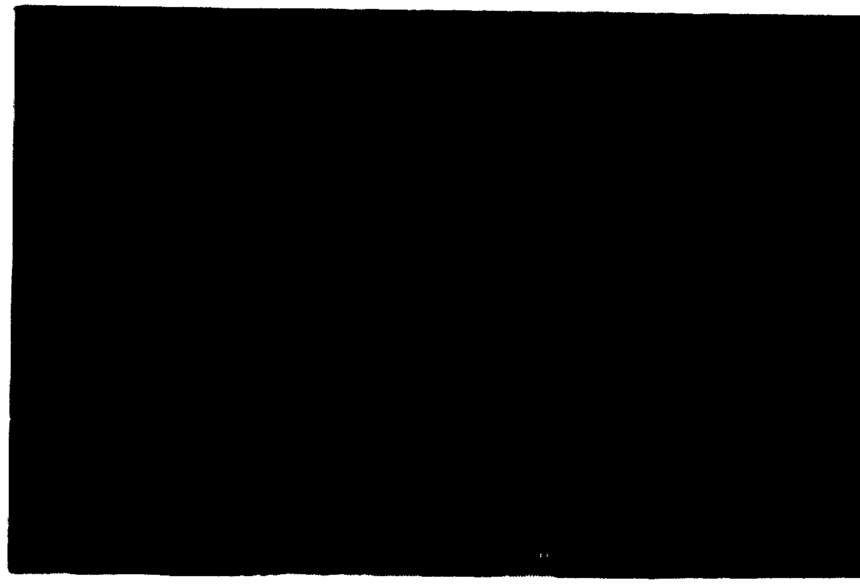


Figure 34

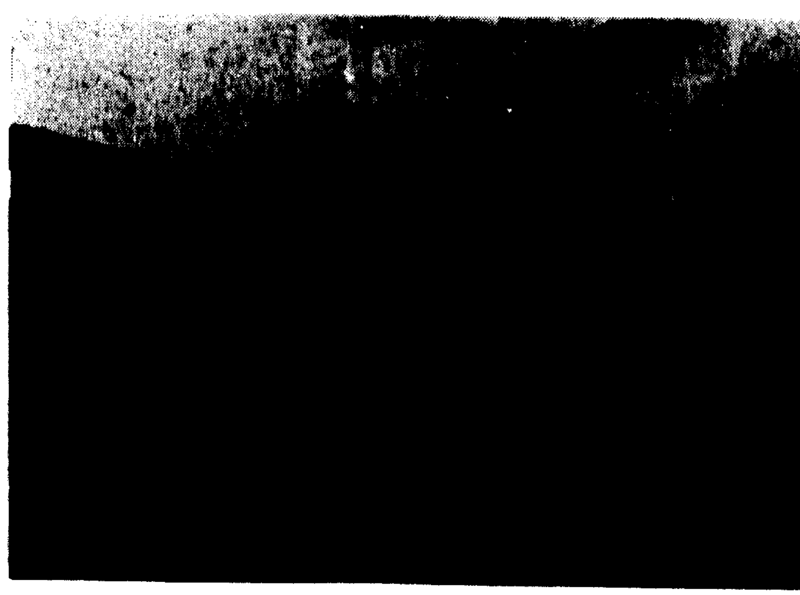


Figure 35

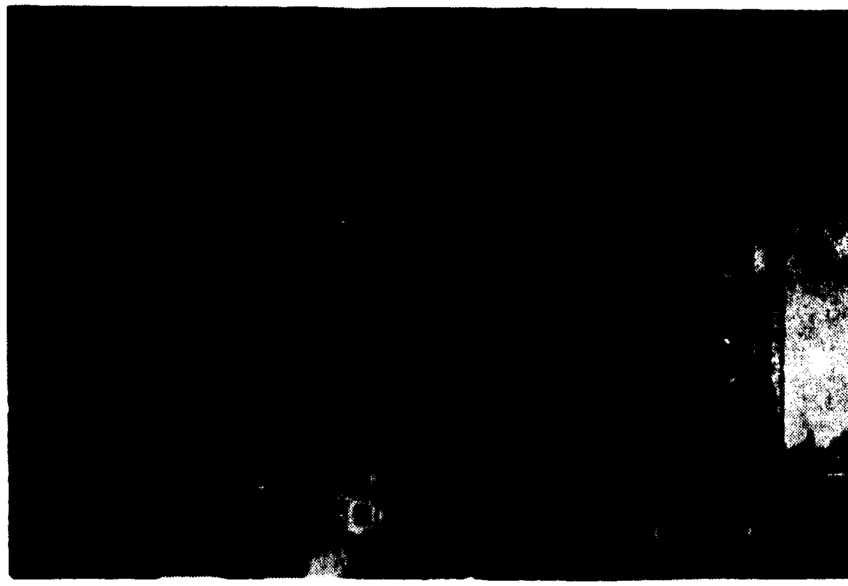


Figure 36

Figure 37

21.12.73