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

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DRAFT FINAL REPORT

CONTRACT No.: 88/92SM

PROJECT No.: DP/YUG/87/015
FOR STEEL FOUNDRY
"JELSINGRAD",BANJA LUKA

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DRAFT FINAL REPORT ON CONTRACT No.: 88/92SM

PROJECT TITLE:

Assistance in Introduction of Technology for the Production of Low and Micro Alloy Steel castings at JELSINGRAD Plant Foundry, Banja Luka, Yugoslavia.

PROJECT NO.: DP/YUG/87/015

OBJECTIVE OF THE PROJECT :

To develop and start pilot plant production of low and micro-alloy steels and prepare a feasibility study to enable "Jelsingrad plant foundry" Banja Luka to adapt new technology with Argon Oxygen Decarburisation in converter.

1. INTRODUCTION

The Project DP/YU/87/015 is a Part of the Mid-Term Development Programme of metai industry in Yugoslavia where a particular importance has been attached to promotion and development of a new materials production whereof high quality steels enter the scope of it. A specific segment of that part of production makes cast steels.

The "JELSINGRAD" Plant is one of the bearers of metalworking industry development in the Republic of Bosnia and Herzegovina and in Yugoslavia on the whole. It falls into the rank of the biggest Yugoslav manufacturer of machine tools and steel castings.

A task of the Project for Jelsingrad Steel Foundry was to further the progress and development of high quality low alloyed, named HSLA (High Strength Low Alloy) steels and high strength abrasion resistant steels, for production of castings, by additional micro-alloying and grain size modification.

For the change in the steelmaking technology several additional equipment are installed:

- Oxygen Activity measuring equipment, where via measurement of the Electro Motoric Force a fast determination of oxygen activity during the refining of steel in the melting furnace is possible. Using this equipment, the melting operater is in charge to determinate the results of steel refining and efficiency during the process and at the final deoxidation and exact determination of aluminium content of the steel.

- For the optimization of alloying elements addition into the melt steel a COMPUTER AIDED CALCULATION (CAC) was installed. In one PC-IBM/AT the programm package EDAT for Databank nad ADD for Alloying was installed and used for calculation of alloys during the steelmaking in EAF and MF-IF.
  On this way:
  - Calculation of ferroalloys was optimized.
  - Utilization of alloying elements in steel and own returned material was optimized.
  - Optimal combination of ferro-alloys depending of the price.
  - The time shortage for calculation and a high accuracy in achievement of desir d chemical composition.
  - The Yield of alloys and addition was determinated.

For the determination of steel structure change points during the heating respectively cooling phases and according to the data aquired optimal termal treatment for HSLA and others microalloy steel, the DILATOMETER was installed.

After working of the expert for steelmaking and foundry technology through three years (APPENDIX 2.), the technology of steel refining in existing electric arc furnaces EAF, in MF-IF and in the casting ladle was mastered.
During and at the end of these period the process procedures and instructions are written. (APPENDIX 3.) During the working period also a Report of the new technology in papers for the Foundrymen Conference in Budva 1989 is given.

In several visits of the expert in steel making and foundry technology also the technology of melting and refining of steel in the induction furnace by ARGON, named ASR-I was installed and the procedure introduced, as well as technical manuals and instructions for using an acid (SiO_2), basic (MgO) and neutral (Al_2O_3) crucible lining, was written.

On this way, the main prerequisite for acquiring increased mechanical properties through the effects of micro-alloying and modification, as well as for EAF as for MF-IF steelmaking practice for the production of HSLA and high strength abrasion resistent steels, was achieved.

In the Feasibility Study at proper selection of newly developed controlled secondary metallurgy processes, which are increasingly more in use in highly developed countries, the CONVERTER REFINING as the most acceptable techno-economic direction of JELSINGRAD Steel Foundry development, based on controlled secondary metalurgy via Argon-Oxygen-Decarburisation, was investigated.

By those type of converter as well as HSLA a high alloyed heat resistent and stainles steels for steel castings, can be produced.

2. CURRENT STATUS OF STEEL PRODUCTION IN "JELSINGRAD" STEEL FOUNDRY, BANJA LUKA, JUGOSLAVIA.

For steelmaking, melting shops of "JELSINGRAD" Steel Foundry, Banja Luka, uses :

a) 4 x electric arc furnaces (EAF), capacities of which are 6-8 tons, together 4 furnaces with transformers of installed capacities 2 000 - 2 500 kVA

b) 2 x Medium Frequency Induction Furnace MF-IF (two melting crucibles, each 2 t capacity), with installed thyristored electrical power of 2000 kVA.

2.1 RAW MATERIAL : METALS:

EAF and MF-IF produce liquid steel by a "conventional" procedure using following raw materials:

1. Domestically manufactured metalls and alloys:

   a) Foundry returns, heads and runners etc.
   b) Purchased scrap.
   c) Ferro alloys: Al, FeSi, SiMn, CaSi, FeMn HC, coke, graphite.

2. Ferro alloys imported:

   FeMn Affine, Mn-Metall, Ni-metall, FeMo, FeV, FeTi, FeCr Affine, FeCr suraffine LC, special alloys in wire as CaSi, FeB, FeTi etc.

2.1.2. RAW MATERIAL : GASES

Gases used are as following:

a) Butane - for drying & heating of refractories.
b) Oxygen - large amounts for furnace melt treatment.
c) Argon - small amounts for MF-IF melt treatment.

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2.1.3. RAW MATERIAL : NON METALLIC COMPONENTS

For the process of steelmelting and refining required slag consist of nonmetallic components:

Limestone or lime as a basic components.
Iron ore for oxidation of metal.
Bauxite, dolomite, fluorspar for liquefy the slag.

2.1.4. RAW MATERIAL: DOMESTIC REFRACTORIES

Refractory material, such as bricks, ramming mass, sand, mortar used for : EAF & MF-IF lining as well transfer and timming ladle linings and the repair is the following:

1. Refractories based on acid components of SiO_2:
   Quarzite sand for MF-IF lining, fire clay brices for teeming ladles and stopper rods.

2. Refractories based on alkaline components of MgO/CaO:
   EAF lining, sinter dolomite, magnesite bricks.

3. Refractories based on neutral components of Al_2O_3:
   Bauxite bricks for timming ladle lining, ramming mass for transfer ladles, clay for repair, etc.

2.1.5. RAW MATERIAL : FOREIGN (IMPORTED) REFRACTORIES.

Due to their chemical composition (< 1% SiO_2) and the high melting point (>1800 C), the refractories which cannot react with the melt itself and which are based on Al_2O_3 or MgO are used for the production of special high-alloyed Cr & CrNi steel in the MF-IF.

1. High Alumina spinell mass for MF-IF lining with <1% SiO_2 and <15 % MgO.

2. High MgO spinell mass for MF-IF with <1% SiO_2 and <15% Al_2O_3.

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3. IMPROVEMENT OF STEELMAKING TECHNOLOGY

Melting shop produces melt by the "conventional" procedure, i.e. "carbon reduction" initiated by iron ore or gaseous oxygen.

The same process is applied to the "new technology" where by UNDP assistance in 1989, the steel refining into optimally economic process with furthest possibilities of dephosphorization, desulphurization, degasing and deoxidation, was introduced.

The "new steelmelting technology" actually accelerates the proces of "conventional" carbon removal and in that way assures the high quality level.

- The first metallurgical process, i.e. dephosphorisation takes place during melting and produces better results for further furnace treatment of the melt.
- By using oxygen for melt degassing, oxidation time decreases and excessive slag oxidation is avoided.
- Synthetic slag reduces refining time and achieves significantly low contents of deleteriars elements, such as phosphor & sulphur, as well as low gas load of the melt: hydrogen, nitrogen & oxygen.
- After the final treatment of liquid steel in the EAF, the steel is tapped into a teeming ladle where modification od nonmetallic inclusion and micro-alloying is carried out & transferred into the foundry shop where it is poured into the moulds.

More information available in a Report delivered at Foundrymen Conference, Budva 1989 :

B.NAZALEVIC & M.VELIKONJA:

"IMPROVEMENT OF STEEL PRODUCTION TECHNOLOGY IN "JELSINGRAD" STEEL FOUNDRY, BANJA LUKA."

3.1. CONVENTIONAL TECHNOLOGY IMPACT.

Due to the excessive noise and heat during the manual addition of elements and alloys, slagging off, sampling etc., the work on EAF is extremely difficult for the foundry workers.

The workers in melting shop are also physically exhausted during manual charging of the MF-IF. This hard work may partly be facilitated by installing the cantilever crane for furnace charging.

3.2. CONVENTIONAL STEELMAKING TECHNOLOGY

Conventional technology for steel production for existing production (SPECIFICATION APPENDIX 1.) of liquid steel in melting shop of "JELSINGRAD", has several stages of melt treatment which enable to obtain required composition, and what is more important, the melt quality necessary for casting.

Above mentioned "Carbon Reduction" is performed for the reason of melt degassing where OXIDATION of the melt produces CO gas, which passes through the melt, blows it and facilitates removal of deleterious gases H & N (hydrogen & nitrogen) in CO (carbon monoxide) bubbles, which than leave the melt.

During the oxidation the P (phosphorus) can also be removed while the slag compcensititon supports his crossing from metal into the slag. Through "slag off" and a removal of P via phosphorouse slag from the melt, the oxidation phase is completed.

The next phase of melt treatment ist the first stage of REFINING PROCESS which aim is to reduce the oxygen content using deoxidants such as:

- CARBON (C) , added in a form of coce, graphite etc.
- MANGAN (Mn) , added in a form of FeMn HC and LC, MnSi.
- SILICON (Si) , added in a form of Si, FeSi, SiMn, CaSi.
- ALUMINIUM (Al) , added in a forma of Al-Metall
- other elements such as Ca, Mg, Ti etc.

In the second stage of melt refining, the REDUCTION & REMOVAL of nonmetalic products of direct deoxidation by synthetic slag, composition of lime, bauxit and alloys, takes place.

When oxygen content in the melt & synthetic slag is lowered by deoxidants, the slag, highly active because of its high content of CaO (lime), is created. That's why DESULPHURISATION of the melt takes place, i.e. S (sulphur) removal by its transfer from the metal into the slag.

Due to the low potential of melt & slag mixing, S (sulphur) removal takes time which generally prolongs the total melting on refining time of steel production in the furnace.

3.3. ADVANCEMENT OF "NEW STEELMAKING TECHNOLOGY"

By introduction of the "New Steelmaking Technology", significant improvements of quality levels & production efficiency are obtained. It is the highest level possible to achieve in EAF practice. However, for the production of high quality HSLA steels & especially special high-alloy steels that level does not match the requirements of current world standards.

That's why the advancement of steel production, improvement in quality and rationalization of metallurgical practice may be achived only by MODERNIZATION of entire metallurgical practice which must use NEW SECONDARY METALLURGY INSTALLATION for refining of steel instead of old melting and refining practices in furnaces EAF & MF-IF.

For the purpose of choosing a secondary metallurgy installation, it is essential to consider current and future production programmes (SPECIFICATION TABLE 1.) of "JELSINGRAD" Steel Foundry, Banja Luka, as well as its abilities for the extension of steel grade production, development of new steel grades and manufacture of entirely new products.

The transfer of "new steelmaking technolcgy" in EAF and MF-IF enabled the production of low and microalloyed quality steels of high strength and notched bar impact strength at low temperature with prominent weldability , named HSLA steels, which will have its due share in the future production programme.

On this way, the possibility for production of castings for wagon building, tractors and vehicles industry and process industry is successful realized.

Further the production of abrasion resistant steels with good and steady notched bar impact strength for parts to dynamical loads and abrasive wear intended for mining and construction industry, thermo-power plants and cement production was introduced.

Of course, the quality of all other steel grades also has been improved since it will allow the adoption of high-price product programmes.

Throughout the years of expert services, training and transfer of tehnology knowledge, the national research and production personel receives the possibility for comparision between JELSINGRAD to other developed countries and the view for elevating of the level of their casting production. In APPENDIX 2. the service data and operation program of expert services is described.

Following the project specification, multitude instructions, specifications, documents and reports, are handed over. Sinopsis of all this papers is given in APPENDIX 3.

APPENDIX 1. :

EXISTING PRODUCTION PROGRAMME OF "JELSINGRAD"
STEEL FOUNDRY, BANJA LUKA

Envisage 8 major steel grade groups:

TYPE AND STEL GRADE	ANNUAL PRODUCTION MOLTEN STEEL (t)	CASTINGS (t)	PERCENT (%)
1. CARBON STEEL (C-cl)	13 000	6 800	56.5
2. MANGANESE STEEL (Mn-cl)	1 000	600	5.0
3. LOW-ALLOY STEEL (Cr,Mo-cl)	3 500	1 550	12.9
4. LOW-ALLOY STEEL (2 MnT-cl)	900	450	3.8
5. HIGH-ALLOY STEEL (CrNi-cl)	190	100	0.8
6. HIGH-ALLOY STEEL (Cr-balls)	750	300	2.5
7. MICRO-ALLOY STEEL (V-cl)	4 000	2 020	16.8
8. OTHER	500	200	1.7
TOTAL	23 390	12 000	100.0

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APPENDIX 2.

EXPERT SERVICES: PROGRAM AND DATE OF REALIZATION

VISIT	DATE	PROGRAM
1.	14.12.- 24.12.1988.	PROMOTION OF STEEL REFINING EAF CURRENT STATUS AND PRACTICE
2.	24.04.- 25.04.1989.	REPORT IN JELSINGRAD
	22.05.- 25.05.1989.	GIFA - DÜSSELDORF
	05.06.- 06.06.1989.	INSTALLATION OF EMK-MEASUREMENT
	10.06.- 30.06.1989.	PROCEDURE FOR STEEL REFINING EAF INTRODUCTION OF OXYGEN MEASUREMENTS INSTALLATION OF ASR-I SYSTEM INSTALLATION OF COMP.AIDED CALCUL. PROMOTION OF STEEL REFINING MF-IF
3.	15.10.- 24.10.1989.	PROCEDURE FOR STEEL REFINING EAF PROCEDURE FOR STEEL REFINING MF-IF COMPUTER CAC FOR EAF & MF-IF
	25.10.- 28.10.1989.	REPORT FOUNDRY CONGRESS BUDVA 1989
	06.11.- 20.11.1989.	VISIT TOURS : SPAIN-FRANCE-GERMANY
4.	08.11.- 13.11.1989.	VISIT OF PHB- ST.INGBERT/GERMANY
	08.12.- 20.12.1989.	PROCEDURE FOR HSLA STEEL IN EAF
5.	05.03.- 11.03.1990.	PROCEDURE FOR MF-IF CRUCIBLE
	15.04.- 01.06.1990.	FEASIBILITY STUDY
	03.06.- 06.06.1990.	VISIT OF PHB- ST.INGBERT/GERMANY
6.	28.10.- 31.10.1990.	PRODUCTION OF HSLA STEEL IN EAF
	15.01.- 30.01.1991.	DRAFT FINAL REPORT

APPENDIX 3.

HANDINGOVER: PRODUCTION PROCEDURES, PROJECT SPECIFICATIONS, DOCUMENTS AND WORKING INSTRUCTIONS

	NAME OF DOCUMFNTS	DATE OF ISSUE
1.	MELTING PROCEDURES FOR EAF:	
	STEEL MAKING EAF-LADLE SYSTEM	20.12.1988.
	STEELMAKING FOR < 0.010% S & P	20.12.1988.
	MELTING PROCEDURE FOR D-STEELGRADES	27.06.1989.
	MELTING PROCEDURE FOR A-B-C-D STEELGRADES INCLUDING EMK & CAC INSTRUCTIONS	27.06.1989.
	COMPUTER AIDED CALCULATIONS	20.06.1989.
	MICROALLOYING OF Al, Ti, B	20.11.1989.
2.	MELTING PROCEDURES FOR MF-IF:	
	STEELMAKING IN MF-IF-LADLE SYSTEM	27.06.1989.
	ASR-I SYSTEM PROCEDURE	27.06.1989.
	MELTING PROCEDURE FOR SiO2 REFRACTORY	27.06.1989.
	MELTING PROCEDURE FOR Al2O3 REFRACTORY	08.03.1990.
	MELTING PROCEDURE FOR MgO REFRACTORY	15.09.1990.
	COMPUTER AIDED CALCULATIONS	20.06.1989.
3.	MANUALS, INSTRUCTIONS, REPORTS	
	INSTRUCTIONS FOR EMK-MEASUREMENT	06.06.1989.
	USER MANUAL FOR PROGRAM ADD	15.06.1989.
	USER MANUAL FOR PROGRAM EDAT	15.06.1989.
	COMPUTER AIDED CALCULATIONS	20.10.1989.
	REPORT FOR BUDVA FOUNDRYMEN CONFERENCE	25.10.1989.
	INSTRUCTIONS FOR ASR-I SYSTEM	20.06.1989.
	FEASIBILITY STUDY	01.06.1990.
	TECHNOLOGY SiO2-CRUCIBLE	15.09.1990.
	TECHNOLOGY Al2O3-CRUCIBLE	15.09.1990.
	TECHNOLOGY FOR MgO-CRUCIBLE	15.09.1990.
	DRAFT FINAL REPORT	15.02.1991.

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THE FUTURE

OF STEEL FOUNDRY

"JELSINGRAD"

BANJA LUKA

4. THE FUTURE OF JELSINGRAD FOUNDRY

The future of JELSINGRAD Steel Foundry, Banja Luka, depends in the great part from the possibility of installation of new equipments for "secondary metalurgy".

TABLE 1. shows the proposal for DEVELOPMENT OF PRODUCTION PROGRAMME OF "JELSINGRAD" STEEL FOUNDRY, BANJA LUKA, expected after the implementation of "Secondary Metalurgy" by converter installation in the melting shop of foundry.

The proposal does not suggest any change in total foundry production:

12 000 t of castings per year corresponding to
24 000 t liquid steel production per year
==

Only the quantity of carbon steel castings is to be reduced:

GROUP 1. : Castings 6 800 t/year to 3 000 t/year.
==

The foundry production capacity refers to the production of low-alloyed, micro-alloyed and HSLA steels:

GROUP 3. + 7. : Castings 3 570 t/year to 4 800 t/year.
==

For which there are all possibilities of necessary further steel treatment in other existing foundry shops: molding bay, frettling shop, heat treatment shop etc.

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4.1. COMPARISON OF STEEL PRODUCTION COSTS. TODAY & IN FUTURE

There mentioned production costs are calculated for 3 different ways of steel production, depends of process lines:

LINE 1. : Melting in EAF by "conventional practice".

LINE 2. : Combination of EAF and "Secondary Metalurgy" installation: EAF - CONVERTER

LINE 3. : Melting of foundry returns in MF-IF and production of "Master Heats" by conventionel MF-IF Practice.

TABLE 2.2. shows THE COMPARISON OF PRODUCTION COSTS of these installations, whereas TABLE 2.1. shows THE DATA FOR THE COMPARISON OF PRESENT AND FUTURE COSTS (after installation of converter).

4.1.1. STEEL PRODUCTION TODAY:

Out of today : 4 x 5 t EAF

In operation: 3 x 5 t EAF
Stand by: 1 x 5 t EAF
Production today: 20 heats/day = 100 t/day = 24 000 t liqu./year

4.1.2. STEEL PRODUCTION IN FUTURE:

Retained furnaces: 2 x 5 t EAF
Combined with: 1 x 5 t CONVERTER
Future: 16 heats/day = 80 t/day = 19 200 t liqu./year

The MF-IF takes over the melting of high-alloy steels:

10 heats/day = 20 t/day = 4 800 t liqu./year

of which :	GROUP 2. :	Mn - steels	2 000 t liqu./year
	GROUP 5. :	CrNi - steels	1 400 t liqu./year
	GROUP 6. :	Cr - steels	1 200 t liqu./year
	GROUP 8. :	other	200 t liqu./year

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For calculation of amortization the value of new equipment is used. For this calculation the value of existing melting shop of 15 mio. DM is supposed, the amortization of 15 % / year gives the amount of 2 250 000.- DM/year, which divided by the production of 24 000 t liqu./year results to worth of:

94.- DM/t of liquid steel

The same calculation way for the "new investment" of 8 mio DM, and 15 % / year gives the amount of 1 200 000.- DM/year as amortization, divided by the production of 24 000 t liqu. steel/year:

50.- DM/t of liquid steel

For the different melting eqippment the amortization is followed:

EAF	31.30 DM/t liqu.steel
CONVERTER	15.60 DM/t liqu.steel
MF-IF	31.30 DM/t liqu.steel

Better working conditions and favourite amortization of EAF + CONVERTER process will enable reduction of work force in melting shop from 60 to 36 workers.

The Plan for disposition of workers is given in TABLE 2.1.

The cost of a work-place is 30 000.- DM/year , consequently the amount for work-places gives:

60 work-places	1 800 000.- DM/year = 75 DM/t liqu.
36 work-places	1 080 000.- DM/year = 45 DM/t liqu.

Personal cost in future for each installation:

EAF	:	24.- DM/t	(15 work places)
CONVERTER	:	14.- DM/t	(9 work places)
MF-IND.FURNACE	:	75.- DM/t	(12 work places)

According to these data and above mentioned parameters in TABLE 2.2. the COMPARISON OF STEEL PRODUCTION COSTS per each of the 3 plants combinations is given.

According to the results, production costs in future will be followed reduced, from 549.00 DM/t liqu.:

to 392.40 DM/t liqu. = - 156.10 DM/t for EAF+CONVERTER

to 328.30 DM/t liqu. = - 220.70 DM/t for MF-IF

Savings in costs due to the reduction of production costs are given in TABLE 10. and equal:

TOTAL SAVINGS : 4 050 480.- DM/year

Since the MF-IF has allready been in operation, this more convenluent way of production could be applied to some selected steel grades since it:

SAVINGS by melting costs	220.- DM/t liqu.steel
SAVINGS by material costs	50.- DM/t liqu.steel
TOTAL SAVINGS by	270.- DM/t liqu.steel

which means that steel production in the MF-INDUCTION FURNACE is 25 % cheaper than in the EAF.

That is why the steel production in the MF-IF is to be increased to 10 heats/day or to 4 800 t/year , which means that without any new investment the cost savings will be :

SAVINGS BY MF-INDUCTION FURNACE : 1 300 000.- DM/year

When the charging material is premelted in a converter - MASTER HEATS- and "after the modernization of melting shop", the MF-IF will serve for melting of all envisaged groups of steel grades given in TABLE 1., where the TO-DAY AND THE FUTURE PRODUCTION OF "JELSINGRAD" STEEL FOUNDRY,BANJA LUKA is given.

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4.2. COMPARISON OF MATERIAL COSTS TODAY & IN THE FUTURE

TABLES: 3.,4.,5.,6.,7.,8.& 9. show COMPARED MATERIAL COSTS for :

1. EAF as present day production
2. EAF + CONVERTER as future production
3. MF-INDUCTION FURNACE as possible production today & in the future.

The results refer to steel GROUPS 1. - 7. ; for the GROUP 8. no changes are envisaged.

TABLE 10. shows the results of calculation of savings by reduction of melting - production costs.

Calculation of total savings due to the cost reduction in charging material is shown in TABLE 11. in which single results for steel groups given in TABLES 2.- 9. are added one to another and expressed as annual production of each installation.

Consequently, after the introduction of CONVERTER TECHNOLOGY, the following savings are to be expected:

COST SAVINGS	DM/YEAR
1. Reduction of melting costs	4 056 480.-
2. Reduction of material costs	3 019 320.-
POSSIBLE ANNUAL SAVINGS TOTAL	7 075 800.-

4.3. USAGE OF RESOURCE MATERIALS, ENERGY & GASES.

TABLE 12. shows the comparison of consumption of materials, energy today, and after the implementation of the converter project in "JELSINGRAD", Steel Foundry, Banja Luka.

Today according to the data , the foundry consumption of energy for melting is 19 000 MWh/year, whereas in future it will equal 13 000 MWh/year - it means that consumption will be reduced by 6 000 MWh/year.

Electrode consumption will be reduced by more than 50% , i.e. from 192 t/year to 80 t/year, due to the change of charging material. Heads, cast remains and bigger pieces which causes the electrode breaks, will be melted in the MF-IF.

Because of better yield of metall and metall additions, the quantity of purchased charging material will be reduced from 595.80 kg/t liqu.steel to 536.30 kg/t liqu.steel i.e by 59.50 kg/t liquid steel.

4.3.1. GAS CONSUMPTION

CONVERTER practice is a pneumatic process, i.e. it uses for melt treatment different gases. Consequently, gas consumption will increase as shown below:

GAS	CONSUMPTION TODAY m3/t	TODAY Mm3	TODAY TDM	IN FUTURE m3/t	IN FUTURE Mm3	IN FUTURE TDM
OXYGEN	5.0	120	24	12	200	40
NITROGEN	0	0	0	5	120	36
ARGON	0	0	0	6	144	288
TOTAL		120	24	23	464	364

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After the introduction of CONVERTER technology and due to the switch in production from carbon steels (GROUP 1.) to medium- and high-alloy steels (GROUP 2. + 7.), there will be an increase in alloys consumption:

4.3.2. CONSUMPTION OF DOMESTIC ALLOYS IN TON/YEAR

	D O M E S T I C A L L O Y S								
	FeSi	CaSi	FeCrHC	FeCrLC	FeMnHC	FeMnLC	SiMn	Ni	Al
	t/year								
TODAY	185	15	228	70	298	45	99	30	85
FUTURE	162	11	823	70	323	10	48	200*	181

* as domestic manufacture FeNi with < 1% S !

4.3.3. CONSUMPTION OF IMPORTED ALLOYS IN TON/YEAR

	I M P O R T E D A L L O Y S								
	FeMnLC	FeMo	Ni-Metall	FeV	FeTi	CaSi WIRE	Al WIRE	FeB WIRE	FeNb WIRE
	t/year								
TODAY	0	15	30	3	1	0	0	0	0
FUTURE	3	80	122	4	5	10	5	2	5

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4.3.4. IMPORTED REFRACTORY MATERIAL

As for the refractories, for the MF-IF there has to be used high-quality material, quantity of which is 50 t/year and costs of 100 TDM/year.

For CONVERTER lining, domestic dolomite or magnesite bricks are used, the quantities of which are 1 000 t/year & out of which 5 % must be imported - Tuyeres lining - 50 t/year.

For ladle linings, domestic material with < 30 % SiO_2 which prevents metall-lining reaction is used.

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TABLE 1.

TODAY & FUTURE PROCESS PROGRAMME FOR "JELSINGRAD" STEEL FOUNDRY , BANJA LUKA

TYPE	ANNUAL PRODUCTION TODAY CASTINGS TON	PERCENT	WITH CONVERTER CASTINGS TON	PERCENT
1. CARBON STEEL (C-cl)	6 800	56.5	3 000	25.0
2. MANGANESE STEEL (Mn-cl)	600	5.0	1 200	10.0
3. LOW-ALLOY STEEL (Cr-Mo-cl)	1 550	12.9	1 200	10.0
4. LOW ALLOY STEEL (2 MnT-cl)	450	3.8	600	5.0
5. HIGH-ALLOY STEEL (Cr-Ni-cl)	100	0.8	1 200	10.0
6. HIGH-ALLOY STEEL (Cr-grind balls)	300	2.5	600	5.0
7. MICRO-ALLOY STEEL (HSLA-STEEL)	2 020	16.8	3 600	30.0
8. OTHER	200	1.7	600	5.0
TOTAL	12 000	100.0	12 000	100.0

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TABLE 2.1.

DATA FOR COMPARISON OF PRODUCTION COSTS OF
TODAY : CONVENTIONAL EAF
THE FUTURE : EAF & CONVERTER & MF-IF

1. STATUS TODAY AND IN THE FUTURE:

	TODAY	FUTURE
EAF :	4 x 5 t	2 x 5 t
CONVERTER :		1 x 5 t
MFIF :	1 x 2 t	1 x 2 t

2. INVESTMENT COSTS:

	WORTH TODAY	WORTH FUTURE
EAF :	14 000 TDM	5 000 TDM
CONVERTER :	-	2 000 TDM
MF-IF :	1 000 TDM	1 000 TDM

3. AMORTIZATION :

	TODAY	FUTURE
TOTAL CAPITAL OF :	15 000 TDM	8 000 TDM
15% / year :	2 250 TDM	1 200 TDM
DM/t :	94.-	31.30 + 15.60 + 31.30
TOTAL DM/t :	94.-	50.-

TABLE 2.1. CONTINUE

4. WORK* COSTS:

WORK PLACE	TODAY EAF	FUTURE EAF	FUTURE CONV.	FUTURE MFIF	FUTURE TOTAL
OPERATER MELTER	27	6	3	3	12
LADLE-MEN	9	3	0	3	6
CRANE	9	3	3	3	9
SCRAP YARD	9	3	0	3	6
TOTAL	60	15	9	12	36
WORK COST IN TDM/YEAR	1 800	450	270	360	1 080
WORK COSTS IN DM/t	5.-	24.-	14.-	75.-	45.-

* WORK-PLACE COST 30 000.-DM/year

5. PRODUCTION:

	TODAY	FUTURE			
PER DAY IN t	100	80	(80)	20	100
PER YEAR IN t	24 000	19 200	(19 200)	4 800	24 000

TABLE 2.2.

