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ENERGY EFFICIENCY AUDIT REPORT
PANNONGLAS IND. CO. LTD, OROSHAZI UVEGGYAR
OROSHAZA, HUNGARY

APRIL 1992

PREPARED BY: RCG/HAGLER, BAILLY, INC.
Arlington, VA

and

EGI CONTRACTING/ENGINEERING
Budapest, Hungary

U.S. EMERGENCY ENERGY PROGRAM FOR EASTERN AND CENTRAL EUROPE

U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT
BUREAU FOR EUROPE
WASHINGTON, D.C. 20253

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USAID Contract EUR-0015-C-00-1007-00

PRELIMINARY ENERGY AUDIT
PANNONGLAS - OROSHAZI UVEGGYAR

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QUALITY ASSURANCE

The contents of this report include recommendations based on data provided by the client plant, measurements made on site, calculations, and engineering judgment. The conclusions reached were based on a limited engagement of only about one week's duration in the plant, and not an exhaustive engineering analysis. RCG/Hagler, Bailly, Inc. certifies that this report conforms to the level of best commercial practice for industrial energy audits of similar level of effort, as conducted in the United States. This report has been prepared under the guidance of a registered Professional Engineer, licensed to practice in the United States.

DRAFT
PRELIMINARY ENERGY AUDIT
PANNONGLAS IND. CO. LTD, OROSHAZI UVEGGYAR
OROSHAZA, HUNGARY

BY
RCG/HAGLER, BAILLY, INC. AND EGI CONTRACTING & ENGINEERING

I. EXECUTIVE SUMMARY

1.1 Introduction

A team of engineers from RCG/Hagler, Bailly, Inc. and EGI Engineering & Contracting visited PANNONGLAS Oroshazi Uveggyar glass container works from May 2-7, 1991 to work together with Oroshazi Uveggyar staff to identify and implement improvements to energy efficiency, a preliminary energy audit.

Based on consumption in 1990 and energy prices prevailing at the time of the visit, total energy costs for 1991 at Oroshazi Uveggyar are estimated as Ft 1.2 billion ($17 million), with the primary energy forms being natural gas (3,490 TJ per year, Ft 890 million per year, $12.7 million) and electricity, (11 MW contracted peak demand, 80 GWh/yr, Ft 308 million per year, $4.4 million).

RCG/Hagler, Bailly estimates the potential for energy efficiency improvement at Oroshazi Uveggyar as 20-25% without process changes. During the survey, the RCG/Hagler, Bailly team identified short-term energy efficiency projects, which represent a cost savings of Ft 251 million per year ($3.4 million), or 20% of 1991 energy costs, at a total cost of Ft 40 million or less, (a financial payback of 2 months).

During the course of the audit, the RCG/Hagler, Bailly team worked together with the staff of Oroshazi Uveggyar to improve regenerator operations, resulting in measurable energy savings estimated at Ft 14 million per year ($200,000).

<u>A. General and Energy Management</u>

A.1 Production - optimize regenerator effectiveness, retire Furnace #2, and optimize production scheduling to save Ft 180 million per year ($2,470,000)

A.2 Energy and utilities - monitor specific energy consumption daily (improve gas metering on furnaces), and form efficiency teams to reduce losses to save Ft 31 million per year ($430,000)

B. Short-term, Low-cost Efficiency Improvements

B.1 Production - install O2 and CO analyzers to improve control of excess combustion air using TDC-3000; reduce rate of waste on Furnace #1 to save Ft 13 million per year ($180,000)

B.2 Energy and utilities - restore waste heat recovery system to save Ft 21 million per year ($290,000)

RCG/Hagler, Bailly recommends the following procurement budget for Oroshazi Uveggyar, subject to final approval by USAID:

A.1 Improve archiving and upgrade supervisory controller interface for TDC-3000: $25,000
A.2 Gas meters for furnaces (connect to TDC-3000): $25,000
A.2 Instruments for air, steam, water efficiency teams: $5,000
B.1 CO and O2 analyzers for furnace combustion efficiency optimization for TDC-3000: $25,000

Oroshazi Uveggyar agrees to pay for installation and other costs necessary to implement the projects and to make full use of the equipment supplied by USAID.

1.2 Brief Description of Recommendations

A. General and Energy Management

A.1. Glass Production - optimize furnace operations:

A.1.1 Adjust regenerator cycle time according to the state of each regenerator, for optimum regenerator effectiveness to reduce gas by 3%, 1,800,000 m3/yr, Ft 14 million/yr, $200,000/yr

A.1.2 Retire Furnace #2 as soon as practical. Develop an optimized (least-cost) production scheduling program to enable the plant to run at production levels as prevailed in January - April 1991, running on only three furnaces. Repaint furnace #3 as required to produce flint glass, according to optimum production schedule. Use TDC-3000 supervisory system to archive optimum runs and improve process control. Save 15,000,000 m3/yr, 2,000 kW, 15,000 MWh/yr, Ft 164 million/yr, $2,300,000/yr

A.2. Energy and Utilities -

A.2.1 Monitor specific energy consumption - include measures of specific energy consumption and estimates of energy

cost of production in daily reports, and take control actions to manage efficiency. Install gas meters on lehr furnaces, upgrade archiving and use this information to develop optimum performance characteristics for various conditions. Reduce plant gas energy by 3%, Ft 24 million/yr, $370,000

A.2.2 Form Efficiency Teams for compressed air, steam, electricity, and water to reduce energy loss. Reduce electricity by 5%, Ft 12 million/yr, $170,000

A.2.3 During time of low heat demand, operate a boiler which can use furnace waste heat and thereby minimize auxiliary firing.

