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# INFORMATION REPORT INFORMATION REPORT

## CENTRAL INTELLIGENCE AGENCY

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| | | | |
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| COUNTRY | Hungary | REPORT | [redacted] |
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SOURCE EVALUATIONS ARE DEFINITIVE. APPRAISAL OF CONTENT IS TENTATIVE.

[redacted]

[redacted] a book entitled "Hungarian Aluminum Industry." The book was prepared for the Hungarian export-import agency KOMPLEX and presents a detailed description, including photographs and drawings, of the aluminum industry in Hungary. 50X1-HUM

2. The publication is printed in English. It is not believed to be classified, but is forwarded in case no other copy is at present available.

Distribution of Attachments:

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# HUNGARIAN aluminium INDUSTRY

KOMPLEX

BUDAPEST

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# I N T R O D U C T I O N

The Hungarian Bauxite Mining looks back on a past of over 30 years and the rich occurences of this material in our country ensure a first class position even on a world scale for the Hungarian Bauxite, Alumina and Aluminium Industries

Parallel to the development of the prospecting for Bauxite and of mining methods have been developing the Alumina Industry and Metallurgy as well as the manufacture of Aluminium salts, of semi-finished and finished products. From the viewpoint of production per head /3,5 kgs per head/ the position hold by the Hungarian Industry is even on a world scale a considerable one.

The methods of Bauxite prospecting have been developing in an up-to-date manner and as a consequence, at present we dispose of modern processes not only as regards the adoption of geological and geophysical methods but also concerning the mineralogical and technological testing of Bauxite.

Our Bauxite mining methods /open mining and deep level mining/ are modern, the mechanization of mining has been developing to a considerable extent. Owing to the development of the Bayer and modified Bayer processes, our Alumina Industry disposes of an up-to-date technology. Our new methods aiming at the extraction of other components of Bauxite /Titanium, Vanadium etc./ as well as of Aluminium salt are of a similar importance.

Hungarian Aluminium Metallurgy applied as one of the first the Soederberg process and nowadays we dispose of 60 KA electrolysis cells with vertically arranged anode studs as well as of modified, heavy duty electrolysis cells with horizontally arranged anode studs.

The development of modern technics calls in many fields of industry and commerce for employing high purity /99,99 %/

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aluminium. Some types of high intensity /27 KA/ refining furnaces were developed first in Hungary, similarly to a method allowing to use the furnaces in aluminium electrolysis systems working on similar intensity.

As a consequence, also the development of the manufacture of semi-products and finished products has become necessary. We dispose of a large scale of experience as regards the manufacture of sheets, strips, different section bars, tubes, foils etc. made of Aluminium or Aluminium Alloys. The last Leipzig Fair too has borne testimony to the high level of the manufacture of finished products e.g. cables /with Aluminium conductors, high purity aluminium protecting coats/, aluminium bus-bars, electrical fittings, transmission lines, food industry, scaffoldings, transport vehicles /tramway cars, busses, waggons, ships etc./. As reference see "Light Metals" /London, March 1956/.

Please find below the description of a hypothetical Alumina Plant with Aluminium Electrolysis Plant. Our data, however, are but informatory, more detailed offers can only be elaborated in the knowledge of the mineralogical, physical and chemical properties of the Bauxite available, after having thoroughly studied the local conditions. We dispose of a modern Light Metal Research Institute as well as of an Aluminium Planning Institute both qualified to solve your problems and to elaborate up-to-date plans in this line, on the basis of many years' experience.

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# A L U M I N A   P L A N T

## of a 60.000 tons/year capacity

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# ALUMINA PLANT
## of a 60.000 tons/year capacity

The raw material used is bauxite, of the supposed following average composition:

| | % |
|---|---|
| $Al_2O_3$ | 51,0 |
| $SiO_2$ | 4,2 |
| $Fe_2O_3$ | 20,0 |
| $TiO_2$ | 2,7 |
| $P_2O_5$ | 0,4 |
| $V_2O_5$ | 0,1 |
| Others | 0,6 |
| Combined water | 21,0 |
| | 100,0 |

The data are applied to a material dried at 105° C. Our plans are based on a material of 20 % water content. In case of bauxites of other composition - of course - we undertake the execution of an other plan, by making the necessary changes in the present scheme.

## I. SHORT TECHNOLOGICAL DESCRIPTION

The technology of the alumina plant to be erected is based upon the "Bayer" process modified due to the up-to-date development of the same. We are in the position, however, to elaborate technological processes for different bauxite qualities, having an excellent Research Institute, laboratories, pilot plants and Projecting Institute with great experiences at our disposal.

The phases of the modified "Bayer" process are the following:

1. Dressing of the raw material
2. Digesting of bauxite and settling of red mud
3. Precipitation of aluminium hydrate
4. Calcination of aluminium hydrate
5. Concentration of diluted caustic lye and removing of the impurities.

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1. DRESSING OF THE RAW MATERIALS

The raw bauxite is arriving in railway cars, wich are emptied by means of a waggon tipper. The bauxite gets into the appropriate crushing equipment by means of a plate conveyer and a bucket elevator. The bauxite crushed to 40 mm size will be forwarded by a conveyor belt to the bauxite storage hall, wherefrom it will be lifted by meens of grabs and transported further by a conveyor belt and an inclined elevator to the drying and roasting kilns. The bauxite passing through the gas- or mascutfired multiple-stage drying kiln, will be freed from its water content and from a certain part of its combined water content and organics too.

The dried bauxite will be crushed in ball mills to the required grain-size and conveyed by means of a suction fan into the storage bunkers. Afterwards adequate quantity of bauxite powder will be mixed with the circulating recovered caustic lye of soda in the mixing tank and the mixture will be pumped to the digesters /autoclaves/.

2. DIGESTING OF BAUXITE AND SETTLING OF RED MUD

In the autoclaves the mixture of caustic lye of soda and bauxite will be heated or indirectly by 8-20 atm. pressure superheated steam. The digestion is performed under 4-15 atm. pressure at a temperature of 140-195$^{\circ}$ C and requires abt 2-6 hours. During this process, the alumina is dissolved by the caustic lye of soda from the bauxite while the insoluble residues of the latter, will form the red mud.

After boiling, the slurry leaving the autoclaves, will be diluted with washing water running back from the settlers and pumped in the settling tank system, where the red mud separates from the clear solution of aluminate. The sodium-aluminate solution is pumped to the precipitators, while the mixture of red mud and aluminate liquor coming from the bottom of the settling tank passes through a washing tank or filter system consisting of several units.

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The red mud leaving the washing system and thrown into the wastepit, contains practically no alkali at all. The washing water serving for the dilution of the digested slurry leaving the autoclaves, is fed into the last settling apparatus, and is led through the whole system. It is customary to submit the sodium aluminate liquor before being pumped into the precipitators, to a so-called control-filtering, removing thus the red mud particles in suspension.

## 3. PRECIPITATION OF ALUMINIUM HYDRATE

First of all, the clear sodium-aluminate liquor has to be cooled to a temperature of 60 - 65° C, then it is pumped into the pneumatically agitated precipitators. During this process, in consequence of agitating and feeding with aluminium hydrate seeds, the sodium aluminate liquor decomposes and about half of its alumina content will be precipitated in form of aluminium hydrate. The separated aluminium-hydroxide will be settled and filtered. One part of the aluminium-hydrate will be utilised for starting the decomposition of the sodium-aluminate liquor, the other part is fed into the rotary calcining kilns.

## 4. CALCINATION OF ALUMINIUM-HYDRATE

The aluminium-hydrate washed twice and coming from the filters, will be fed into the rotary calcining kilns. The kilns could be fired by producer gas or by oil. In the kilns the aluminium-hydroxide looses its combined water at a temperature of abt.1200° C and is transformed into alumina. To prevent the loss of a great quantity of alumina powder through the flue gas exhausting system, the exhauster is provided with mechanical gas cleaning and electrical dust precipitator equipment. The recuperated alumina dust which contains water, will be fed again into the calcining kilns. The calcinated alumina falls from the openings arranged at the end of the kilns and passes the recuperator pipes where it is cooled by means of suction air. The produced alumina is forwarded by means of pneumatic conveyors - operated by suction or pressure - into the alumina silos.

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## 5. CONCENTRATION OF THE DILUTED CAUSTIC LYE AND REMOVING OF THE IMPURITIES

The caustic soda liquor circulating in the plant having been diluted by different washing waters, has to be adequately concentrated before re-using. The concentrated lye after an addition of fresh caustic soda - in order to recover the losses - will be pumped back into the dressing plant and mixed with bauxite again.

During the process, the caustic soda liquor accumulates the impurities more and more, so that it has to be concentrated to a higher degree of concentration after which the impurities and salts may be separated from it partly by cooling and partly without.

The separation and utilization of the by-products increases the overall economics of the process and, on the other hand, cleans the recirculating liquor.

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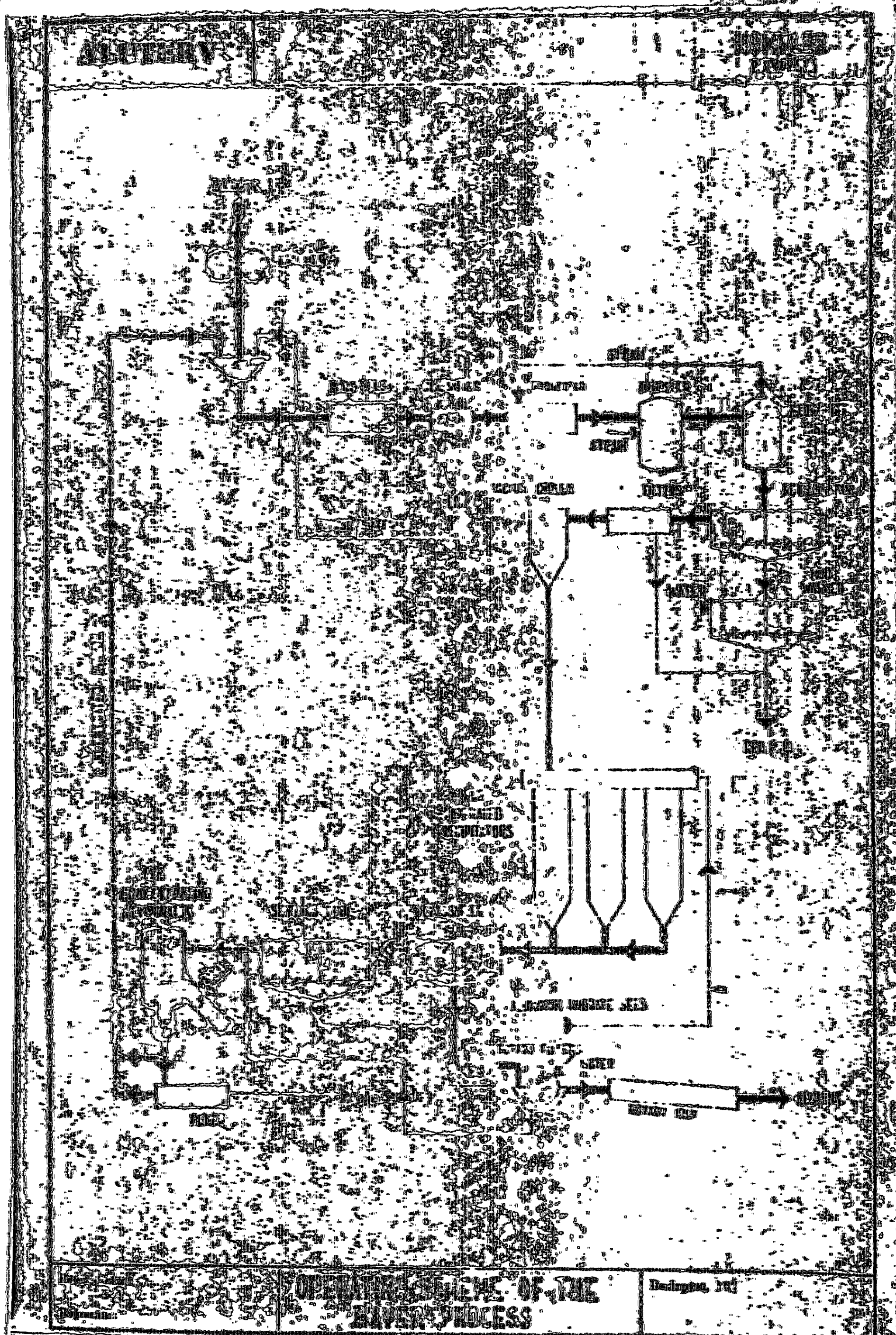


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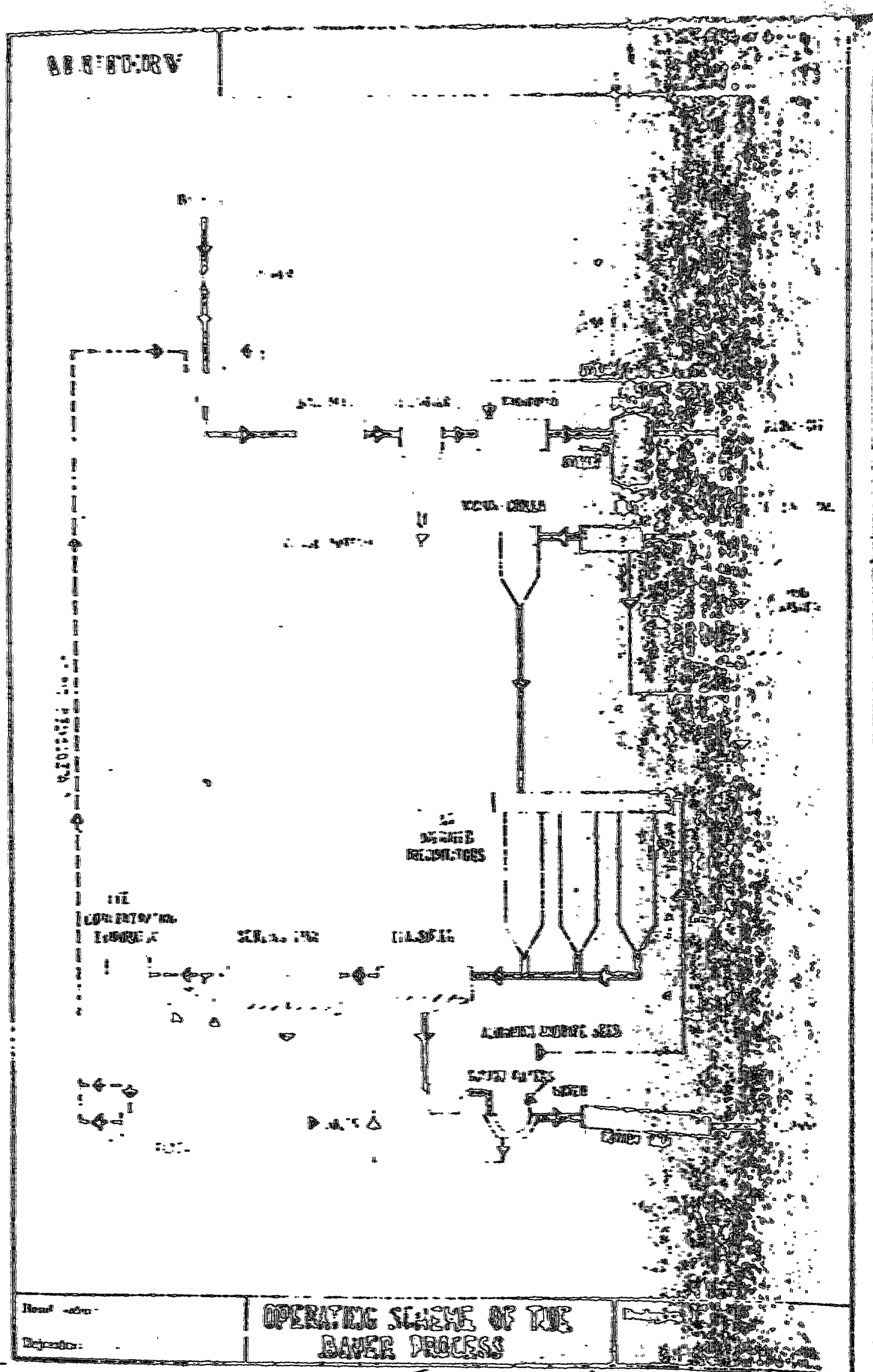


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## II. MACHINERY EQUIPMENTS

| Item | Denomination | Pcs | Function and technical data |
|---|---|---|---|
| 1. | Waggon tipping device | 1 | Unloading the raw bauxite from the waggons |
| 2. | Coarse crushers | 2 | Cylindrical crushers dia 1150 mm x 800 mm for pre-crushing |
| 3. | Fine crushers | 2 | Dia 1000 mm x 1000 mm for crushing to 20-30 mm grain size |
| 4. | Grabs | 2 | To feed the raw bauxite into the bauxite hall and into the bunkers |
| 5. | Bauxite bunkers | 3 | Each with a capacity of 33 m3 for the intermediate storage of crushed wet bauxite |
| 6. | Roasting kilns | 3 | Rotary or stage kiln with producer gas or masout-firing, for drying and roasting the wet bauxite |
| 7. | Gas cleaning equipments | 3 | Electrostatic dust separating equipment for the recuperation of bauxite particles from the flue gas |
| 8. | Bauxite silo | 1 | With a capacity of 260 m3 for the storage of crushed dry bauxite |
| 9. | Grinding mills | 3 | Dia 2200 mm x 3700 mm, pneumatic ball mill producing bauxite of adequate grain-size |
| 10. | Bunkers for bauxite | 3 | Each with a capacity of 150 m3, for the intermediate storage of ground bauxite |

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| Item | Denomination | Pcs | Function and technical data |
|---|---|---|---|
| 11. | Mixing tanks | 4 | For mixing the bauxite powder and caustic lye of soda |
| 12. | Weighing machines | 3 | Tank for weighing the bauxite powder |
| 13. | Lye storage tanks | 3 | For the storage of caustic lye of soda required for bauxite digesting |
| 14. | Autoclaves /digesters/ | 20 | Each with a capacity of 32 m3 for steam-heating at 25 atm. pressure, with heating coils. |
| 15. | Settling tanks /thickeners/ | 7 | Dia. 14 m, height 10 m, with 5 chambers, for the separation of red mud and washing of red mud respectively |
| 16. | Kelly filters | 5 | Pressure operated filtrating apparatusses, each with a filtering surface of 100 m2 for the filtering of the sodium aluminate liquor. |
| 17. | Cooling apparatusses | 3 | Double-stage vacuum coolers for the cooling of sodium aluminate liquor |
| 18. | Precipitators | 24 | Dia. 7 m, height 28 m, pneumatically agitated tanks for decomposing the aluminate liquor |
| 19. | Drum filters | 8 | Vacuum operated drum filters, 4 filters having a filtering surface of 24 m2 and 4 having a filtering surface of 12,5 m2, for filtering and washing the aluminium hydrate |

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| Item | Denomination | Pcs | Function and technical data |
|---|---|---|---|
| 20. | Cable railway | 1 | with 6 travelling dump cars, each with a capacity of 750 kgs, for the conveying of aluminium-hydrate to the rotary calcining kilns |
| 21. | Hydraulic separator | 1-2 | For classifying the aluminium hydrate particles |
| 22. | Settling tanks | 2 | Dia 6 m, height 12 m, with 6 chambers, for settling the aluminium-hydrate from the sodium aluminate liquor |
| 23. | Rotary calcining kilns | 4 | Dia 2,8 m, length 50 m, provided with recuperators,for the calcination of aluminium hydrate |
| 24. | Gas cleaning equipments | 4 | Centrifugal and electrostatic gas cleaning equipment for the recuperation of alumina dust from the flue gases |
| 25. | Pneumatic alumina conveyors | 2 | Pneumatic exhauster equipment for conveying the produced alumina into the alumina silos pneumatically |
| 26. | Oil or producer gas firing equipments | 4 | With fuel tanks, with air-steam- or pressure spray-burners for the firing of rotary calcining kilns |
| 27. | Lye concentrating apparatusses | 5 | Quickstream condensers operating with quadruple effect, each with a heating surface of 1000 m2 for the |

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| Item | Denomination | Pcs | Function and technical data |
|---|---|---|---|
| | | | concentration of diluted sodium aluminate liquor |
| 28. | Salt separator | 1 | Cooling device with condensers and filters, to remove the impurities from the sodium aluminate liquor |
| 29. | Bagging machine or special tanks or special waggons if needed | 1 | To fill the alumina in bags. |

## III. SPECIFIC CONSUMPTIONS RELATING TO THE PRODUCTION OF 1 TON OF ALUMINA

The specific consumption i.e. the quantities of raw materials, power etc. required for the production of one ton of alumina, depend first of all on the quality of the bauxite. In this regard the $Al_2O_3$ and $SiO_2$ content and mineralogical properties are of a decisive importance. With the decline of the quality of the bauxite i.e. with the reduction of the $Al_2O_3$ content and the rise of the $SiO_2$ content, the auxiliary raw material requirements and the power consumption increase, while the capacity of the equipments decrease and finally all the cost determining factors, independent of the produced quantity, rise /wages, overhead expenses, amortisation/.