COMPARISON OF PRODUCTION COSTS TODAY AND AFTER INVESTMENT OF CONVERTER IN "JELSINGRAD" STEEL FOUNDRY, BANJA LUKA.

COSTS FOR 1000 kg LIQUID STEEL	PRICE DM/unit	TODAY EAF U/t	TODAY EAF DM/t	FUTURE EAF+CONVERTER U/t	FUTURE EAF+CONVERTER DM/t	FUTURE MFIND-FURNACE U/t	FUTURE MFIND-FURNACE DM/t
1. MELTING							
El.energy	200.-/Mwh	800	160	500	100	650	130
Electrodes	6.-/kg	8	48	4	24	0	0
Work	30000.-/y	60	75	15	24	12	75
Dolomite	1.-/kg	30	30	10	10	0	0
Magnesite	2.-/kg	20	40	10	20	0	0
MFIF mass	2.-/kg	0	0	0	0	10	20
Ladles	1.-/kg	40	40	20	20	40	40
Oxygen	200.-/Mm3	10	2	5	1	0	0
Maintenance	15.-/h	3	45	1	15	1	15
Chem.lab.			15		15		15
Amortization			94		31		31
1. MELTING TOTAL			549.00		260.30		326.30
2. TREATMENT OF "SECONDARY METALLURGY"							
Work	30000.-/y			15	14	0	0
Oxygen	200.-/Mm3			10	2	0	0
Argon	2.-/m3			5	10	1	2
Nitrogen	300.-/Mm3			5	1.5	0	0
Compr.air	100.-/Mm3			5	0.5	0	0
Al for heating	3.-/kg			8	24	0	0
Dolomite	1.-/kg			20	20	0	0
Magnesite	2.-/kg			10	20	0	0
Ladles	1.-/kg			10	10	0	0
Maintenance	15.-/h			1	15	0	0
Amortization					15.6	0	0
2. TOTAL "SEC.METALLURGY"					132.6		2
TOTAL 1. + 2.			549.-		392.40		328.30

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TABLE 3.

COMPARISON OF CHARGE COSTS: GROUP 1.
CARBON STEEL

GRADE	C	Si	Mn	P	S	Al
TARGET	0.25	0.45	0.80	0.020	0.010	0.040

COSTS FOR 1000 kg LIQUID STEEL:

CHARGE	PRICE	TODAY EAF		FUTURE EAF+CONV.		FUTURE MFIND-FURN	
	DM/Unit	U/t	DM/t	U/t	DM/t	U/t	DM/t
1. Riser	280.-/t	500	140	0	0	1020	285.6
2. Purchased	200.-/t	650	130	950	190	0	0
3. Turnings	100.-/t	0	0	100	10	0	0
4. FeSi	180.-/%kg	10	18	6	10.8	3	5.4
5. CaSi	550.-/%kg	1	5.5	1	5.5	1	5.5
6. FeMnHC	150.-/%kg	6	9	0	0	1	1.5
7. SiMn	150.-/%kg	4	6	4	6	4	6
8. Al	4.-/kg	4	16	1	4	2	8
9. Coke	1.-/kg	5	5	5	5	1	1
10. Other			10		5		5
TOTAL METALLIC CHARGE			339.50		236.30		318.0
1. Lime	200.-/t	30	6	40	8	0	0
2. Limestone	50.-/t	30	1.5	30	1.5	0	0
3. Iron ore	200.-/t	15	3	15	3	0	0
4. Diverse			2		1		20
TOTAL NON METALLIC CHARGE			12.50		13.50		20
TOTAL			352.-		249.80		338.-

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TABLE 4.

COMPARISON OF CHARGE COSTS : GROUP 2.
MANGANESE STEEL

GRADE	C	Si	Mn	P	S	Cr	Al
TARGET	1.20	0.40	12.50	0.050	0.010	1.50	0.100

COSTS PER 1000 kg LUQUID STEEL

CHARGE	PRICE DM/Unit	TODAY EAF U/t	TODAY EAF DM/t	FUTURE EAF+CONVERTER U/t	FUTURE EAF+CONVERTER DM/t	FUTURE MFIND-FURN U/t	FUTURE MFIND-FURN DM/t
1. Riser 12Mn	400.-/t	500	200	0	0	1000	400
2. Purchased	200.-/t	550	110	900	180	0	0
3. FeCrHC	2.-/kg	14	28	25	50	5	10
4. FeSi	1.8/kg	15	27	7	12.6	7	12.6
5. FeMnHC	1.5/kg	95	142.5	170	255	20	30
6. SiMn	1.5/kg	10	15	10	15	20	30
7. Al	4.-/kg	5	20	2	8	3	12
8. Other			20		10		10
TOTAL METALLIC CHARGE			562.50		510.60		504.60
1. Lime	200.-/t	60	12	60	12	0	0
2. Other			10		5		20
TOTAL NON METALLIC CHARGE			22		17		20
TOTAL CHARGE			584.50		527.60		524.60

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TABLE 5.

COMPARISON OF CHARGE COSTS: GROUP 3.
LOW-ALLOY Cr-Mo STEEL.

GRADE	C	SI	Mn	P	S	Cr	Ni	Mo	Al
TARGET	0.25	0.45	0.65	0.010	0.010	1.20	0.60	0.30	0.050

COSTS FOR 1000 kg LIQUID STEEL

CHARGE	PRICE	TODAY		FUTURE			
		EAF		EAF+CONVERTER		MFIND-FURN	
	DM/Unit	U/t	DM/T	U/t	DM/t	U/t	DM/t
1. Reiser CrMo	400.-/t	500	200	0	0	1020	408
2. Purchase	200.-/t	600	120	1000	200	0	0
3. FeSi	1.8/kg	10	18	6	10.8	3	5.4
4. CaSi	5.5/kg	2	11	1	5.5	1	5.5
5. FeMnHC	1.5/kg	8	12	2	3	4	6
6. FeCrHC	2.-/kg	20	40	20	40	2	4
7. FeMo	20.-/kg	2	40	3	60	1	20
8. Ni-Metall	20.-/kg	3	60	1	30	1	30
9. FeV, FeTi	30.-/kg	2	60	1	30	1	30
10.Other			20		10		10
TOTAL METALLIC CHARGE			581.-		439.30		508.90
1. Lime	200.-/t	50	10	40	8	0	0
2. Limestone	50.-/t	30	1.5	30	1.5	0	0
3. Iron ore	200.-/t	15	3	15	3	0	0
4. Others			2		1		20
TOTAL NON METALLIC CHARGE			16.50		13.50		20.-
TOTAL			597.50		452.80		528.90

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TABLE 6.

COMPARISON OF CHARGE COSTS : GROUP 4.
LOW-ALLOY Mn-STEEL

GRADE	C	Si	Mn	P	S	Al
TARGET	0.15	0.45	1.30	0.020	0.010	0.050

COSTS FOR 1000 kg LIQUID STEEL

CHARGE	PRICE DM/Unit	TODAY EAF U/t	TODAY EAF DM/t	FUTURE EAF+CONVERTER U/t	FUTURE EAF+CONVERTER DM/t	FUTURE MFIND-FURN U/t	FUTURE MFIND-FURN DM/t
1. Riser 2Mn	300.-/t	500	150	0	0	1020	306
2. Purchase	200.-/t	600	120	1000	200	0	0
3. FeSi	1.8/kg	10	18	6	10.8	3	5.4
4. CaSi	5.5/kg	2	11	1	5.5	1	5.5
5. FeMnHC	1.5/kg	24	36	20	30	5	7.5
6. SiMn	1.5/kg	5	7.5	3	4.5	3	4.5
7. Al	4.-/kg	4	16	2	8	2	8
8. Others			20		10		10
TOTAL METALLIC CHARGE			378.50		268.80		346.90
1. Lime	200.-/t	30	6	40	8	0	0
2. Limestone	50.-/t	30	1.5	30	1.5	0	0
3. Iron ore	200.-/t	30	6	30	6	0	0
4. Others			5		2		20
TOTAL NON METALLIC CHARGE			18.50		17.50		20.-
TOTAL			397.-		286.30		366.90

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TABLE 7.

COMPARISON OF CHARGE COSTS : GROUP 5.
HIGH-ALLOY Cr-Ni STEEL.

GROUP	C	SI	Mn	P	S	Cr	Ni	Al
TARGET	0.40	1.50	0.80	0.040	0.010	25.0	20.0	0.05

COSTS FOR 1000 kg LIQUID STEEL

CHARGE	PRICE	T O D A Y EAF		F U T U R E EAF+CONVERTER		MFIND-FURN	
	DM/Unit	U/t	DM/t	U/t	DM/t	U/t	DM/t
1. Riser CrNi	5.-/kg	500	2500	0	0	1030	5150
2. Purchase	200.-/t	450	90	600	120	0	0
3. FeSi	1.8/kg	30	54	20	36	5	9
4. FeCr HC	2.-/kg	150	300	350	700	0	0
5. FeCr LC	4.-/kg	50	200	10	40	50	200
6. FeMn HC	1.5/kg	0	0	10	15	0	0
7. FeMn LC	3.5/kg	10	35	0	0	5	17.5
8. Ni-Metall	20.-/kg	120	2400	210	4200	10	200
9. Al	4.-/kg	4	16	2	8	2	8
10. Others			50		25		30
TOTAL METALLIC CHARGE			5645.-		5144.-		5114.50
1. Lime	200.-/t	150	30	100	20	0	0
2. Others			20		5		20
TOTAL NON METALLIC CHARGE			50.-		25.-		20.-
TOTAL			5695.-		5169.-		5134.50

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TABLE 8.

COMPARISON OF CHARGE COSTS : GROUP 6.
HIGH-ALLOY Cr STEEL, GRIND BALLS

GRADE	C	Si	Mn	P	S	Cr	Mo	Ni	Al
TARGET	3.0	0.80	0.80	0.050	0.020	18.0	1.80	1.00	0.05

COSTS FOR 1000 kg LIQUID STEEL

CHARGE	PRICE	TODAY		FUTURE			
		EAF		EAF+CONVERTER		MFIND-FURN	
	DM/Unit	U/t	DM/t	U/t	DM/t	U/t	DM/t
1. Riser Cr	1200.-/t	500	600	0	0	1020	1224
2. Purchase	200.-/t	400	80	750	150	0	0
3. FeSi	1.8/kg	15	27	10	18	5	9
4. CaSi	5.5/kg	2	11	1	5.5	1	5.5
5. FeCr HC	2.-/kg	150	300	280	560	15	30
6. FeMn HC	1.5/kg	10	15	5	7.5	3	4.5
7. FeMo	20.-/kg	10	200	20	400	1	20
8. Ni-Metall	20.-/kg	5	100	10	200	1	20
9. Al	4.-/kg	4	16	0	0	0	0
10. Others			20		10		20
TOTAL METALLIC CHARGE			1369.-		1351.-		1333.-
1. Lime	200.-/t	60	12	40	8	0	0
2. Others			20		5		20
TOTAL NON METALLIC CHARGE			32.-		13.-		20.-
TOTAL			1401.-		1364.-		1353.-

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TABLE 9.

COMPARISON OF CHARGE COSTS : GROUP 7.
MICRO-ALLOY STEEL HSLA

GRADE	C	SI	MN	P	S	Cr	Mo	Ni	V	Al
TARGET	0.20	0.40	0.70	0.010	0.010	1.50	1.00	0.60	0.20	0.050

COSTS FOR 1000 kg LIQUID STEEL

		TODAY		FUTURE			
CHARGE	PRICE	EAF		EAF+CONVERTER		MFIND-FURN	
	DM/Unit	U/t	DM/t	U/t	DM/t	U/t	DM/t
1. Riser CrMo	450.-/t	500	225	0	0	1020	459
2. Purchase	200.-/t	500	100	1000	200	0	0
3. FeSi	1.8/kg	10	18	6	10.8	3	5.3
4. CaSi	5.5/kg	2	11	1	5.5	1	5.5
5. FeCr HC	2.-/kg	18	36	20	40	0	0
6. FeCr LC	4.-/kg	0	0	0	0	3	12
7. FeMn HC	1.5/kg	10	15	4	6	0	0
8. FeMn LC	3.5/kg	0	0	0	0	5	17.5
9. FeV	30.-/kg	2	60	1	30	1	30
10.FeMo	20.-/kg	5	100	10	200	1	20
11.Ni-Metall	20.-/kg	2	40	4	80	1	20
12.Al	4.-/kg	4	16	2	8	2	8
13.Others			15		5		20
TOTAL METALLIC CHARGE			626.-		585.30		597.30
1. Lime	200.-/t	50	10	40	8	0	0
2. Limestone	50.-/t	30	1.5	30	1.5	0	0
3. Iron ore	200.-/t	10	2	10	2	0	0
4. Others			20		5		20
TOTAL NON METALLIC CHARGE			33.50		16.50		20.-
TOTAL			659.50		601.80		617.30

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TABLE 10.

COMPARISON OF COST SAVINGS AFTER INVESTMENT OF "CONVERTER".

1. SAVINGS BY REDUCTION OF PRODUCTION COSTS

	UNIT	TODAY EAF	IN FUTURE EAF+CONVERTER	IN FUTURE MFIND.FURNACE
PRODUCTION	T/YEAR	24 000	19 200	4 800
PRODUCTION COSTS	DM/T	549.-	392.90	328.30
SAVINGS	DM/T	0	- 156.10	- 220.70
TOTAL	DM/YEAR		2 997 120.-	1 059 360.-
SAVINGS TOTAL	DM/YEAR		4 056 480.-	

TABLE 11.

COMPARISON OF COST SAVINGS AFTER INVESTMENT OF "CONVERTER".

2. SAVINGS BY REDUCTION OF CHARGE COSTS

PRODUCTION				TODAY	IN FUTURE			
				EAF	EAF+CONVERTER		MFIF	
	TOTAL	EAF+	MFIF	DM/t	SAVINGS	SAVINGS	SAVINGS	SAVINGS
GROUP		CONV.			DM/t	DM	DM/t	DM
1.	6000	6000	0	352.00	-102.20	613 200	- 14.00	0
2.	2400	400	2000	584.50	- 56.90	22 760	- 59.90	119 800
3.	2400	2400	0	597.50	-144.70	347 280	- 68.60	0
4.	1200	1200	0	397.00	-110.70	132 840	- 30.20	0
5.	2400	1000	1400	5695.00	-526.00	526 000	-561.00	785 400
6.	1200	0	1200	1401.00	- 37.00	0	- 48.00	57 600
7.	7200	7200	0	659.50	- 57.70	415 440	- 42.20	0
8.	400	200	200	?	?	?	?	?
	24000	19200	4800			2 057 520		961 800

TOTAL SAVINGS PER ANNUM 3 019 320.- DM

TABLE 12.

RESOURCE OF ENERGY, REFRACTORY, FERROALLOYS AND OTHERS MATERIALS FOR "JELSINGRAD" STEEL FOUNDRY BANJA LUKA.

MATERIAL		UNIT	USAGE IN EAF U/t	USAGE IN EAF U/year	USAGE IN EAF+CONVERTER + MFIF U/t	USAGE IN EAF+CONVERTER + MFIF U/year	RESOURCE IN
1.	MELTING						
1.1.	El.energy	MWh	787	19 000	530	13 000	YU
1.2.	Electordes	kg-ton	8	192	4	80	YU
2.1.	Dolomite	kg-ton	30	720	50	960	YU
2.2.	Magnesite	kg-ton	20	500	10	200	YU
2.3.	Mass for IF	kg-ton			10	50	IMPORT
2.4.	Ladles mass	kg-ton	40	960	24	576	YU
2.	METALLIC CHARGE						
3.1.	Purchase	kg-ton	550	13 200	450	10 800	YU
4.1.	FeSi	"	7.7	185	6.8	162	YU
4.2.	CaSi(wire)	"	0.6	15	0.9	21	IMPORT
4.3.	FeCrHC	"	9.5	225	34.3	823	YU
4.4.	FeCrLC	"	2.9	70	3.0	70	YU
4.5.	FeMnHC	"	12.4	298	13.5	323	YU
4.6.	FeMnLC	"	1.8	45	0.5	13	IMPORT
4.7.	SiMn	"	4.1	92	2.0	48	YU
4.8.	FeMo	"	0.6	15	3.3	80	IMPORT
4.9.	Ni-Metall	"	2.5	60	13.9	322	YU
4.10.	FeV, FeTi, FeB	"	0.3	5	0.6	14	IMPORT
4.11.	Al	"	3.5	85	7.5	181	YU
TOTAL			595.8	14 300	535.7	12 857	
3.	NON METALLIC CHARGE						
5.1.	Lime	"	40	960	40	768	YU
5.2.	Limestone	"	30	720	20	576	YU
5.3.	Iron ore	"	30	720	20	576	YU
5.4.	Other	CONVERTER + MFIF 192 TDM					YU
TOTAL			100	2 400	80	1 920	

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FEASIBILITY STUDY

FOR STEEL FOUNDRY "JELSINGRAD", BANJA LUKA

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FEASIBILITY STUDY
FOR STEEL FOUNDRY "JELSINGRAD", BANJA LUKA

1. INTRODUCTION

The goal of this feasibility study is to give the evaluation of the most acceptable, techno-economic way of further development of melting shop in "JELSINGRAD" Steel Foundry, Banja Luka. The development will be realized by the application of controlled secondary metallurgy process which are the final objective of future melting shop modernisation.

The economic analysis of change in production costs caused by the change of steel production technology accompanied with the introduction of "Secondary Metalurgy" is made in the D.F.R. to evaluate the validity and payability of the investment.

The Feasibility Study comprises the analyses of changes which the introduction of converter technology of different systems will cause and in D.F.R. the effects are written that this technology has on:

- Current and future production assortiment.
- Usage of energy resources, technical gases, refractories, ferro-alloys and other consumable materials.
- Current and future production costs.
- Evaluation of organizational, technical and professional abilities for the application of new technology.
- Expert opinion on improvement of enviromental and working conditions as the consequence of introduction of new technology.
- Expert evaluation of dependence on import of consumable goods and spare parts which new technology requires.
- Installation lay-out- evaluation of investment costs for the new process; equipment specifications and papers necesary for international soliciting for tenders for project investment.

2. CHOICE OF CONVERTER TECHNOLOGY

Converter technology opens new possibilities in the control of steel production, oxidation & refining process. In that respect, it is very difficult to choose the adequate technology according to comparison of investment costs only regardless of production costs of different steel groups.

The choice of equipment does not depend only on the possibility to apply it to the production of as many different steel grades as possible, but also on production and maintenance costs, availability of raw material, etc..

The three (3) well-known converter equipment systems and types of technology will be considered here. The aim is to compare demands and possibilities of applying than in "JELSINGRAD" Steel Foundry, Banja Luka, according to their specific process characteristics.

1. AOD - ARGON OXYGEN DECARBURIZATION PROCESS
   UNION CARBIDE
   INSTALLATION : SALEM, ENGLAND

2. MRP - METALL REFINING PROCESS
   MANNESMANN DEMAG
   INSTALLATION : MANNESMANN DEMAG HÜTTENTECHNIK, DUISBURG, WEST GERMANY

3. VARP - VACUUM ARGON REFINING PROCESS
   THYSSEN
   INSTALLATION : MAN - GUTEHOFFNUNGSHÜTTE OBERHAUSEN, WEST GERMANY

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3.1. AOD - CONVERTER TECHNOLOGY

The best known converter technology for the production of high-alloy Cr- & CrNi- stainless steels is AOD process, patented in USA by UNION CARBIDE 24.07.1962. USA Pat.: 30046107. FIG.1.

Not until to beginning of 1970 did UC manage to improve AOD process the way it exists now; it is done by a series of corrections in process stages, and additional applications of high-quality refractories, asymetric walls, etc., so that current production of high-alloyed Cr- & CrNi- steels in AOD matches the bulk-production of non alloyed steel in BOF converters.

The basic principle of high-alloyed Cr- steel treatment at a low pressure of carbon monoxide CO is that in AOD the injected oxygen is deluted by an inert gas, nitrogen or argon, and in that way decrease the partial pressure of CO.

The equation:

$$C + X.O2 + Y.INERT\ GAS = 2.X.CO + Y.INERT\ GAS$$

$$p_{CO} = \frac{2.X}{2.X + Y} \text{ bar}$$

where : X - portion factor for oxygen volume
Y - portion factor for inertgas volume
p_{CO} - partial pressure of CO gas in melt in bar.

Portion factor indicate the BLOWING RATIO in AOD process, as well as possible : 10:1 .. 1:1 ...to 1 : 10.

Thus enables carbon oxidation without/or with little chromium oxidation, as shown in diagram, FIG. 2.

While at first AOD process was used for high-alloyed Cr-steels, today AOD process is used for refining of most steels & alloys families such as:

- stainless steels, acid resisting-, heat-resisting steels, superalloys,

- steels for electrical engineering industry, dynamo steels, Armco iron, etc.

- tool steels for hot & cold working,

- low-alloy HSLA steels, carbon steels, etc.

AOD process is part of a DUPLEX steelmaking process in which the melt made of steel shop returns, scrap and different alloys is melted in a conventional melting furnace and than, without any carbon reduction transfered to the AOD vessel for decarburization and refining.

Furnaces for melting can be any kind: EAF's, CUPOLA furnaces or INDUCTION furnaces.

During melt treatment in AOD vessel, the process gases, oxygen, nitrogen & argon, are injected through submerged horizontal tuyeres, located in the lower section of the vessel. The total amount i.e. the maximum flow rate of injected gases is 1 m/t.min.

For the high-alloyed Cr- steel production, lowering of partial pressure of CO by blowing an inert gas, nitrogen or argon, promotes carbon removal without excessive oxidation of chromium. This allows using lower-cost high-carbon ferroalloys which lowers the required quantity of twice of expencive low-carbon alloys.

Owing to limited flow rate of injected process gases of 1 m3/t.min , the problem of blowing dissolved oxygen that arises is that there's no enough oxygen to accelerate decarburisation. Thus, when blowing RATIO: oxygen : inert gas, is 1:3, only 0.25 m3 oxygen per ton and minute is injected and the maximal decarburization rate is below of 0.015 %C/min ; consequently decarburization time is considerably longer.

By blowing the process gases through horizontal tuyeres located in the lower part of the vessel, decarburization, deoxidation and steel refining are carried out.

The greatest barrier for using AOD technology in low-alloy steel production has long been significant wall-errosion in the vicinity of tuyeres and which consequently causes high costs for refractory and its repair.

Even greater problem in applying AOD process in low- and medium-alloy steel refining is the phenomenon of negative heat balance, especially when treating heat sizes of about 10 t of molten steel.

With changes in the process itself, application of exothermic effects of oxidation by Al & Si metalls added to the melt, balance of heat losses, and computer control, it has become possible to control thermal and metallurgical balance in AOD vessel.

The introduction of the top lance for an additional oxygen injection has opened the new possibility of CO -> CO2 burning, thus using waste gase energy for heating in the upper part of the vessel. It has also enabled the reduction of heat losses as well as the amount of Al & Si necessary for melt heating. The portion of exothermic alloys that can be saved in this way is unknown.

Nowadays AOD converter process may be used for any heat size between 1 and 150 ton, regardless of the initial composition. Anyway it provides the attainment of the aimed composition, required temperature and highest quality regarding the accurance of non-metallic oxide inclusions and sulphide inclusions with the least possibile content of residual element and gases in steel.

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3.2. MRP CONVERTER TECHNOLOGY

The first European converter produced especially for steelmaking named MRP - Metall Refining Process, has been developed in 1982 at Mannesmann DEMAG Hüttentechnik AG, Duisburg, as a "secondary metalurgy" process for heat sizes of 5 - 130 t . FIG. 3.

MRP has been aimed to open new possibilities in steel production and also for processing smaller heat sizes, since "ladle secondary metalurgy", due to relatively small mass of molten steel inclined to fast cooling, wasn't able to ensure safe and reliable steel refining.

First installations were mounted in 1983 in FRG:

- KARL GROSSMANN STEEL FOUNDRY, Solingen, 8 t MRP vessel,
- PHB STEEL FOUNDRY, St.Ingbert/Saar, 8 t MRP vessel,
- KRAUSS MAFFEI STEEL FOUNDRY, München, 10/20 t MRP vessel.

MRP is also a DUPLEX process. Steel is melted in a primary installation: EAF, CUPOLA furnaces or INDUCTION furnaces, and than poured into an MRP vessel. Process gases are injected through vertical tuyeres located in the bottom of the vessel. The process is automatically controlled by the regulation of process gas flow rate until desired stage of treatment is achieved.

Since each gas passes through the melt the process gases are used stoichimetric, i.e. gas application matches the chemical reaction of certain process phases.

The gases used are: oxygen, nitrogen & argon. In the future, in a special process version named "DIOXY", argon will be partly replaced by carbon dioxid CO_2, especially in countries which do not manufacture argon gas.

For tuyeres protection, while the converter is out of operation, compressed air is used.

The highest flexibility of MRP process can be seen in strong stirring of the melt by injected gases, the flow rate of which is up to 2 m3/t.min, which decreases the necessary time to several minutes, which again reduces the required amount of Al & Si metals for heating.

The advantage of a vertical position of tuyeres in the bottom of the vessel is that erosion of the wall around the tuyeres is considerably reduced, which decreases the consumption of refractory material.

The change of the tuyere position from wall side to bottom & from horizontal to vertical one, increases refractory performance by 100%, i.e. for the same type of steel as compared with the same refractory lining life is doubled.

That is the reason why nowadays the tuyeres position in the AOD vessel is going to be changed from horizontal wall side position to the vertical bottom one.

The introduction of a top lance for oxygen blowing enables burnig of CO --> CO2, and thus allows an additional usage of energy. This lowers heat losses during the blowing up to 30%.

While heating with Al & Si, the large supplies of oxygen whose flow rate is up to 2 m3/t.min makes it possible to rise temperature up to 70 degree C per minute which reduces process time and facilitates better economic proficiency of low-alloy & carbon steel refining process.

The experience has confirmed that MRP technology can successfully be used for any steel production programme and that its advantages are especially useful for the foundries with miscellaneous programmes of high-alloy Cr, low-alloy HSLA & carbon steel production.

In accordance with the demands, in the MRP vessel it is possible to refine any heat size, from 1 t up to 150 t.

Technological potentials of MRP process are the following:

- DECARBURZATION to the aimed values, especially of high-alloy Cr steel to < 0.02 % C. LC- and ELC steel grades.

- DEPHOSPHORIZATION to the aimed values, especially of low- & medium - alloyed and unalloyed steels down to < 0.003 % P = < 30 ppm P.

- DESULPHURIZATION of all types of steel grades to values below solubility limit of sulphur < 0.003 % S = 0.001 % S = 10 ppm S.

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- DEGASSING - hydrogen removal to the values of = < 1 ppm in a converter after decarburization, or to = < 2.5 ppm in a teeming ladle after tapping.

- DEOXIDATION - oxygen removal until a balance after primary deoxidation with Al, Si, Ca is achieved and complete flush of deoxidation products with synthetic slag consisting as the 12 CaO. 6 Al_2O_3 in a protective argon atmosphere.

- ALLOYING of steel to the narrowest alloyig tolerances regardless of ferroalloys quality in respect of carbon content.

- HEATING of steel, temperature control, until desired temperature for casting is achieved.

As the result of the above mentioned technological possibilities, the steel production in MRP converter process possess the following properties:

- All MECHANICAL PROPERTIES, toughes especially, are improved.

- Significantly LOW SEGREGATION, especially of sulphur which is reduced to the values below the solubility limit.

- ELIMINATION of HOT FEARING.

- Complete ELIMINATION OF FLAWS caused by gases in steel.

For getting better insight in working conditions operating potentials, economic efficiency and other operating parameters see TABLE 13. in which the results of:

COMPARISON OF OPERATING COSTS FOR AOD, MRP & VARP (6 t) CONVERTERS, the annual production being 24 000 t of medium-alloy steel such as HSLA steels.

is given.

3.3. VACUUM CONVERTER TECHNOLOGY

The application of VACUUM in steelmaking with "secondary metallurgy" equipment has been known for 50 years now.

The process is based on molten steel treatment in a ladle under low pressure = vacuum, which causes a decrease in the partial pressure of CO during oxidation of high-alloyed Cr - steels.