B. Short-term, Low-cost Efficiency Improvements

B.1. Glass Production

B.1.1 Install continuous exhaust gas analyzer on furnaces to measure O2 and CO at TDC-3000 - use this measure together with regular O2 measurements at combustion chamber ports to reduce excess air and monitor damper leakage. Reduce gas by 2%, 9.7 MFt/yr, $135,000/yr

B.1.2 Reduce waste rate Furnace #1 - feed bottle-making machine #2 and make other quality improvements to reduce waste from 22.8% to 20% or less. Reduce melt 3% on Furnace #1, saving 234,000 m3/yr, 420 MWh/yr, 3.1 MFt/yr, $42,000/yr

B.2 Energy and Utilities

B.2.1 Waste heat recovery - modify system to recover heat from glass melting to produce hot water/steam. Reduce type 2 gas by 70%, 14 TJ/yr, 21 MFt/yr, $290,000/yr.

C. Capital Improvements

C.1 Production

C.1.1 Replace furnace #2 with improved design - consider offering this project to investors as part of a Joint Venture

C.2 Energy and utilities

C.2.1 Install package boilers, specifically designed to fire

inert gas (Type 2), one sized for winter and one sized for summer load. Either: (1) block off waste heat recovery system from furnace stack, or (2) divert exhaust gases to old stack to avoid back-pressure on furnaces.

C.2.2 Increase efficiency of compressed air supply - install smaller high-efficiency compressor to manage load, improve efficiency of existing machines.

C.2.3 Study feasibility of installing combined cycle electric power generation system - For each furnace install a gas turbine (about 2MW) specifically designed to burn inert gas (Type 2). Install a 40 bar superheated steam boiler/turbogenerator system (about 1.5 MW). Feed the exhaust gas from the turbine to the superheater. Feed mixed exhaust gas from furnace and turbine to evaporator section.

PANNONGLAS Ind. Co., Ltd.
Oroshazi Uveggyar

Summary of energy efficiency projects

	Gas TJ Annual	Electric Peak MW	MWh/yr	Cost MFt/yr	MUS$/yr
I. Base case	3,490	11.000	80,000	1,200	$16.7

Recommendations:

	Gas TJ Savings	Electric savings Peak MW	MWh/yr	Cost savings MFt/yr	MUS$/yr
A. General & Energy Management					
A.1.1 Regenerator	52	-0.005	-4	14	$0.20
A.1.2 Retire furnace #2	435	2.000	15,000	164	$2.27
A.2.1 Energy monitoring	100			24	$0.37
A.2.2 Efficiency teams	5		4,000	13	$0.18
B. Short-term, Low-cost Efficiency Improvements					
B.1.1 Furnace O2 & CO	35			10	$0.14
B.1.2 Waste #1	7		420	3	$0.04
B.2.1 Heat recovery	14			21	$0.29
II. Optimized case	2,842	9.005	60,584	951	$13.3
Total savings	648	2.045	19,416	249	$3.4
Percent of base	19%	19%	24%	21%	20%

II. INTRODUCTION

PANNONGLAS IND. CO. LTD. Oroshazi Uveggyar is located in Oroshaza in southeastern Hungary. The company manufactures has three main products: (1) flint glass containers (clear glass) for bottles, food preserve mason jars and the like, (2) green glass containers such as wine bottles, and (3) sheet glass including laminated glass (not operational at the time of the audit).

Energy represents about 25-30% of manufacturing cost. Gas is the major energy cost; formerly all gas consumed at Oroshazi Uveggyar was a low heating value local gas (known as inert gas because of its very high 65% CO_2 content). Over the years, all production processes have been converted to natural gas, with inert gas now being used only for heating purposes. The plant has an electrical load of 11 MW; formerly up to 2 MW was supplied by heat recovery steam generators (HRSG with auxiliary firing on inert gas) driving condensing/extraction steam turbines (12 bar superheated steam), but this system has been out of service for about four years. The HRSG are now fired by inert gas.

The major energy consuming systems are:

1. glass container furnaces - 4 Zorg-design natural gas-fired furnaces with reversing-flow regenerators
   - #1- 270 tons/day melt flint glass, 5 years old
   - #2- 220 tons/day melt flint glass, 10 years old
   - #3- 203 tons/day melt green glass, 1 year old
   - #4- 220 tons/day melt green glass, 6 years old

2. lehr furnaces - (4, gas-fired) for annealing glass containers

3. sheet glass furnace (HSH) - now shut down

4. boilerhouses (3) with a total of 5 boilers 5 ton/hr each

5. air compressors - 4 electric driven at 1.6-2.0 MW each

6. sand dryers - gas-fired rotary dryers

Formerly, the float glass operations at OroshazI Uveggyar formed part of the company, but this operation has been spun-off as HUNGUARD, a joint venture with Guardian Industries of U.S.A. Management hopes that a similar partial privatization of Oroshazi Uveggyar will take place in the near future, as part of Hungary's industrial restructuring program.