Supposing the above mentioned average bauxite composition, the specific requirements for the production of 1 ton of alumina are the following:

| | | | |
|---|---|---|---|
| Raw bauxite | 2,6-3,2 | tons/1 ton of $Al_2O_3$ | |
| Dry bauxite | 2,0-2,3 | " | " |
| Caustic soda /96%/ | 0,110-0,150 | " | " |
| Steam 21 atm. | 2,3-3,2 | " | " |
| Steam 4,5 atm. | 4,0-6,0 | " | " |
| Fuel /10.000 cal/kg/ | 0,150-0,260 | " | " |
| Electric current | 320-380 kWh | " | " |

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The above data refer exclusively to the production of alumina, the own consumption of the power plant supplying the alumina plant has not been considered.

## IV. INFORMATORY MATERIAL BALANCE REFERRED TO ONE HOUR PRODUCTION

In case of a capacity of 60.000 tons per year, the plant has to produce 7 t/hour of alumina. As a consequence, the under-mentioned quantities have been considered for some of the most important phases of the technological process:

| | |
|---|---|
| 1/ Raw materials | bauxite 21 tons/h<br>caustic soda 1 ton/h |
| 2/ Bauxite crushing | bauxite 21 tons |
| 3/ Bauxite drying | dry bauxite 15 tons |
| 4/ Bauxite mixing | bauxite powder 15 tons/h<br>concentrated caustic lye of soda containing 270 g/litre $Na_2O$... 55 m3/h |
| 5/ Quantity of slurry to be digested | 60 m3/h |
| 6/ Slurry to be settled | 165 " |
| 7/ Quantity of sodium aluminate liquor | 126 " |
| 8/ Quantity of the red mud produced | 6,95 tons/h |
| 9/ Water for red mud washing | 105 m3/h |
| 10/ Quantity of the aluminium hydrate produced | 12,5 tons/h |
| 11/ Calcinated alumina produced | 7,0 " |
| 12/ Separated salt /impurities/ | 0,6 " |

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The $Al_2O_3$ content of the produced alumina is not less than 98.7-99.2 %

V. DESCRIPTION AND ROUGH ESTIMATE OF THE POWER SUPPLY OF THE ALUMINA FACTORY WITH A CAPACITY OF 60.000 TONS/YEAR

Starting data

| | | | |
|---|---|---|---|
| a/ Steam requirement: | digesting | 21 ata /absolute atm./ | 20 tons/h |
| | others | 4,5 " | 50 " |
| | own consumption of the power plant | | 10 " |
| | Total: | | 80 tons/h |
| b/ Electric power: | for the alumina production 350 kWh/ton | | 2600 kW |
| | own consumption of the power plant | | 500 " |
| | other plant consumption | | 100 " |
| | water plant | | 300 " |
| | Total load: | | 3500 kW |
| c/ Compressed air: | For the pneumatic agitation and for pneumatic material handling | | 900 m3/ton |
| d/ Water requirement: | for the lye concentrating apparatusses and other industrial water requirements | | 150 m3/ton |

VI. TECHNICKAL DESCRIPTION

a/ Power plant

To supply the steam- power required for the alumina production a back-pressure steam-power plant with a working pressure of 25 ata has been designed, connected continuously to the public network on the electric side.

In view of a high safety factor, we designed 4 masout-fired steam boilers with a max. capacity of 50 tons/h and a working pressure of 25 ata, each, supplying 400° C superheated steam, with the required feed-water equipment, masout storage and auxiliary equipments.

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There are 2 steam turbines, with directly coupled generators. The steam turbine is designed for an inlet pressure of 22 ata, and a back-pressure of 4,5 ata. The generator has a capacity of abt 5000 kW, supplying 10500 V, 50 cycles, 3-phase current

1 steam pressure reducer and cooling equipment is provided for a pressure of 25/4,5 ata.

1 switch plant and control room equipment with all the instruments and accessories required.

12 various transformers with a rate of transformation of 10,5/0,4/0,23 kV mounted on the most important consumption places, and the required switchboards.

The electric .quipments of the alumina factory, motors, switches and cables.

b/ Compressor plant

A central compressor plant is required for the supply of compressed air. For this purpose piston- or other type compressors of a strong design is projected with gearing, directly coupled with the electric motor.

The plant consists of 3 units with an /inlet/ air capacity of 3000 m3 and 7 atm each, out of which two units are running and one is a spare one. The air tanks and the air cooling equipment are arranged outdoor. An electrically driven crane had been designed to facilitate the erection and the maintenance.

c/ Industrial water supply

For water supply the water of a river can be used by means of a water station. The pump house consists of the following parts:

4 pumps with a capacity of 480 m3/h each and a manometric head of 68 m, directly coupled with an electric motor, with all the accessories, piping and hand-operated erection crane.

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The water piping is made of suitably dimensioned steel pipes coated with double bitumenous jute layer, Provision is made for adequate valves and fittings.

d/ Electric power and steam generation

| | |
|---|---|
| Steam requirement per year for the alumina plant is | 600.000 tons |
| Own consumption of the power plant | 85.000 " |
| Total yearly requirement | 685,000 tons |
| Electric power generation, on the generator terminals per year | 35,000.000 kWh |
| Own consumption of the plant | 4,000.000 " |
| Total useful generation per year | 31.000.000 kWh |
| Consumption of the alumina plant per year | 26,000.000 kWh |
| Available for sale | 5,000.000 kWh |

The power economy of the alumina plant is in equilibrium. The electric power generated relative to the steam consumption is sufficient to cover the requirements and only a small surplus arises.

VII. BUILDINGS OF THE ALUMINA PLANT

The buildings required for the plant equipments are made of iron frame work. The filling walls are made of bricks. The foundations of the mechanical equipments, tanks, etc, are made of concrete and reinforced concrete respectively. The required cubature of the shops is the following:

| | |
|---|---|
| Bauxite store | 60.000.m3 |
| Dressing plant | 30.000 " |
| Digesting plant | 55.000 " |
| Precipitation | 80.000 " |
| Calcination | 35.000 " |
| Lye-concentration | 30.000 " |
| Total | 290.000 m3 |

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The entire alumina plant is built in a pavilion-system, the buildings accomodating the various departments being at a determindd distance from each other. The shops are connected by means of bridges, through wich the material handling from one shop into the other is carried out. The piping too will be aceomodated here.

Not included in the above statement are the various auxiliary shops /machine tool shop, laboratory etc./ as well as the management building. The alumina plant and the aluminium electrolysis plant /aluminium plant/ must be considered as one unit, so that their requirements must be considered commonly.

In view of the climatic conditions and considering the fact that the alumina plant is a hotworking plant, some of the departments may be accomodated on the open area. The rotary calcining kilns and the precipitator tanks can be located for instance in the open area. Of the calcining equipment only those parts would be accomodated in a closed building, where the handling and operation of the machine is accomplished. In this way abt 80.000 m3 building volume can be economised.

According to the above, the total built-in volume /cubature/ of the technological plant /alumina plant/ amounts to abt. 210.000 m3.

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# A L U M I N I U M   P L A N T

## of a 20.000 tons/year capacity

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# A L U M I N I U M  P L A N T
## of a 20.000 tons/year capacity

### 1. GENERAL DESCRIPTION OF THE PLANT

The plant is designed to be built according to the General Disposition Scheme at a scale of 1 : 1000 as enclosed. The Power Station should be situated within a 200 metres distance from the plant boundary for the sake of securing a low loss and low cost of power supply. The area required by the plant has a length of 750 m and a width of 250 m.

From the viewpoint of location it is preferable that the longitudinal axis should form a 20-30 degree angle with the wind direction prevailing in the plant area.

The plant is bordered by a railroad designed for the plant, running parallel to one of the longer sides. Parallel to the railway are situated all the buildings dealing with the material handling or else, whose operation requires contact with the railway.

The porductive plant unit proper, the Electrolysis Plant is situated alongside the longitudinal axis and is designed to accomodate abt. 160 electrolyser cells needed to attain the capacity set as a target.

On the side near the Power Station the Electrolysis Plant joins the Rectifier Plant, whose job is to rectify the A.C. supplied by the power station into D.C. as required for the operation of the Electrolysis Plant.

The office building to house the central management of the plant is designed to be situated on the other side of the Electrolysis Plant, opposite the railroad. On the same side is to be located the Laboratory, whose task is to control and record the conditions of production as regards the quality of the product.

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The number of the auxiliary buildings required for the full operation of the plant is 19, adding up a total of built-in area of

37.000 square metres.

This is 19,7 % of the total plant area.

The total area of the plant is 250 x 750 = 187.500 sq.m.

## 2. TECHNOLOGY AND PLANT ORGANISATION

### 2.1 The main product

The technology of the aluminium plant follows basically the principle of electrolysis at melting temperature, as is usually employed in this industry. All the requirements of up-to-date production have been considered in the designing of the aluminium plant. Special attention has been given to attain a maximum saving of material and energy, furthermore to secure a continuous plant operation and to organize the most rational material handling. Steps have been taken to make it possible that the usable portion of the slag could again be used. For particulars see paragraph 2.2.

The production itself takes place in the electrolysing cells, whose design has followed the most modern technological principles. The cells have a capacity of 54.000 amperes, are fitted with vertical power entries and are equipped with the Soederberg-type continuous work anodes.

Abt. 160 such cells are required to reach the capacity set as a target. The cells are connected in series and are situated in four rows in accordance with the dimension of the Electrolysis Plant. The theoretical output of one cell is as follows:

18,063 kg Al/hour.

Average power efficiency can be put at 84 %, one unit having consequently an hourly output of roughly 15,2 kg aluminium, adding up to 365 kg aluminium a day. Bearing in mind that the

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Elektrolysis Plant is working continuously, and taking 365 days into account, the yearly output of one cell is

133,2 to aluminium/year.

Now taking the 160 cells, as have been planned, into consideration, it appears that 151 are required to attain a production of 20.000 tons/year, while the 9 cells left serve as a reserve, respectively will be at disposal for the periodic renovation service.

A cell consists of two major parts: the cathode part is a sheet iron tank structure, lined with an insulating layer and with a layer of conducting carbon bricks in which the liquid electrolyte of melting temperature /930 to 950°/ takes place. Into this hangs the other main part of the cell, the anode, consisting of suspended iron structure jacket, enclosing the anode carbon block serving as current conductor. The carbon block is heated by the heat of the current and of the electrolyte. By this heating process the anode mass is being burnt on the spot. Horizontally fitted steel bars built into the cathode and steel studs fixed up vertically in the anode serve as a connection with the power carrying network.

The steel bars and steel studs join the power carrying system made of rolled aluminium bus-bars, leading through the Electrolysis Plant, connecting the cells in series. Leaving the plant and conducted through the building situated between the Electrolysis Plant and the Rectifier Plant they serve as collecting bus- bars for the D.C. of the rectifier system.

The liquid electrolyte of melting temperature is a melting product containing fluorine salts and alumina /$Al_2O_3$/. The latter, being the basic material for the manufacture of aluminium, dissociates as an effect of treatment by electric current. Molten aluminium, obtained this way, being heavier than the electrolyte, will settle on the bottom of the cathode tank, whereas the oxygen will combine with the anode carbon

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hanging into the bath, and will form partly CO, partly $CO_2$ gases. These gases will be collected by the cast iron jacket fitted around the anode and will than be led to the burner mounted on the shorter side of the cell. Hare the gases still combustible will be burned with addition of fresh air. Combustion products will be led away by a pipe system to the exhaust ventilators arranged in the shop. The latter pump the gases into iron chimneys high enough to make sure, that the gas leaving the chimney can do no harm to the environment.

In the case water supplies available are sufficient, a gas cleaning equipment can be added to the exhaust equipment. The fluorine contained in the gas can be absorbed and made thus safe against its effect detrimental to health.

Though theoretically the alumina alone takes part in the process of electrolysis, certain losses in cryolite /$Na_3AlF_6$/ and aluminium fluoride /$AlF_3$/ appear to be unavoidable and have to be made up for.

The aluminium as collected in the cathode tank of the cells will have to be tapped every 3-4 days. This process takes place with the help of suction pipes under vacuum.

The electrolyser cells have a 4,1 to 4,6 V operation voltage. Occasionally, however, when the ratio of alumina contents in the electrolyte drops below a critical limit, the cells suddenly adjust themselves to a higher voltage. This is the so called anodic effect and while it lasts, the cell voltage may rise for a short period to 30-40 volts.

The anodic effect can be stopped by breaking up the hard crust that has formed on the electrolyte surface and by supplying additional alumina to the bath.

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The raw liquid aluminium as gained in the cells will be transported to the foundry in electric trucks, where it will be fed into electrically heated furnaces. The different qualities of aluminium produced by the cells, if necessary, can be equalized in the furnaces. The aluminium thus equalized and rested gets rid of its gas contents, and the electrolyte contents of the metal will swim up to the surface in form of cinder /slag/.

The metal having been sufficiently rested and deslagged, will be founded from the mechanically tilted furnaces into casting machines consisting of a chain of ingot moulds with continuous motion, in which the molten aluminium solidifies in the form of ingots weighing about 15 kg /pigs/.

On part of the production will be turned in slabs designed for the rolling mills. Automatic, semi-continuous casting equipments are provided for the manufacture of the slabs. Ingots and slabs for rolling or pressing will be finished in the foundry as well.

Smooth operation of the electrolyser cells requires that the cinder accumulating in the electrolyte should be periodically removed. The cinder is made up of moldered carbon of the anode and also of electrolyte sticking to the grains. The process of flotation is employed to regain the cryolite and alumina contents of this cinder, and to use again both materials. Following proper handling the cryolite regained by flotation can again fed into the cells.

Two ventilator systems provide for fresh air supplies for the furnace hall. Fresh air is being blown into the air of the furnace hall through channels laid underground between the cell-rows. Airing lanterns fitted parallelly to the longitudinal axis of the furnace hall are provided to enhance the ventilation.

Power required for the operation of the plant is supplied by the rectifying station, which, as is shown on the enclosed sketch, consists of eight groups, six thereof have to secure

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the normal operation of the plant, one serves as a warm spare unit to be at disposal should any of the working groups break down, while the eighth group is designed for the carrying out of repair and periodic maintenance works.

The rectifier system consists of the mercury vapour rectifiers. The rectifier units employed are of a six-phase type in order to improve the sinusoid response and to diminish the distortion by superharmonics. Every unit consists of six anodes. Every anode is in a separate vacuum housing to restrict the overall vacuum space. A common pump system is provided for securing the vacuum of the six anodes.

Back-current switches mounted in the D.C.circuit have to provide for the selective safeguard of the rectifying groups. Furthermore there have been provided safeguards for each of the phases inasmuch as separate switches serve for the selective switching off of the individual anodes between the transformers, and rectifiers.

Electric power is, as designed, to be provided directly by the Power Plant by way of bus-bar systems spanned on poles. This bar system feeds the double collecting bar system situated in the other part of the rectifier shop. The latter bar system is in connection with the regulating and the main transformers, supplying the rectifying groups and with the transformers designed for the power supply for any other plant purposes.

The eight regulating transformers belonging to the eight main transformers have to provide the D.C. voltage required by the number of cells in operation. The main transformers transform the three-phase current arriving from the Power Plant into the six-phase A.C. to feed the rectifiers.

The transformer repair shop situated near to the Rectifier shop is to provide for the periodic supervision and the routine repair work of all the transformers. This building is connected by a standard gauge railway with the main railway

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and the transformer building so that the transport of transformers should take the minimum time and trouble.

Two oblong buildings are situated parallel with the railroad. The one nearer to the head building houses the general repair shops, while the other one is designed to serve as store for materials needed for the operation of the plant, /e.g. cryolite, aluminium fluoride, anode carbon, cathode carbon etc./.

The Foundry building joins the farther end of the Electrolysis Plant. The building partly serves as a store for finished products, for packing and shipping as well. The alumina silos are situated about in the center line of the Electrolysis Plant building. Alumina supplies arriving by rail are conveyed pneumatically from the railway cars into the storing silos. The laboratory will be on the side of the Electrolysis Plant opposite to the Foundry. This laboratory is designed to carry out quickly analysis work with a view to control constantly the output of the individual cells as well as to supervising the plant operation. The laboratory supplies data for the equalizing work to be carried out in the Foundry and also determinate the chemical analyses of the finished products.

## 2.2 By-products

The cinder to be removed from time to time during the operation of the cells, contains considerable quantities of cryolite and alumina. The cinder overwhelmingly consists of grains separated from the anode carbon, that happen to fall into the electrolyte and being lighter than the same are floating on its surface. For the sake of smooth plant running the cinder with the electrolyte particles sticking to them, have to be removed.