Vacuum in converter process has first been introduced in 1973 at:

THYSSEN EDELSTAHLWERKE, Witten, West Germ., with 35 t converter:

> "In order to lower the partial pressure of CO at the end of atmospheric decarburization in a converter, and thus perform carbon oxidation using oxygen dissolved in slag & metall."

Due to the very convenient working conditions and good chromium reduction and chromium yield, thus process is used for high-alloy Cr steels and a production of ferroalloys in following steel shops:

- THYSSEN EDELSTAHLWERKE, Witten, West Germ, 35 t VODC 1973,
- UGINE, ARDOISE, France, 30 t VODC 1979.
- LOKOMO, NELES OY, Tampere. Finland, 12 t VODC 1981.

3.3.1. VARP - VACUUM ARGON RAFFINATION PROCESS.

A completely new type of vacuum technology is the installation of 15 t VARP convertor in the foundry of THYSSEN:

FRIEDRICH WILHELM HÜTTE, Mülheim, West.Germ. 15 t VARP , 1983.

This type of converter is used for the production of low- and medium-alloy steels (80 %), austenitic stainless steels (5%) and grinding steels (15%) in FWH THYSSEN Foundry, Mülheim.

Since melting installations of ca. 14 t have the capacity bigger than the usual heat sizes for casting between 5 - 10 t, each heat is at the end of the process divided into two different steel grades and tapped into two ladles.

Such specific demands make the production costs higher than those for AOD or MRP converter process. Comparison of the production costs is shown in TABLE 13.

The increase of production costs of :

+ 68.-DM/t

as compared to AOD and MRP, is due to higher melting costs caused by an additional adjustment of required carbon content & temperature for further VARP processing.

Steel treatment in VARP converter requires more time and also more Al & Si for heating which greatly reduces the performance of refractory linings.

As compared to AOD & MRP technologies the production costs of 216.50 DM/t are higher by:

+ 106.25 DM/t and + 64.85 DM/t

respectively the MRP & AOD costs.

The COMPARISON OF Production COSTS different Processes is given in the above TABLE:

PROCESS	MELTING DM/t	CONVERTOR DM/T	TOTAL DM/t	DIFFERENCE DM/T
AOD	265.05	151.65	416.70	+-00
MRP	265.05	110.25	375.30	- 41.40
VARP	323.05	216.50	539.55	+ 122.85

Expert opinion is that VARP is an interesting process because it is entirely carried out in vacuum and consequently there's no need to eliminate waste gases.

The investment for introduction of vacuum installation equals the costs of waste gases elimination in atmospheric-type converters.

The positive aspect of vacuum treatment especially for undeveloped countries which do not have gas industry, is that total argon consumption for the process is only < 1 m3/t.

VARP process is also a DUPLEX process. In order to shorten tap-tap time in the melting furnace for low-alloy steels, the heat has to be prepared for the vacuum treatment.

In FWH foundry the steel is melted in an EAF & after dephosphorization with oxygen, decarburization to lower carbon level is carried out. After that, the melt is heated in a furnace to the temperature of 1700 C, tapped in a transfer ladle from which it is then charged into the VARP vessel for vacuum treatment.

The VARP vessel resembles AOD or MRP one, same that on the upper conical part there's an additional flange for a vessel cover = vacuum cover.

For stirring and mixing the melt, about 50 l argon/min is supplied throug the vessel bottom, which gives excellent working conditions under vacuum pressure.

Oxidation is performed by blowing oxygen through a water-cooled supply lance at the rate of max. 0.5 m3/t.min. Since there's no other possibility to perform oxidation in a converter, oxygen for heating by Al & Si must be blown from above.

Metallic and non metallic additions can be made to a converter during the process time by vacuum hopper as an alloying device. Sampling and temperature measurements are performed when the vessel is opened.

After finishing the process, the vessel gets opened, refined steel is tapped in a teeming ladle where trimming and final deoxidation are carried out. Common to all converters and consequently to the VARP one, is the problem of atmospheric tapping in a ladle since excessive temperature losses and melt reoxidation take place.

High temperature losses during vacuum process require high temperature which badly influences the performance of refractory linings and operating costs as well.

The flexibility of the process is limited because of the fact the converter during the process itself is completely closed. The relative low stirring rate causes low mixing energy (rate of 50 l/min) and adjustment of temperature or composition takes time of about 3 min. In atmospheric conditions the slag mixing, metallic & lime additions, heating by Al & Si oxidation is not possible.

For each process step in the production of high-alloyed Cr steel and stainless steel, it is necessary to obtain an adequate low working pressure (vacuum) and then by blowing oxygen induces slag/metall stirring.

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Thanks to computer monitoring of the process and good vacuum installations, the process today gives satysfactory results that conform to the highest quality demands:

- LOW SULPHUR content in steel < 0.005 % S

- LOW CONTENT OF GASES :

  OXYGEN activity < 4 ppm
  HYDROGEN content < 2 ppm
  NITROGEN content < 50 ppm unalloyed
  " Cr-STEEL < 100 ppm

- IMPROVED MECHANICAL PROPERTIES:

  TOUGHNESS + 100 %
  EXTENSION + 25 %

- SURFACE FLOWS REDUCTION:

  NONE HOT TEARING,
  NONE POROSITY,
  NONE SHATTER CRACKS etc.

- RELIABLE CHEMICAL COMPOSITIONS:

  NONE WRONG COMPOSITION

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TABLE 13.

COMPARISON OF OPERATING COSTS FOR AOD, MRP & VARP CONVERTERS (6t).

THE ANNUAL PRODUCTION 24 000 t OF MEDIUM ALLOY STEELS SUCH AS HSLA STEELS.

PER 1000 KG LIQUID STEEL

	PRICE	AOD EAF+AOD		MRP EAF+MRP		VARP EAF+VARP	
	DM/Unit	U/t	DM/t	U/t	DM/t	U/t	DM/t
1. MELTING IN EAF							
1. El.energy	200.-/MWh	500	100	500	100	650	130
2. Electrodes	6.-/kg	4	24	4	24	5	30
3. Work	30000.-/year	15	18.8	15	18.8	15	18.8
4. Dolomite	1.-/kg	10	10	10	10	15	15
5. Magnesite	2.-/kg	10	20	10	20	15	30
6. Ladles	1.-/kg	20	20	20	20	20	20
7. Oxygen	200.-/Mm3	5	1	5	1	15	3
8. Maintenance	15.-/h	1	15	1	15	2	30
9. Chem.Lab.			15		15		15
10.Amortization	5 Mio		31.3		31.3		31.3
1. MELTING TOTAL			265.05		265.05		323.05

TABLE 13.

CONTINUED

PER 1000 KG LIQUID STEEL

	PRICE DM/Unit	AOD EAF+AOD U/t	AOD EAF+AOD DM/t	MRP EAF+MRP U/t	MRP EAF+MRP DM/t	VARP EAF+VARP U/t	VARP EAF+VARP DM/t
2. SECONDARY METALLURGY							
1. Work	30000.-/year	9	11.25	9	11.25	12	15.-
2. Oxygen	200.-/Mm3	12	2.40	10	2.-	15	3.-
3. Argon	2.-/m3	10	20.-	2	4.-	1	2.-
4. NITROGEN	300.-/Mm3	3	0.90	10	3.-	0	0
5. Compr.air	100.-/Mm3	5	0.50	5	0.50	0	0
6. Steam	100.-/t	0	0	0	0	0.2	20.-
7. Dolomite	1.-/kg	40	40.-	20	20.-	40	40.-
8. Magnesite	2.-/kg	0	0	0	0	10	20.-
9. Ladles	1.-/kg	10	10.-	10	10.-	10	10.-
10.Al-heating	4.-/kg	10	40.-	8	32.-	16	64.-
11.Maintenance	30.-/h	0.5	15.-	0.5	15.-	1	30.-
12.Amortization	2 Mio		12.50		12.50		12.50
2. TOTAL SECONDARY METALLURGY			151.65		110.25		216.50
TOTAL 1. + 2.			416.70		375.30		539.55

5. PROPOSAL FOR A CONVERTER PROCESS TO BE APPLIED IN "JELSINGRAD" STEEL FOUNDRY, BANJA LUKA.

5.1. BASIC MATERIAL

Basic materials are similar to the ones for the EAF process, except that new materials containing impurities such as : P, S, C, As, Pb, Zn, etc. can be also used.

EAF + CONVERTER combination easily reduces such impurities. In that way, all discarded metal scraps, sponge iron, etc. can be used although such metarial has never been used before.

5.2. MELTING FURNACE PURPOSE

The purpose of the EAF furnace is only melting; hence, heavy strain on workers and excessive load of refractory linings are avoided.

Further, EAF is not used for metallurgical treatment any longer, so that the number of highly schooled workers and experts necessary for steelmaking process will be reduced.

5.3. CONVERTER PROCESS

A converter process is automatic; workers perform only control operations envisaged by the workplan:

- usage and choice of process gases
- slag preparation
- sampling
- alloy preparation etc.

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Since the metter's working place is at control console, he is not exposed to noise, heat and dust any more. Besides, the process being automatic the high-working skill is not required.

The converter vessel is placed in a closed room connected with an installation for waste gas elimination. Thus, the vessel cannot pollute the working environment with dust and gases either during oxidation and melt treatment, or charging and tapping, since it is completely isolated from the workly environment.

5.4. PROPOSAL FOR CONVERTER PROCESS AND INSTALLATION.

On the basis of technological potentials, comparison of production costs and processes themselves, the following proposal for the introduction of converter technology in "JELSINGRAD" Steel Foundry, Banja Luka , could be made:

1. The process itself influences the choice of installation only when a vacuum process is concerned. According to operating costs for vacuum converter technology and the foundry production programme which includes mainly low-, and medium-alloy steels:

   "VARP VACUUM CONVERTER" ist out of question.

2. Atmospheric converter processes AOD and MRP, can use almost the same vessel, the differences only being in :
   - CONVERTER DESIGN,
   - GAS SUPPLY SISTEM,
   - TUYERES POSITION
     AOD- vessel has tuyeres located horizontally in the lower part, whereas MRP vessel has ones located vertically in the bottom part.

   Refractory material costs show the difference of: + 20.-DM/t for AOD converter. That's the reason why we find that vertical way of bottom gas blowing MRP is better than the horizontal one of AOD.

6. GAS CONTROL IN ATMOSPHERIC CONVERTERS IS SIMILAR.

6.1. AOD - GAS CONTROL

With AOD control of process gases, the gas amount in a protective tuyere pipe (shroud) always equals about:

SHROUD (PROTECTION) GAS FLOW RATE = 0.20 m3/t.min

The middle or PROCESS tuyere pipe contains the appropriate mixture of oxygen and an inert gas. The amount of which is about:

PROCESS GAS FLOW RATE = 0.80 m3/t.min

Thus, the total amount of process and shroud gas in AOD vessel equals:

TOTAL GAS FLOW RATE = < 1 m3/t.min

For that reason, the ratio of oxygen to inert gas O2 : INERT (maximum) 4 : 1 and can be changed to 3:1, 2:1, 1:1, 1:2, 1:3, 0:1 etc., depending on the operating stage of oxidation in AOD vessel and on the need to lower the partial pressure by dissolving oxygen with an inert gas.

The neutral gas supplyed to the process tuyeres pipe and the oxygen amount in the mixture is thus reduced. Reduction of oxygen in the process gas, the amount of which is up to 0.80 m3/t.min, badly influences rate of the process, particularly decarburization.

6.2. MRP - GAS CONTROL

The MRP vessel does not use the mixture of gases in the process or shroud pipe device but only pure gases. It is a neutral gas that is always supplied through the shroud tuyere pipe:

SHROUD GAS FLOW RATE = 0.1 m3/t.min

Throgh the middle process tuyere pipe only one gas is supplyed, either oxygen or inert gas, to the amount of:

PROCES GAS FLOW RATE = max. 2 m3/t.min

The total amount of process and shroud gases equals:

TOTAL GAS FLOW RATE = max. 2 m3/t.min

Hence, in MRP vessel the ratio O2:INERT Gas is between 20:1 and 10:1 depending only on oxygen amount regardless of oxidation stage of the process.

Reduction in the partial pressure is obtained by a process patented under name" PULSATING BLOWING" i.e. by alternating blowing of oxygen and inert gas. Thus, as compared to AOD process, decarburization by MRP process is 2.5 to 10 times higher.

An additional oxygen lance enables burning of resulting CO into CO2. As in AOD process, it leads to the heating of melt as well as refractories in the vessel.

7. CONVERTER DESIGN AND PARAMETERS.

According to data in TABLE 13. and technological process itself, the design and parameters of the converter to be installed have to be decided upon.

The proposal given in TABLE below should serve as a condition while placing the purchase order for equipment for "JELSINGRAD" Steel Foundry, Banja Luka.

1. CONVERTER DESIGN :	SYMETRIC
2. CONVERTER OPERATING VOLUME:	0.5 m3/t or ca. 3 m3
3. GAS BLOWING:	VERTICALLY
4. NUMBER OF TUYERES:	TWO (2)
5. TUYERE POSITION:	VERTICAL AT THE BOTTOMM OF VESSEL
6. GAS FLOW RATE:	SHROUD < 2 m3/min = 120 m3/h PROCESS <12 m3/min = 600 m3/h
7. ADDITIONAL DEVICE:	OXYGEN LANCE < 12 m3/min = 600 m3/h

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8. EQUIPMENT SPECIFICATION FOR CONVERTER PLANT "JELSINGRAD", STEEL FOUNGRDY, BANJA LUKA

A converter plant serves for "secondary metallurgy" treatment of low-, medium- & high-alloy steels for "JELSINGRAD", Steel Foundry, Banja Luka.

Regardless of the decision who will be chosen supplier of the equipment, attention must be paid to the possibilities that this equipment opens for the further development of the foundry itself.

Main components of the modern converter system are the following:

1. CONVERTER VESSEL
2. TRUNNION RING WITH DRIVE SYSTEM FOR VESSEL TILTING
3. CONTROL & SUPPLY OF PROCESS GASES TO TUYERES & LANCE
4. ALLOYING DEVICE
5. OPERATING PLATFORM
6. CONTROL CONSOLE
7. BURNER FOR VESSEL DRYING & HEATING
8. ENVIROMENT PROTECTION & SYSTEM FOR WASTE GASE CLEANING
9. COMPUTER FOR PROCESS CONTROL

Since all these components can be either imported or manufactured in the country itself according to the supplyer's drafts, the perfection of their structure and correspondence to each other regarding the desired steel refining process, should be ensured as soon as the order is made and not after delivery itself.

8.1. CONVERTER VESSEL

The possibility of intercharging the vessel should be considered in advance, so that in cause of capacity extention, the costs of new investment could be reduced and the production capacity and the productivity increased.

The vessel consist of 3 parts : upper, middle and bottom.

The UPPER part is of a symetric conical shape and attached to the part by flange. In case of transfer of a lined vessel, attention should be paid to lining weight and crane and crane track girder capacity.

Parts for vessel transfer are welded on the cone. For the protection of connecting elements (screws, nuts etc.) the flange is completely covered with protective segments.

The MIDDLE part of the vessel is of a cylindrical shape and welded to a BOTTOM to make a whole. In the middle of the vessel bottom there are tuyeres opening.

For transfer and tapping of an empty or lined vessel, the adequate elements for hoist lifting should be installed. Material specification for the vessel anticipates 15-20 mm thick plate for steam boilers AST 41 acc. to DIN 17135.

For gas and moisture evolving during drying or vessel operation, the vessel should have at least 4 holes per m3 of area, diameters of which are 10 mm.

8.2. VESSEL ROTATION

The vessel is mounted and joined to the trunnion ring by connecting elements. In that way the vessel is free to move upwards and downwards and can be rotated for 360 degree by driving system for rotation whose main gear is attached to one side of the ring.

The ring is of welded construction fabricated from steel plate for boilers H II and has two axles forget of 25 CrMo steel or other similar material.

One of the axles carries the gear for vessel rotation while the other is perforated for process gas supply to each separate tuyeres. Both axles are located in ball bearings which enable vessel rotation around them.

Drive system is provided with an electrical motor and additional gears; in case of power failure the manual rotating or rotating by nitrogen or compressed air drive motor schould be provided.

The speed of rotation : 0.1 - 1 rpm.

8.3. CONTROL & SUPPLY OF PROCESS GASES.

Gas control system must have the ability to precisely measure the quantity of injected gases and digitally display the results on the control panel.

It is necessary to determine the oxygen flow rate for the unit of time , minute, and the total oxygen amount for each process phase. Since the process is calculated stoichimetrically the main process indicator should be oxygen consumption.

Other gases, argon and nitrogen, are also measured and their total consumption is recorded on a counter.

The control panel should also contain display for pressure, quality and quantity of gas in a shroud and process tuyeres pipes, recording the obtained results on a printer.

The AOD process needs an automatic control of O2:INERT GAS ratio, which is to be performed by a control switch.

As for supply system, to a connecting tuyeres pipe at the bottom of the vessel there has to be provided gas supply through a ring axle, for each gas in tuyeres two pipes. Gas supply pipes must not hinder the vessel rotation of 360 degree.

An oxygen supply pipe for a lance must not hinder the normal converter operation when the lance is not used.

Gas control system is to envisage the following gas rates:

A - TUYERES

NUMBER OF TUYERES:	TWO (2)
TUYERES PIPE DIA :	NOT KNOWN
GAS FLOW RATE :	SHROUD 1 - 2 m3/min for Ar, N2 etc.
	PROCESS < 12 m3/min for O2 + INERT
	COOLING 100m3/h COMPRESSED AIR

B- OXYGEN LANCE

OXYGEN BLOW RATE :	12 m3/min for O2
BLOWING PIPE DIA :	NOT KNOWN
PIPE MATERIAL :	NOT KNOWN

Operating pressure of all stored gases : < 20 bar .

8.4. ALLOYING DEVICE

The alloying device provides addition of the required quantity of alloys and other substances in the vessel without unterrupting the process itself.

Material preparation requires alloy and lime weighing system.

8.5. OPERATING PLATFORM

The operatign platform serves for the access to the vessel & its protection. One of its shields closes the room and the platform itself spans the ladle pit during tapping.

The operating platform also protect the crew while sampling, temperature measuring, follow up of the process etc. The platform is mounted on movable wheels with electric motor drive.

DIMENSION are : 3 x 4 m.

8.6. CONTROL CONSOLE

The control console contains all instruments for the operating the process. The operator leaves the console only for sampling, temperature measuring, etc.

Vessel rotation, gas control, flue gas cleaning, work information and computer processing- all these actions are performed and controlled at the console itself. The control console has all control boxes for converter operations:

- electric devices with power supply
- process gas control
- control desk
- computer system for process control
- etc.

8.7. BURNER FOR VESSEL DRYING & HEATING

A burner using oxygen and naturals gas is used for vessel drying after lining and heating of vessel while out of operation.

The capacity of the burner has to be enough to heat the vessel linig form ca. 300 C up to 1400 C in a two-hours period.

The burner installation should have a system for control and measuring of oxygen and natural gas as well as an automatic flame protector with the UV (ultra violet) sonde-recorder.

Another protection of the burner is needed in case of power or gas supply failure.

The burner itself consists of a metal part which is inserted into a converter opening. Since the burner uses oxygen, the quantity of flue gases is small, which means that an additional fume gas cleaning is not required.

8.8. ENVIRONMENT PROTECTION & SYSTEM FOR WASTE GASE CLEANING

Two sides of the vessel are closed, the third is closed by an operating platform and the upper part of the vessel is closed by an hood installed right above the vessel opening. This prevents waste gases to spread into the foundry shops and the same time facilitates the optimal exploitment of waste gase cleaning installation.

The system for environment protection also includes the system of gas cooling by its dissoluting with secondary air at the vesel opening.

The cleaning of waste gases produced by oxygen practice by 600 m3 OXYGEN per hour an installation of:

30 000 m3/h capacity has to be provided

With proper distribution of work of EAF furnaces, i.e. when two EAF instead of four EAF are used, it is possible to obtain reserve capacity of 30 000 m3/h for gas cleaning.

8.9. COMPUTER SYSTEM FOR PROCESS CONTROL

Gas regulation must be computer controlled. It facilitates fast charges of gas quality & quantity, temperature & pressure compensation. The proper RATIO with precise records of consumed gases.

The analogue computer should be used for this purpose. The computer equipment for converter process comprises a compatible PC IBM/AT with software programmes for :

- oxygen calculation & quantity
- temperature follow up & melt heating
- process control with lime quantity calculation
- alloy & reducing agent calculations.

By this conditions, the converter facilities can be ordered.

FERROTRON

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9. LAY - OUT OF "SECONDARY METALURGY" INSTALLATION IN "JELSINGRAD" STEEL FOUNDRY, BANJA LUKA.

In the drawings for the CONVERTER TECHNOLOGY INSTALLATION is given:

9.1. DRAWING NO.: 1. MASS 1: 200

FOUNDRY'S LAY-OUT WITH INDICATED CONVERTER POSITION
GROUND-PLANT

9.2. DRAWING NO.: 2. MASS 1 : 200

CONVERTER'S DISPOSITION IN THE MELTING SHOP
GROUND-PLANT

9.3. DRAWING NO.: 3. MASS 1 : 200

CONVERTER'S DISPOSITION IN THE MELTING SHOP
CROSS-SECTION

FERROTRON : Dr.J.MACH
M.VELIKONJA

MOERS 5.1.1991.

FERROTRON

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Sauerstoff-Meßanlagen

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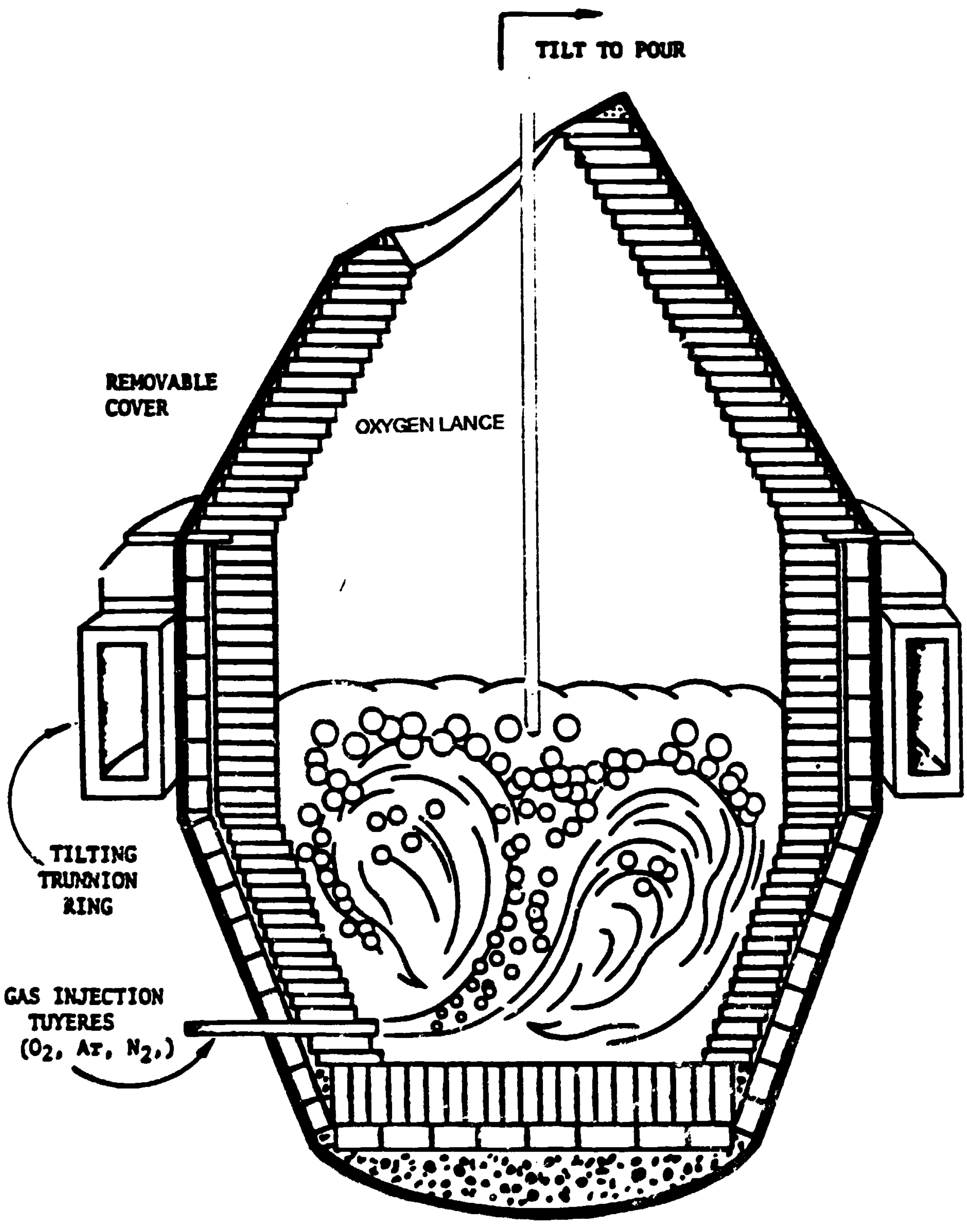
Probenahme

Telefon
(02841) 25262
Telex
8 121 300 ft d
Telefax
(02841) 16536

Ferrotron Elektronik GmbH
Meß- und Regeltechnik
Am Schürmannshütt 30
4130 Moers 1



SLIKA 1.: AOD KONVERTOR

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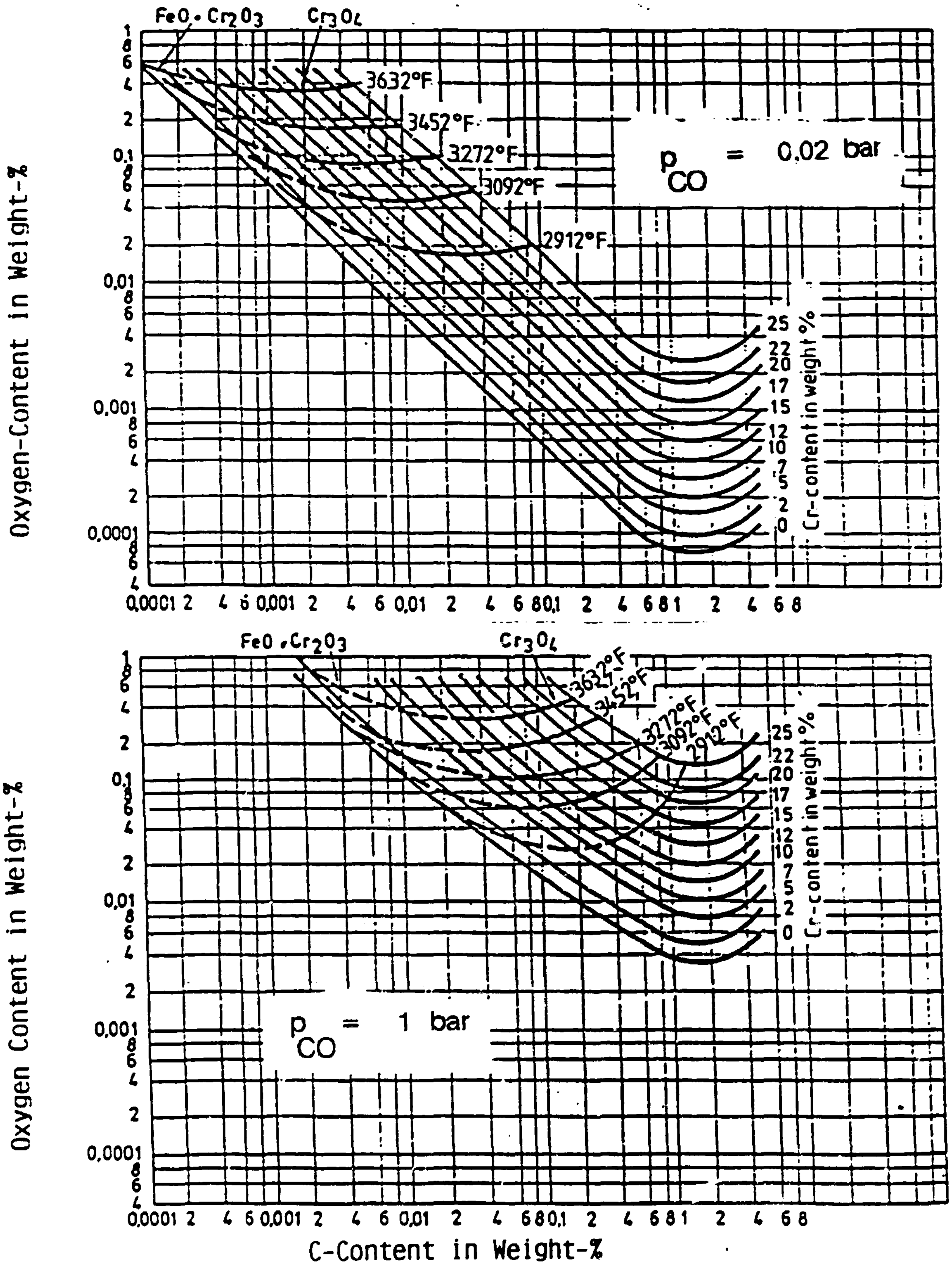
FEASIBILITY STUDY