A team of senior engineers from RCG/Hagler, Bailly, Inc. and EGI

Contracting & Engineering, carried out site activities at Oroshazi Uveggyar glass container works from May 2-7, 1991 to work together with Oroshazi Uveggyar staff to identify improvements to energy efficiency. The project manager for the effort was Mr. CSIZMADIA Jeno, Manager of the Energy Division at Oroshazi Uveggyar. The RCG/Hagler, Bailly team consisted of:

David KEITH, RCG/Hagler, Bailly, Project Director
Pascal HABAY, RCG/Hagler, Bailly, Manager for Hungary
KOVACSICS Istvan, EGI Project Engineer for Oroshazi Uveggyar
LONTAY Zoltan, EGI Project Manager
BELCAK Zoltan, EGI Project Manager

The RCG/Hagler, Bailly team presented its recommendations and draft summary report to Mr. CSONT Jozsef, Technical Director, Mr. GORBICS Ferenc, Production Director, Mr. CSIZMADIA Jeno, and other senior staff at the final review meetings May 6-7, 1991, before leaving Oroshazi Uveggyar.

The RCG/Hagler, Bailly team observed that the standard of management and engineering expertise already in place at Oroshazi Uveggyar is very good. Technical staff is very knowledgeable about energy conservation in general, especially in relation to their process. The RCG/Hagler, Bailly team expects that this staff, with a market-driven focus, and a few additional instruments, tools, and equipment, will be fully capable of making significant improvements to energy efficiency. The staff of Oroshazi Uveggyar have already begun adapting to market conditions.

The RCG/Hagler, Bailly team would like to express their sincere appreciation for the extraordinary openness and assistance, willingness to accept recommendations and change operating procedures, and warm hospitality offered by the staff of Oroshazi Uveggyar. It is only because of their openness and cooperation that this effort was possible. The RCG/Hagler, Bailly team is glad to have had the opportunity to become friends with the staff of Oroshazi Uveggyar, and hopes to return their hospitality at some time in the future, whenever Oroshazi Uveggyar staff visit the United States.

III. OROSHAZI UVEGGYAR ENERGY CONSUMPTION ANALYSIS

A graphical presentation prepared by RCG/Hagler, Bailly of basic data received from Oroshazi Uveggyar on energy consumption, production, specific energy consumption, and other key parameters is attached as Appendix 1.

These graphs are provided for use by the staff of Oroshazi Uveggyar in identifying variations in energy efficiency. The analysis is a tool to point the way for more detailed investigations, in order to optimize performance. These detailed investigations are beyond the scope of the current study, but several points are evident from the analysis. The main points arising from the analysis which were used to develop specific recommendations in this report are as follows:

1. From January 1, 1991 through April 30, 1991, the plant operated at the following average production rates:
   Flint glass - 251.35 tons/day (91,741 tons/yr)
   Green glass - 237.70 tons/day (86,760 tons/yr)
   Total glass - 489.05 tons/day (178,501 tons/yr)

2. Glass melting furnaces operated at load factors significantly below capacity (gross production basis):
   #1 - 60.3%
   #2 - 69.8%
   #3 - 68.5%
   #4 - 62.5%
   Based on rated capacities, it might have been possible to make the full production from 3 furnaces instead of 4.

3. Specific energy consumption (gas usage per ton) is much higher for Furnace #2 than the others.

4. Specific energy consumption for each furnace is highly variable, at a given level of production. This could be made more consistent, at a level lower than the present average, through improved to energy management and control of process operations.

5. The gas consumption for operating each furnace (as approximated by regression analysis of daily data for January-April 1991 with engineering judgment used to adjust regression curves) is estimated by RCG/Hagler, Bailly as follows:

#1: 29,000 m3/day plus 100 m3 per gross ton of glass
#2: 41,000 m3/day plus 105 m3 per gross ton of glass
#3: 21,000 m3/day plus 97 m3 per gross ton of glass
#4: 24,000 m3/day plus 95 m3 per gross ton of glass

6. Operation at low load factors (low pull rates) has significantly increased the energy cost of glass in 1991.

7. Generation of waste material (scrap to be remelted) was much higher on Furnace #1 than the others.

IV. OROSHAZI UVEGGYAR ENERGY COST ANALYSIS

4.1 Gas supply costs

Natural gas (29.4 MJ/m3) is known as Type 1 gas and inert gas (11.0 MJ/m3) is known as Type 2 gas. As of May 1991, the following gas tariff was in effect for Oroshazi Uveggyar, (converted based on Ft 72 = $1.00):

Demand charge: Ft 280,000 per GJ/hr per month ($3.89)

Energy charge: Ft 259 per GJ ($3.60)

1990 annual consumption and expected 1991 costs

Demand charge:
Type 1 - 14,000 m3/hr: Ft 115 million/yr
Type 2 - 5,000 m3/hr: Ft 15 million/yr

Energy charge:
3,490 TJ/yr: Ft 903 million/yr

Total gas cost: Ft 1,033 million, $14.3 million

4.2 Electricity supply costs

As of May 1991, the following electricity tariff was in effect for Oroshazi Uveggyar, (converted based on Ft 72 = $1.00):

Demand charge: Ft 370 per kW per month ($5.14)
Energy charge:
On-peak (peak) Ft 4.50 per kWh ($0.063)
On-peak (day) Ft 3.00 per kWh ($0.042)
Off-peak (night) Ft 2.25 per kWh ($0.031)

Oroshazi Uveggyar also pays a slightly higher demand charge because it is supplied by two feeders, for greater reliability. The company receives a slight credit because it has power factor correction systems in place (synchronous motors on air compressors plus correction capacitors).