This cinder is transported from the Electrolysis Plant to the Regenerating Plant where it will be treated by the flotation process.

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The cinder will be crushed and classified. Reagents to enhance foaming will be added before the mixture is fed into the flotation cells. The carbon and the foam will leave while after proper drying the remaining flotated alumina and cryolite can be again well used.

The flotation equipment has a capacity of handling 2000 tons of cinder yearly.

## 3. MATERIALS NEEDED FOR THE PLANT

### 31. Raw materials

In order to utilize the full capacity of the plant the following raw materials are required yearly and monthly respectively:

| | | Need/year | need/month |
|---|---|---|---|
| alumina | abt. | 40.000 tons | 3.340 tons |
| cryolite | " | 1.320 " | 110 " |
| anode mass | " | 11.340 " | 945 " |
| aluminium fluoride | " | 580 " | 32 " |
| cathode carbon | " | 648 " | 54 " |
| ramming mass | " | 650 " | 54 " |

### 3.2 Basic stores

It is advisable to maintain considerable quantities as basic stores of the above mentioned raw materials in the interest of undisturbed and smooth plant operation, since the materials are being shipped from great distances to the plant. It is recommended to store permanently these materials for a three-months' period of plant operation, taking into consideration eventual delays as to the shipping of materials.

Suggested basic stores should therfore be as follows:

| | | |
|---|---|---|
| alumina | 5000 - 10.000 | tons |
| cryolite | 200 - 300 | " |
| anode mass | 2000 - 3000 | " |
| aluminium fluoride | 100 | " |

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| | |
|---|---|
| cathode carbon | 150-200 tons |
| sodium fluoride | 12 " |
| ramming mass | 160 " |

Dimensions of the store-houses are determined by the quantities to be stored.

## 4. POWER AND WATER REQUIREMENTS

### 4.1 Electric power

The aluminium plant running day and night represents a practically peakless operation. It follows, that energy peaks are practically out of question and that the power requirement of the plant can be considered as constant.

To figure out the power requirements of the plant one has to start from the 20.000 tons set as the capacity target and a constant 54.000 ampere D.C. intensity needed for this task. Now taking into account that each cell requires an average of 4,5 V voltage, the total 151 working cells will add this up to 675 V D.C. voltage requirement. This gives an output of 36,7 MW and considering that the efficiency of the rectifier equipment is 94 %, the total power needed amounts to

39,2 MW.

Power is also required for the auxiliary shops, that may be estimated roughly at

2,8 MW

so that the overall plant need of power appears to be

42 MW.

Taking into account the relatively good efficiency of the aluminium plant, the A.C. requirement can be set at

46,5 MVA.

Considering this output value, the power consumption during a work year of 8.760 work-hours amounts to

344.000 MW hours,

while the total consumption of the plant amounts to

368.000 MW hours.

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4.2

To run the rectifier equipment securely, it is indispensable to employ cooling water to transfer the heat due to the cathode loss of the rectifier vans. The water to perform this cooling effect represents the major part of the water needed by the plant.

The ingot casting system of the Foundry requires equally considerable water supplies, since the latent heat produced by the solidification of the molten metal has as well to be disposed off by cooling water.

Considering all these factors, the total water consumption of the plant appears as follows:

| | |
|---|---|
| cooling water for the rectifiers | 2.500 $m^3$/day |
| water required for gas cleaning /provided the scheme will be carried out/ | 400 " |
| cooling water for the Foundry | 1.200 " |
| compressors, shops etc. | 400 " |
| drinking water | 100 " |
| Totally | 4.600 $m^3$/day |

The temperature of industrial water as given above for cooling is understood to be 15° C. Should the water available fail to meet this temperature, the same may be raised up to 25° C. The quantities stated above should in this case be adequately corrected upwards.

In areas poor in water it is advisable to build a cooling tower or to choose an other appropriate system.

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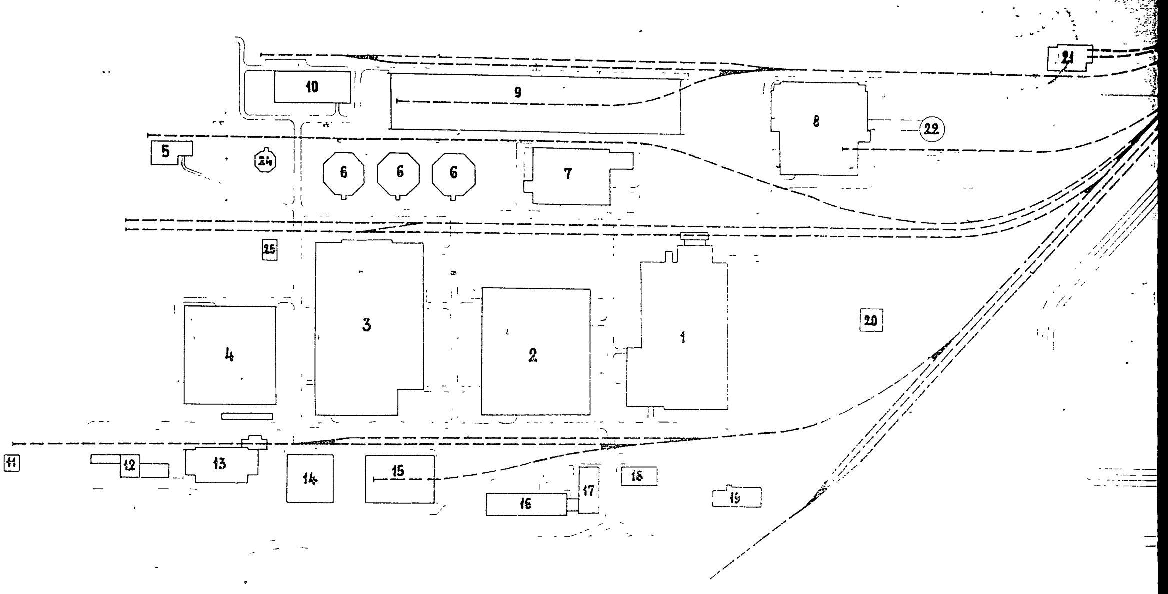


1. DRESSING PLANT
2. DIGESTORS AND SETTLING TANKS
3. PRECIPITATION AND FILTERING OF ALUMINAHYDRATE
4. CALCINATION OF HYDRATE
5. WATERSTATION
6. COOLING TOWERS
7. CONCENTRATION OF LEACH
PRECIPITATION OF VANADIUMSALT
8. POWERPLANT
9. COAL STORAGE
10. GAS PRODUCERS
11. OIL STORAGE
12. MAGAZINE OF ENGINES AND IRON
13. SILOS FOR ALUMINA
14. STORAGE OF SMALLER MATERIALS
15. REPAIRSHOP AND FOUNDRY
16. SOCIAL ESTABLISHMENTS
17. DIRECTION
18. LABORATORY
19. GARAGE
20. ARTESIAN WELL FOR DRINKING WATER
21. LOCOMOTIVE SHED
22. CHIMNEY
23. TAILINGS /RED MUD/
24. COOLING TOWER FOR GASPRODUCERS
25. TRANSFORMERSTATION

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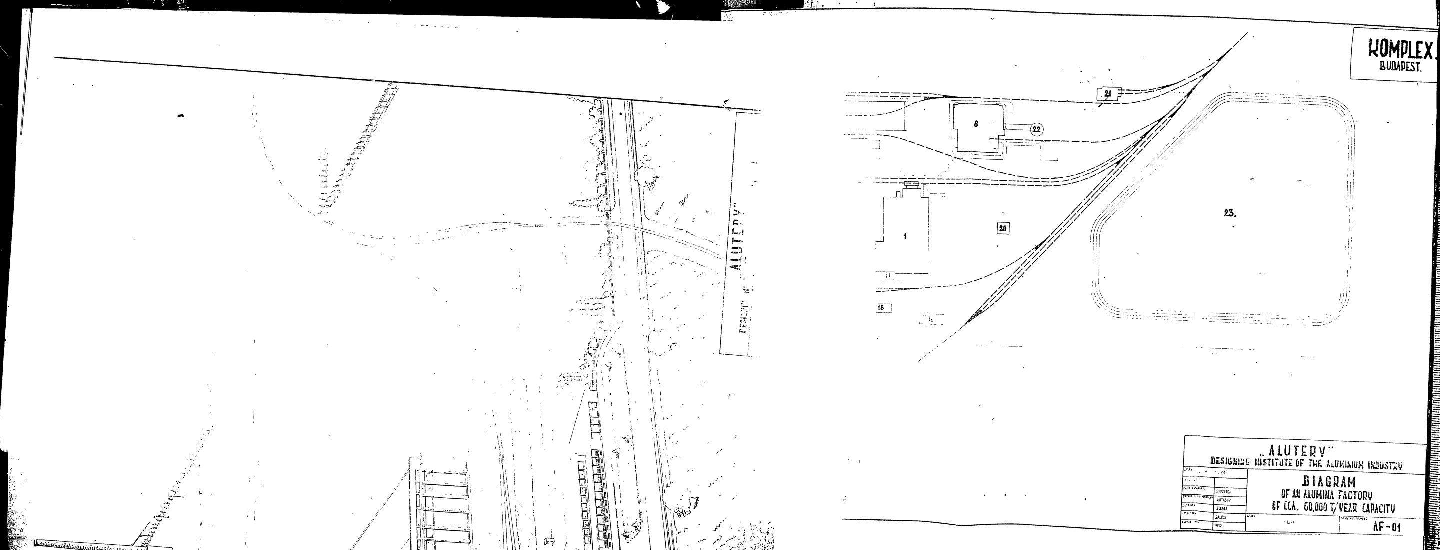


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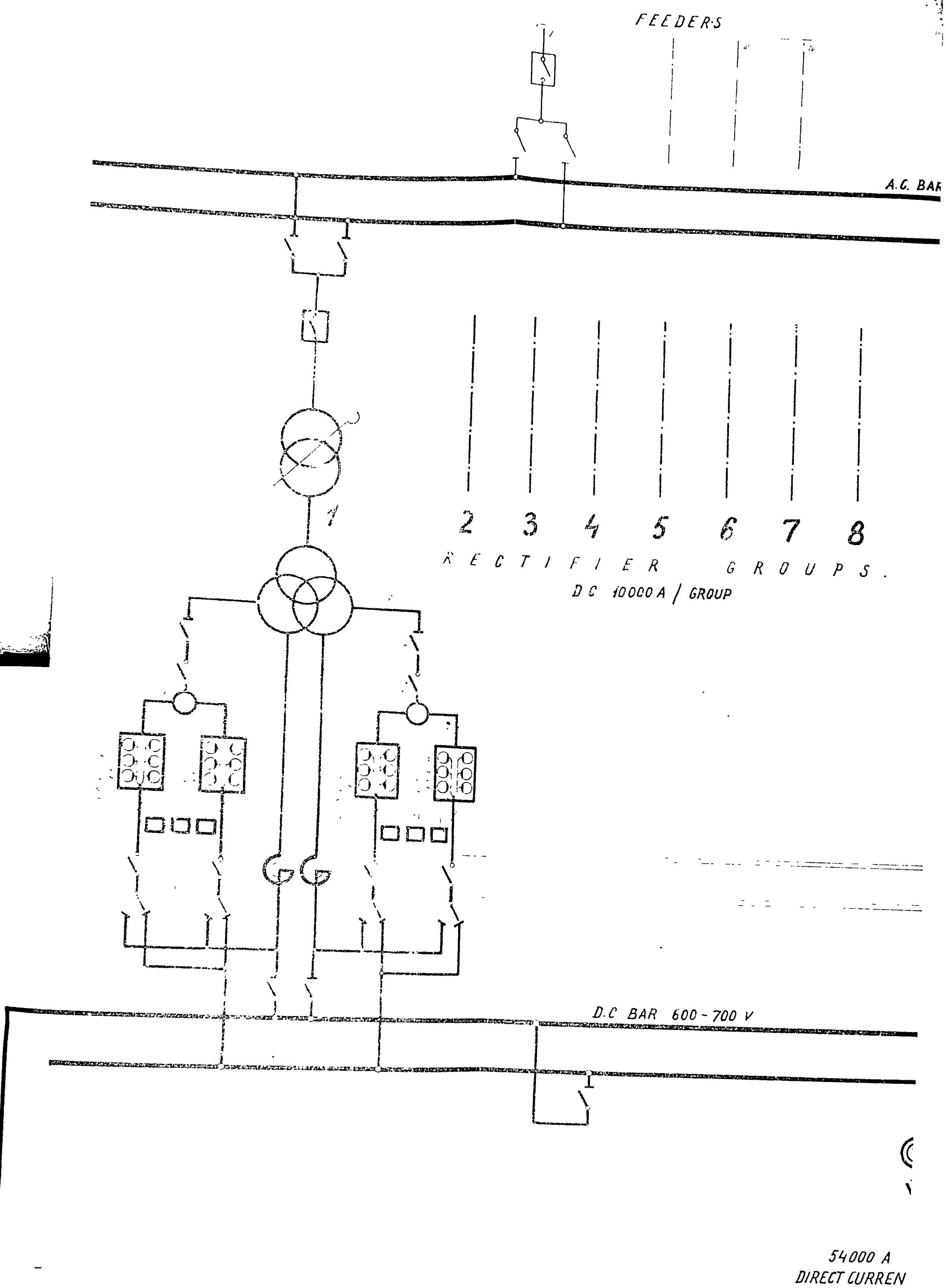


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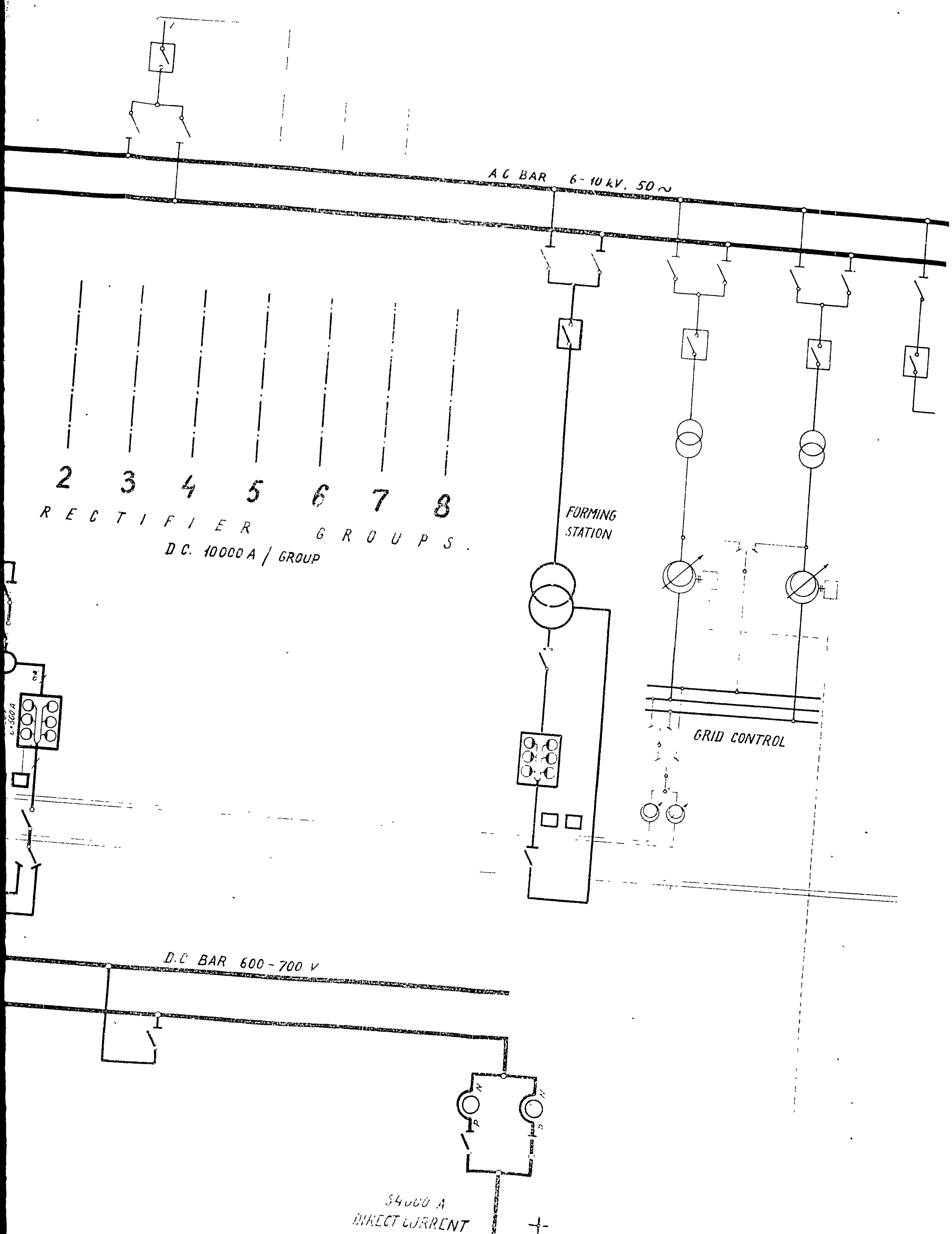