'JELSINGRAD', BANJA LUKA



SLIKA 2. : DIAGRAM RAVNOTEZA U SISTEMU
FE - CR - C - O - TEMPERATURA

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Telex
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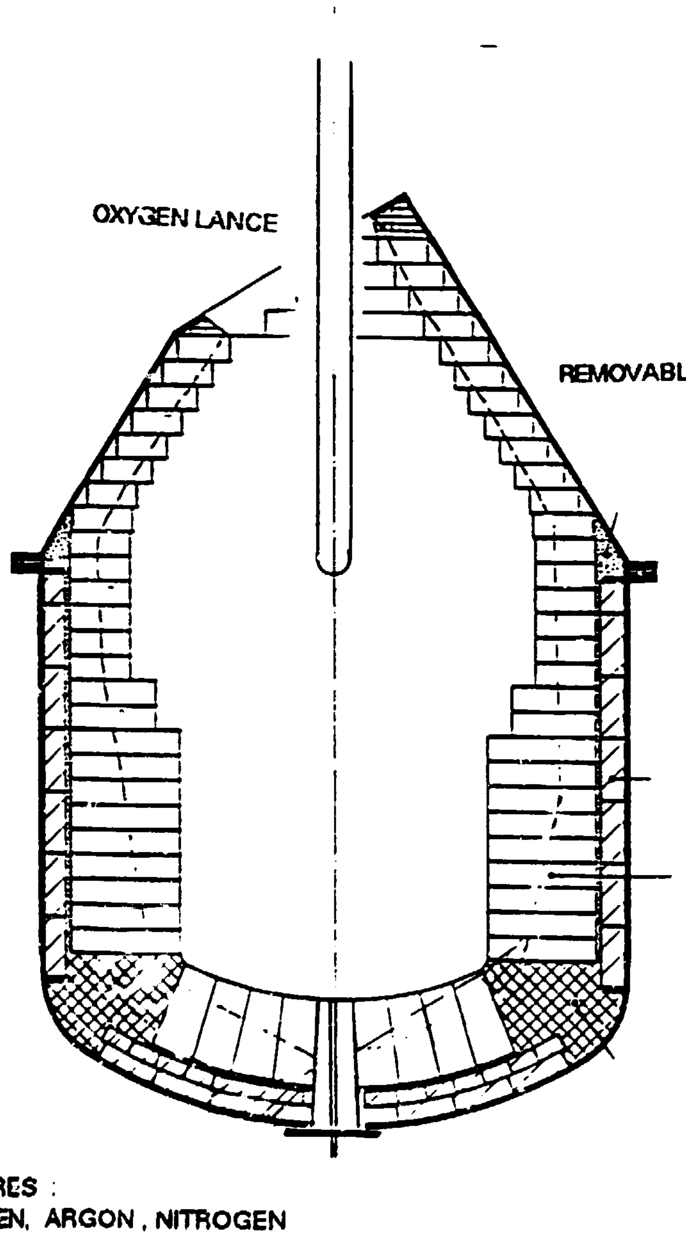

SLIKA 3 : MRP KONVERTOR

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Tauchtemperatur
Probenahme

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Am Schürmannshütt 30
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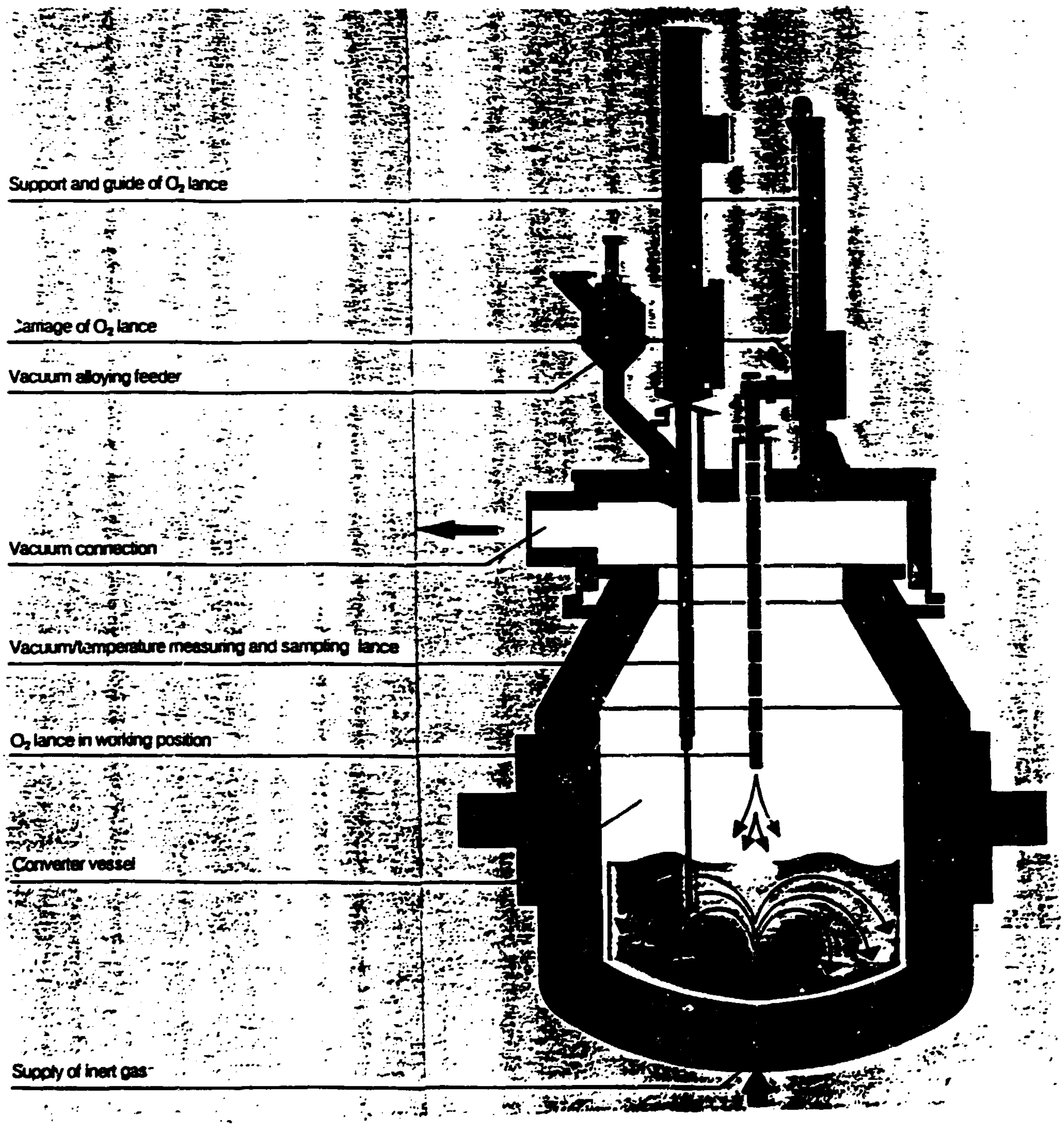
FEASIBILITY STUDY

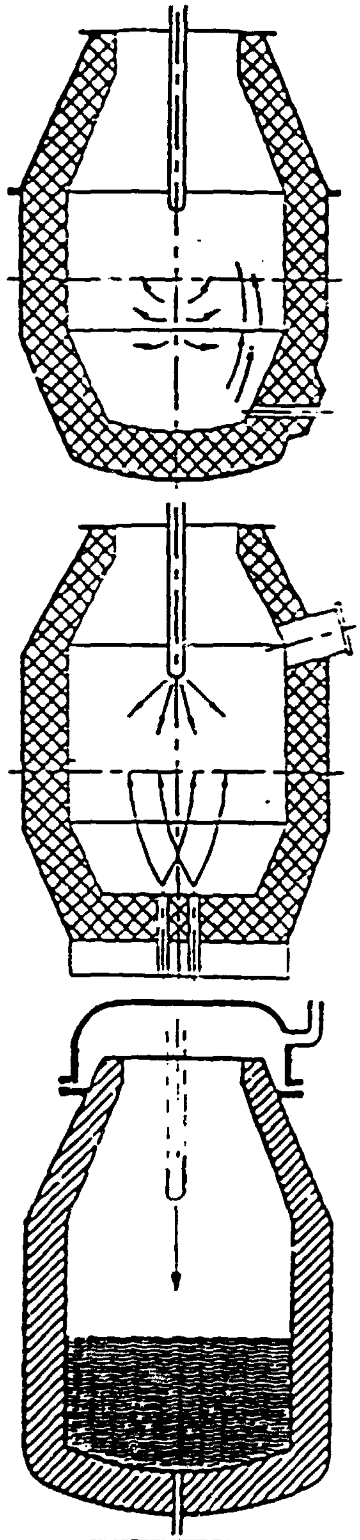
"JELSINGRAD", BANJA LUKA



SLIKA 4 : VAKUM VARP KONVERTOR

FEASIBILITY STUDY

'JELSINGRAD', BANJA LUKA



AOD – L KONVERTOR

PROCESS GAS: LANCE < 2 m3/T,MIN
TUYERES < 1 m3/T,MIN

SPECIFIC VOLUME: 0,4 – 0.5 m3/T
LINING LIFE 50 – 100 HEATS
TUYERE ARRANGEMENT: SIDEWALL

MRP – L KONVERTOR

PROCESS GAS : LANCE < 2 m3/T.MIN
TUYERES < 2 m3/T,MIN

SPECIFIC VOLUME : 0,4 – 0,6 m3/T
LINING LIFE 100 – 300 HEATS
TUYERE ARRANGEMENT: BOTTOM

VARP – KONVERTOR

PROCESS GAS : LANCE < 0,5 m3/T,min
STIRRING < 0,1 m3/T,MIN

SPECIFIC VOLUME : 0,6 – 0,8 m3/T
LINING LIFE 40 – 80 HEATS
STIRRING ARRANGEMENT . BOTTOM

SLIKA 5.: UPORED DESIGNA I PARAMETARA
ZA AOD , MRP . VARP KONVERTOR

REFERAT ZA SAVETOVANJE LJEVACA U BUDVI 1989

UNAPREDJENJE TEHNOLOGIJE PROIZVODNJE TALINE U LIVNICI CELIKA "JELSINGRAD" , BANJA LUKA

AUTORI :
DIPL.ING.BRANKO NAZALEVIC, RAZVOJ, LIVNICA"JELSINGRAD", BANJA LUKA
DIPL.ING.MARIJAN VELIKONJA, Metalurski Savetnik, ZAP.NJEMACKA

SADRZAJ

Kao unapredjenje tehnologije smatra se primena nove tehnologije proizvodnje visokocvrstih celika kod "klasicne" proizvodnje taline za livnicu, i to kod :

- RAFINACIJE CELIKA U ELEKTROLUCNOJ PECI

Da bi se moglo i u buduce pratiti razvoj i uspjeh nove tehnologije, na osnovu grafickih prikaza data je ocena sadasnjeg rada kod tog aggregata.

Prikazom rezultata nove tehnologije potvrdjuje se mogucnost ubrzavanja "klasicne tehnologije" u elektrolucnoj peci:

1. Za vrijeme toplenja izvodi se prvi metalurski rad u vidu odfosforenja uloska sto vodi do pogodnih rezultata kod dalje obrade taline.

2. Upotrebom kisika za odplinjavanje taline smanji se vrijeme oksidacije i sprijecava prekomerna oksidacija taline putem sljake.

3. Pomocu sintetickih sljaka skrati se vreme rafinacije taline i postize vrlo nizke sadrzaje stedljivih elemenata: fosfora i sumpora i nizko obterecenje taline plinovima: vodonika, azota i kisika.

4. Putem optimalne desoksidacije i rafinacija celika u peci i u kazanu, pomocu sinteticke sljake, dolazi se do taline velike cistoce i visokih mehanskih osobina .

1. UBRZAVANJE RADA ELEKTROLUCNE PECI

1.2. UBRZAVANJE FAZE TOPLENJA

Ubrzavanje rada u fazi toplenja zavisi u glavnom od jacine transformatora i time od ponude elektricke energije po toni i vremenu. U JELSINGRADU je ponuda elektricne snage svega 400 KVA/t, sto znaci, da je teoretski najkrace vrijeme toplenja oko 90 minuta. Zbog objektivnih razloga ta se snaga ne koristi sto vodi do produzenja toplenje. Kod nepogodnih uslova traje toplenje na cak i do 200 minuta.

Na SLIKI 1. prikazan je nacin sadasnjeg rada. Iz prikazanog diagrama je razvidan dosadasnji nacin toplenja ulozka, kao i nacin pristupa obrade tekuce taline sa oksidacijom i sa rafinacijom do konacne izrade taline celika za lijevanje.

Vrijeme toplenja izvodi se kao samostalni radni stepen izrade taline. Dok ulozak nije istopljen, nema metalurskih posega, te zbog toga u ulozku nema dodataka za formiranje sljake. Elektricna energija smanji se odmah nakon je zadnji komad zaronio u talinu. Posto je u tom momentu talina hladna ceka se prvo na povisenje temperature i tek onda pocinje oksidacija taline. Kriterij za fazu toplenje taline je vrijeme od 150 do 180 minuta nakon uklapanja elektricne snage i dovoljna temperatura za uzimanje prve probe.

Na SLIKI 2. prikazan je nacin rada nakon prenosa savremene tehnologije toplenja.

Faza toplenja izvodi se punim koristenjem tansformatora sa maksimalnom lektricnom snagom i taj se snaga zbog "pjenusace sljake" od krecnjaka moze koristiti i za vrijeme oksidacije.

Samo taj pristup skrati vrijeme sarze za 40 do 60 minuta.

Stvaranje "pjenusace sljake" za vrijeme toplenja ne koristi samo skratenju vremena zbog pogodnih uslova za koristenje pune snage transformatora, nego se usput izvodi metalurska obrada taline, sa rezultatom potpunog odfosforenja taline. Zbog pogodnih uslova za tu obradu (FeO, bazicnost sljake i niska temperatura) i kuvanjem taline sprijecava se nabijanje taline sa plinovima.

Takav nacin rada obezbedi svakoj sarzi jednake metalurske uslove na kraju toplenja i time osigurava daljnoj preradi jednake polazne uslove sto sprijeci individualna odstupanja u kvalitetu proizvodene taline.

1.3. UBRZAVANJE KUVANJA

Rafinacije taline kuvanjem snizi sadrzaj plinova u talini. Da bi se moglo postici sigurne rezultate odplinjenja taline, treba odgovarajucom brzinom odgoriti potrebnu kolicinu ugljenika. Ako se za kuvanje upotrebi ruda, brzina odgorenja je mala pa se zbog toga trazi odgor oko 0.50 % C. Kod oksidacije pomocu plinskog kisika potreba ugljenika je samo 0.30% C uz potrosnju od 6 Nm3 kisika/t, za isti efekat odplinjenja taline.

Posto postoji u "Jelsingradu" mogucnost upotrebe plinskog kisika od 200 Nm3/h, to je oko 0.6 Nm3/t,min , vrijeme oksidacije iznosi 10 do 15 minuta, a brzina odgora ugljenika oko 2 % C/h.

1.4. UBRZAVANJE RAFINACIJE

Za vrijeme rafinacije dodje zbog pratecih uslova do povisenja sadrzaja plinova u talini, a narocito vodonika i azota a pri tom je odlucujuci faktor samo vrijeme trajanja rafinacije.

Zbog toga je potrebno vrijeme rafinacije sto vise skratiti.

Cilj rafinacije je desoksidacije i odstranjivanje nemetalnih ukljucaka sa jedne i odsumporenje taline sa druge strane.

Desoksidaciju taline brzo se moze postici samim zaronjenjem odgovarajucih elemenata desoksidacije u talinu. Brzina odstranjivanja nemetalnih ukljucaka i odsumporenje taline zavisi u velikom mjeru od brzine toplenje i pripreme pratece sljake.

Prateca sljaka podupire uslove metalurskog rada i preuzima stetne komponente u svoj sastav.

Da bi se obezbedio sto brzi prelaz komponenata iz taline u sljaku, samo jedna se komponenta u jedanput skida i samo za nju se pripreme optimalni uslovi.

Nova tehnologija koristi domace materijale za sastav sintetickih sljaka, koje se zbog niske tacke toplenja brzo tope i time skrate vrijeme toplenja, a zbog njihove velike aktivnosti prema sumporu, bitno skrate vrijeme rafinacije.

2. PRATECI USLOVI ZA UBRZAVANJE IZRADE CELIKA

2.1. ODFOSFORENJE TALINE

Odstranjivanje fosfora izvodi se, kao gore napomenuto, vec za vrijeme toplenja taline. Kao poznato reagira fosfor sa kisikom rastopljenim u talini celika i stvara fosforpentoksid:

$$2/P/ + 5/O/ = P_2O_5$$

Iz gornje reakcije izvode se kvantitativni uslovi za odstranjivanje fosfora sa ravnoteznom konstantom :

$$Kp = \frac{a(P_2O_5)}{a/P/^2 . a/O/^5}$$

Prema toj konstanti zavisi odfosforenje taline od aktiviteta kisika u talini i od sadrzaja fosfornog pentoksida u sljaci. Ti se uslovi mogu postici na primer pomocu krecne sljake, koja veze fosforni pentoksid prema reakciji:

$$(P_2O_5) + 3\ (CaO) = (3\ CaO\ .\ P_2O_5)$$

i time podupire prelaz fosfora u sljaku.

Za sljake zasicene sa CaO prikazana je odvisnost Kp od temperature sa:

$$lg\ Kp = 5300/T - 19.4$$

Iz tih teoretskih razlaganja rezultira novi nacin rada, gde se koriste vrlo pogodni uslovi za odstranjenje fosfora:

USLOVI ODFOSFORENJA	OBRADA ZA VRIJEME TOPLENJA
- visoki sadrzaj kisika u talini	- dodatak rude
- visoki sadrzaj CaO u sljaci	- dodatak krecnjaka
- niska temperatura	- faza toplenja

Koristeci te uslove, krajem toplenja skida se sljaka i time je odfosforenje taline zakljuceno.

2.2. SMANJENJE SADRZAJA PLINOVA H2 i N2

Kao vec gore napomenuto, smanjenje sadrzaja plinova H2 i N2 u talini izvodi se putem kuvanja taline pomocu oksidacije ugljenika sa zeljeznom rudom A:

$$C + Fe_2O_3 = CO\ (plin/) + 2FeO\ (sljaka)$$

ili plinskim kisikom B:

$$2\ C + O2\ (plin/) = 2\ CO\ (plin/)$$

U prvom kao i u drugom slucaju, rezultat oksidacije je stvaranje plina CO , koji prodire kroz talinu. Plin CO razredjuje u sebi plinove H2 i N2 , koje se nalaze u talini i nosi jih sa sobom, sto vodi do smanjenja njihovog sadrzaja u talini.

Posto je proces termodinamicki osiguran i zavisi samo od kolicine "produvanog CO plina" za vrijeme oksidacije, smanjenje H2 i N2 u talini moze se u naprijed odrediti, time sto se odredi kolicina ugljenika kao izvor CO plina a vrijeme oksidacije pomocu kolicine rude ili zapremine kisika dovodenog u talinu.

Oksidacija putom rude (A) trazi zbog negativne energijske bilance duze vrijeme za odgor ugljenika, pa zbog toga vecu kolicinu odgora od 0.50 % C kod brzine odgora oko 1 % C/h .

Oksidacija kisikom (B) je eksotermna, odgor ugljenika je bez zastoja u zavisnosti od ponude kisika. Jednokovrijedni efekat odplinjenja, kao gor napomenuto, moze se postici vec kod odgora od 0.30% C kod brzine odgora od 2 % C/h, sto trazi ponudu kisika od 0.5 Nm3/t,min .

USLOVI SMANJENJA H2 i N2	OBRADA KOD OKSIDACIJE
- stvaranje CO plina	- oksidacija rudom, kisikom
- najmanje 5 Nm3 CO /t	- 0.1% C = 2 Nm3 CO
- pogodna temperatura	- oksidacija kisikom
- tekuca sljaka	- malo sljake sa boksitom

2.3. ODSUMPORENJE TALINE

Kao poznato, sumpor je u tekucem zeljezu prisutan kao FeS a uslovi za njegovo odstranjivanje su prisutnost onih elemenata u talini, koji imaju manju prostu energiju stvaranja sulfida kao zeljezo.

Drugi uslov odstranjivanja sumpora iz taline je, da sulfidi elemenata sa manjom prostom energijom u zeljezu su netopni, a sto vise topni u sljaci.

Prvi kao i drugi uslov najbolje ispunjava elemenat Ca, koji je u obliku krecnjaka i kreca sastavni dio svih sljaka kod rada na elektrolucnoj peci. Pod uslovom stvaranja calcium - sulfida, reakcija odsumporenja taline je sledeca :

$$/FeS/ + (CaO) = (CaS) + (FeO)$$

Iz konstante ravnoteza razvide se uslovi za prelaz sumpora od zeljeza u calciumsulfid i time njegov prelaz iz taline u sljaku:

$$K_S = \frac{a_{(CaS)} \cdot a_{(FeO)}}{a_{/FeS/} \cdot a_{(CaO)}}$$

Sto veci je aktivität (CaO) i sto manje ima (FeO) u sljaci, to brze predje sumpor iz taline u sljaku. Konstanta Ks mogla bi se prikazati i na drugi nacin:

$$K_S = \frac{f_{(CaS)} \cdot (\%S) \cdot a_{/O/}}{a_{(CaO)} \cdot /\%S/ \cdot f_{/S/}}$$

pa se onda matematickim resenjem i pojednostavljenjem dolazi do formule odsumporavanja :

$$\frac{(\%S)}{/\%S/} = \frac{(S - O - RAZMER)}{/\%O/}$$

FORMULA ODSUMPORAVANJA pokazuje, da je podela sumpora medju taline zeljeza i sljake u glavno zavisna samo od aktivnosti kisika u talini, sto znaci od stepena desoksidacije taline za vrijeme odsumporavanja.

G.W.Healy je na osnovu iztrazivanja od J.Chipmana izradio diagram , sto je prikazan na SLIKI 3. :

Pomocu linija jednakih aktivnosti CaO u sljaci (SLIKA 3.2) i jednakih S-O-RAZMERA u sljaci (SLIKA 3.3) prikazuju se sastavi sljaka u ternarnom diagramu CaO - Al2O3 - SiO2 .

Time je zavisnost izmedju S-O-RAZMERA i aktivnosti CaO u sljaci poznata poznata i moze nama direktno sluziti kao receptura za sastav najefikasnih rafinacijskih sljaka tako za snizenje sumpora kao i za nemetalne ukljucce u talini.

Kod tehnickih sljaka elektrolucne peci sa dolomitnim ozidom, kod sastava sljake treba racunati i sa 5 - 10% MgO. Time se podizu linije aktiviteta CaO i S-O-RAZMER-a u nesto vise temperature, sto prikazuje SLIKA 3.1 .

Iz gornjih uslova i podataka, mogu se izraditi uslovi za brzo odsumporavanje taline:

USLOVI ODSUMPORAVANJA	USLOVI KOD RAFINACIJE
- visoka temperatura	- pre ispusta sarze
- aktivnost /O/ mala	- desoksidacija sa Al
- aktivnost CaO velika	- rafinacijska sljaka : krec, boksit, C , FeSi

3. REZULTATI I DISKUSIJA REZULTATA

SLIKA 4. Prikazuje shematski nacin rada u elektrolucnoj peci u livnici "Jelsingrad", Banja Luka, time sto upore-djuje "staru" i "novu" tehniku toplenja i rafina-cije celika za livnicu.

SLIKA 5. Prikazuje sadrzaj fosfora za vrijeme obrade taline kod pet proba:
1. proba na kraju toplenja
2. proba na kraju oksidacije
3. proba nakon desoksidacije
4. proba nakon rafinacije
5. proba rezultat iz livnog lonca

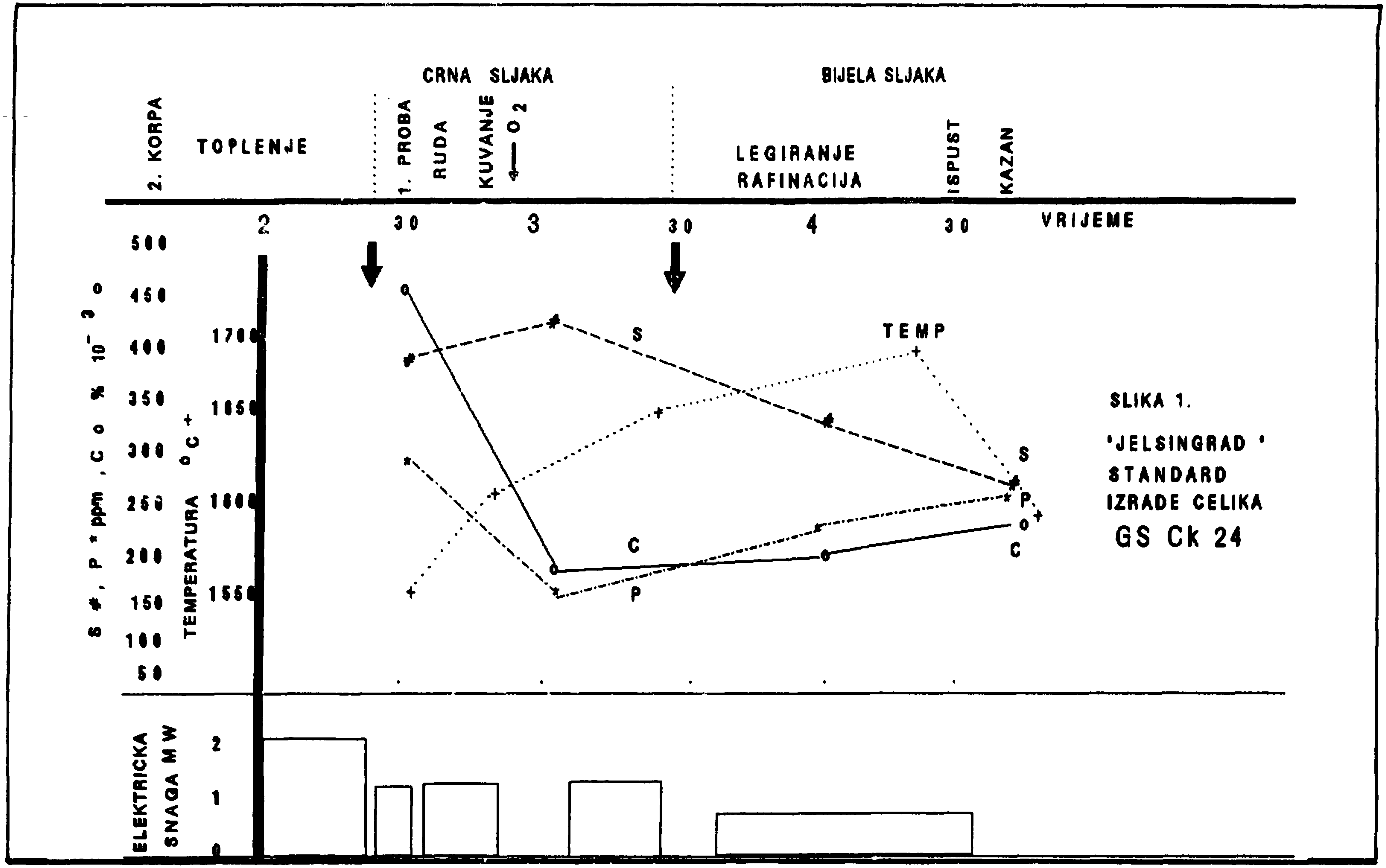
SLIKA 6. Prikazuje sadrzaj sumpora za vrijeme obrade taline kod gore napomenutih pet proba.

SLIKA 7. Daje rezultate pracenja sadrzaja azota kod pet proba.