1990 annual consumption and expected 1991 costs

1. Peak demand (avg): 11,000 kW, Ft 48.84 million, $678,000
2. Energy: 80,000 MWh/yr, Ft 260 million, $3.6 million

Total electric cost: Ft 308 million, $4.4 million

V. RECOMMENDATIONS FOR ENERGY EFFICIENCY IMPROVEMENT

Recommendations by RCG/Hagler, Bailly for energy efficiency improvement have been grouped in three categories:

A. General and Energy Management
These projects are opportunities which are recommended for immediate action, and require little or no expenditure. These projects affect management systems and techniques, rather than process equipment. These projects are the primary focus of the USAID Emergency Energy Program for Hungary.

B. Low-cost, Short-term Improvements
These projects are low-cost improvements to process plant and equipment which are recommended for implementation in the short-term (in 1991). Because of the low cost and quick payback (less than one year), these projects could be implemented from the company's annual maintenance budget. Some of these projects may be of interest to the USAID Emergency Energy Program for Hungary.

C. Capital Improvements
These projects are longer term projects, requiring investment which is outside the plant's annual maintenance budget. Such projects would require more careful study, beyond the scope of this preliminary energy audit. These projects are also beyond the scope of funding under the USAID Emergency Energy Program for Hungary.

A. GENERAL AND ENERGY MANAGEMENT

GLASS PRODUCTION
Oroshazi Uveggyar Action A.1.1 - Optimize furnace regenerator operations

1. Process Area

Glass melting furnaces

2. Statement of Recommendation

Adjust regenerator cycle time according to the state of each regenerator, for optimum regenerator effectiveness.

3. Description/Rationale

3.1 Existing Conditions

Regenerator cycle time has been set at 20 minutes since the furnaces were placed into operation. This setting is based on the manufacturer's recommendations from around 1970. Indications from the thermocouples installed are that the regenerators perform differently from one side of a furnace to the other, that the exhaust gas dampers may be leaking, and that the rate of heat transfer is not constant over the regenerator cycle. However, there are uncertainties in this data because of the response time of the thermocouples and the possibility of clogging of the thermocouples. Such clogging would be likely to occur by deposition of a layer of insulating dust or glass on the thermocouple as the dusty stack gas passes by.

3.2 Findings

The RCG/Hagler, Bailly team worked together closely with the staff of Oroshazi Uveggyar to clearly demonstrate that the 20 minute regenerator cycle time was not optimal for all furnaces, and measurable energy savings were achieved during the audit.

Based on analysis of the time-temperature profile of the exhaust gas and combustion air, the generator cycle time was reduced to 10 minutes, and measurable energy savings of 3-5% (gas consumption) was documented for at least two of the furnaces. The results were unclear for the other furnaces because of process changeovers and during the experiment.

This simple change resulted in significant immediate savings during the course of the audit, which was very exciting for both Oroshazi

Uveggyar staff and the audit team. However, after much analysis and discussion, the RCG/Hagler, Bailly team concluded that the use of the thermocouple time-temperature profile curves was not sufficient to be assured of complete optimization, because of the response time of the thermocouples and possible clogging. It may be possible to further improve the results, but a structured experiment, on a trial-and-error basis, will be required for optimization. It is expected that different cycle times will result for each furnace after the optimization.

4. Benefits

4.1 Energy savings

Following the conclusion of the one-week audit, the regenerator cycle time was changed to 10 minutes. This resulted in measurable energy savings, and the plant was left in a more efficient condition, saving about 2% of the natural gas per ton of glass in the melting furnaces. RCG/Hagler, Bailly team estimates that optimization could further improve this figure to 3% savings. This represents a savings of 1.8 million cubic meters of gas or Ft 14 million per year ($200,000/yr).

4.2 Other benefits (costs)

Additional savings, such as improved quality and hence reduced generation of scrap, are possible since the temperature at the arch, and thus of the glass melt, was found to be more consistent with the shorter cycle time. These benefits are beyond the scope of this report and are therefore not estimated.

Additional cost will be required to maintain the dampers, control valves, and other moving parts associated with the regenerator cycling. These costs are assumed to be negligible, as agreed by Oroshazi Uveggyar.

A slight additional cost for electricity will be required because of the more frequent cycling (6 times per hour instead of 3).

5. Implementation cost

None, except cost of first phase of audit (estimated as $25,000, including travel from U.S. and per diem).