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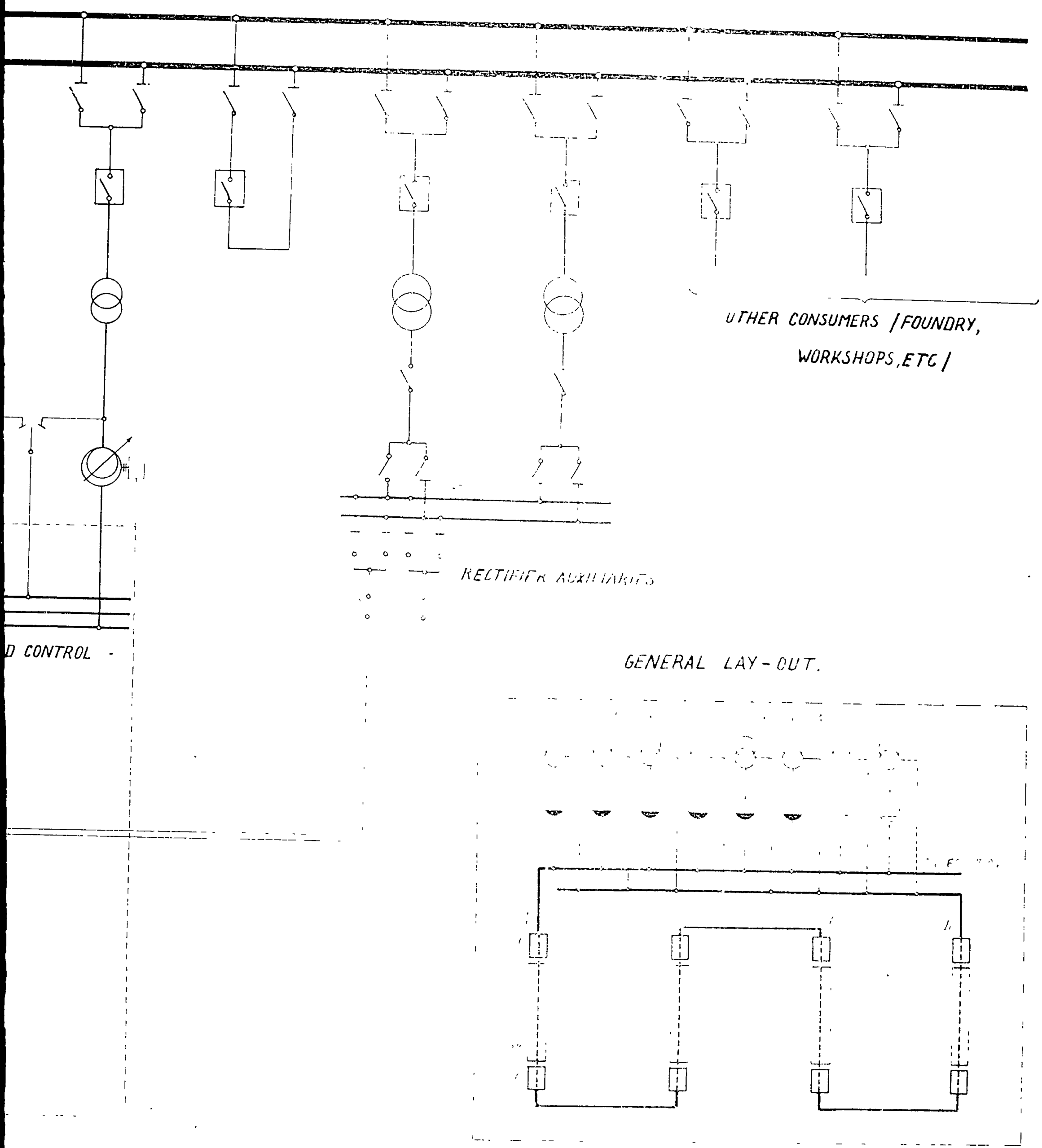


ALUTERV
DESIGNING INSTITUTE OF THE ALUMINIUM INDUSTRY

ELECTRICAL SCHEME
OF AN ALUMINIUM ELECTROLYSIS PLANT
OF 20.000 T YEAR CAPACITY

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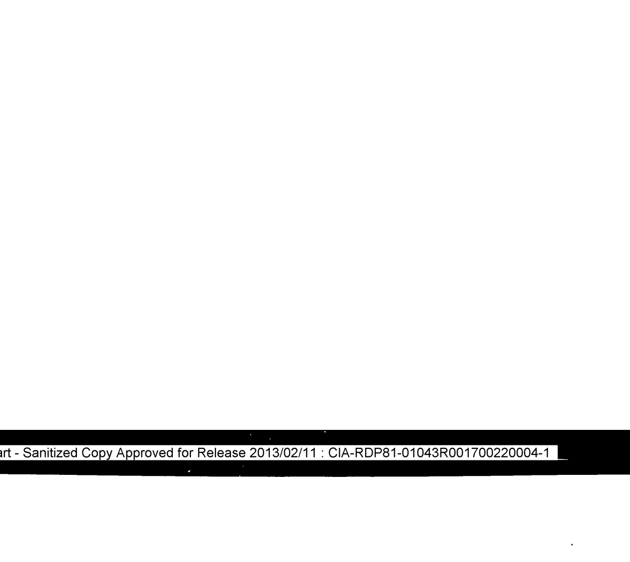


## LEGEND:

1 BAUXITE - YARD
2 CRUSHER-WET GRINDER-MIXING
3 NATRON SOLVER
4 DIGESTORS
5 SETTLING TANKS (DORR APPARATUS)
6 KELLEY FILTERS
7 COMPRESSORS
8 KÖRTING COOLERS
9 HIDRATE SETTLING TANKS
10 PRECIPITATION
11 HYDRATE FILTERING
12 CALCINATION
[illegible] LYE EVAPORATION
[illegible] POWER PLANT
15 COAL - YARD
[illegible] [illegible] TRIBUTING CENTRE
[illegible] [illegible]WITCH - HOUSE
[illegible] TRANSFORMERS
[illegible] [illegible]ECTIFIERS
[illegible] ELECTROLYSIS - PLANT
[illegible]A ALUMINA - SILOS
21 MOULDING AND FINISHED PROD ST.
22 ANODE-MASS STORE
[illegible] GAS DRAWING STACK
24 WORKSHOP
[illegible] MAGAZINE
[illegible] BUREAU - LABORATORY
27 BATH - DRESSING ROOMS
[illegible] DIRECTION
29 ENTRANCE

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|---|---|---|
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| OSZT VEZ / TERVEZŐ / ELLENŐR | PRIMARY ARRANGEMENT<br>OF AN ALUMINIUM PLANT OF 10 000 t/YEAR<br>AND OF AN ALUMINA PLANT OF 20 000 t/Y CAP | |
| PAUSZOLTA / BUDAPEST 56 VI | VÁZLAT<br>LÉPTÉK 1 2000 | 673A-0E.01 2 |

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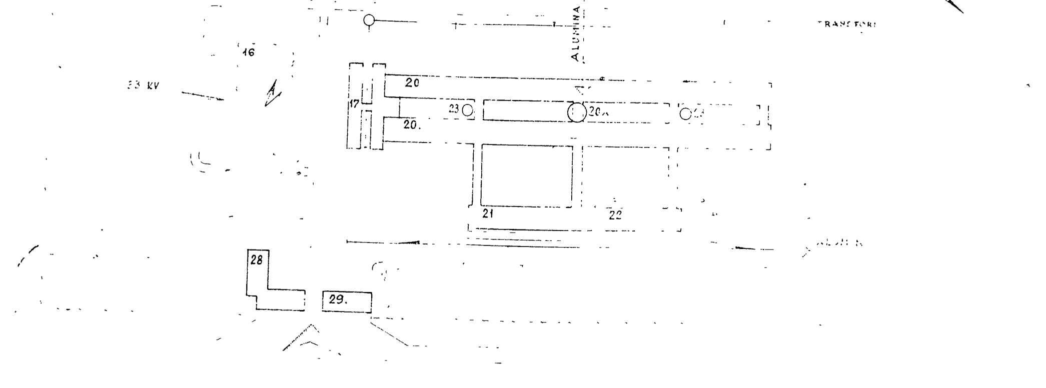


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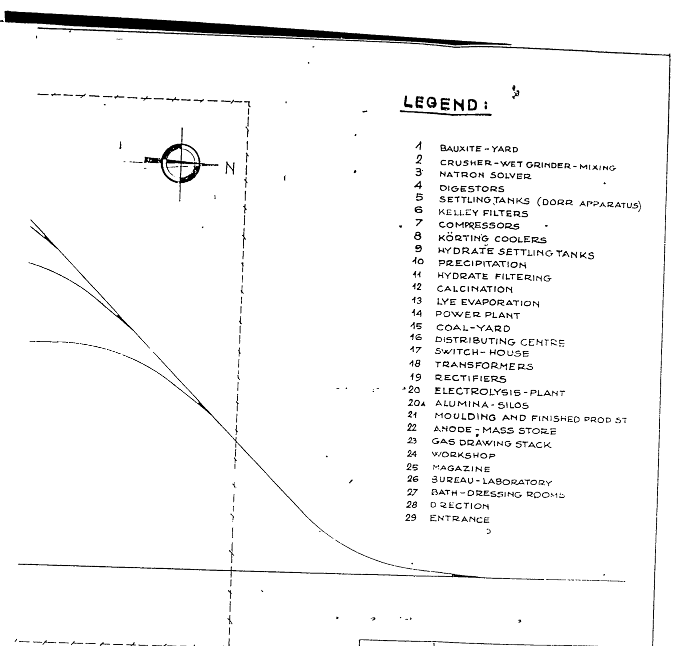


## LEGEND:

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3 NATRON SOLVER
4 DIGESTORS
5 SETTLING TANKS (DORR APPARATUS)
6 KELLEY FILTERS
7 COMPRESSORS
8 KÖRTING COOLERS
9 HYDRATE SETTLING TANKS
10 PRECIPITATION
11 HYDRATE FILTERING
12 CALCINATION
13 LYE EVAPORATION
14 POWER PLANT
15 COAL-YARD
16 DISTRIBUTING CENTRE
17 SWITCH-HOUSE
18 TRANSFORMERS
19 RECTIFIERS
20 ELECTROLYSIS - PLANT
20A ALUMINA - SILOS
21 MOULDING AND FINISHED PROD ST
22 ANODE - MASS STORE
23 GAS DRAWING STACK
24 WORKSHOP
25 MAGAZINE
26 BUREAU - LABORATORY
27 BATH - DRESSING ROOMS
28 DIRECTION
29 ENTRANCE

| | | |
|---|---|---|
| ÉPITÉSZET | **ALUTERV**<br>ALUMINIUMIPARI TERVEZŐ INTÉZET | |
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| OSZT VEZ / TERVEZŐ / ELLENŐR | PRIMARY ARRANGEMENT OF AN ALUMINIUM PLANT OF 10 000 T/YEAR AND OF AN ALUMINA PLANT OF 20 000 T/Y CAP | |
| RAJZOLTA / BUDAPEST, 56 VI 11 | VÁZLAT<br>LÉPTÉK 1:2000 | 673A-OÉ 01 1 |

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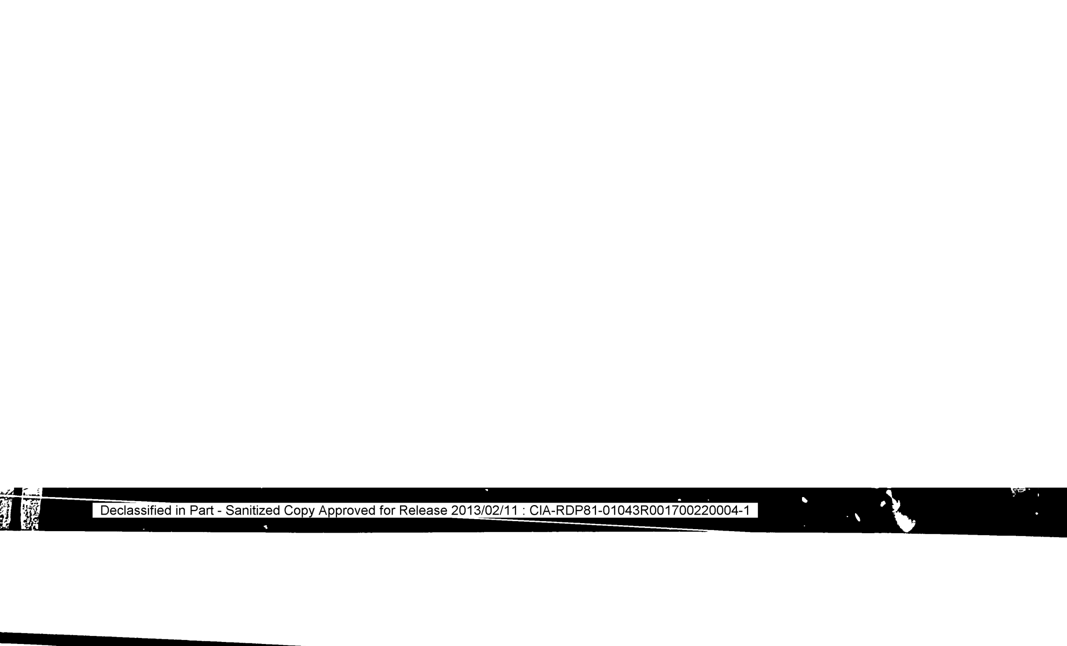
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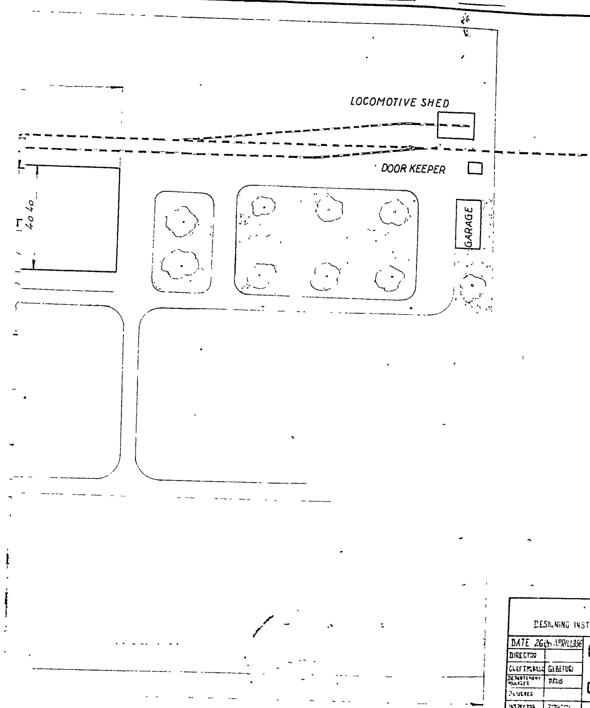


**KOMPLEX.**
**BUDAPEST.**

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DESIGNING INSTITUTE OF THE ALUMINIUM INDUSTRY

| | | |
|---|---|---|
| DATE 26th APRIL 1956 | | **GENERAL DISPOSITION OF AN ALUMINIUM PLANT OF CCA. 20000 TO/YEAR CAPACITY** |
| DIRECTOR | | |
| CHIEF ENGINEER | GEBEFUGI | |
| DEPARTMENT MANAGER | PÁRIS | |
| DESIGNER | | |
| INSPECTOR | ZORKÓCZI | SCALE - 1:4000 |
| DRAUGHTSMAN | | DRAWING NUMBER AS-00 |

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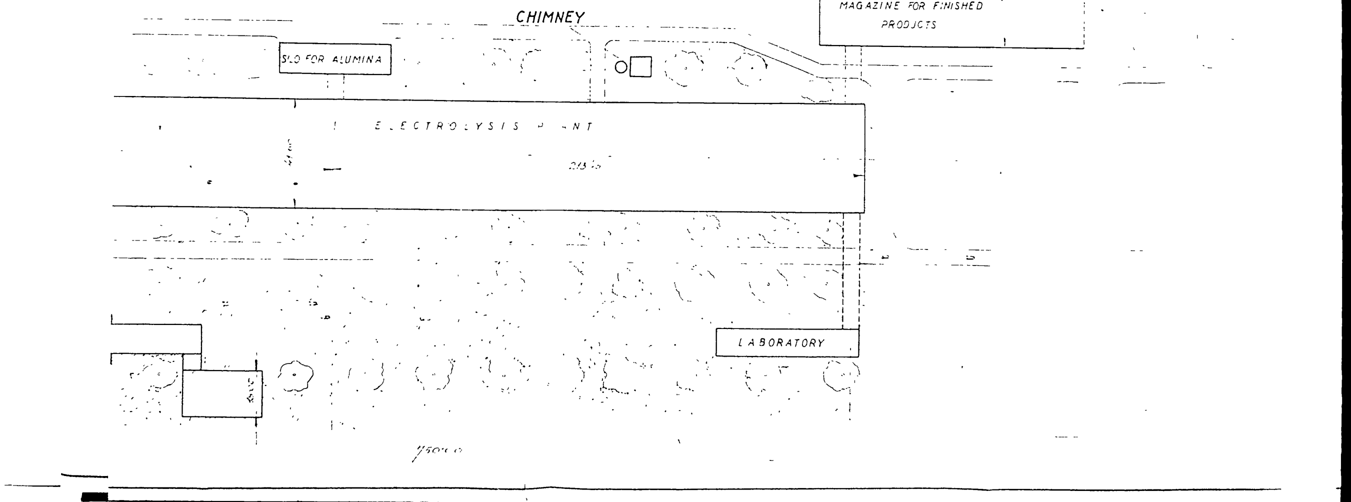


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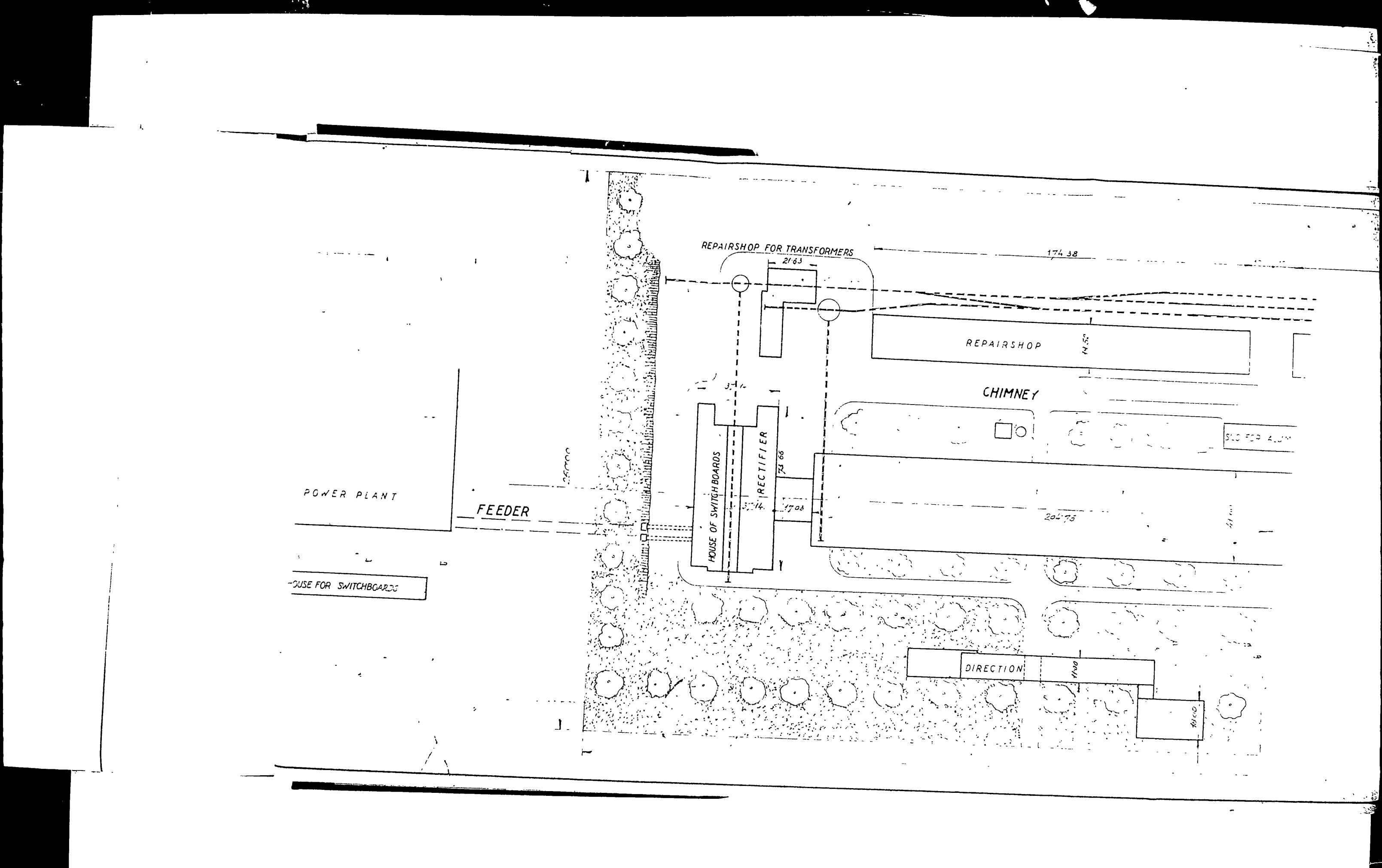