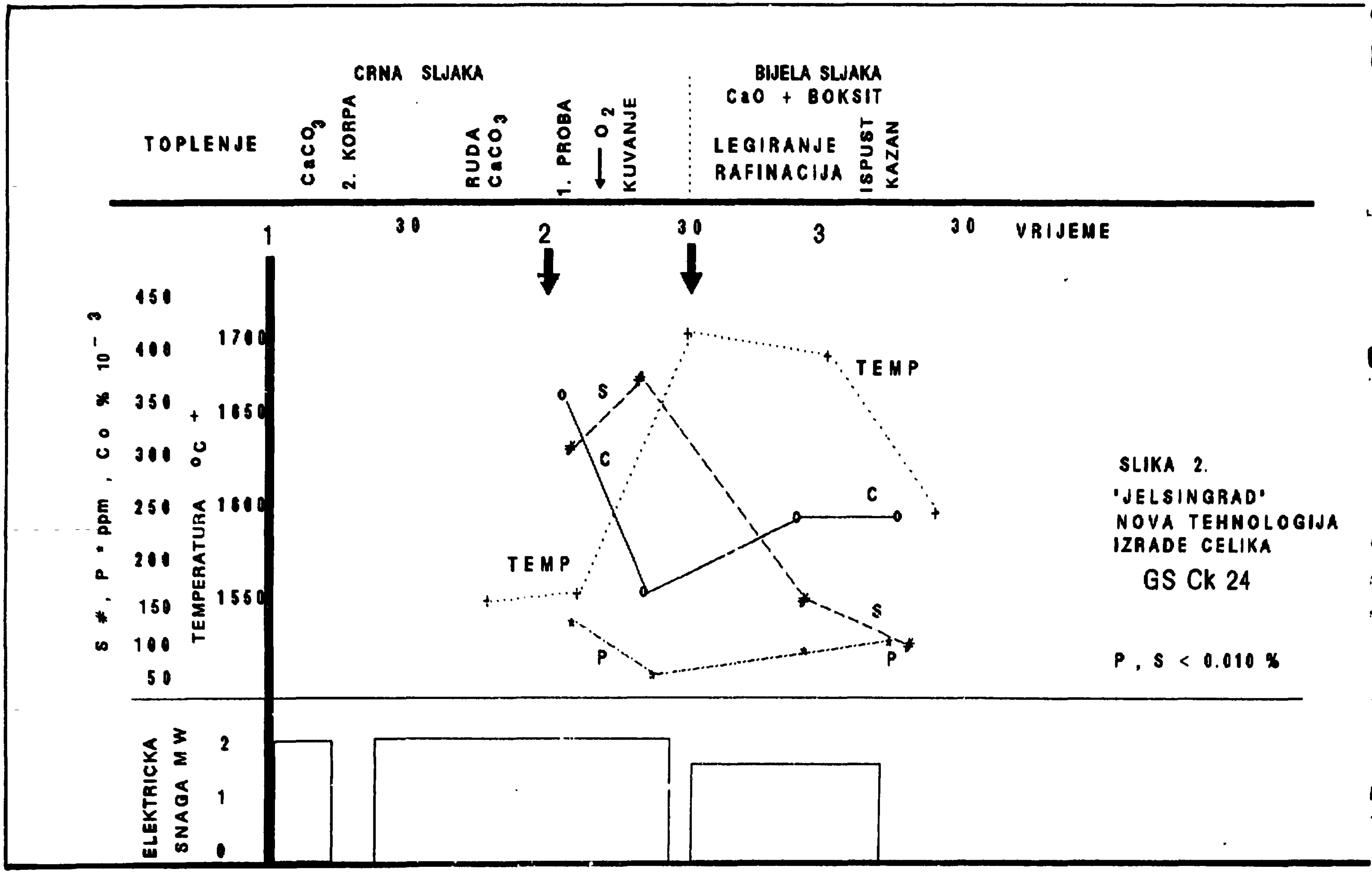
SLIKA 8. Daje TABELU rada po novoj tehnologiji, sa opisom metalurgije rada, dodataka, sastav sljake i uslova za postizanje napomenutih rezultata.

SLIKA 9. Prikazuje rezultate sadrzaja sumpora u konacnoj probi iz livnog lonca nakon rada po novoj tehnologiji.

SLIKA 10. Prikazuje rezultate sadrzaja fosfora u konacnoj probi iz livnog lonca za vrijeme rada po novoj tehnologiji.



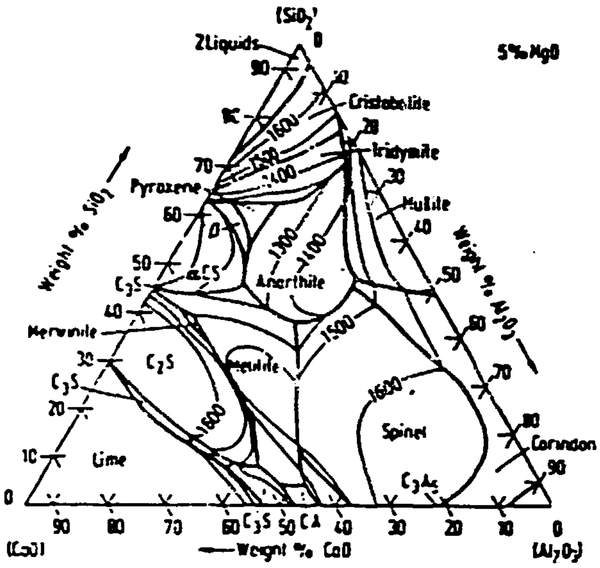
SLIKA 1.
'JELSINGRAD'
STANDARD
IZRADE CELIKA
GS Ck 24

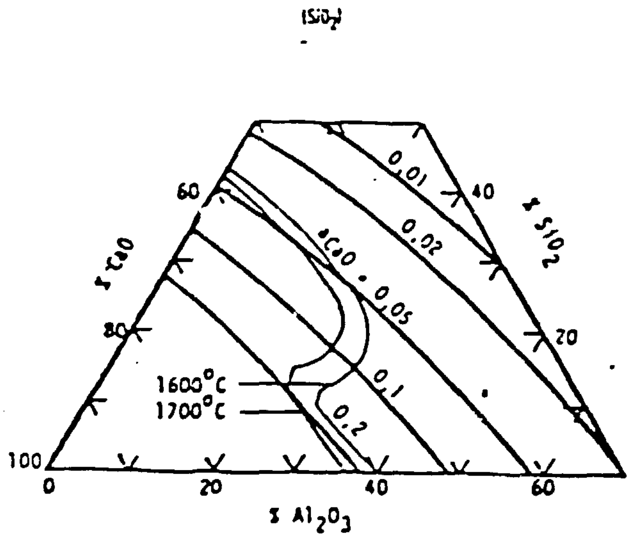


SLIKA 2.
'JELSINGRAD'
NOVA TEHNOLOGIJA
IZRADE CELIKA
GS Ck 24

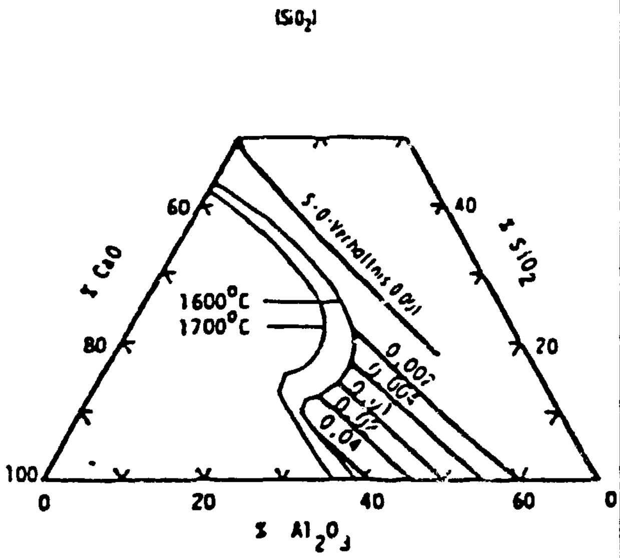
ODSUMPORENJE TALINE

SLIKA 3.1. : TERNARNI SISTEM Al_2O_3 – CaO – SiO_2





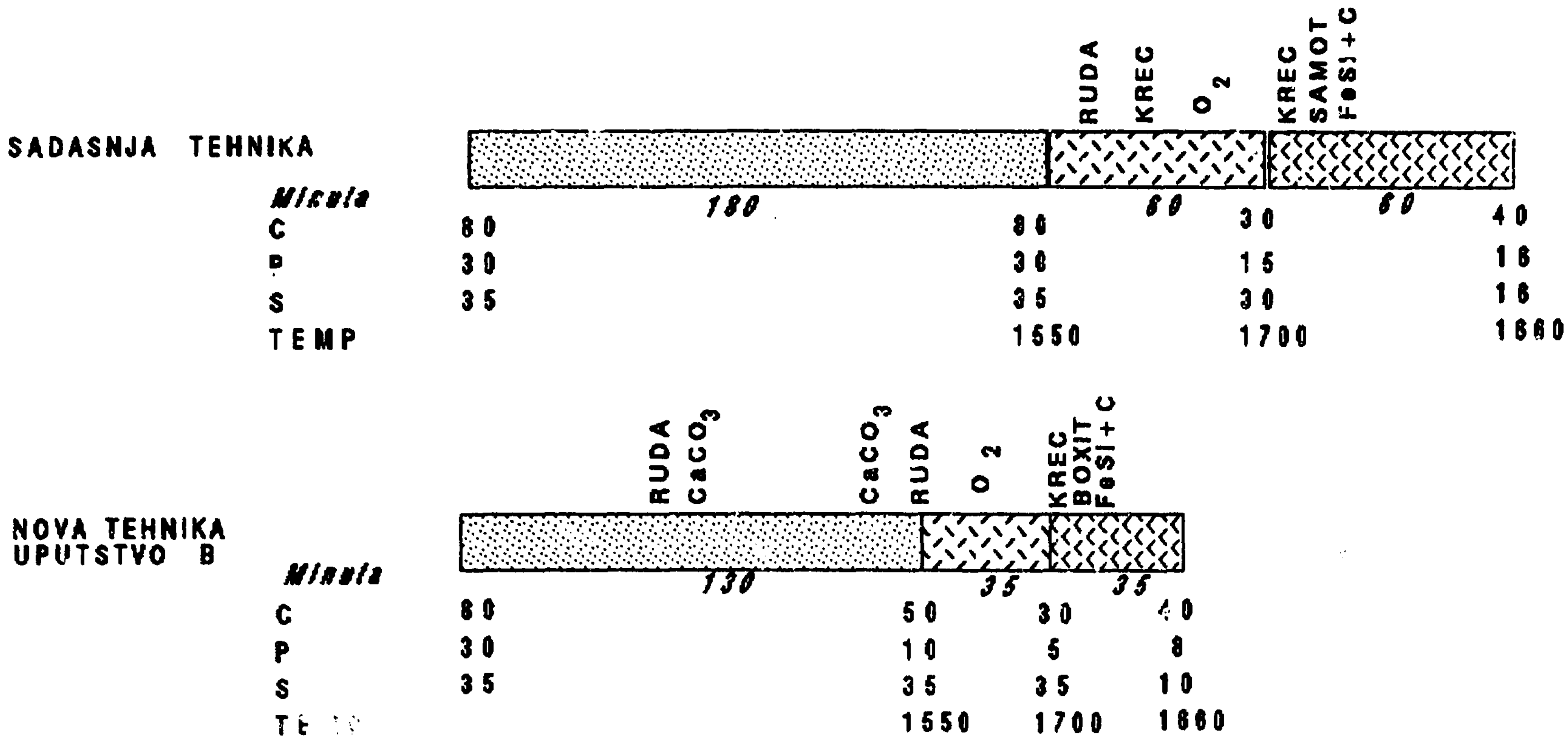
SLIKA 3.2. :
LINIJE JEDNAKIH AKTIVNOSTI a_{CaO}



SLIKA 3.3. :
LINIJE JEDNAKIH VRIJEDNOSTI ZA
' S – O – RAZMER'

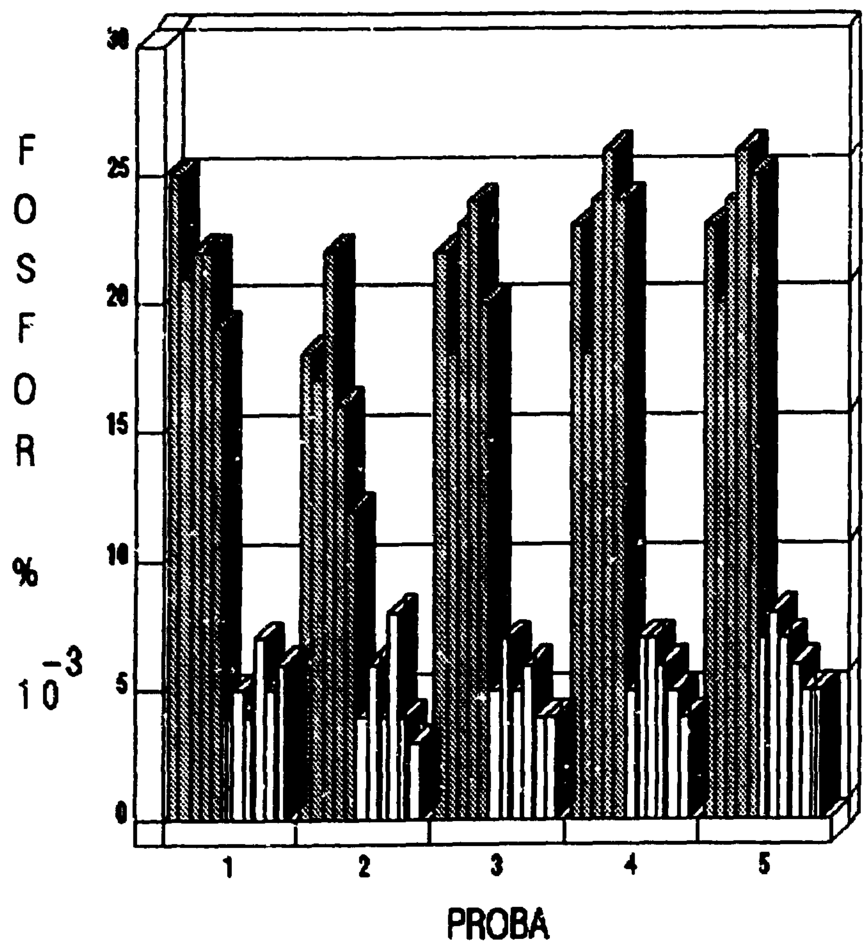
SLIKA 4.

SHEMATSKI PRIKAZ RADA U ELEKTROLUCNOJ PECI " JELSINGRAD "



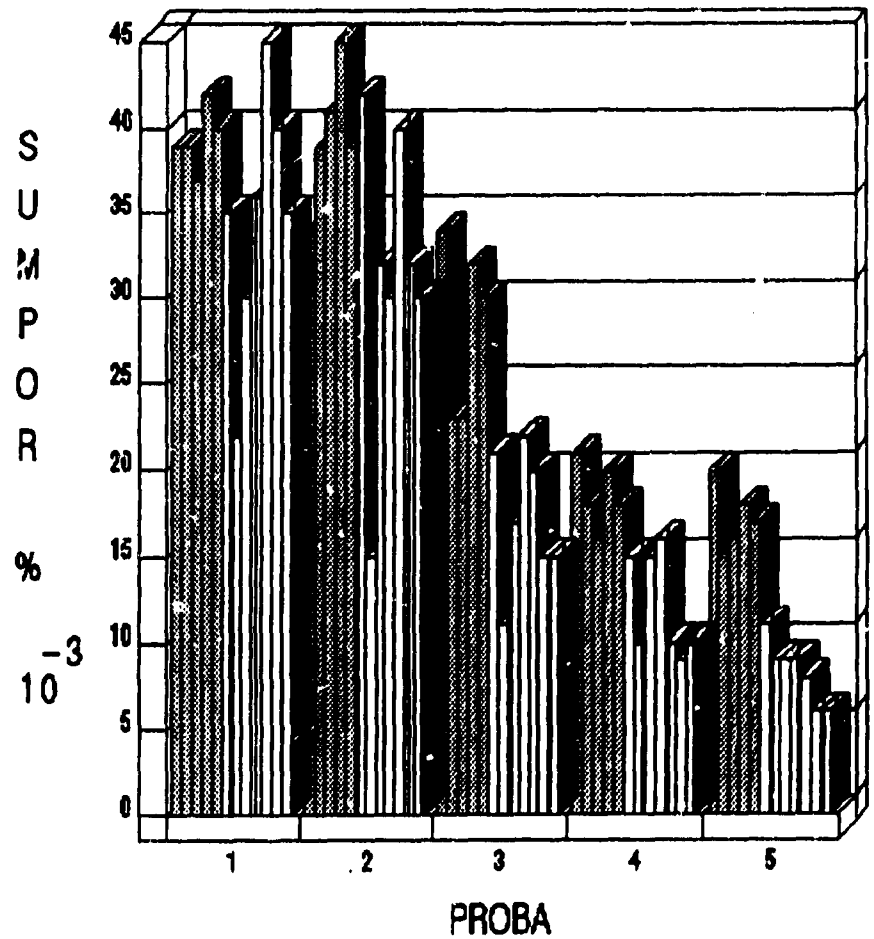
SLIKA 5. "JELSINGRAD"

ELEKTROLUCNA PEC



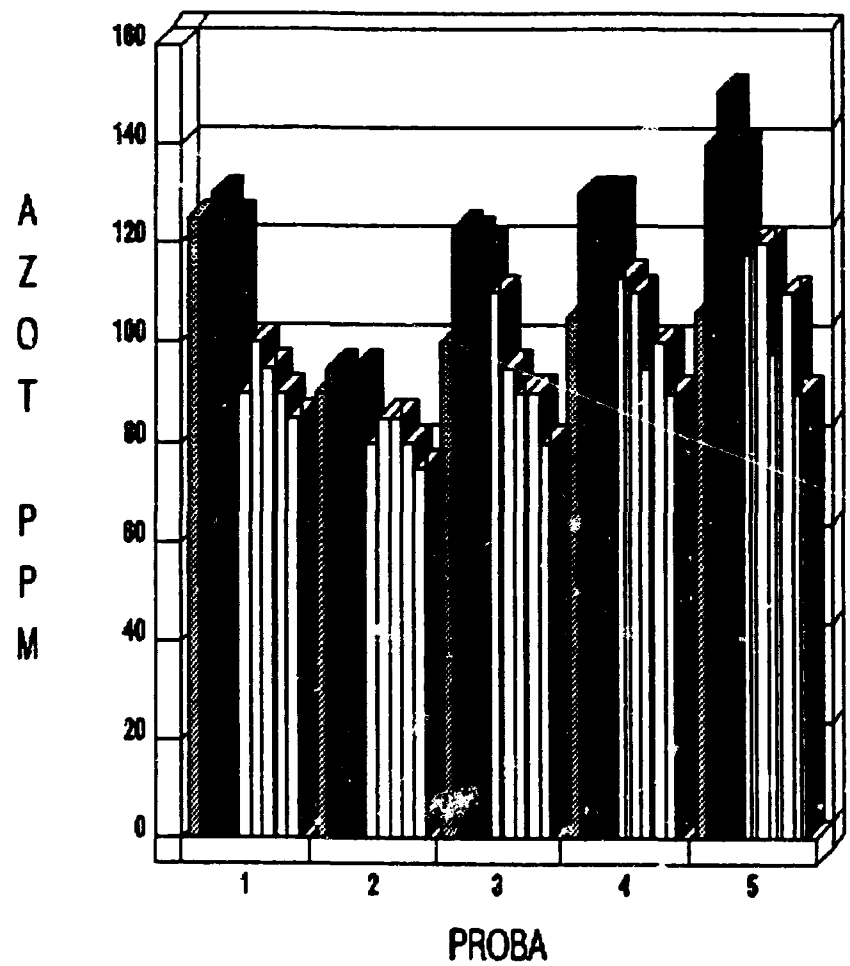
SLIKA 6. "JELSINGRAD"

ELEKTROLUCNA PEC



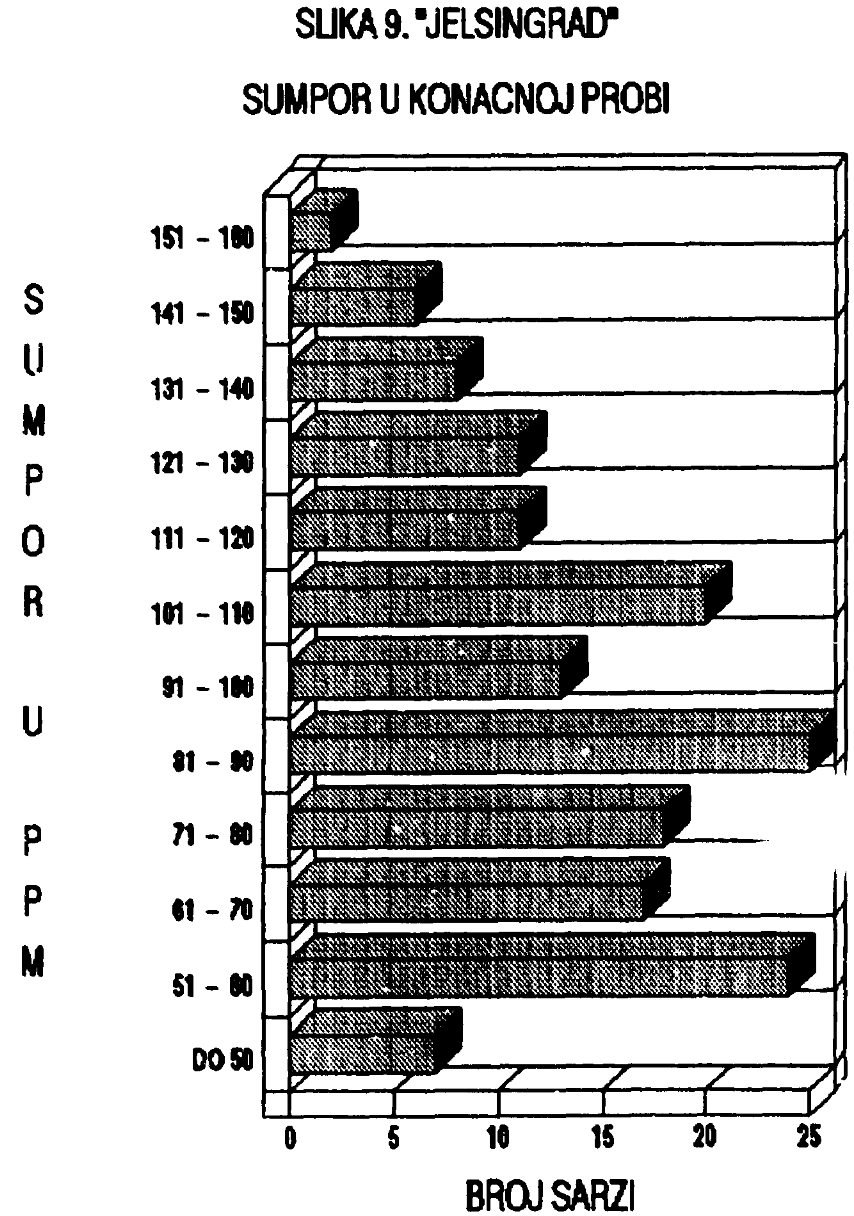
SLIKA 7. "JELSINGRAD"

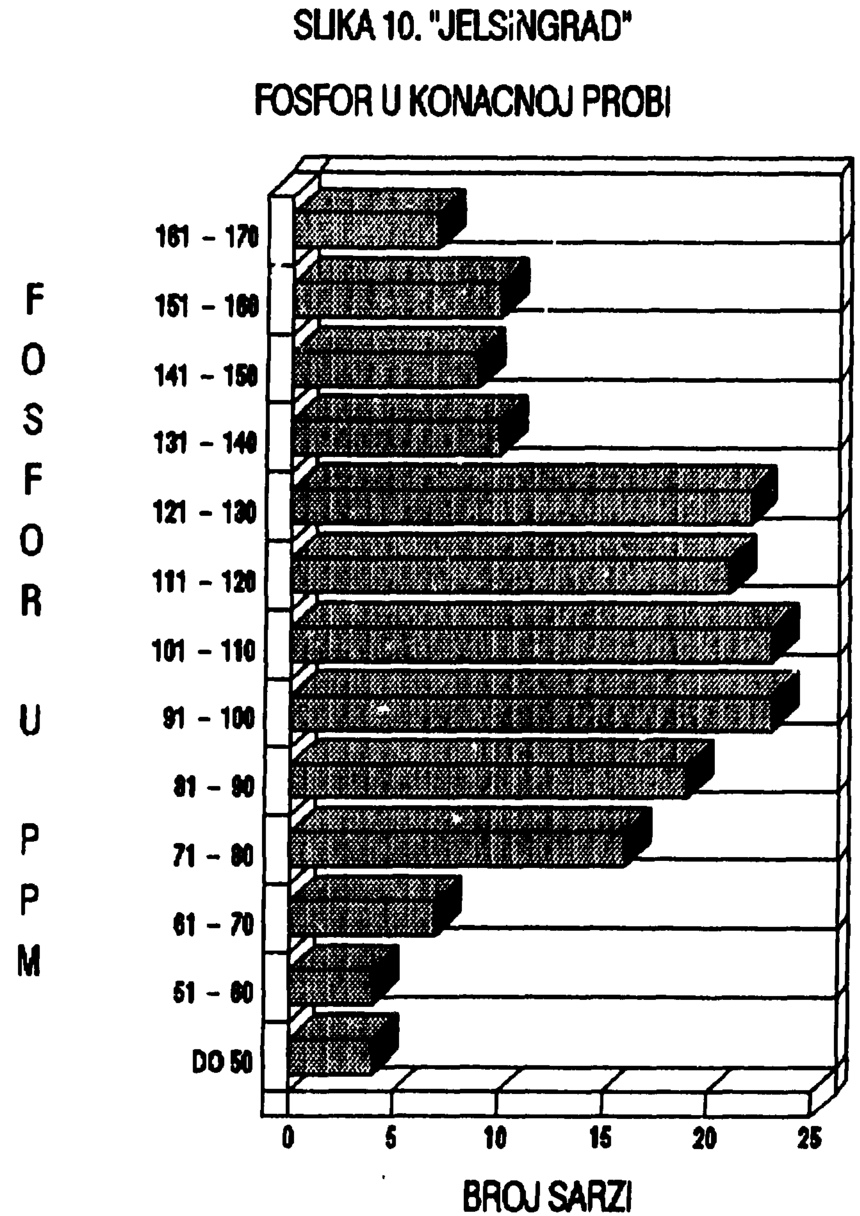
ELEKTROLUCNA PEC



SLIKA 8.: NOVA TEHNOLOGIJA RADA NA ELEKTROLUCNOJ PECI "JELSINGRAD"

STEPEN	1.	2.	3.	4	5.
TRAFO SNAGA	MAKSIMALNA	MAKSIMALNA	MAKSIMALNA	REDUCIRANA	ISKLOP
VRIJEME MINUTA	70	60	35	35	5
METALURGIJA RADA	SARZIRANJE TOPLENJE	TOPLENJE ODFOSFORENJE	OKSIDACIJA ODPLINJENJE	DESOKSIDACIJA LEGIRANJE RAFINACIJA	ISPUST KAZANSKE KOREKTURE MIKROLEGIRANJE
DODACI	ULOZAK LEGURE	KRECNJAK RUDA	BOKSIT KISIK, RUDA	KREC BOKSIT Al, FeSi, C	Al, C, CaSi MIKROLEGURE FeV, FeTi , FeB ,
SLJAKA		CRNA: $CaO > 40\ \%$ $SiO_2 < 20\ \%$	CRNA: $CaO > 30\ \%$ $SiO_2 < 15\ \%$	BIJELA: $CaO > 50\ \%$ $SiO_2 < 10\ \%$ $Al_2O_3 > 30\ \%$	BIJELA: SINTETICKA
USLOVI METALURSKOG RADA		$FeO > 20\ \%$ $B > 2.0$ TEMP. $< 1600^0$ C	$FeO > 30\ \%$ $B > 2.0$ TEMP. $= 1650^0$ C	$FeO < 0.5\ \%$ $B > 4.0$ TEMP. $> 1650^0$ C	$FeO < 0.5\ \%$ $B > 5.0$ TEMP. $= 1600^0$ C


SLIKA 9. "JELSINGRAD"
SUMPOR U KONACNOJ PROBI
S U M P O R U P P M
151 - 160
141 - 150
131 - 140
121 - 130
111 - 120
101 - 110
91 - 100
81 - 90
71 - 80
61 - 70
51 - 60
DO 50
0
5
10
15
20
25
BROJ SARZI