6. Financial analysis

Payback period (based on cost of audit funded by USAID) = capital cost/net annual cost savings

$25,000/$200,000 = 1.5 months

7. Implementation schedule

The project was implemented on the spot. Additional improvement will result from optimization by Oroshazi Uveggyar, which is expected to be completed by the time of the follow-up audit visit in August 1991.

A. GENERAL AND ENERGY MANAGEMENT

GLASS PRODUCTION
Oroshazi Uveggyar Action A.1.2 -
Retire furnace #2 and optimize production scheduling

1. Process Area

Glass melting furnaces and lehr glass annealing furnaces

2. Statement of Recommendation

- Retire Furnace #2 as soon as practical.
- Develop an optimized (least-cost) production scheduling program to enable the plant to run at production levels as prevailed in January - April 1991, running on only three furnaces.
- Repaint furnace #3 as required to produce flint glass, according to optimum production schedule.
- Improve maintenance of exhaust gas dampers and other key components to reduce heat loss and increase production capacity.
- Complete installation of supervisory control system for TDC-3000, so as to optimize performance.
- Carry out optimization tests and archive results using upgraded data storage system for TDC-3000
- Monitor energy consumption at lehr furnaces with TDC-3000 by installing gas flowmeters with signal outputs.

3. Description/Rationale

3.1 Existing Conditions

In theory, the production quantity from January 1 - April 30, 1991 could have been made using three glass melting furnaces instead of four. This was not done because of the following rationale:

- Uncertainty regarding the market conditions - the market in 1991 was the worst ever.

- Uncertainty regarding the ability to restart Furnace #3, given its old age.
- Systems of production scheduling, inventory control, and planning, which are based on traditional factors rather than computerized optimization.

Depending on the market conditions, Oroshazi Uveggyar may shut down Furnace #2 in the fall of 1991.

3.2 Findings

The RCG/Hagler, Bailly team carried out detailed analysis of daily production data for January 1 - April 30, 1991 (see appendix). This analysis revealed that production could have been maintained using three furnaces at about 85% load instead of four furnaces at about 64% load.

The RCG/Hagler, Bailly team found the level of expertise very high at Oroshazi Uveggyar, and is quite confident that the staff will be able to cope with the current market conditions running only three furnaces.

Further, the efficiency of Furnace #2 has deteriorated very badly. The furnace is 10 years old, twice its design life. The fixed energy cost of continuing the operation of Furnace #2 is $6,000 per day.

Unfortunately, the RCG/Hagler, Bailly team is not confident that the market will return to its pre-1991 level this year, and therefore finds that continued operation of Furnace #2 is not justified.

At the final briefing during the plant audit, RCG/Hagler, Bailly strongly recommended that Oroshazi Uveggyar shut down Furnace #2 immediately. Oroshazi Uveggyar agreed to do so as soon as practical.

4. Benefits

4.1 Energy savings

RCG/Hagler, Bailly estimates that optimization will enable the full production to be performed by three furnaces. This will save the fixed energy consumption of Furnace #3 (gas and electric) and will enable the variable energy consumption per unit of glass to be reduced slightly.

The RCG/Hagler, Bailly team estimates that this optimization could

reduce energy consumption as follows:

reduce gas consumption by 15 million cubic meters per year
reduce electrical peak demand by 2 MW
reduce electrical energy consumption by 15,000 MWH/yr

This represents an energy savings of Ft 164 million per year ($2.3 million).

4.2 Other benefits (costs)

Additional savings, such as improved quality and hence reduced generation of scrap, are possible since reduced operation will be possible for the bottlemaking machine associated with Furnace #1, which has a high scrap rate. These benefits are beyond the scope of this report and are therefore not estimated.

A small additional cost will be required from time-to-time to repaint Furnace #3, if it becomes necessary to change over production from green glass to flint glass and vice versa. Through optimum production scheduling, this cost should be very small.

5. Implementation cost

Equipment required:

Least-cost production scheduling program	$100,000
Upgrade TDC-3000 data storage archiving	5,000
Other (to be determined later)	50,000
TOTAL	$155,000

On-going operations and maintenance expenses (increase) $100,000/yr

Optional - rehabilitation of Furnace #2 (if necessary)
estimated cost $1 million
preferred solution - replace Furnace #2 (recommendation C.1.1)

6. Financial analysis

Payback period (including investments by both USAID and Oroshazi Uveggyar) = capital cost/net annual cost savings

$155,000/($2,300,000 - $100,000) = 0.07 year (4 weeks)

7. Implementation schedule

By RCG/Hagler, Bailly during U.S. Emergency Energy program:
Procure improved data archiving system for TDC-3000 and deliver to plant by 1 August 1991.

By Oroshazi Uveggyar:
Retire furnace #2 as soon as practical, procure production schedule optimizing system, carry out archiving runs, improve damper maintenance, and institute monitoring systems using TDC-3000 by 31 Dec 91.

9. Specification of equipment for A.I.D. procurement

Data archiving -
- TDC-3000 5.25" floppy disk drives (4)
- FDD converter assembly (4)
- FDD signal cable (4)
- FDD power cable (4)
- Trend DB diskettes (50)

A. GENERAL AND ENERGY MANAGEMENT

ENERGY & UTILITIES
Oroshazi Uveggyar Action A.2.1 -
Monitor energy efficiency and complete installation of supervisory system for optimization

1. Process Area

Energy Dept.