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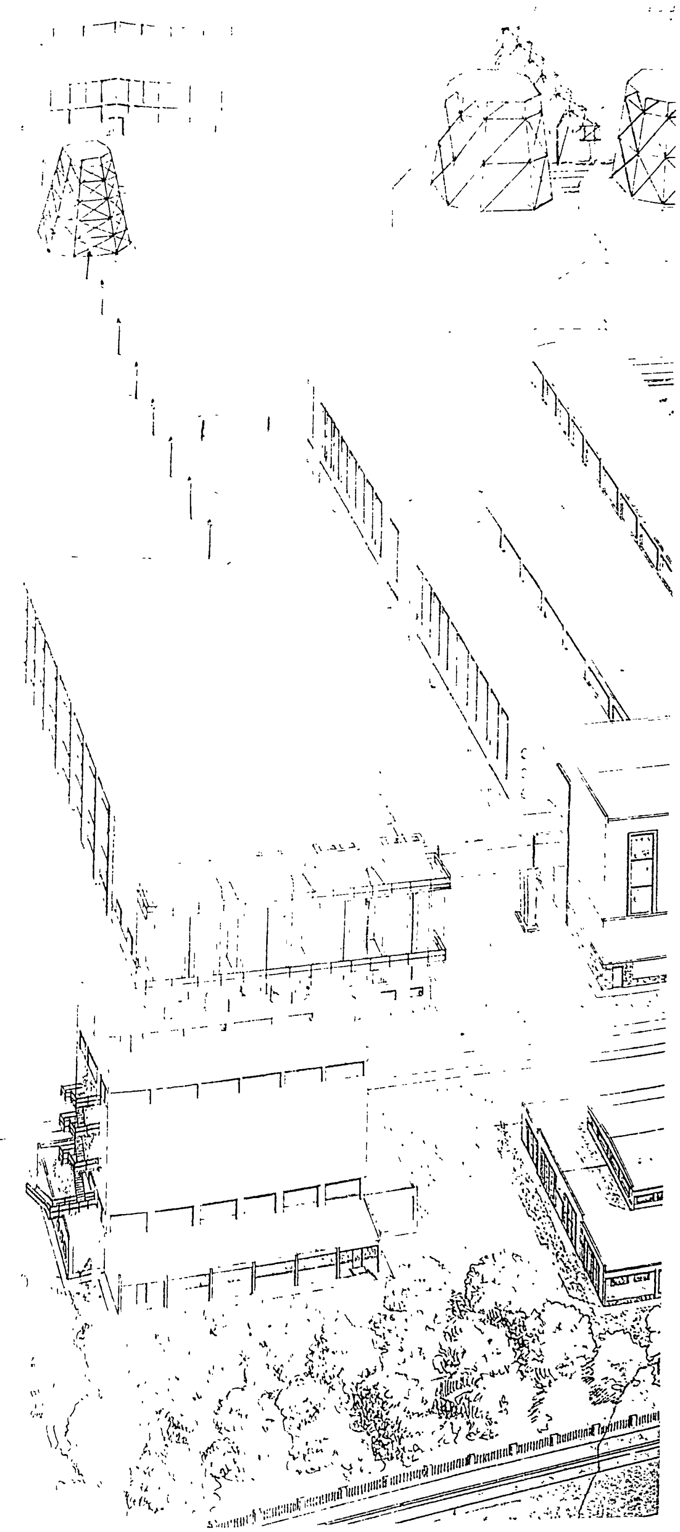

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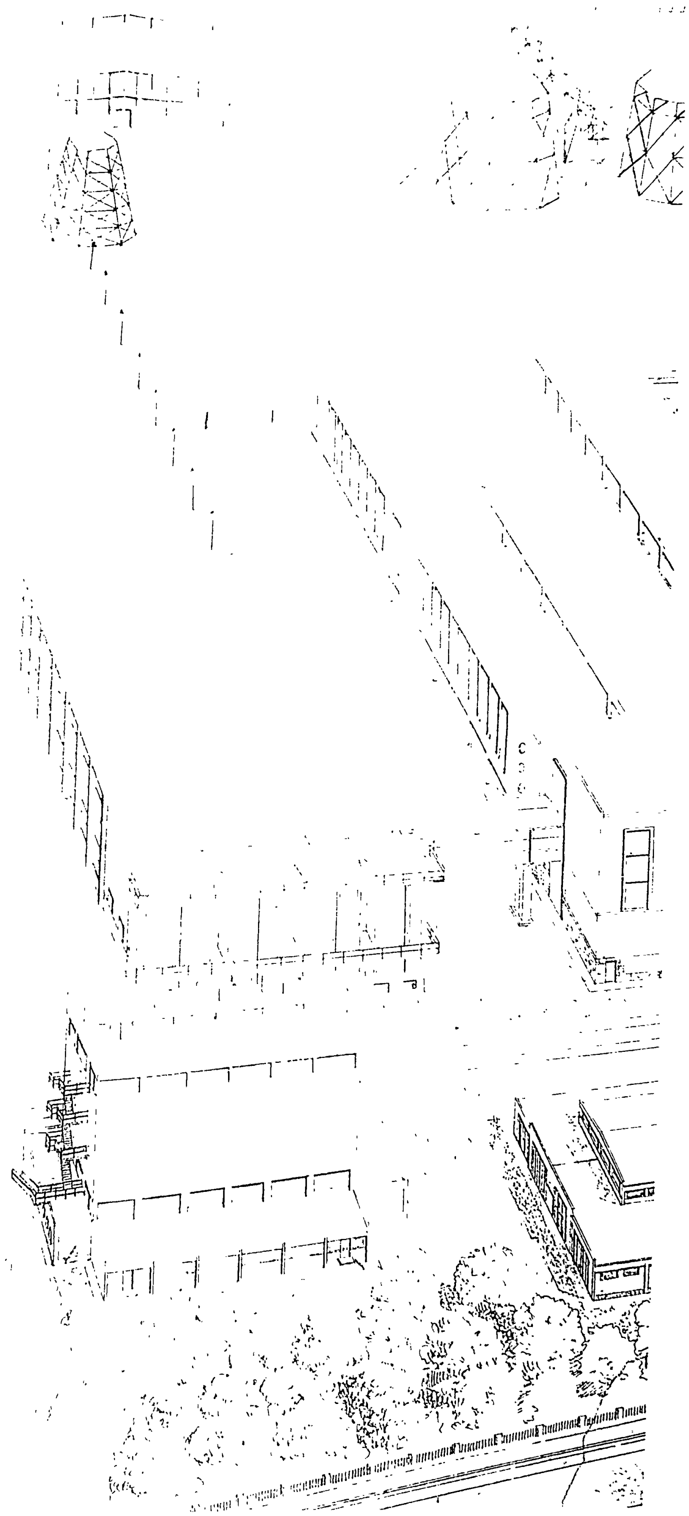

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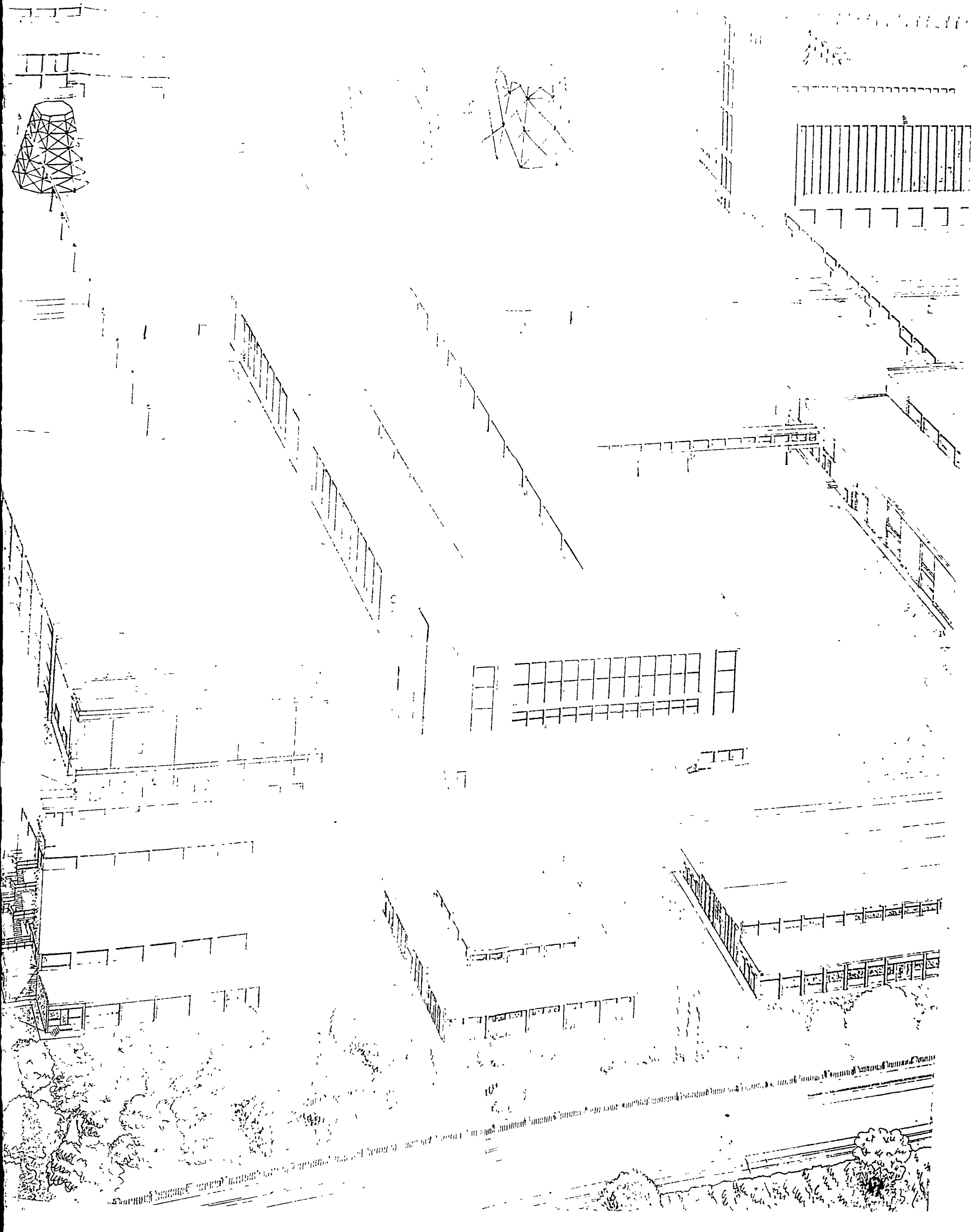

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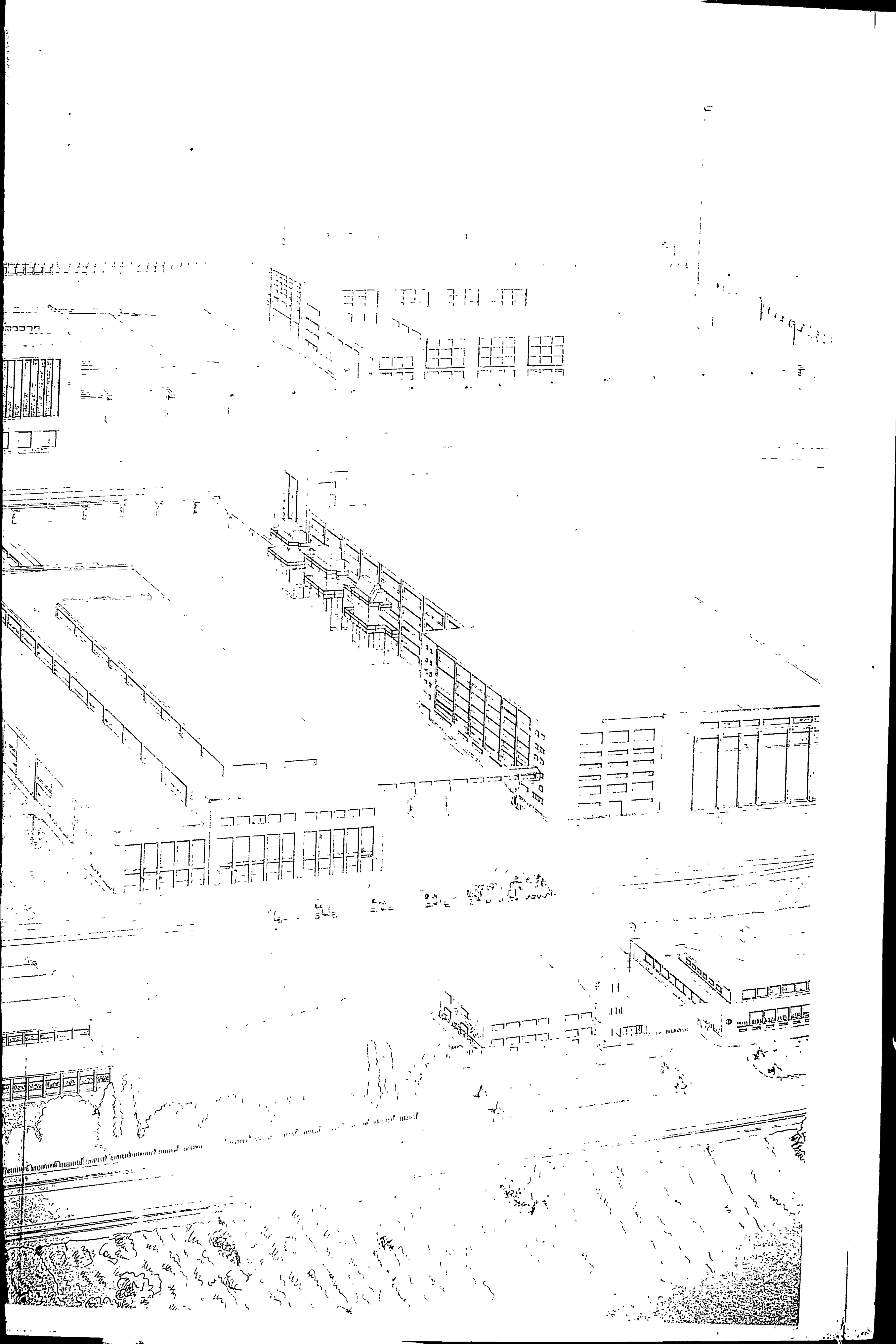

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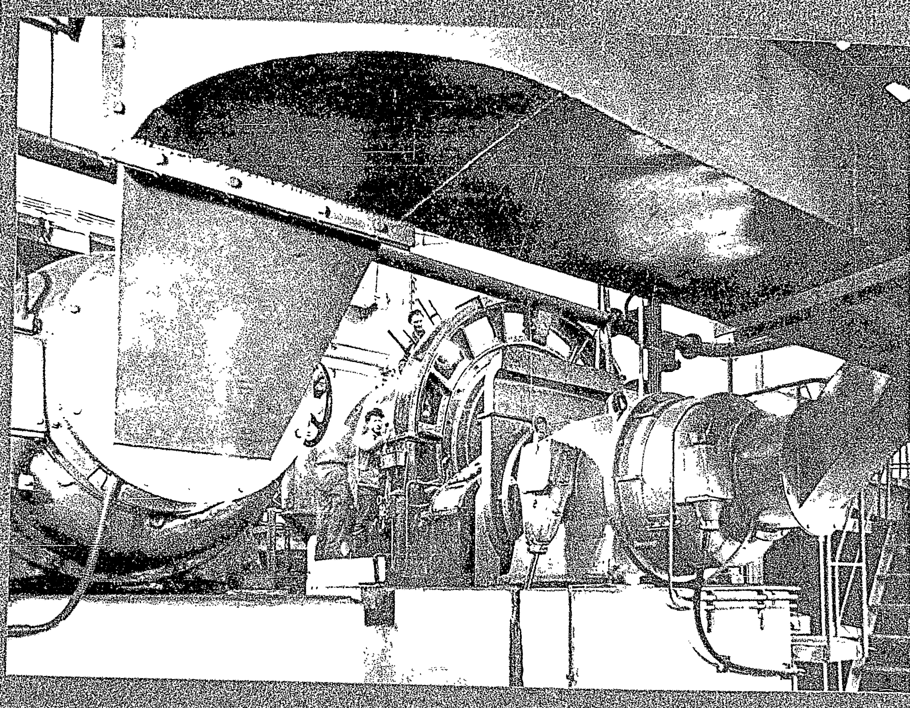

KUGELMÜHLEN
BALL CRUSHERS

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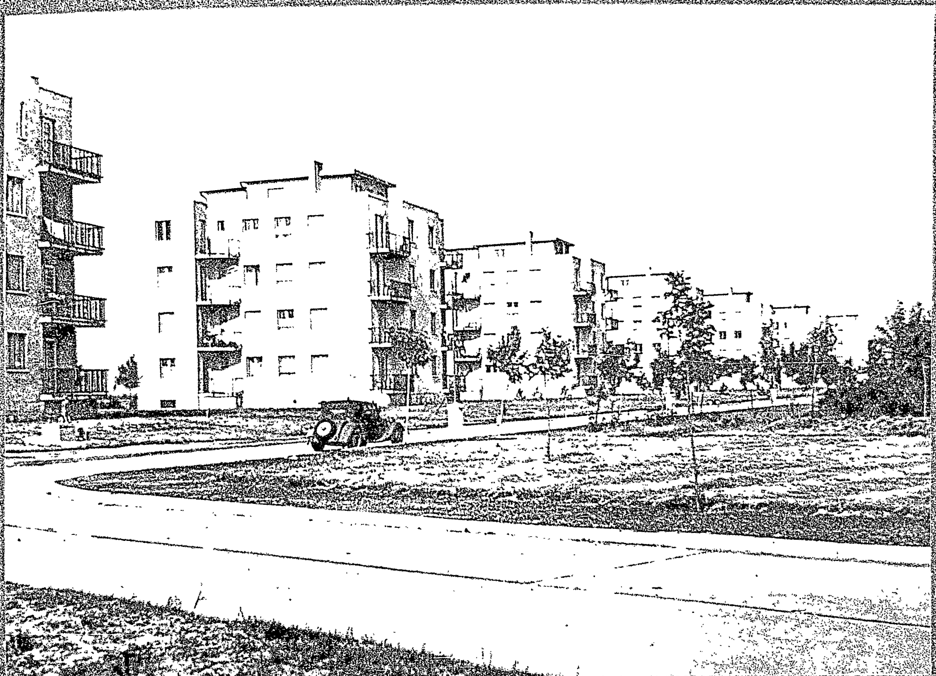