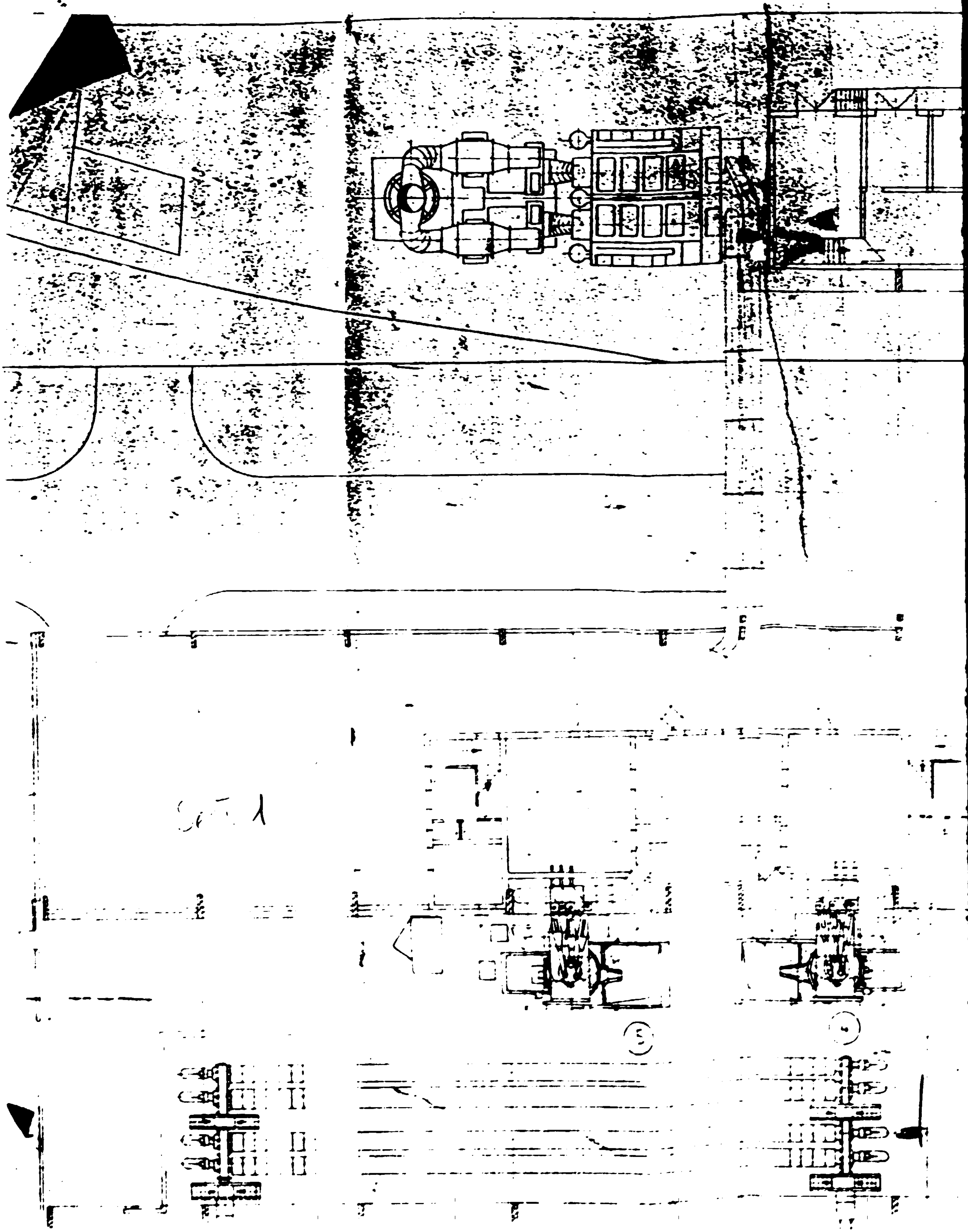

SLIKA 10. "JELSINGRAD"
FOSFOR U KONACNOJ PROBI
F O S F O R U P P M
161 - 170
151 - 160
141 - 150
131 - 140
121 - 130
111 - 120
101 - 110
91 - 100
81 - 90
71 - 80
61 - 70
51 - 60
DO 50
0
5
10
15
20
25
BROJ SARZI

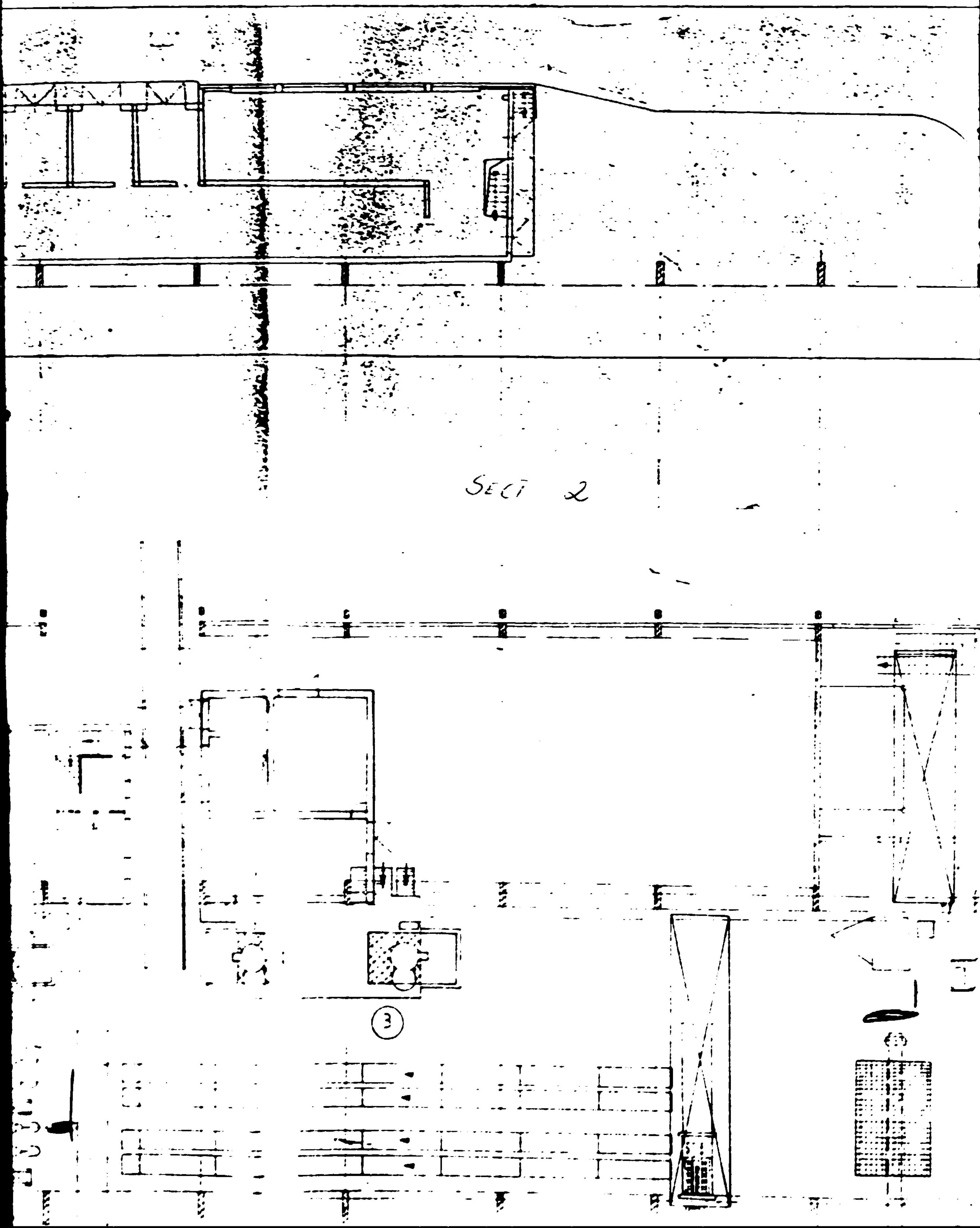
SLIKA 8. ' TEHNOLOGIJA JELSINGRAD '

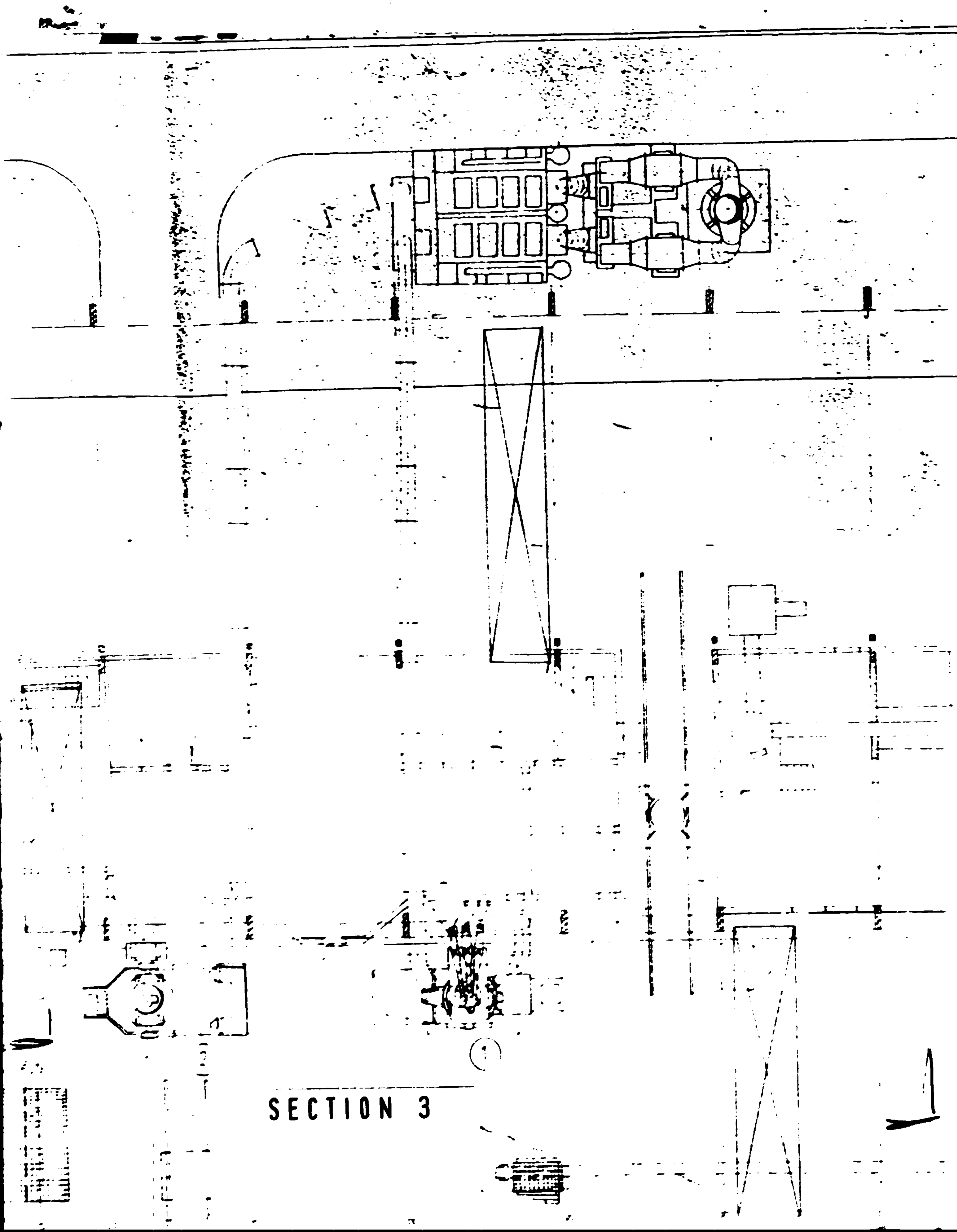
	ZAHTJEV KVALITETA I ANALIZE			
FOSFOR,SUMPOR	< 0.005%	< 0.010%	< 0.015 %	< 0.020%
PINHOLE	NEMA	NEMA	NEMA	NEMA
UKLJUCCI	MALO	MALO	SREDNJE	SREDNJE
CVRSTOCA	VISOKA	SREDNJA	SREDNJA	NORMA

MATERIJALI , DODACI I LEGURE ZA VRIJEME IZRADE TALINE U LUCNOJ PECI

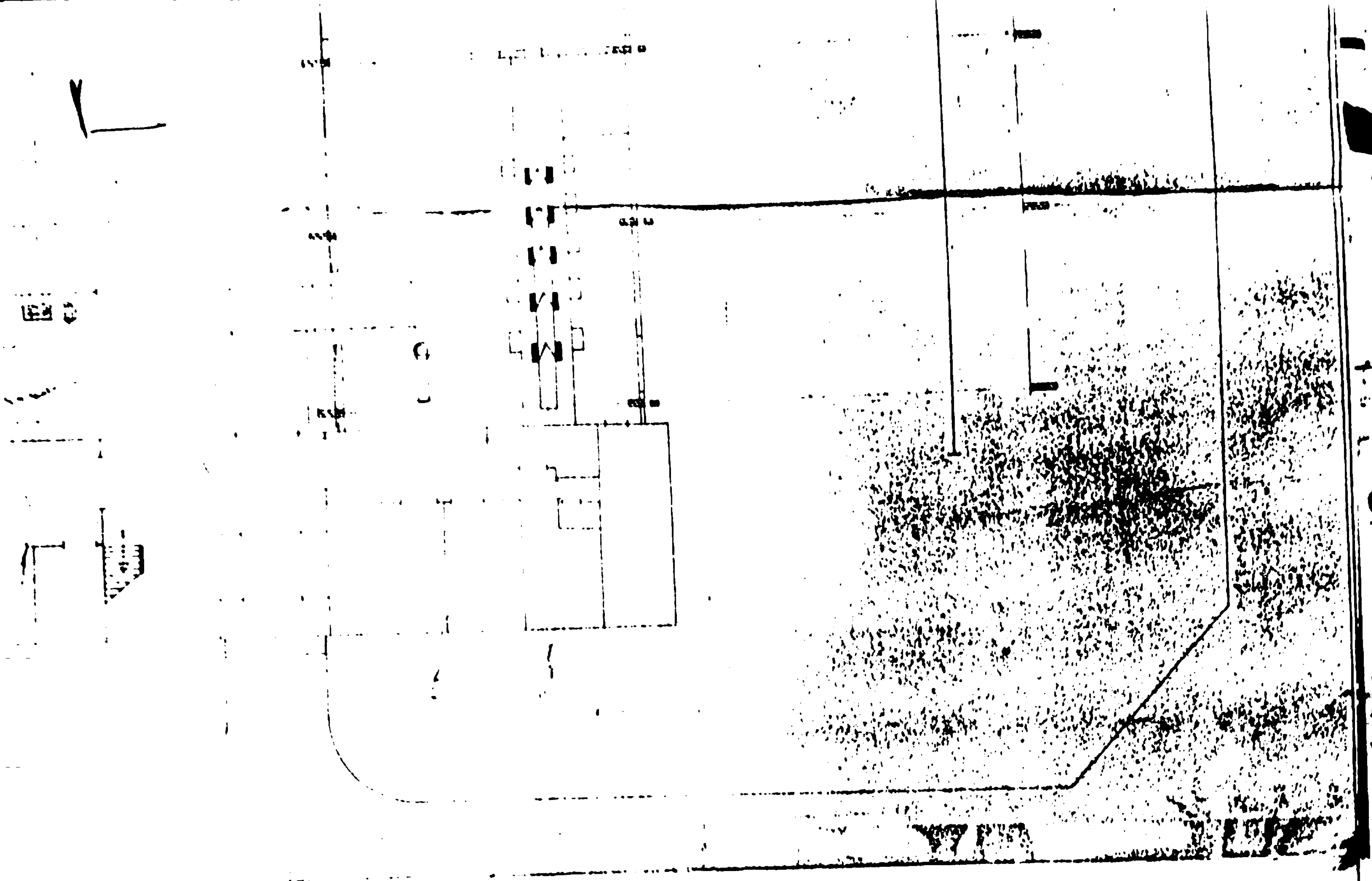
UPUTSTVO	A	B	C	D
1. ULOZAK				
RUDA	100	100	100	–
KRECNJAK	100	100	100	100
KOKS	–	–	50	50
2. NAUGLICENJE UDUVANJEM				
KARBURITA KG/T	5	5	–	–
3. OKSIDACIJA TALINE				
RUDA	100	100	50	50
KISIK ZA % C	0.30%	0.30%	0.30%	0.30%
KRECNJAK	100	100	50	50
BOKSIT	–	–	50	50
KARBURIT	–	–	3	3
4. PROMENA SLJAKE				
NAKON TOPLENJA	DA	DA	DA	DA
NAKON OKSIDACIJE	DA	DA	DA	NE
NAKON RAFINACIJE	DA	NE	NE	NE
5. DESOKSIDACIJA TALINE				
ALUMINIUM KG/T	2	2	2	2
6. RAFINACIJA TALINE				
KREC	100	50	50	30
BOKSIT	30	30	30	–
FESI	10	10	10	10
KARBURIT	5	5	5	5
CA – KARBID	30	10	–	–




SECT 2
3



SECTION 3



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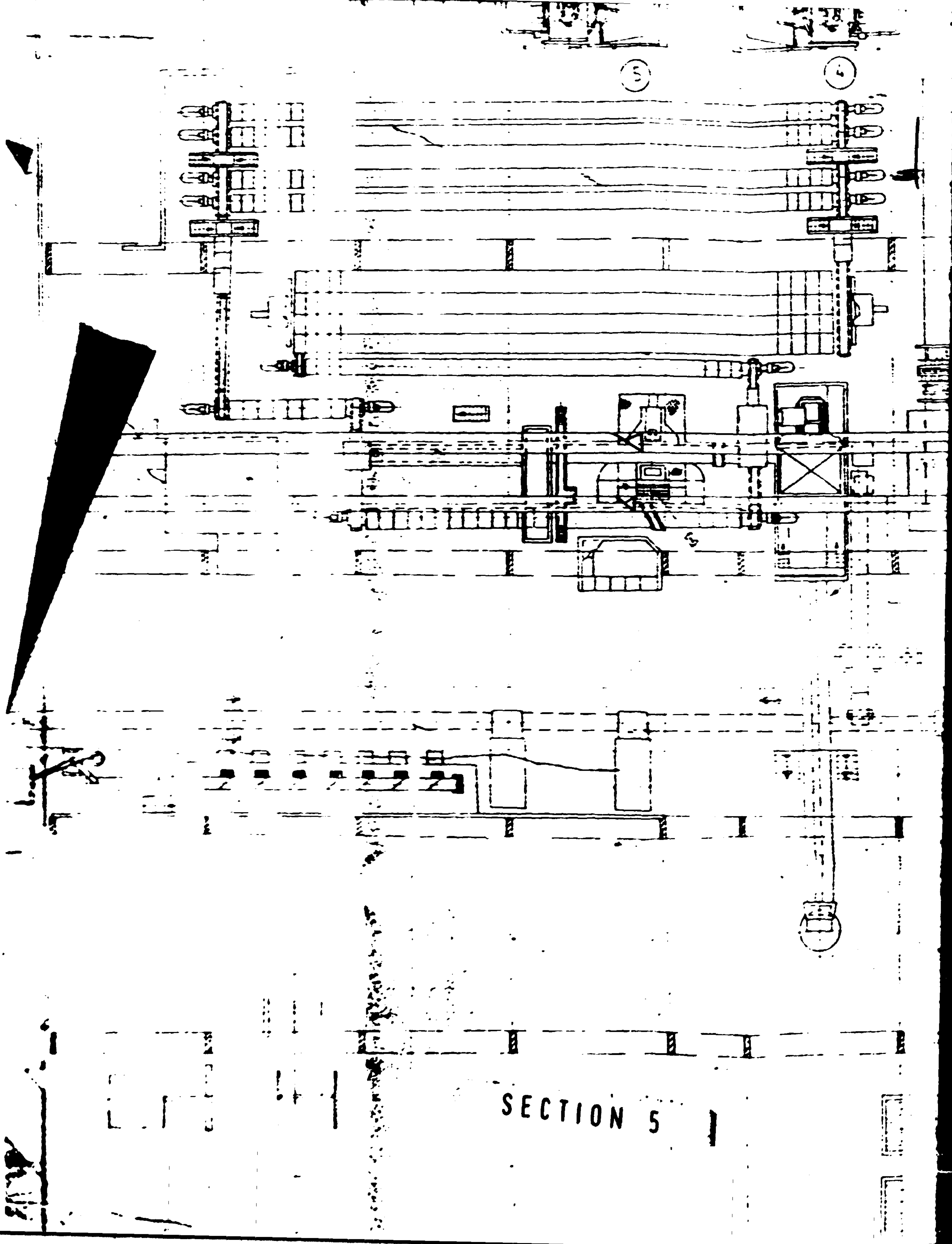

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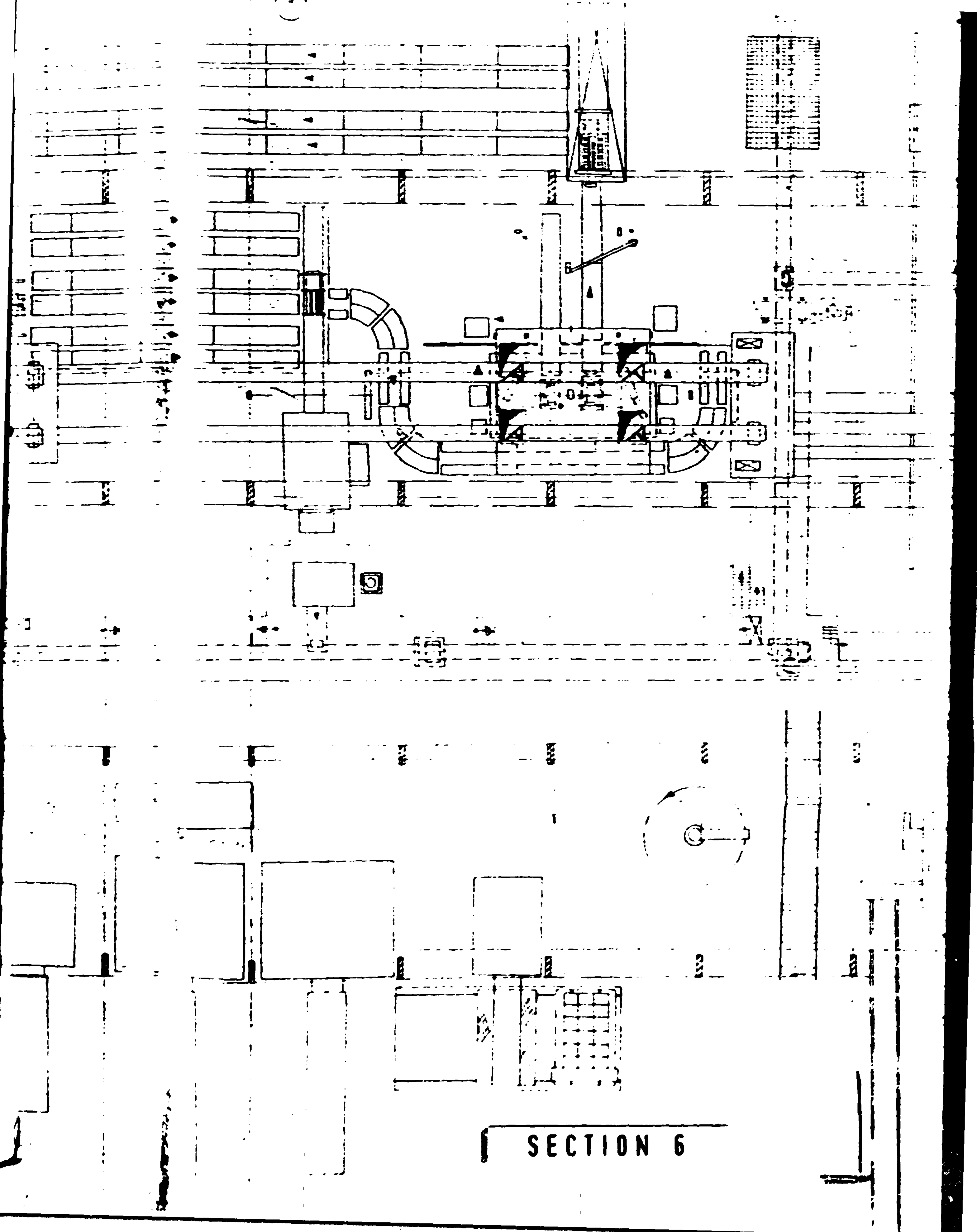