2. Statement of Recommendation

Plant management needs to be able to obtain the information needed quickly enough to exercise the control required to improve efficiency in the use of energy and other valuable inputs. There are several steps required to achieve closed loop control for efficiency.

Step 1 - The daily report should be modified to include calculation of the ratio of energy consumption (gas and electric) to tons of production (gross and net). Oroshazi Uveggyar management agreed to add this information to the daily report as soon as possible.

Step 2- A management information system (M.I.S.) should be installed on Energy Department's PC computer to provide the information necessary for energy management. This system should have software designed to calculate the necessary performance ratios and to present information to management in an easily-understandable form, preferably graphical with trends and scatter diagrams.

Step 3 - Management must use the information to make short-term management decisions which lead to control actions (changes) which affect plant operations. A plant-wide management control system should be developed on a daily basis.

Step 4 - Realistic energy management targets should be set, based on improvements in performance ratios. Specific projects, operational changes, and maintenance procedures should be carried out in order to achieve these targets (such as those suggested elsewhere in this report), and success of these actions should be measured and documented by the M.I.C.S.

Step 5 - Gas consumption at lehr furnaces (glass bottle annealing) should be monitored and brought into the control system for efficiency, to achieve additional benefits.

Step 6 - The supervisory control system for the TDC-3000 should be completed as soon as possible. This will require:
1) Upgraded interface cabling
2) Control room improvements for EMI protection
3) System programming

3. Description/Rationale

3.1 Existing Conditions

The system of management information and control in place at Oroshazi Uveggyar is typical of most factories in Hungary. Production is based on plans, and management exercises control over the process to see that the plan is carried out. These plans set performance targets, which are based on input and output quantities.

A vast amount of data is collected every day, in the form of logs and other records from many different sources, including the TDC-3000. These data are used to assemble daily reports. The main purpose of these daily reports is to monitor production quantity and also quality (scrap). At present, the information regarding energy consumption is not systematically brought together with production data in the daily reports.

3.2 Findings

Energy usage should be well correlated with production, as indicated by the results of a regression analysis. In such a regression analysis, RCG/Hagler, Bailly analyzes the correlation between energy consumption and the physical production processes which constitute energy demand. In Oroshazi Uveggyar, RCG/Hagler, Bailly obtained daily production and energy consumption data for the four glass melting furnaces, which was entered into a statistical analysis database.

The amount of energy consumed in any given period (dependent variable) should be correlated to the production achieved during the same period (the independent variables).

Separate regression analyses were carried out for Oroshazi Uveggyar on each furnace. The independent variable selected for Oroshazi Uveggyar was daily production (tons) of melted glass (gross or net). The dependent variable was natural gas consumption in the corresponding furnace.

RCG/Hagler, Bailly analyzed daily data during a four-month sample period (January 1, 1991 - April 30, 1991). Compared to our experience in carrying out similar analyses in other plants in other countries, the indicator of correlation between energy consumption and gross furnace production is lower than expected. This analysis indicates that

(1) energy consumption varies excessively for a given level of production, and

(2) energy consumption in the furnaces at Oroshazi Uveggyar has an extremely high fixed cost component (fixed radiation and convective losses).

The results of the analysis are indicated in the tables on the following two pages. In each table, the constant term and variable term is indicated, as are other indicators of variation and statistical significance ("t" test).

In the first set of tables, the daily gross furnace output (tons of melted glass pulled) is compared to the furnace gas energy consumption (cubic meters per day).

In the second set of tables, daily net production line output (good glass bottles produced) is compared to the ratio of gas energy cost to good glass bottles. Because the dependent variable is a ratio calculated from the independent variable, correlation coefficients are inherently higher in this analysis.

These tables may be used to compare furnace performance, and also to develop equations of energy consumption and energy cost at varying production rates. The typical such equation from these linear regression lines is:

$$y = ax + b,$$

where y = dependent variable (such as energy consumption)
x = independent variable (production)
a = slope, "x coefficient"
b = intercept, "constant"

Oroshazi Uveggyar
Regression based on daily data Jan. 1 - April 30, 1991

1. RELATIONSHIP BETWEEN PRODUCTION AND ENERGY CONSUMPTION

Independent variable: furnace production, gross tons per day
Dependent variable: gas consumption, cubic meters per day

Furnace #1 - Regression Results:

Constant	31,600	cubic meters per day
Std Err of Y Est	2,614	
R Squared	0.664	(medium correlation)
No. of Observations	95	
Degrees of Freedom	93	
X Coefficient(s)	84.79	cubic meters per ton
Std Err of Coef.	6.24	cubic meters per ton
t test	13.58	(significant - good prediction)

Furnace #2 - Regression Results:

Constant	57,662	cubic meters per day
Std Err of Y Est	2,132	
R Squared	0.002	(no correlation)
No. of Observations	95	
Degrees of Freedom	93	
X Coefficient(s)	5.24	cubic meters per ton
Std Err of Coef.	12.26	cubic meters per ton
t test	0.42	(NOT significant - NO prediction)

Furnace #3 - Regression Results:

Constant	26,573	cubic meters per day
Std Err of Y Est	2,140	
R Squared	0.449	(fair correlation)
No. of Observations	95	
Degrees of Freedom	93	
X Coefficient(s)	59.00	cubic meters per ton
Std Err of Coef.	6.78	cubic meters per ton
t test	8.70	(significant - medium prediction)

Furnace #4 - Regression Results:

Constant	24,415	cubic meters per day
Std Err of Y Est	1,826	
R Squared	0.468	(fair correlation)
No. of Observations	95	
Degrees of Freedom	93	
X Coefficient(s)	95.11	cubic meters per ton
Std Err of Coef.	10.50	cubic meters per ton
t test	9.05	(significant - medium prediction)

Oroshazi Uveggyar
Regression based on daily data Jan. 1 - April 30, 1991

2. COST EFFICIENCY - RELATIONSHIP BETWEEN PRODUCTION, WASTE AND ENERGY CONSUMPTION

Independent variable: line production, net tons good bottle per day
Dependent variable: unit cost, specific gas energy cost (Ft/kg net)

Production Line #1 - Regression Results:

Constant	5.66 Ft/kg
Std Err of Y Est	0.38
R Squared	0.82 (good correlation)
No. of Observations	95
Degrees of Freedom	93
X Coefficient(s)	-0.021 Ft/kg per ton/day
Std Err of Coef.	0.001
t test	-20.70 (significant - good prediction)

Production Line #2 - Regression Results:

Constant	7.62 Ft/kg
Std Err of Y Est	0.20
R Squared	0.89 (good correlation)
No. of Observations	95
Degrees of Freedom	93
X Coefficient(s)	-0.03 Ft/kg per ton/day
Std Err of Coef.	0.001
t test	-28.08 (significant - good prediction)

Production Line #3 - Regression Results:

Constant	4.62 Ft/kg
Std Err of Y Est	0.30
R Squared	0.78 (good correlation)
No. of Observations	95
Degrees of Freedom	93
X Coefficient(s)	-0.019 Ft/kg per ton/day
Std Err of Coef.	0.001
t test	-18.48 (significant - good prediction)

Production line #4 - Regression Results:

Constant	4.20
Std Err of Y Est	0.14
R Squared	0.75 (good correlation)
No. of Observations	95
Degrees of Freedom	93
X Coefficient(s)	-0.018
Std Err of Coef.	0.0009
t test	-16.77 (significant - good correlation)

The data from these regression lines are plotted in the scatter diagram found in the Appendix. RCG/Hagler, Bailly notes that the regression lines generated by the computer should be adjusted slightly in those cases in which engineering judgment is available, especially if regression correlation coefficients are not high.

Data regarding energy consumption collected by the TDC-3000 is organized, analyzed and presented to management on a daily basis. However, performance ratios such as energy per unit of production are not calculated on a daily basis, although this could be done from the available meters and daily reports. Providing this information directly to management would give a good picture of how well the process is performing, in terms of energy efficiency, on a daily basis, so that management can exert short-run control actions which would improve efficiency.

The TDC-3000 supervisory system is designed to achieve these benefits. However, development of the installation of the TDC-3000 supervisory system has been delayed because of a number of problems, such as interfacing (shielded coaxial cable), electro-magnetic interference (control room EMI), overheating and humidity (control room environmental conditions), and delays in completing programming (being done in-house instead of contracted out).

4. Benefits

4.1 Energy savings

The RCG/Hagler, Bailly team estimates that improvements to management information and actions to control operational efficiency, can achieve energy savings in the amount of 5-10% of annual energy consumption, based on experiences of similar companies in the U.S. and Europe which have upgraded their digital control systems. However, to be conservative the RCG/Hagler, Bailly team assumes a savings of 3% of gas consumption in calculating the benefits of the system. The expected value of the energy savings is:

Gas - management control
Savings 100 TJ/yr, Ft 24 million/yr, $370,000

4.2 Other benefits

Additional savings, such as reduced electricity consumption, are possible, but are not estimated.

5. Implementation cost

Equipment required:

Gas meters	$15,000
Energy Dept. computer software	1,000
Complete programming of TDC-3000 supervisor	50,000
Supervisory controller interface	5,000
EMI protection components	3,000
TOTAL	$74,000

Annual operations and maintenance expenses (increase)
$50,000 per year

6. Financial analysis

Payback period (including investments by both USAID and Oroshazi Uveggyar) = capital cost/net annual cost savings

$74,000/($370,000 - $50,000) = 0.2 year (3 months)

7. Implementation schedule

By RCG/Hagler, Bailly during U.S. Emergency Energy program:
Procure gas flow meters for lehr furnace and glass melting furnaces and deliver to plant by 1 August 1991. Deliver project files for Lotus software for Energy Dept. Procure supervisory system interface cabling and supervisory system control room EMI protection equipment and deliver to plant by August 1, 1991.

By Oroshazi Uveggyar:
Institute daily efficiency monitoring as soon as possible, develop efficiency tracking software, and install gas meters by 10 September 1991.