ARBEITERSIEDLUNG
WORKERS COLONY

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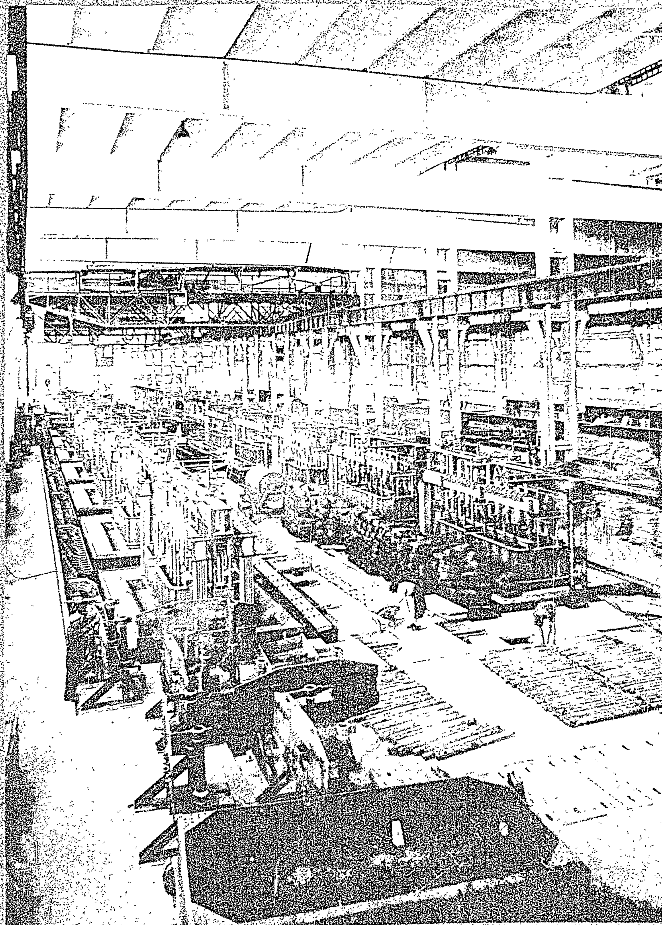

REDUZIERÖFEN

ELEKTROLYSING CELLS /REDUCTION FURNACES/

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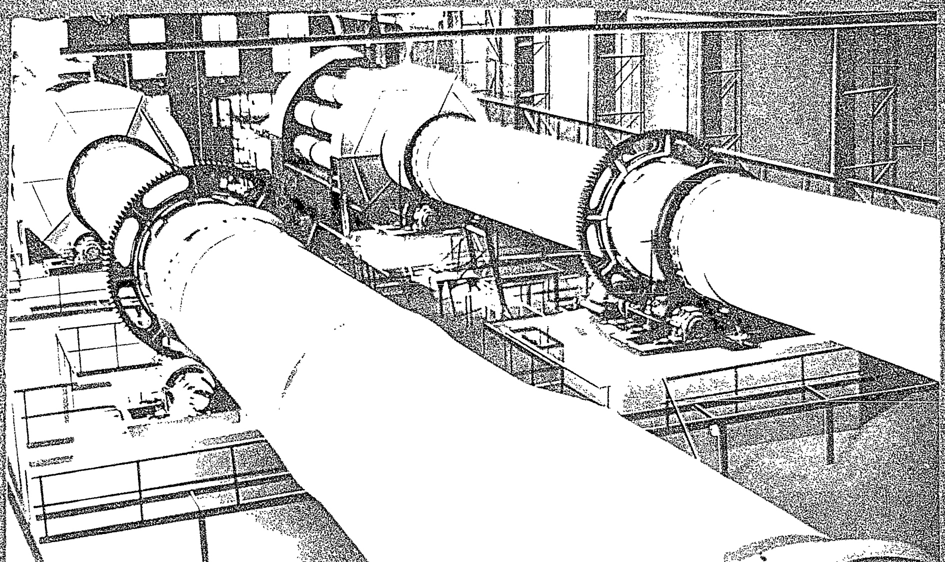

KALZINIERDREHÖFEN MIT REKUPERATOREN
ROTARY CALCINING KILNS WITH REKUPETATORS

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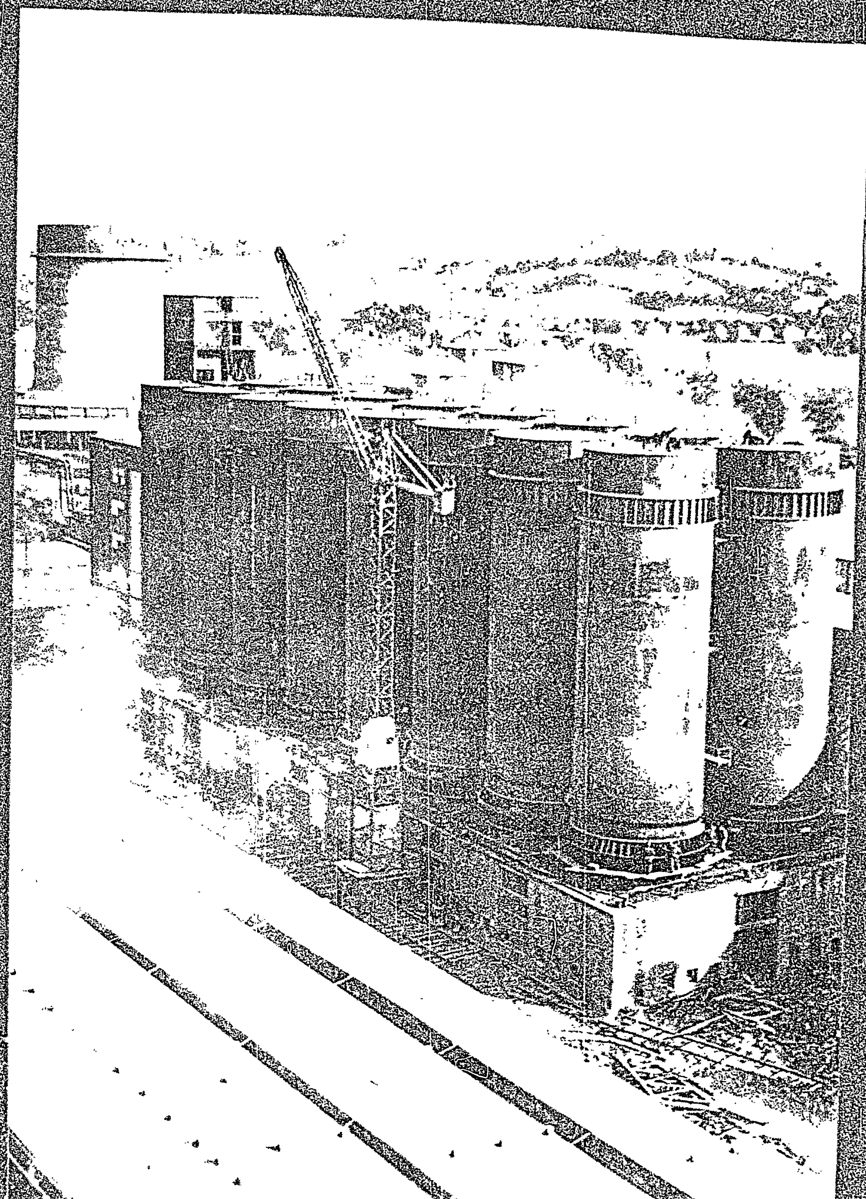

LUFTAUSRÜHRER VOR VERFERTIGUNG

PNEUMATICALLY AGITATED PRECIPITATOR BEFORE COMPLETION

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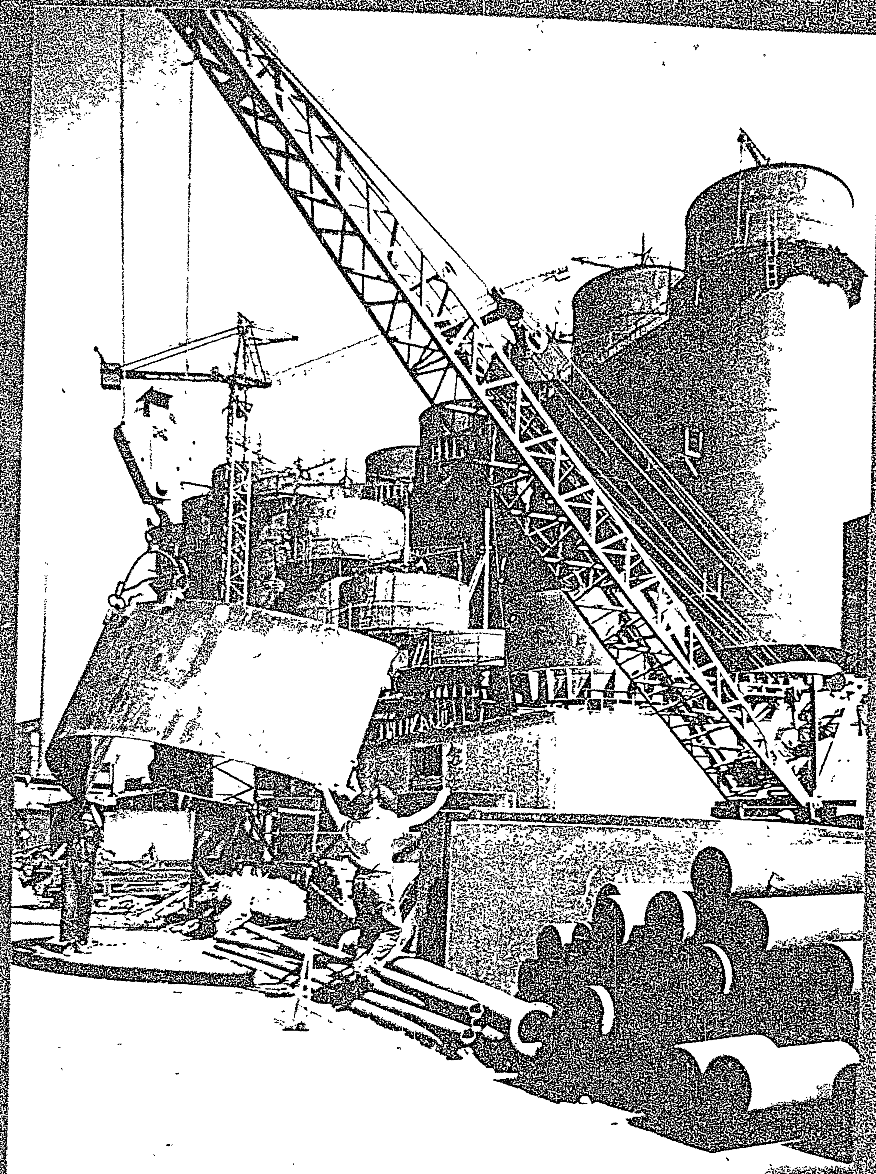

LUFTAUSRÜHRER UNTER BAU

PNEUMATICALLY AGITATED PRECIPITATOR TOWERS DURING ERECTION

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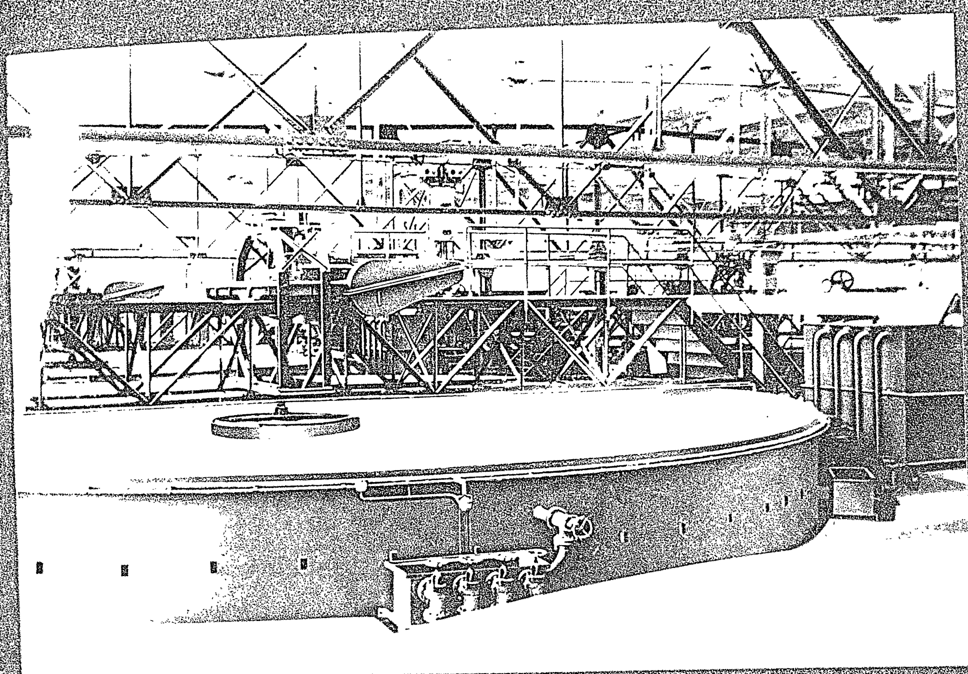

DORR-ABSETZBEHÄLTER-OBERES NIVEAU
SETTLING TANK UPPER LEVEL

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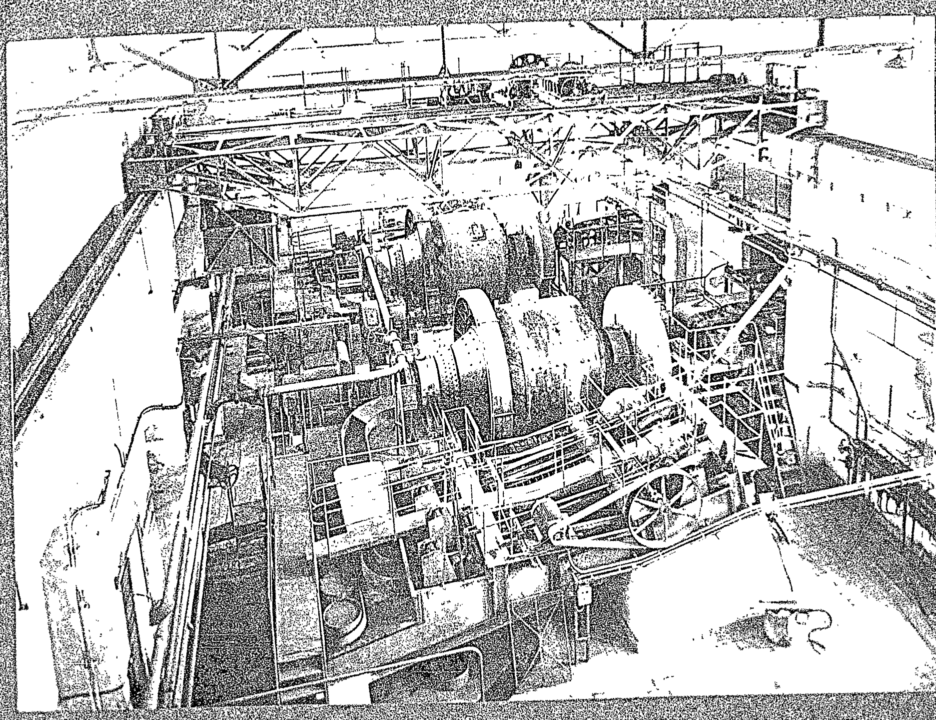

AUFBEREITUNGSANLAGE- NASSMAHLANLAGE
DRESSING DEPARTMENT WET CRUSHING

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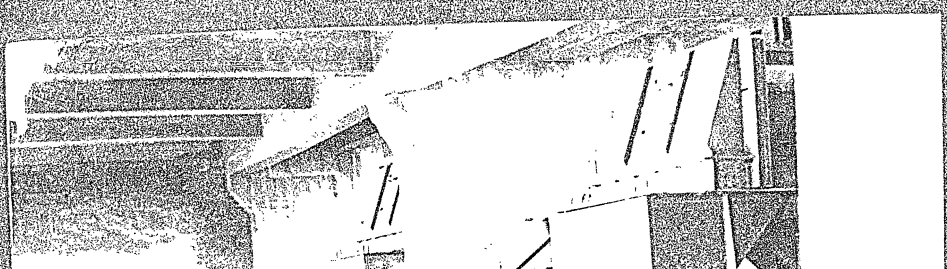

HAMMERBRECHERANLAGE
HAMMER CRUSHERS

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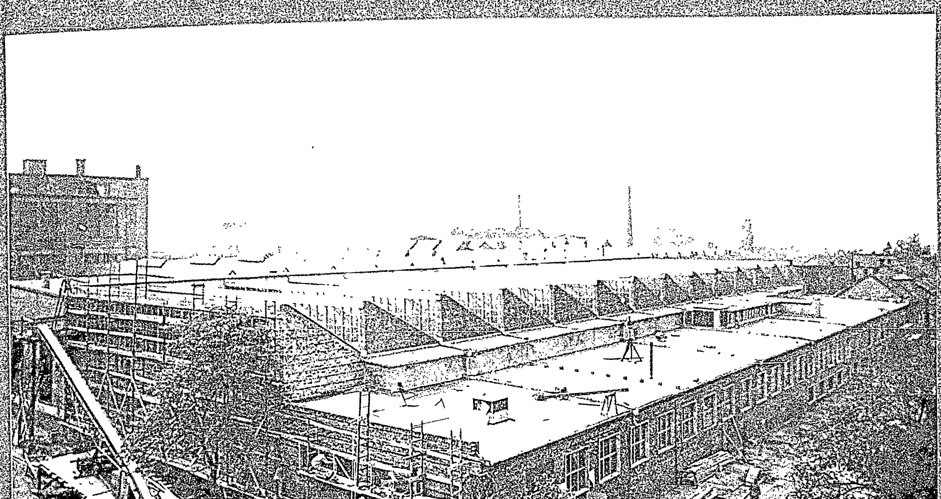