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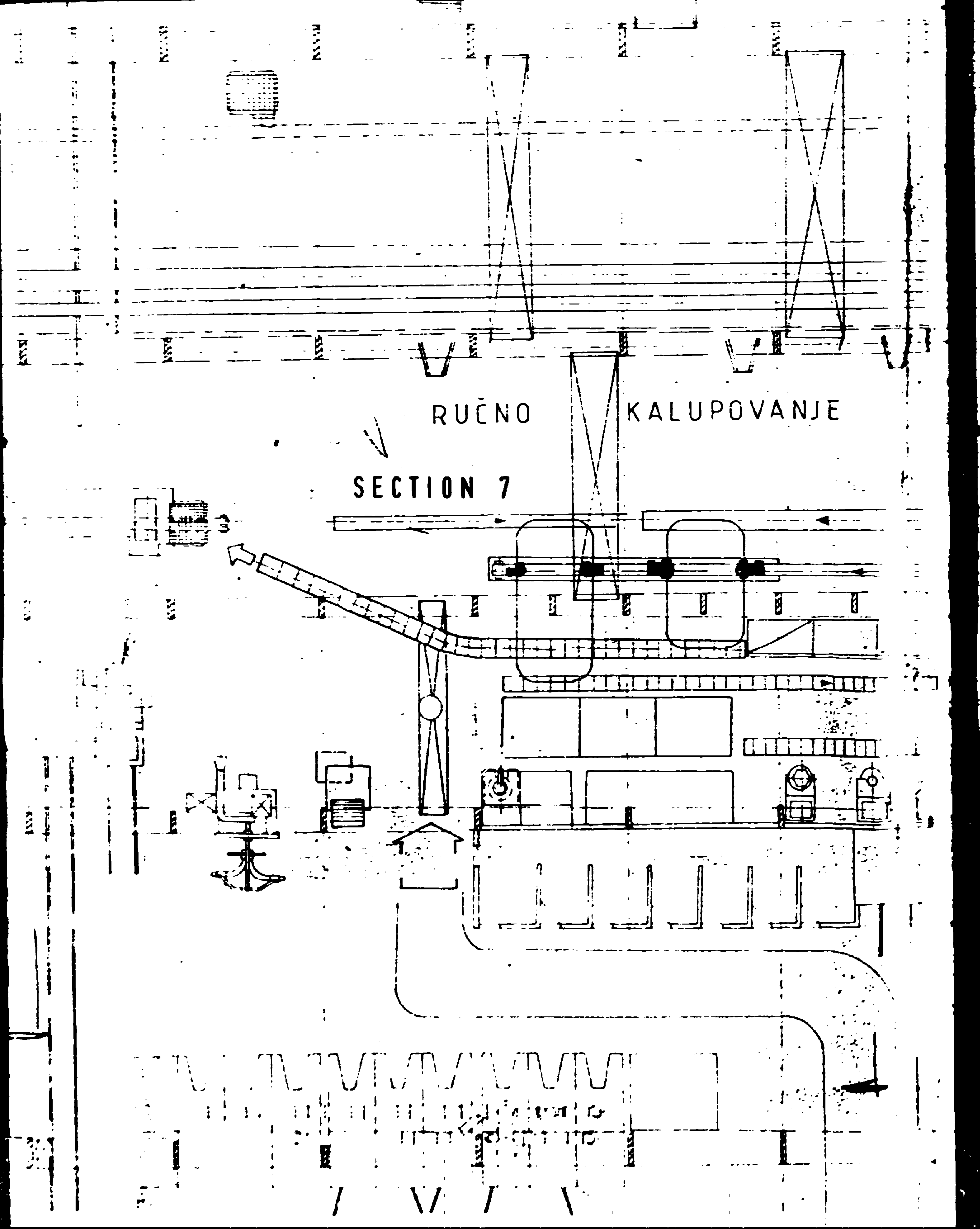
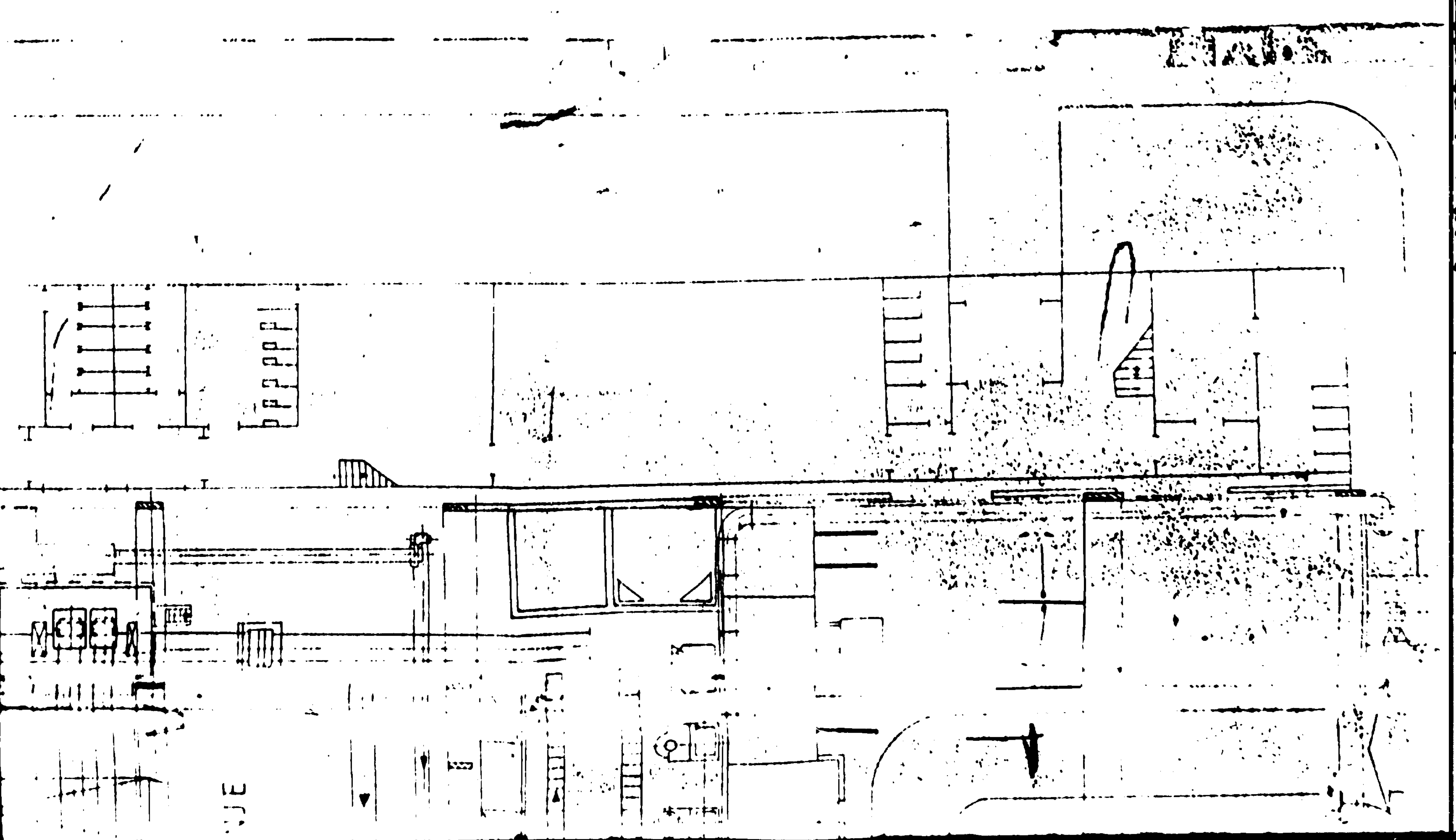
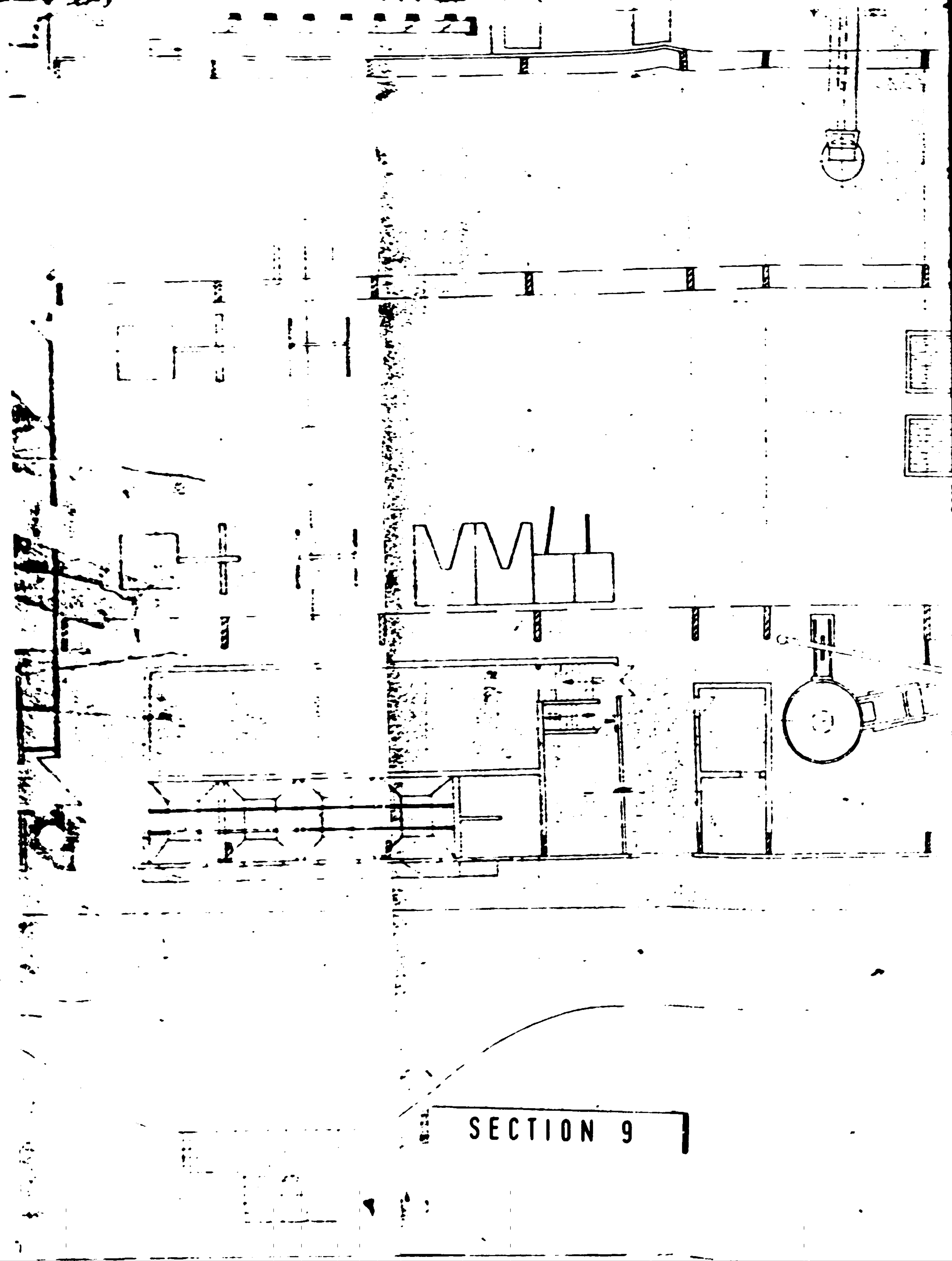

RUČNO KALUPOVANJE
SECTION 7

SECTION 8

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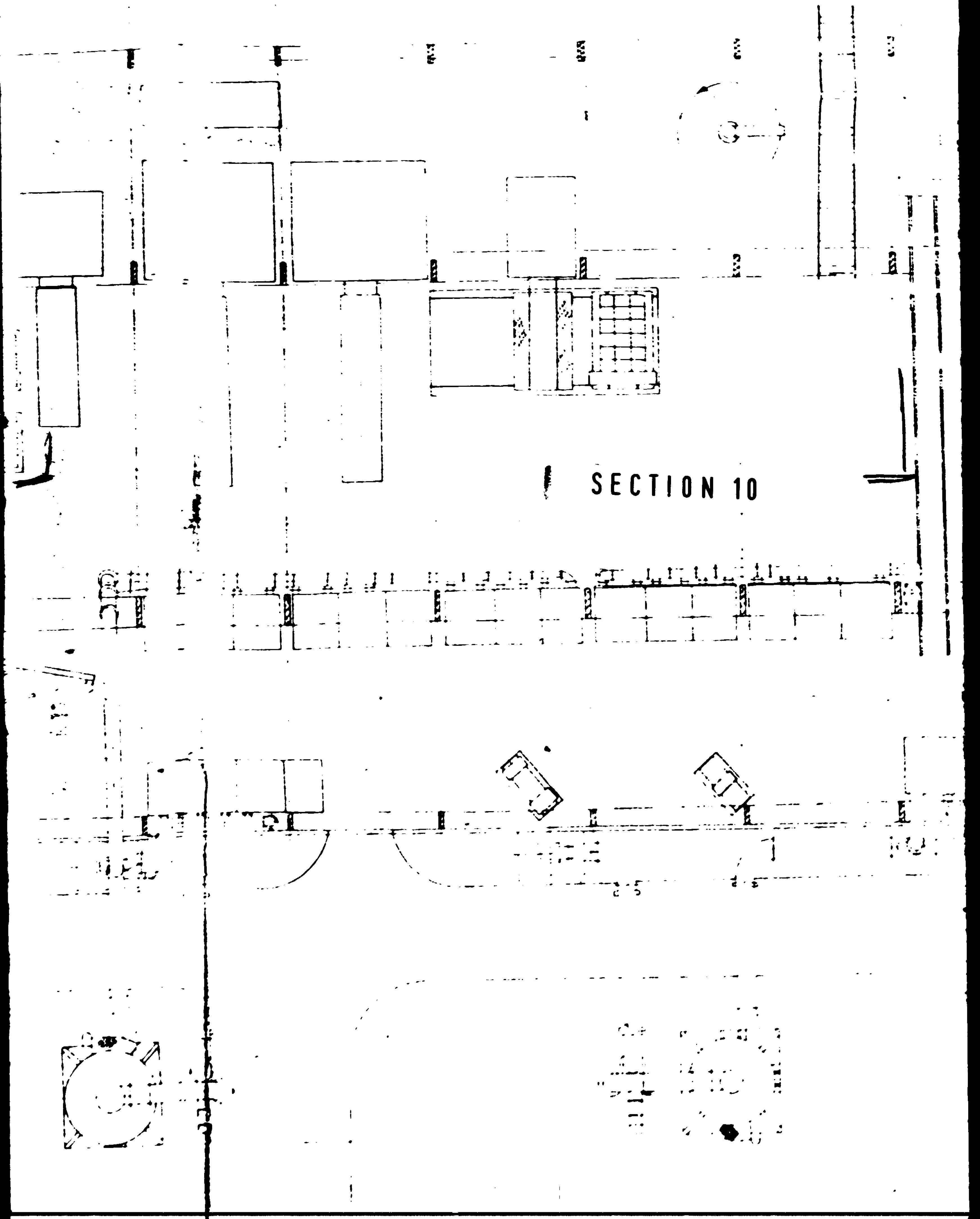
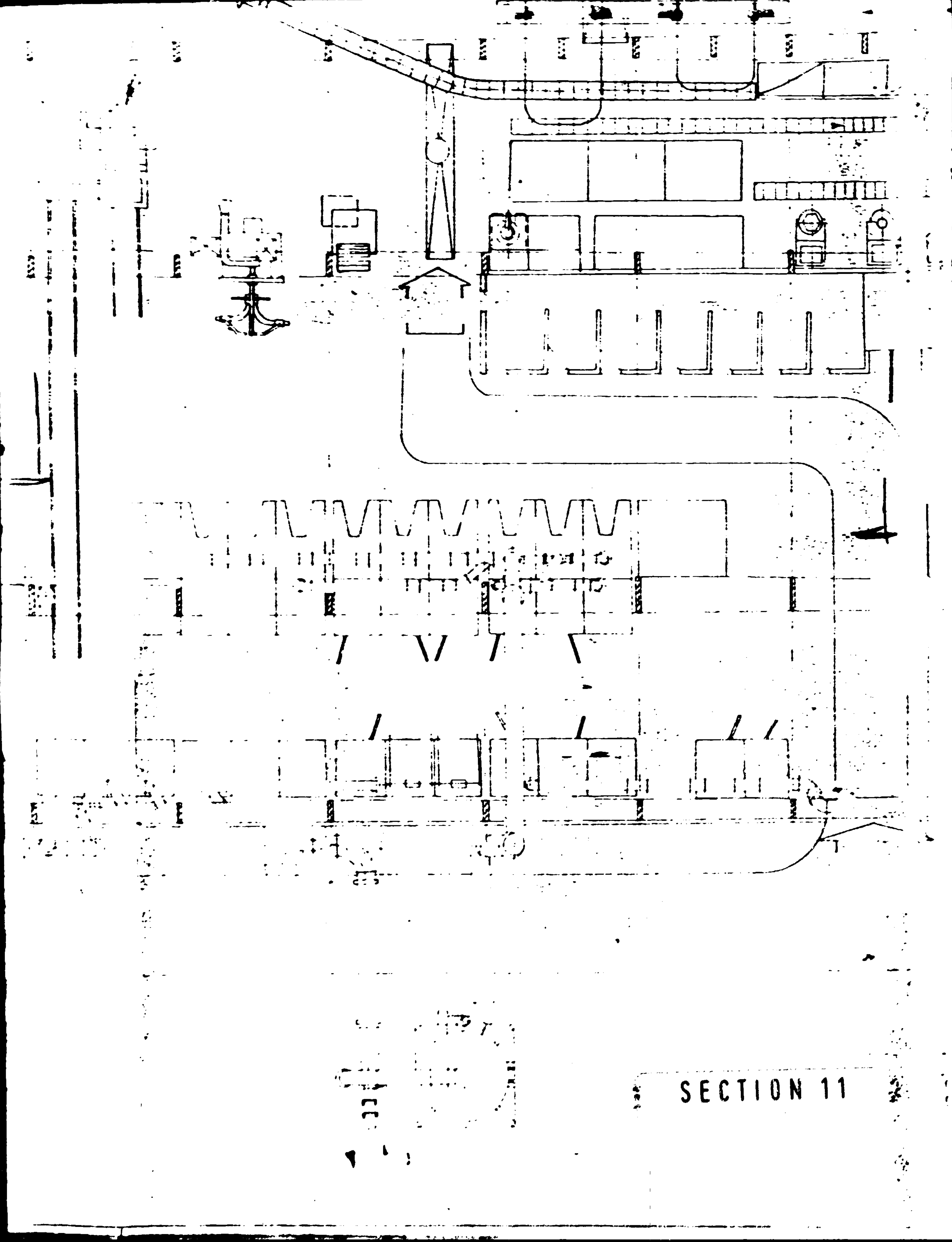
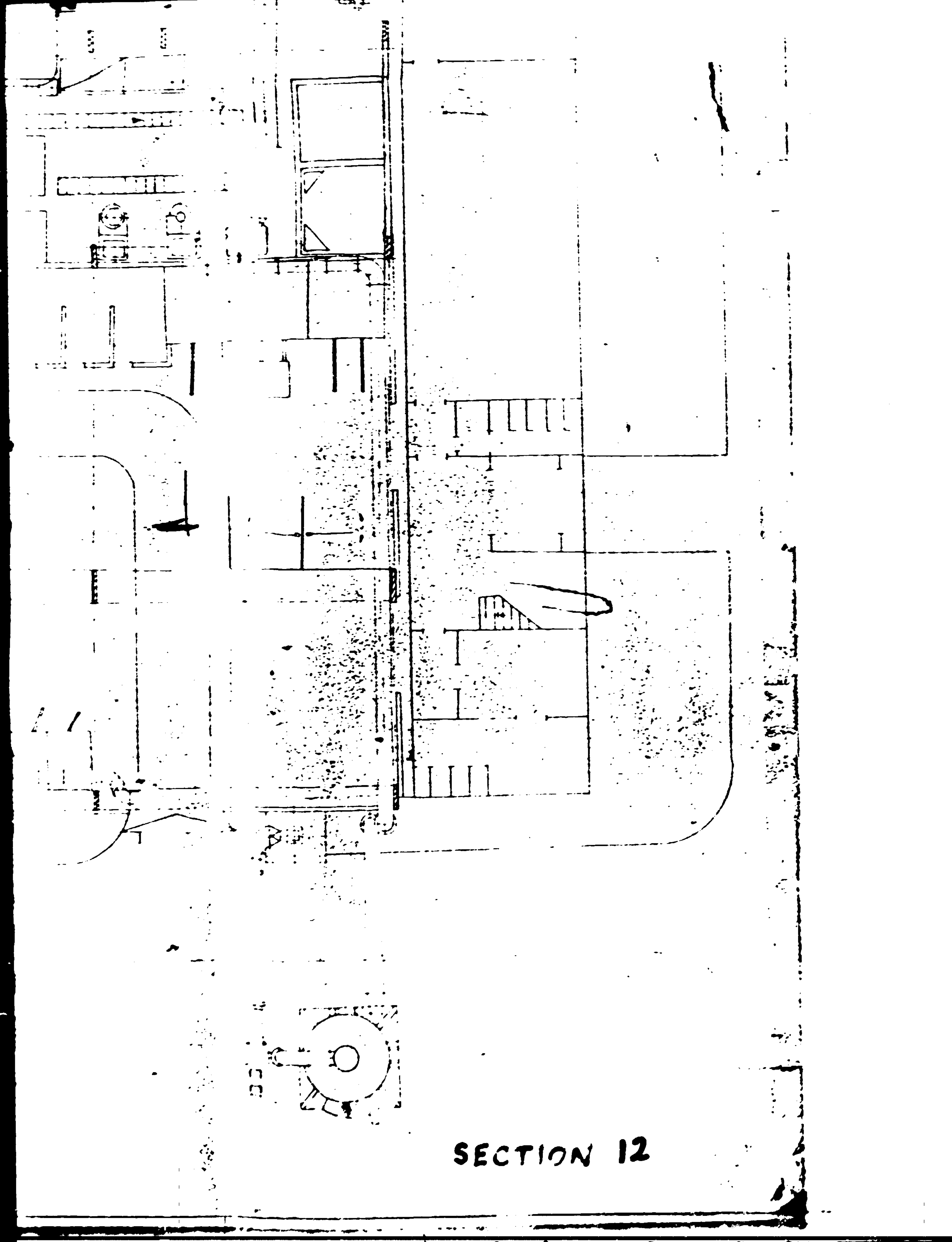

SECTION 10


SECTION 11



SECTION 12

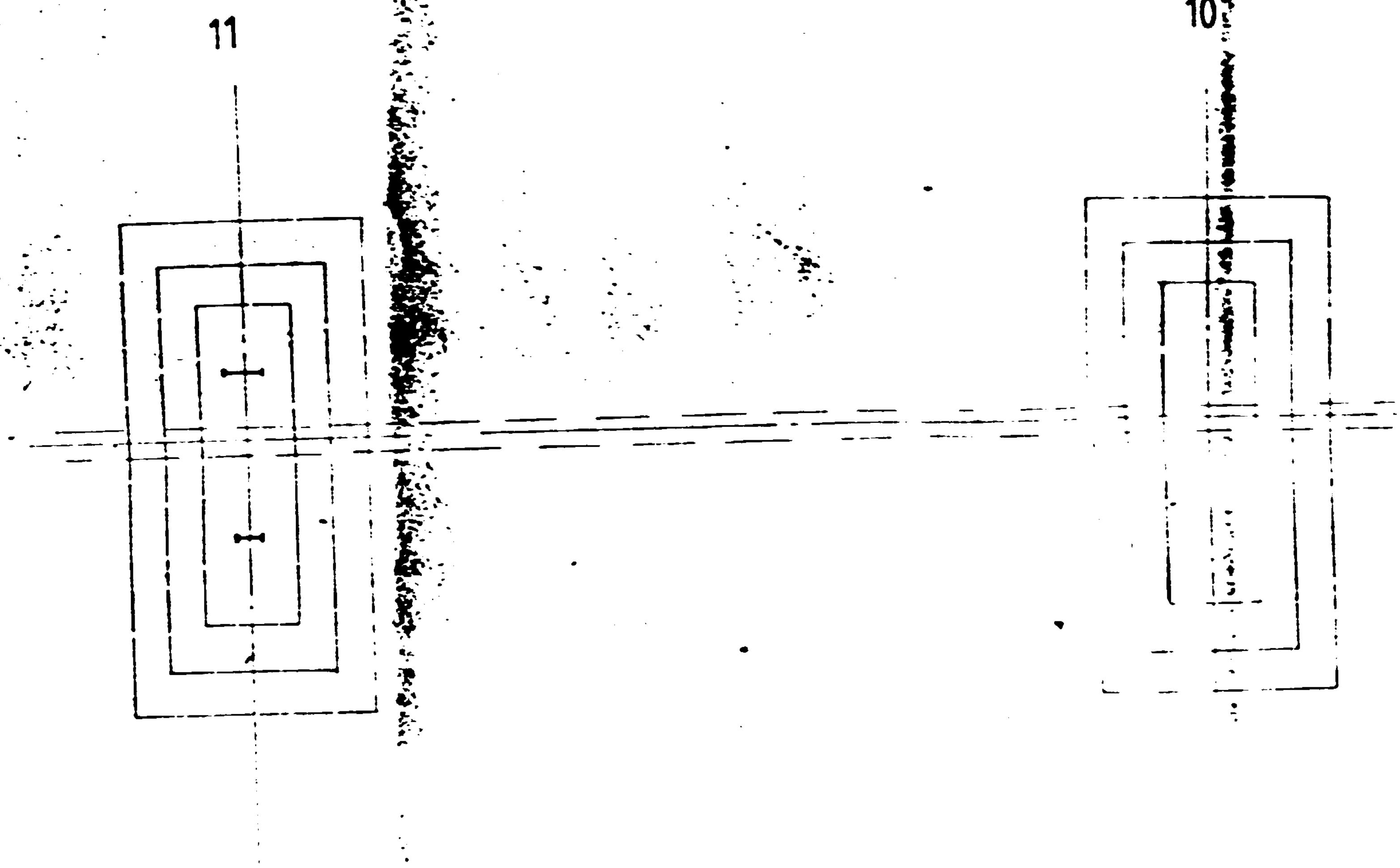
LEGENDA

1. ELEKTROLUČNA PEĆ
2. KONVERTOR
3. INDUKCIONA PEĆ
4. ELEKTROLUČNA PEĆ
5. ELEKTROLUČNA PEĆ

SECTION 13

	Datum	Prezime	Potpis	
konstruis	mart 90'			JELŠINGRAD STEEL FOUNDRY
crtao	mart 90'	LIPOVAC [illegible]		
uskladio				
ovjerio				

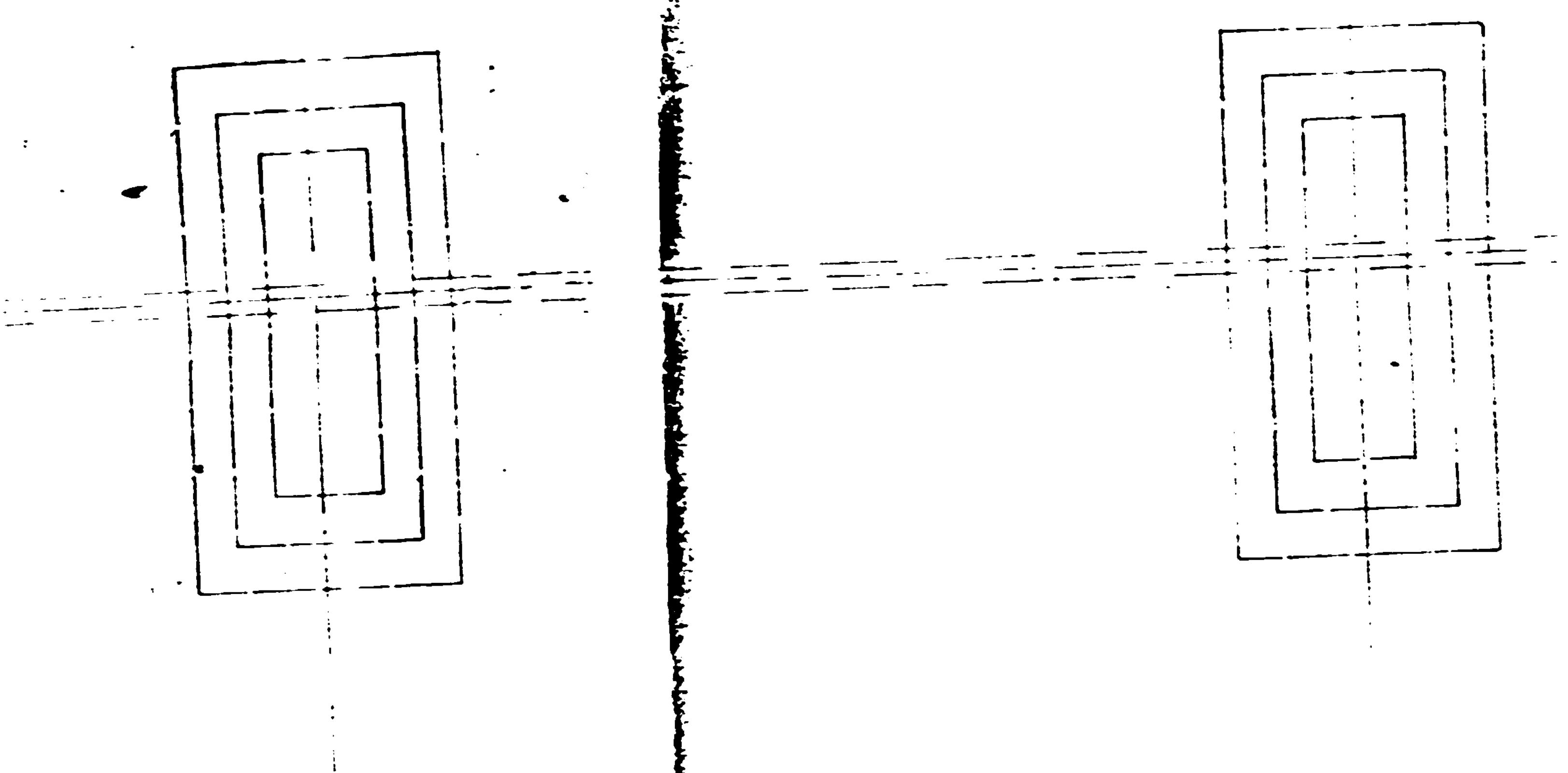
Mjerilo	FEASIBILITY STUDY	br projekta: YUG/87/015
1:200	- FOUNDRY'S LAY-OUT WITH INDICATED CONVERTER POSITION	br crteža 001