HILFSANLAGEN
AUXILIARY SHOPS

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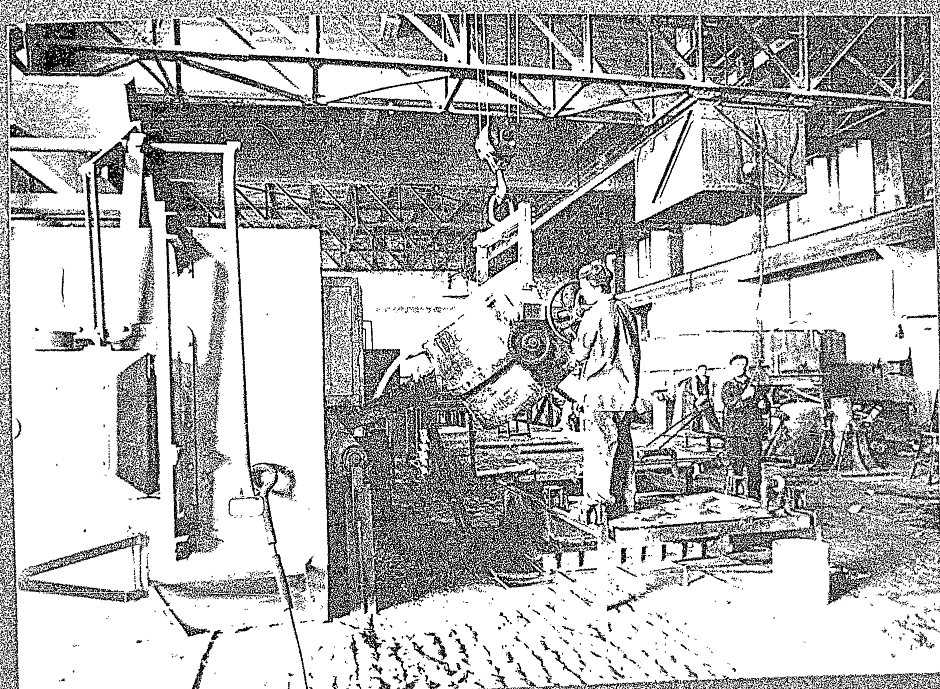

EGALISIERÖFEN IN DER GIESSEREI
THE FOUNDRY EQUALISING FURNACES

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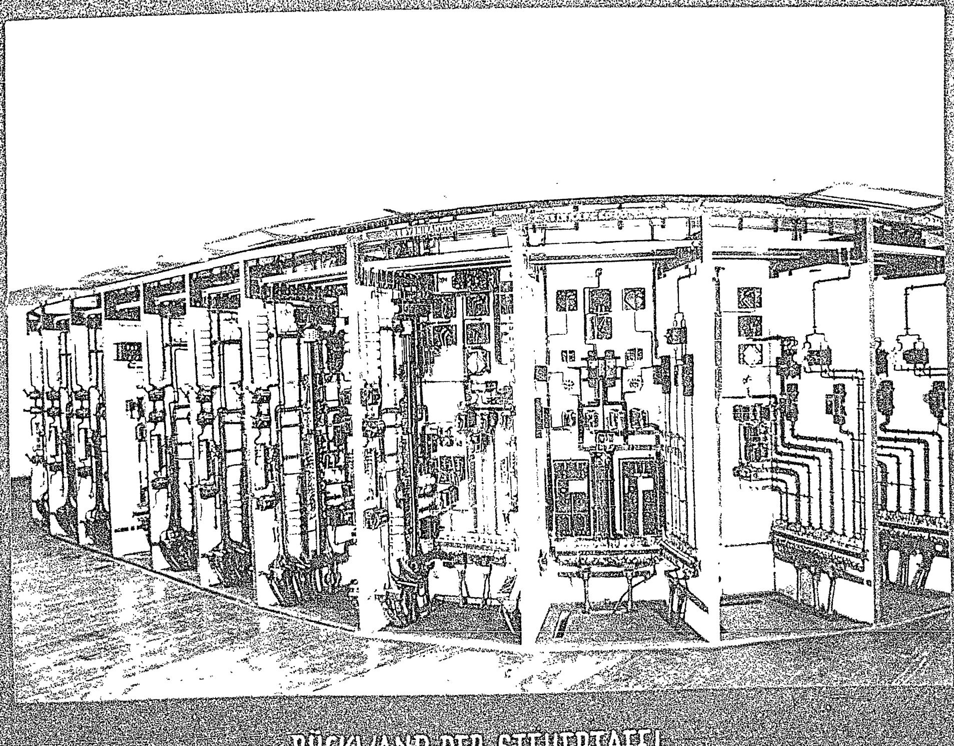

RÜCKWAND DER STEUERTAFEL
CONTROL PANEL BACKSIDE

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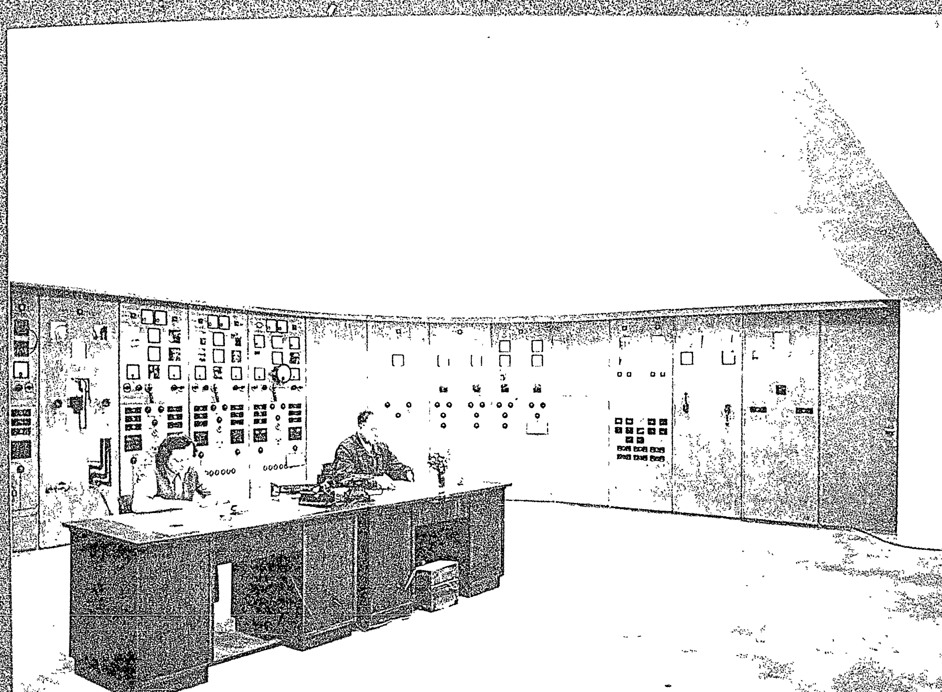

KOMMANDORAUM
CONTROL ROOM

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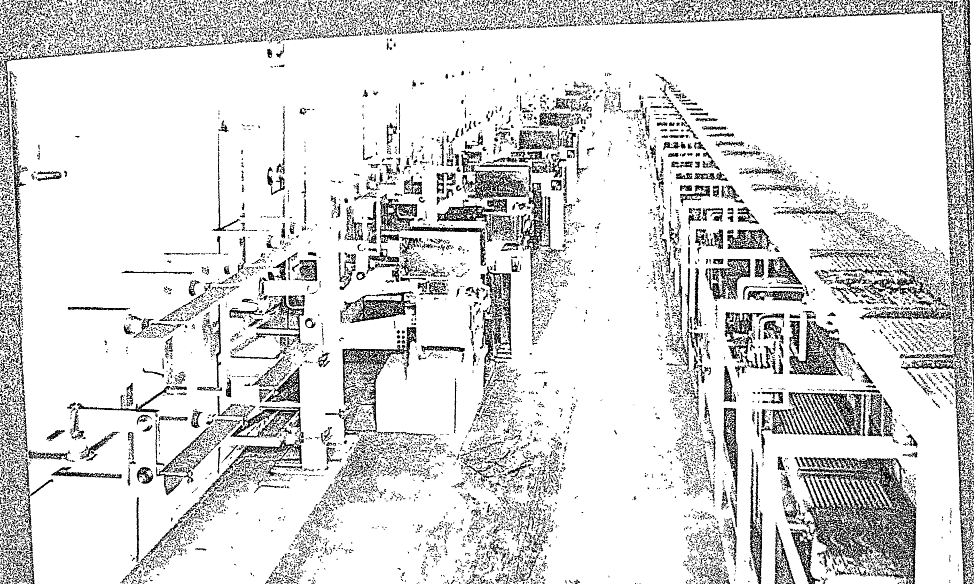

SCHALTRAUM MIT GLEICHSTROMSAMMELSCHIENEN
SWITCH ROOM WITH D.C. COLLECTING BUSBARS

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SCHALTRAUM MIT GLEICHSTROMSAMMELSCHIENEN
SWITCH ROOM WITH D.C. COLLECTING BUSBARS

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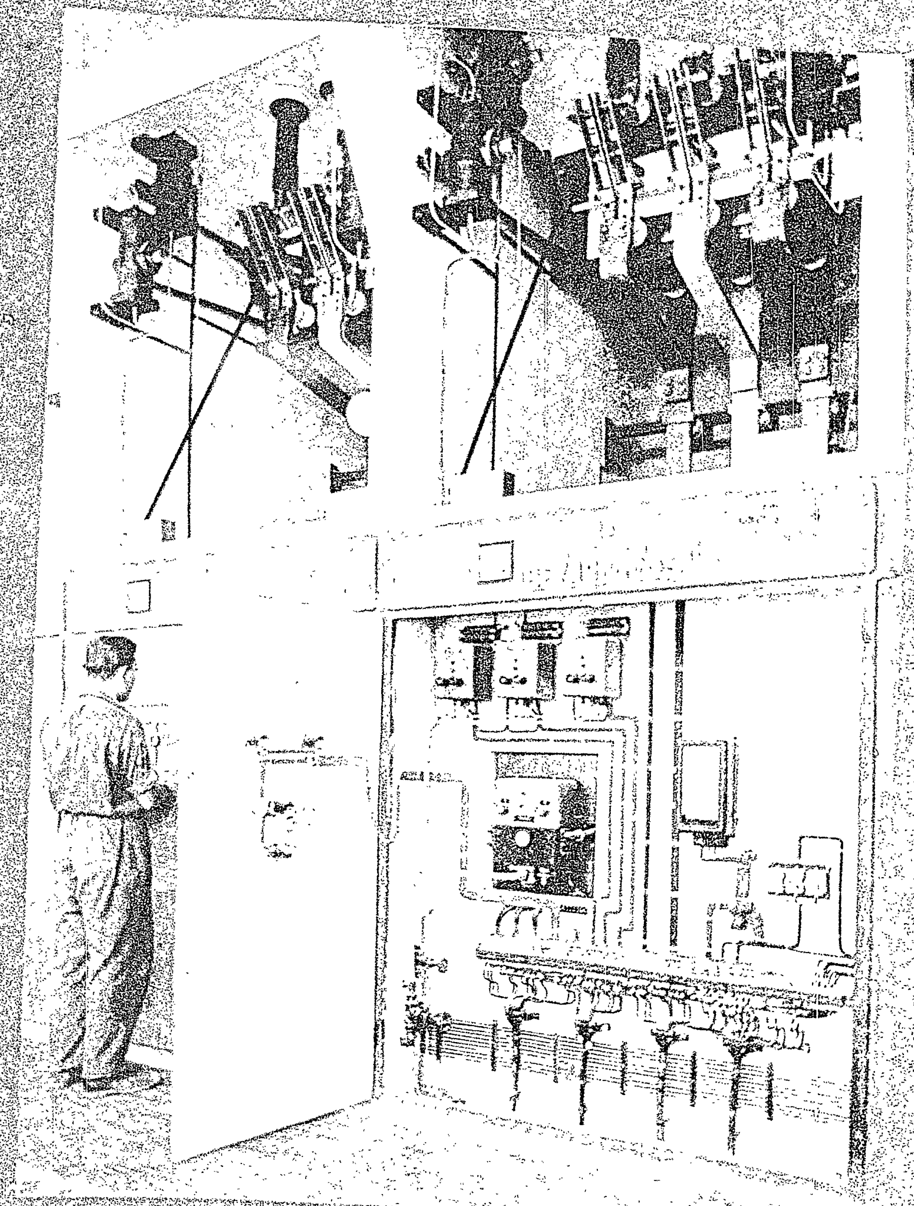

6 KV SCHALTZELLE
6 KV SWITCH CELL

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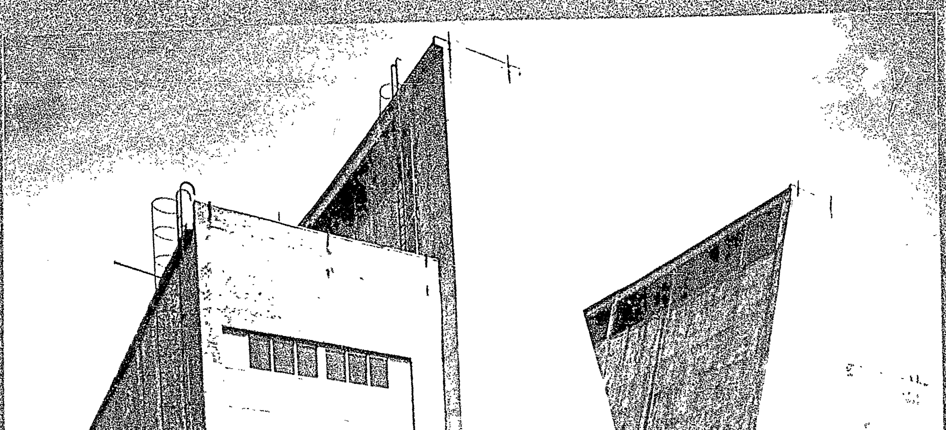

SCHALTHAUS, GLEICHRICHTER UND TRANSFORMATORENGEBÄUDE
SWITCH HOUSE AND RECTIFIER BUILDING WITH TRANSFORMERS

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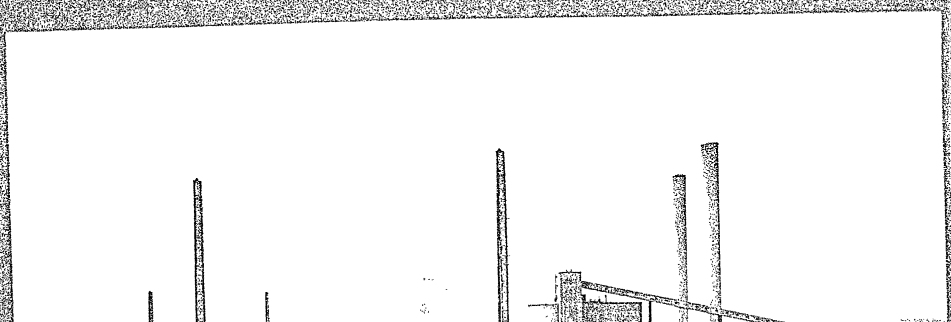

SAMMELSCHIENENSYSTEM ZWISCHEN KRAFTWERK UND GLEICHRICHTERANLAGE
BUSBAR SYSTEM CONNECTING THE POWER PLANT TO THE RECTIFIER PLANT—

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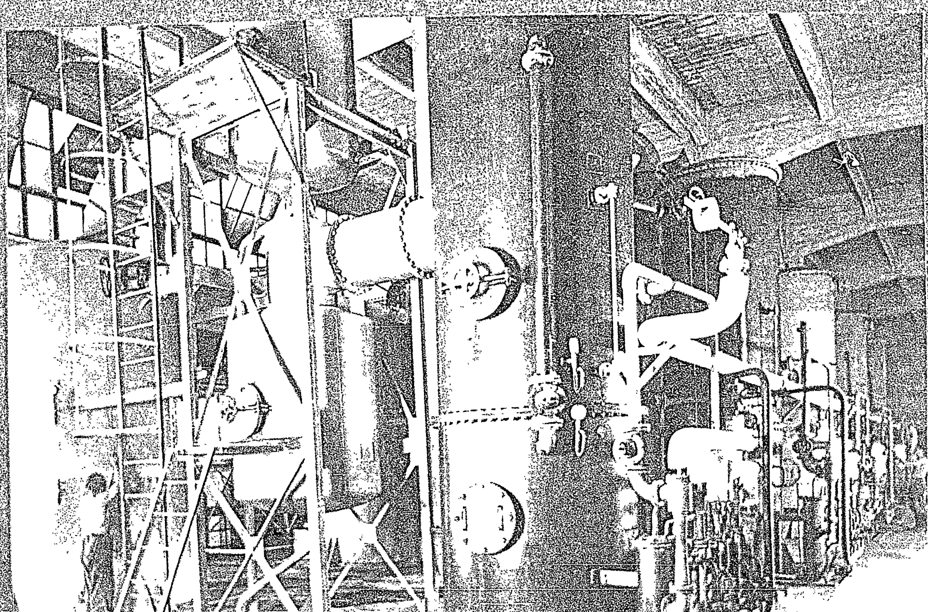

LAUGENKONZENTRIERAPPARATE
LYE CONCENTRATING APPARATURES

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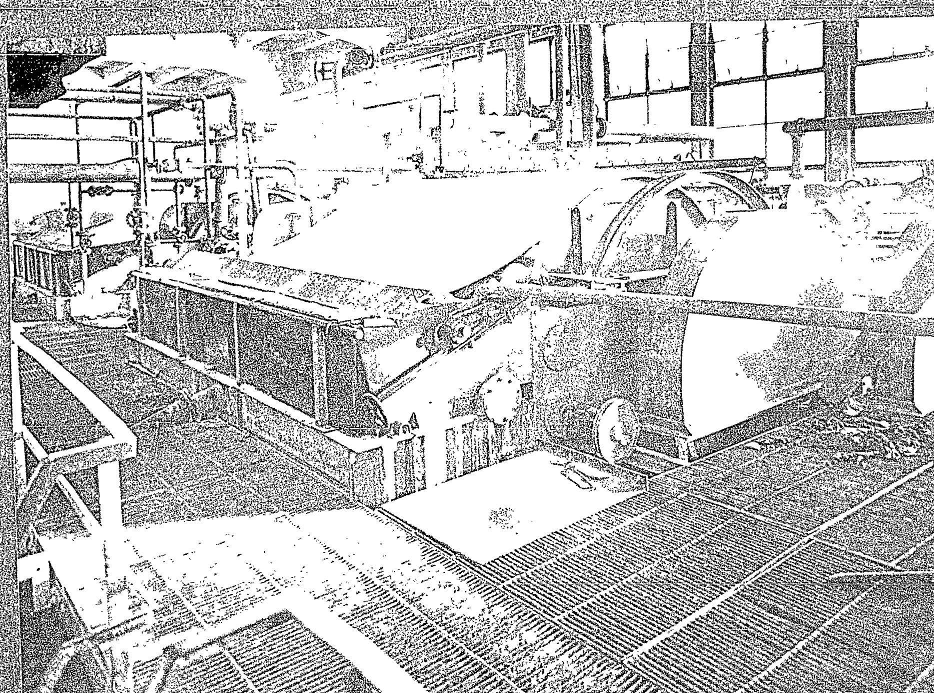

VAKUUMTROMMELFILTER
VACUUM OPERATED DRUM FILTER

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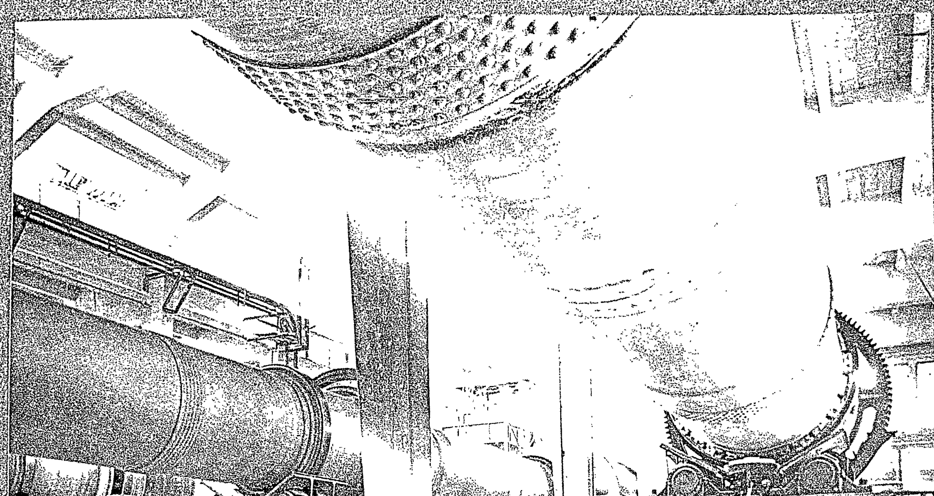

KALZINIERDREHÖFEN
ROTARY CALCINING KILNS

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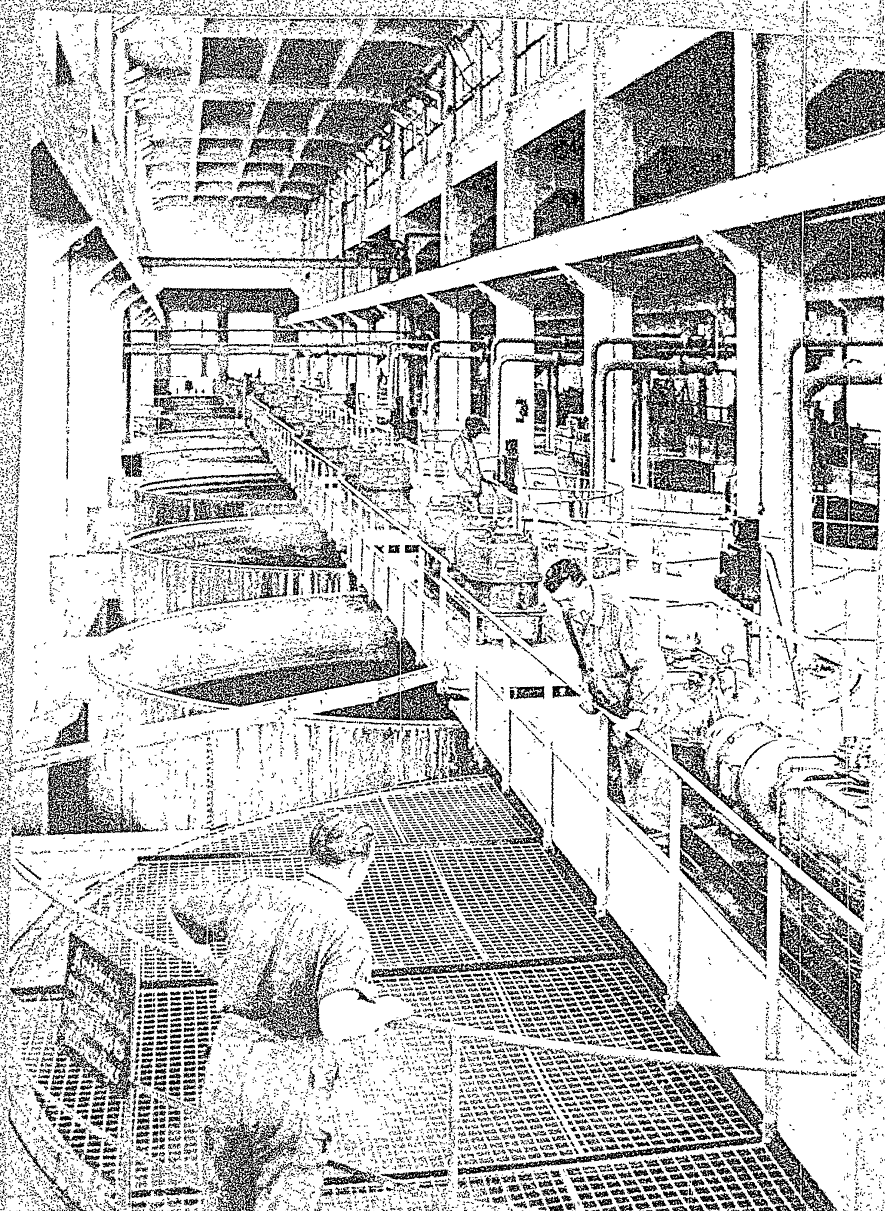

MECHANISCHER AUSRUHRER MIT RUHRWERK
PRECIPITATOR BATTERY WITH MECHANICAL AGITATION

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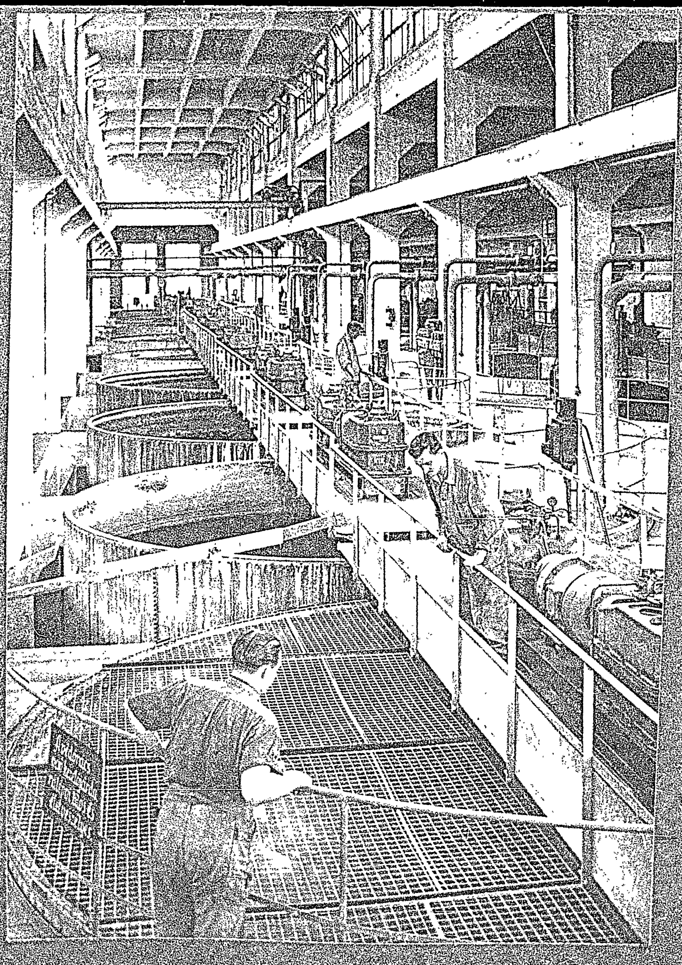

MECHANISCHER AUSRÜHRER MIT RÜHRWERK
PRECIPITATOR BATTERY WITH MECHANICAL AGITATION

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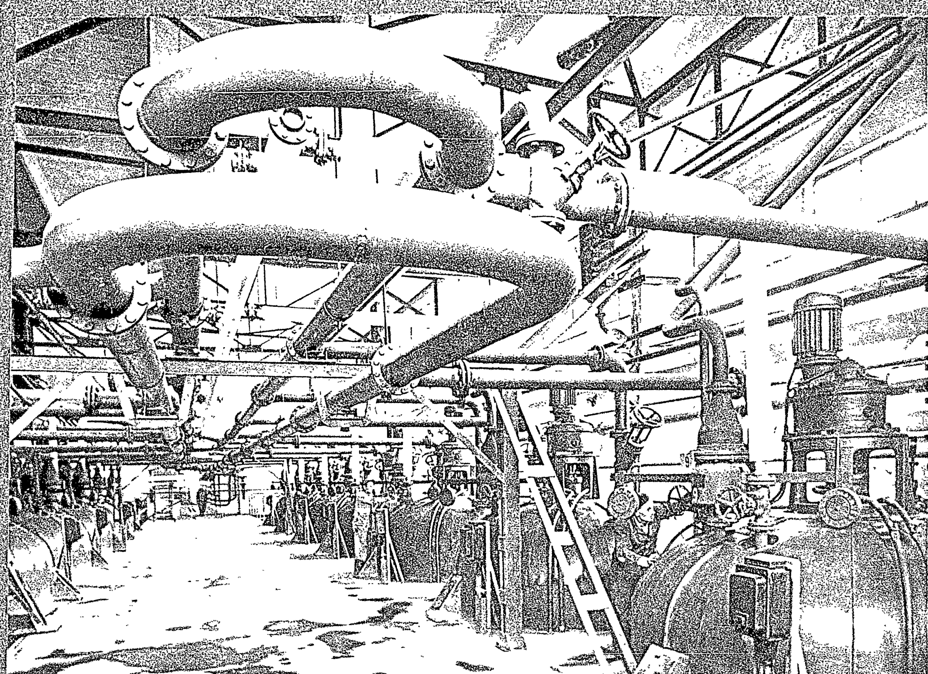

AUTOKLAVE, OBERES NIVEAU
UPPER LEVEL OF DIGESTERS

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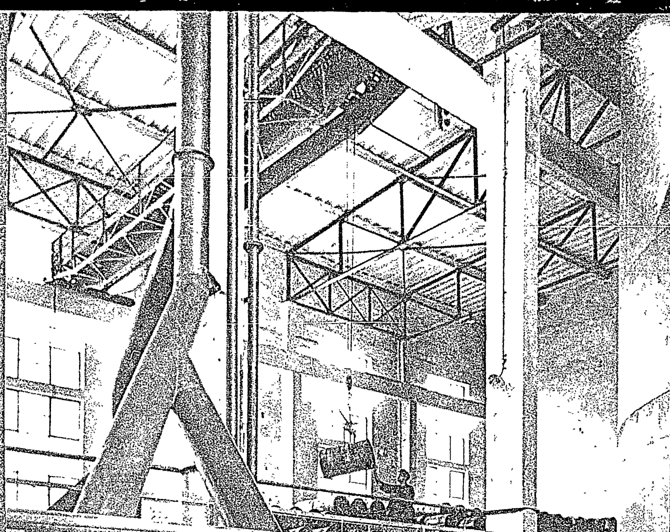

AETZNATRONMANIPULATION UND AETZNATRONLAUGENBEHÄLTER
CAUSTIC SODA HANDLING AND PREPARATION OF CAUSTIC LYE OF SODA

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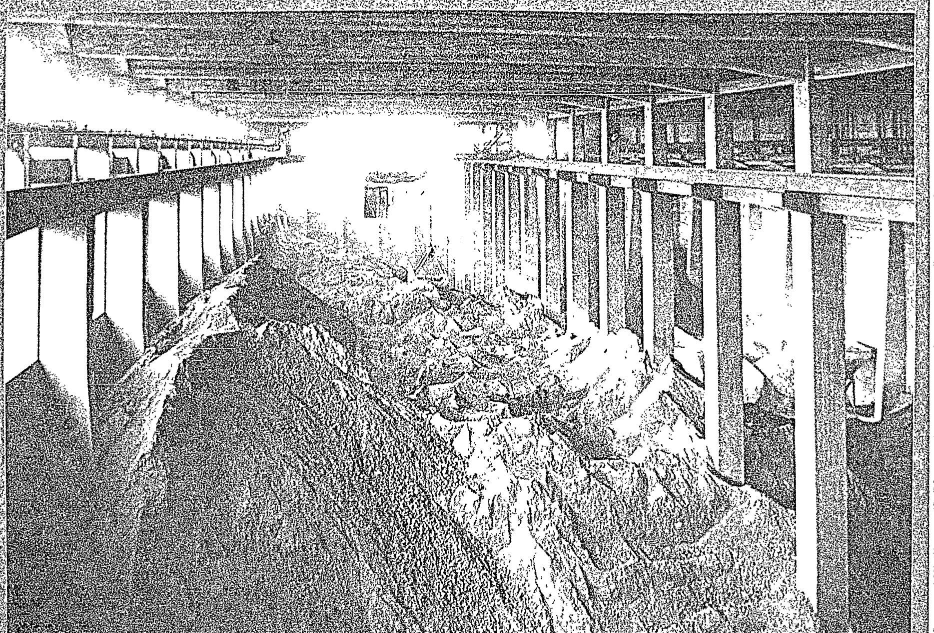

BAUXITLAGERRAUM MIT GREIFER WÄHREND DER ARBEIT
BAUXITE STORAGE HALL WITH GRAB IN OPERATION

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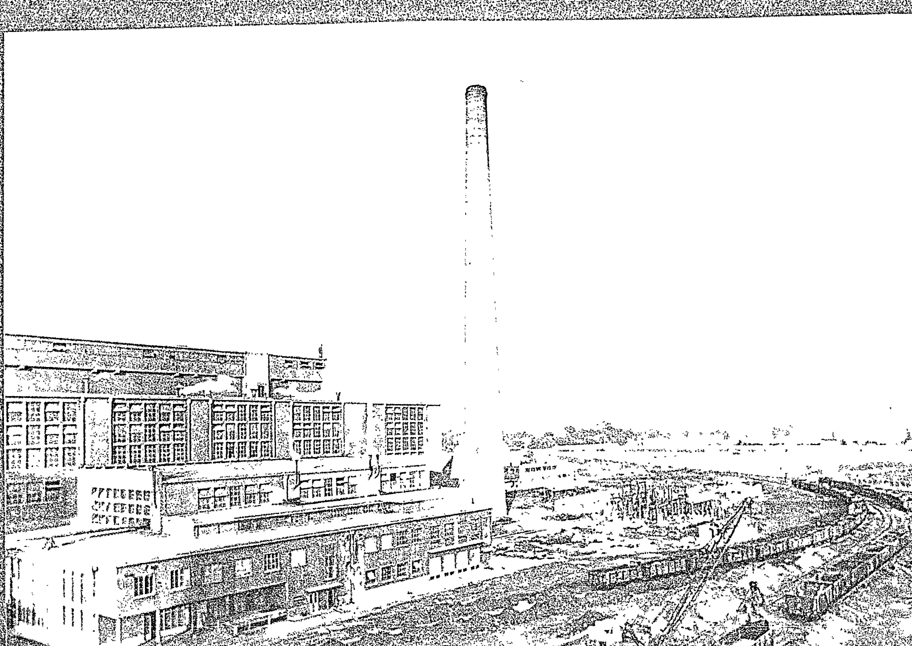

DAMPFKRAFTZENTRALE
STEAM POWER PLANT

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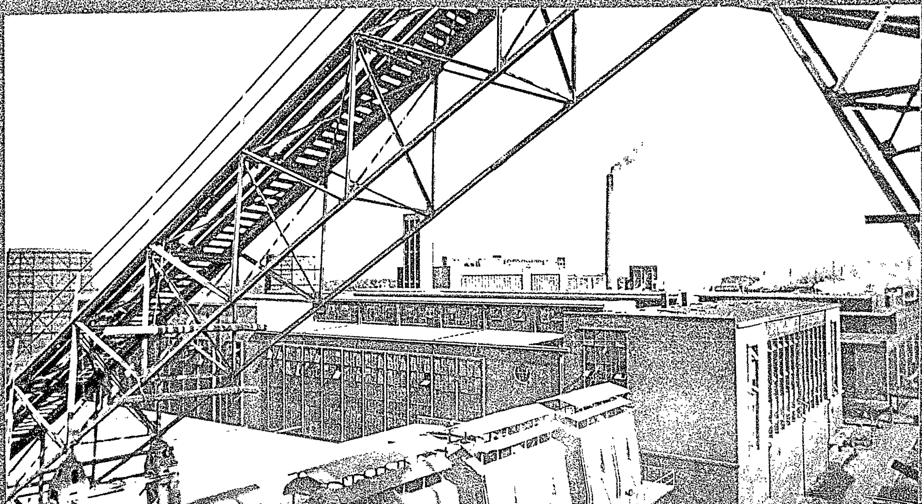

ANSICHT EINER TONERDEANLAGE
VIEW OF AN ALUMINA PLANT

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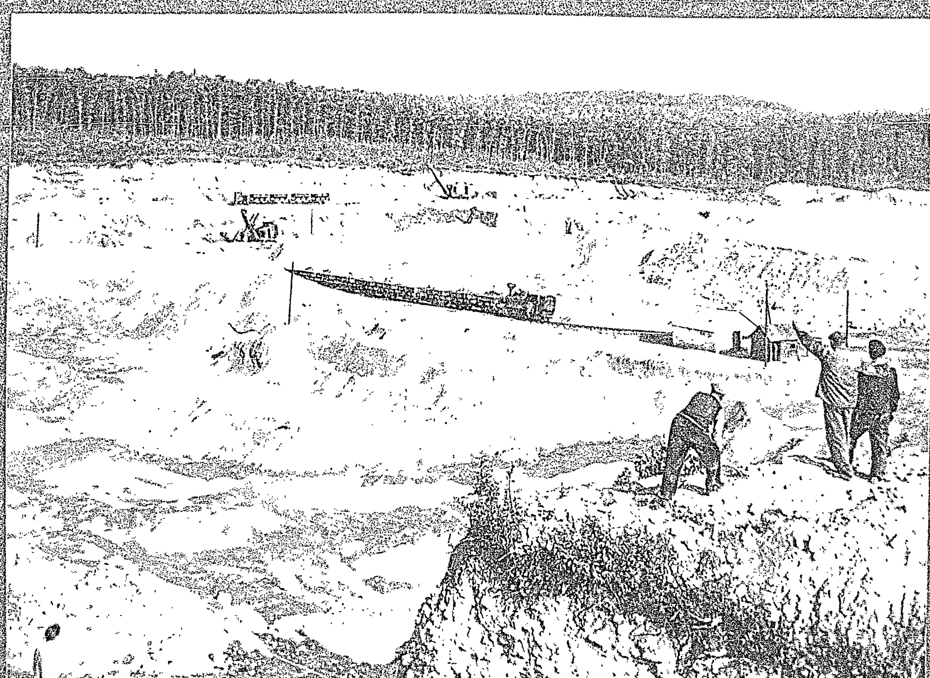

BAUXITGRUBE
OPEN MINING OF BAUXITE

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