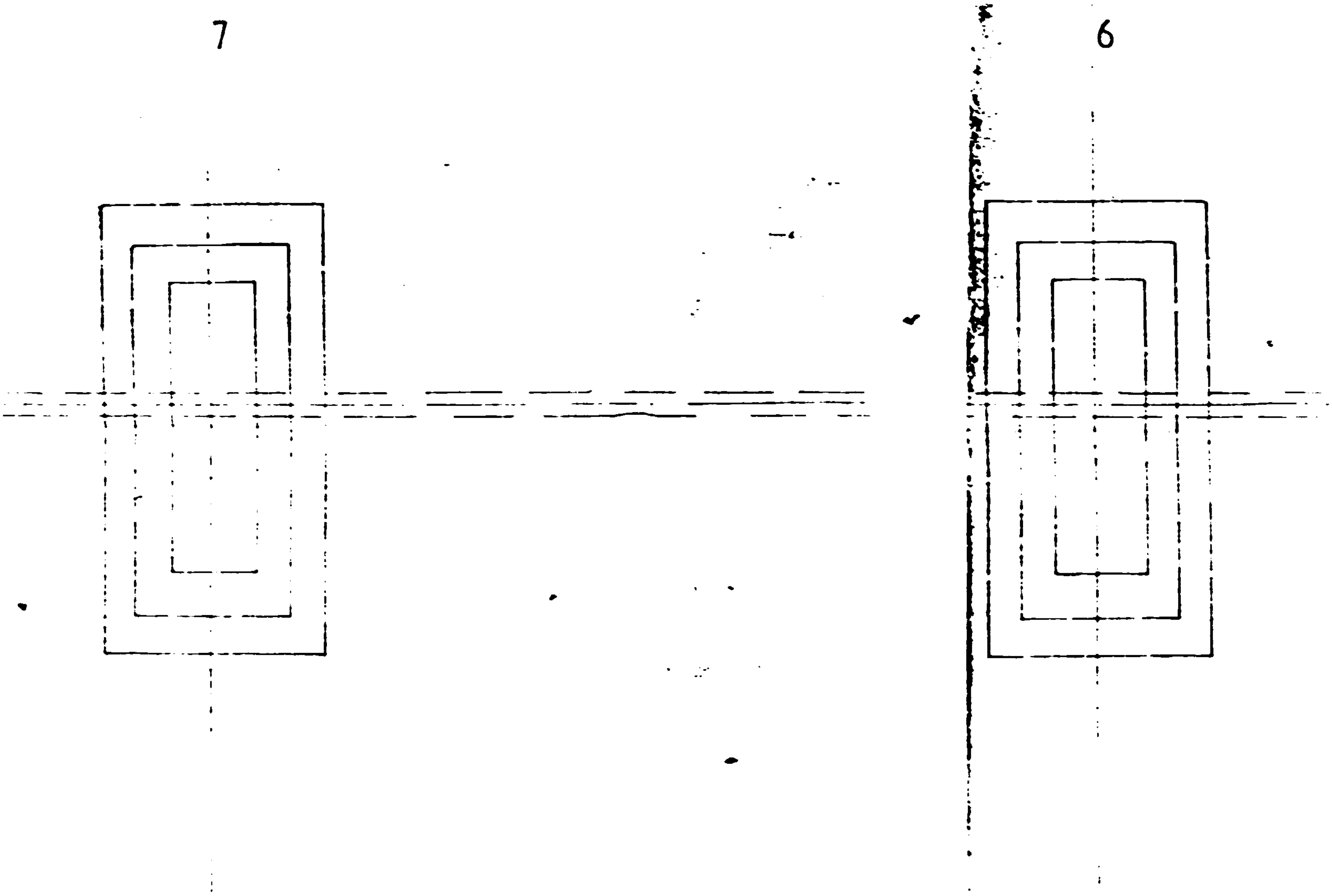
Sect. 1

9

8



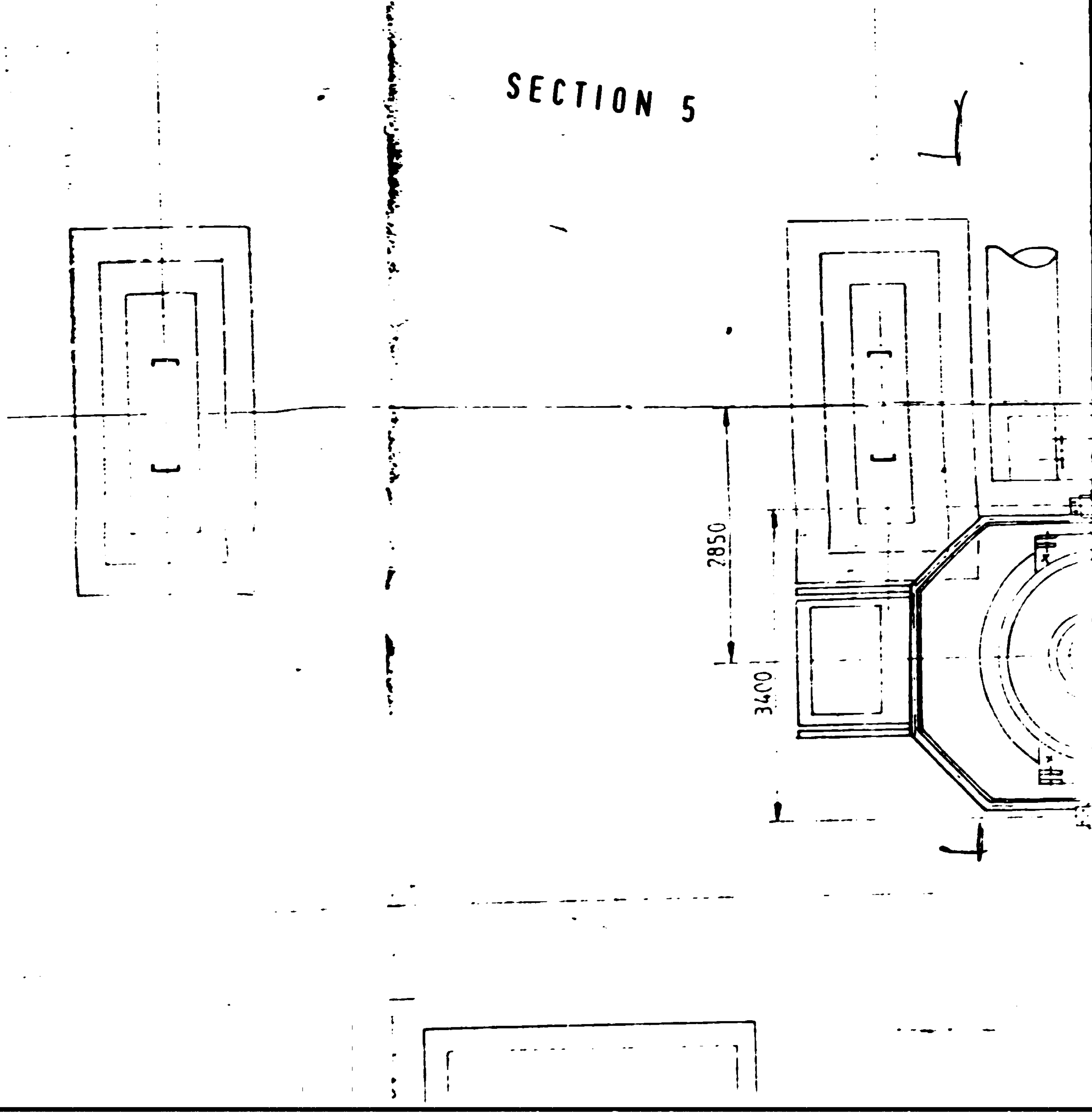
SECT 2



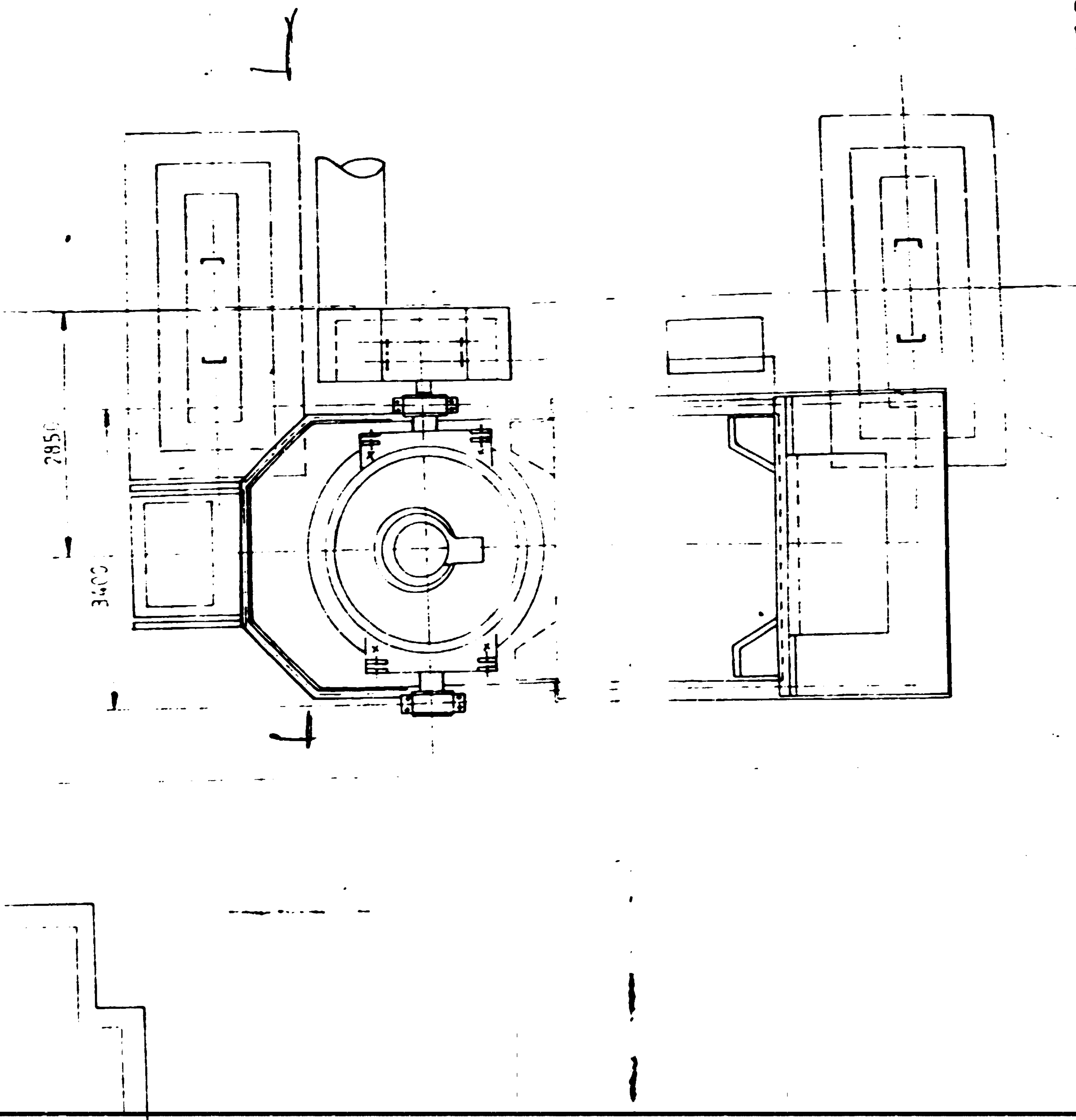
SECTION 3

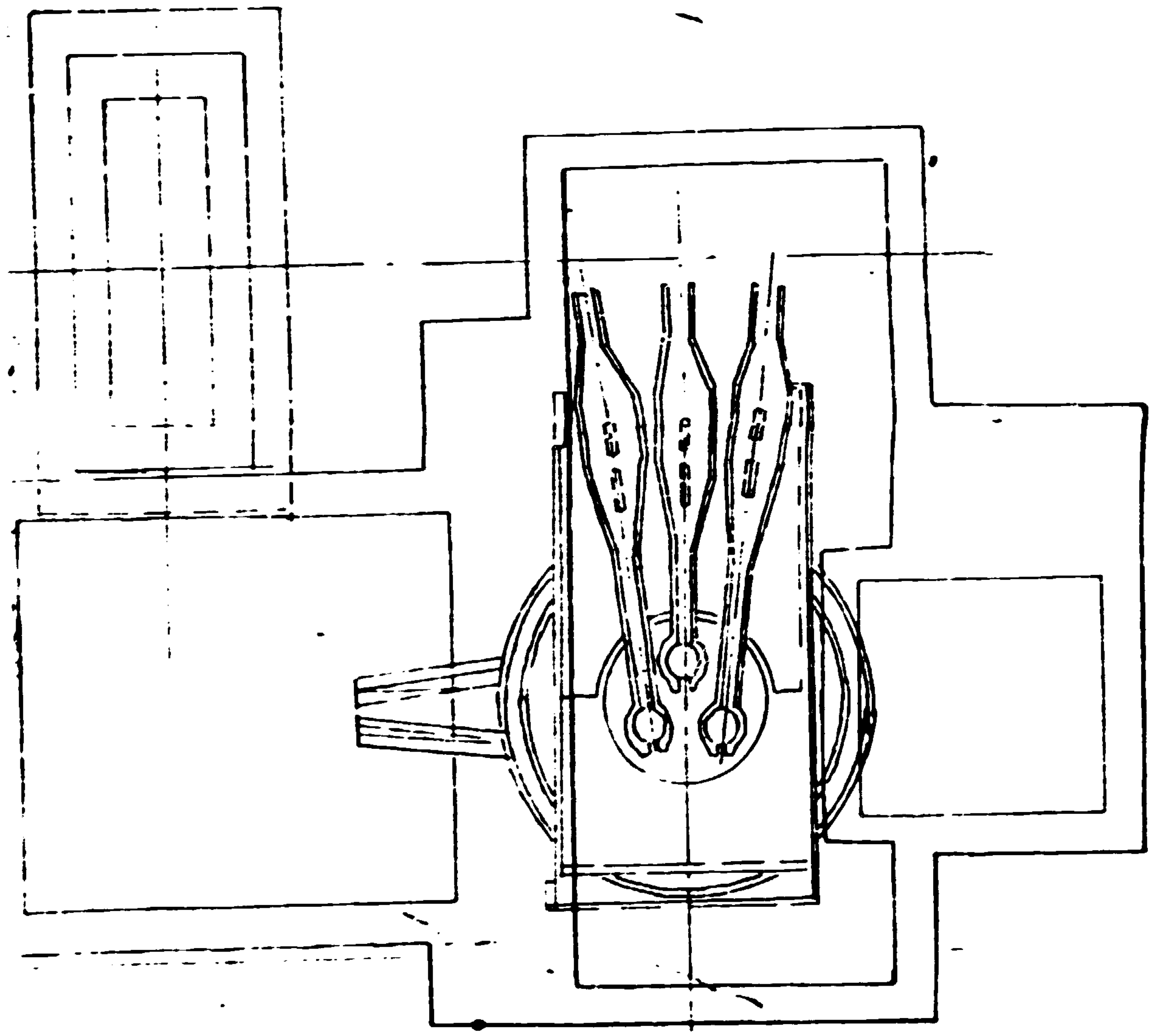
SECTION 4

SECTION 5

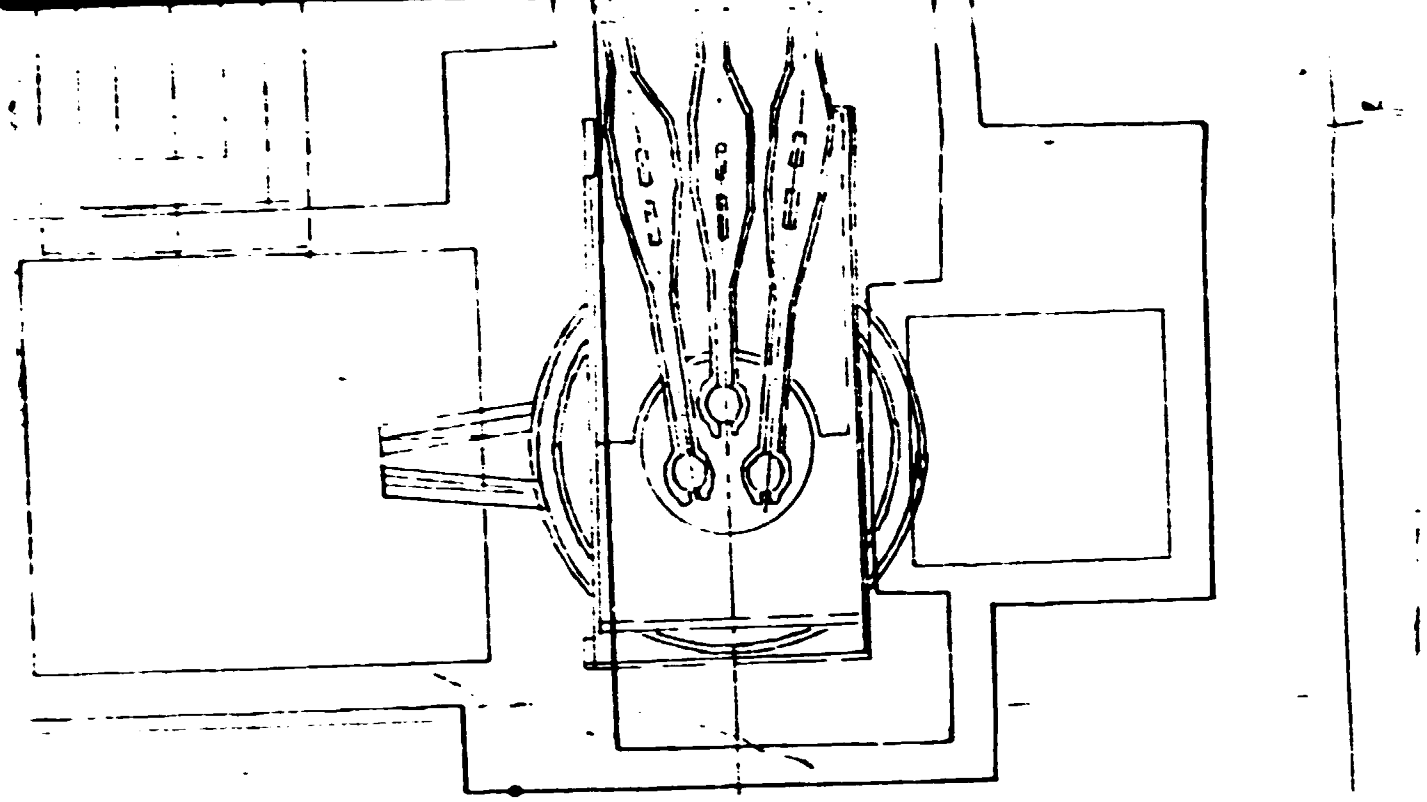


SECTION 6



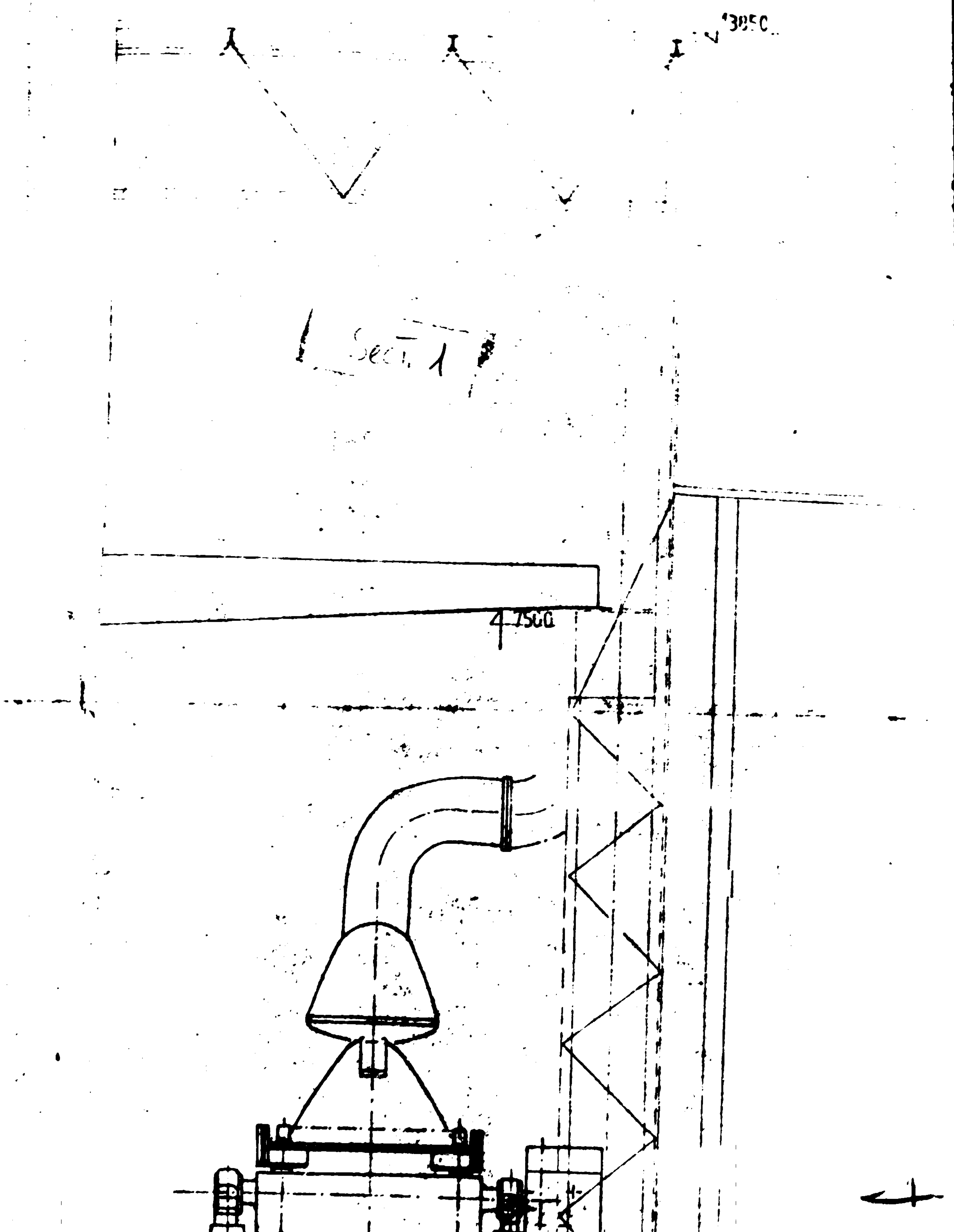


SECTION 7

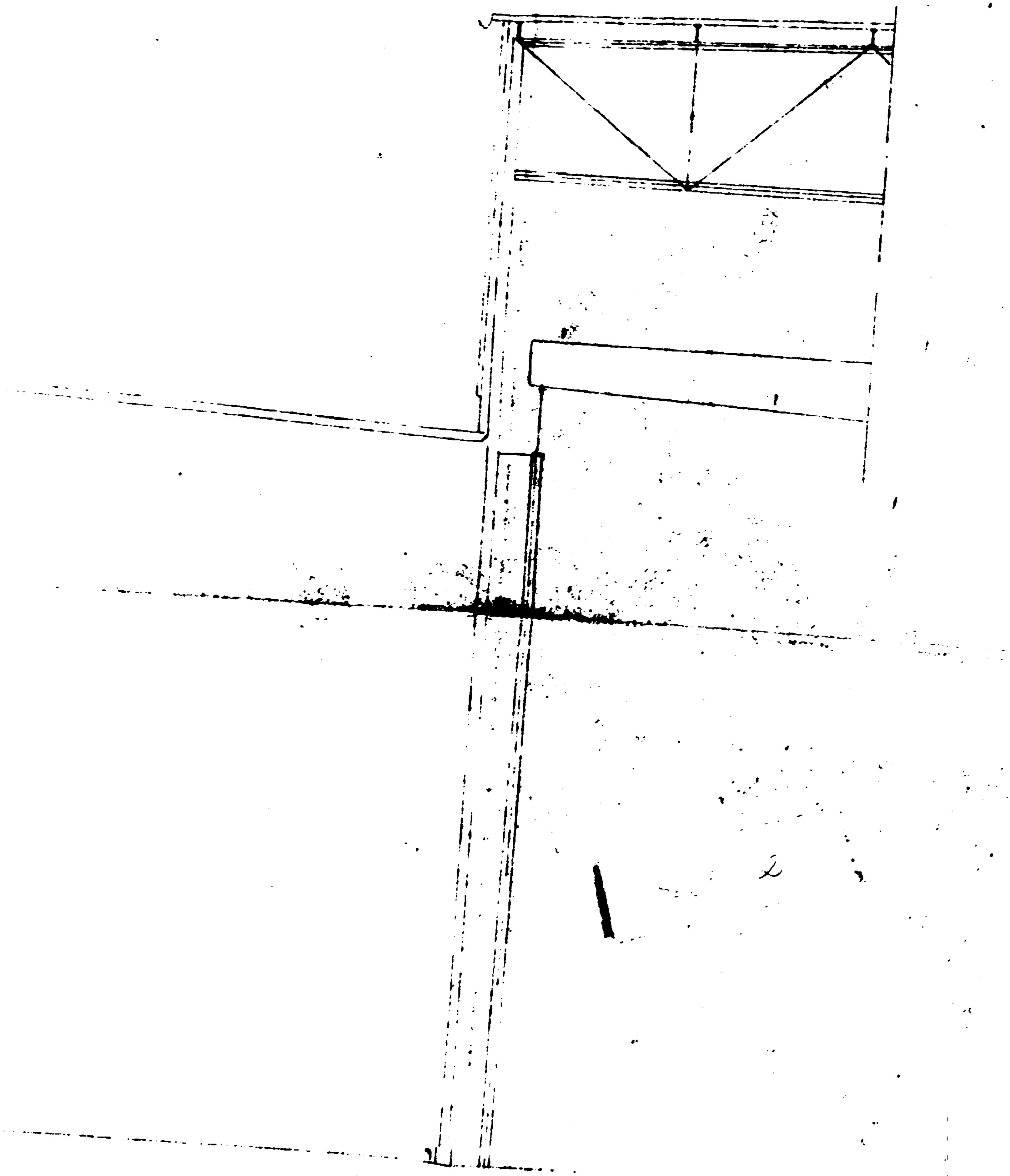


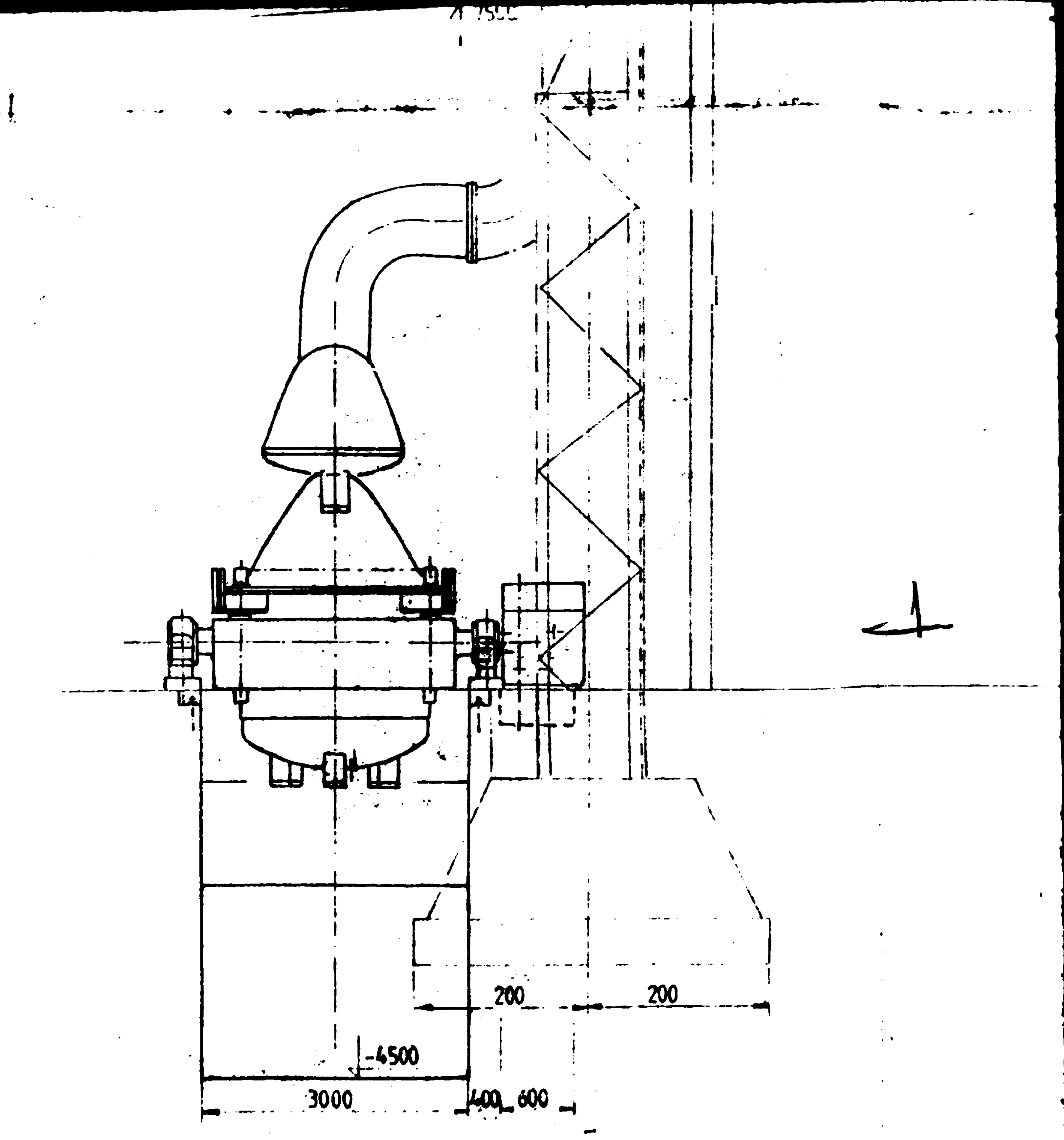
SECTION 8

	Datum	Prezime	Potpis	
konstruis	mart 90			JELŠINGRAD STEEL FOUNDRY
crtae	mart 90	LIPOVAC I.		
uskl.s JUS				
ovjerio				br projekta: YUG/87/015
Mjerilo: 1:200	CONVERTER'S DISPOSITION			[illegible] 002



3050
Sect. 1
4.2500





SECTION 3

SECTION 4

	Datum	Prezime	Potpis
kunstruis.	mart 90		
crtao	mart 90	LIPOVAC I.	
uskl. s JUS			
ovjerio			

JELŠINGRAD
STEEL FOUNDRY

Mjerilo: 1:200

CONVERTER'S DISPOSITION

br. projekta: YUG/87/015

br. crteža: 003

FERROTRON

Ferrotron Elektronik GmbH
Meß- und Regeltechnik
Am Schürmannshütt 30
4130 Moers 1

Telefon (02841) 25262
Telex 8121300
Telefax (02841) 16536

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