8. Specification of equipment for procurement under A.I.D. program

Gas flowmeters for melting and lehr furnaces (7) - Annubar type ANR 75 for Honeywell TDC-3000, as follows:

Flow Sensor units:
- quantity 1 - 125 mm I.D., nominal
- quantity 1 - 150 mm I.D., nominal
- quantity 1 - 200 mm I.D., nominal
- quantity 4 - 50 mm I.D., nominal

Flow pressure sensor units:
- quantity 1 - 1.45 bar
- quantity 1 - 1.05 bar
- quantity 1 - 1.28 bar
- quantity 1 - 1.00 bar
- quantity 3 - 0.03 bar

Transmitter units to TDC-3000:
quantity 7 - 41101-3001-14-01
quantity 7 - 41220-3001-13

TDC 3000 Supervisory room components -
Shielded coaxial cable, 2 pcs, 250 meters each, (diameter sized for BNC connectors)
EMI shielding floor mat
Rotating recording thermo-hydrograph and charts

A. GENERAL AND ENERGY MANAGEMENT

ENERGY & UTILITIES
Oroshazi Uveggyar Action A.2.2 -
Put energy efficiency teams in action to reduce energy losses

1. Process Area

Energy Management

2. Statement of Recommendation

The RCG/Hagler, Bailly team recommends that Oroshazi Uveggyar form "Energy Efficiency Teams" for electric motors, compressed air, heat, steam and hot water. Personnel for this team should be drawn from Oroshazi Uveggyar staff, and this exercise should become a continuous part of plant operations and maintenance.

The Compressed Air Efficiency Team would be responsible to evaluate efficiency of compressed air systems, and to seek out and repair leaks in compressed air lines. The Heat Efficiency Team would be responsible for combustion efficiency, insulation, and the identification and repair of leaks in steam and hot water systems. The Electric Motor Efficiency Team would be responsible to survey electric motor load and efficiency, check and clean motors, replace underloaded motors, rewind or replace motors with excessive reactance, and develop a plan for introduction of high efficiency motors.

3. Description/Rationale

3.1 Detailed Description

The Compressed Air Efficiency Team should have the following tasks:

- Based on design data, make an inventory of all uses of compressed air
- On a monthly basis, carry out an analysis of air compressor efficiency and record in logbook. If less than design, investigate the causes.
- Carry out a survey of the plant every month to identify compressed air leaks, and record them in a log book. Measure the flow of leaks using a velometer and prepare a report, with the monthly cost of each leak clearly indicated. Develop a plan for leak repair, based on

priority.

The Heat Efficiency Team should have the following tasks:

- Develop an inventory of the uses of steam, hot water, and other forms of heat in the plant.

- On a monthly basis, carry out an analysis of boiler efficiency and record in logbook. If less than design, investigate the causes, such as high air/fuel ratio or excessive blowdown.

- Carry out a survey of the condition of steam and hot water pipe insulation in the plant, using thermocouples and other temperature indicators.

- Check the operation of all steam traps in the plant on a monthly basis, using the "glove test" or other simple methods. Repair or replace leaking traps as found.

The Electric Motor Efficiency Team should have the following specific tasks:

- Based on nameplate and available meters, make a complete inventory of all motors over 5 kW, which identifies the motor number, rating (kW), location, age, voltage, rpm, running amperes, expected annual energy consumption, description of use.

- Obtain curves of efficiency vs. percentage load and power factor vs. percentage load from Oroshazi Uveggyar's major suppliers of motors families of motors now installed in the plant. (Typical curves are included in RCG/Hagler, Bailly's report for reference).

- Develop specifications for the procurement of new motors for the plant, for new applications. Obtain manufacturer's data on price, efficiency and power factor (cos phi) for alternative lines. In the U.S., manufacturers offer two types of electric motors - standard motors and high efficiency motors which reduce energy consumption by 3-10% for the same application. The increase in efficiency is greatest for smaller sizes (under 50 kW), since large motors are relatively efficient. The high efficiency motor costs about 50% more than the standard motor, but in applications with high duty factor (over 4,000 hours per year, like Oroshazi Uveggyar), this incremental cost can be recovered in one year or less. RCG/Hagler, Bailly

expects that the results of this analysis will result in the development of a new specification, for high efficiency motors.

- After carrying out the analysis and developing the new high efficiency specification for new motors, consider the possible replacement of existing motors with high efficiency motors on a phased basis. One way to implement this policy would be to buy a quantity of high efficiency motors which would be used to replace burned-out motors, instead of rewinding them. Often, rewound motors have lower efficiency than new motors, as the magnets can suffer reduced flux if they are overheated in the process. Efficiency loss can also result because rewinding is usually done to lower quality standards than new manufacturing, so increased friction can result from slight misalignment. Finally, if wire of smaller diameter or higher resistivity is used in the rewind job, resistive losses will increase. It is the RCG/Hagler, Bailly team's experience that a rewound motor has an efficiency 1-5% less than a new motor, and rewinding costs 50% or more of the cost of a new motor.

- Using portable volt-ammeter, power factor meter, carry out an electric motor load survey. The load (kW, kVAR, cos phi), voltage on each phase, and efficiency of all motors over about 10 kW should be checked using a systematic procedure.

- Using a strip-chart demand recorder, carry out power demand survey (kW, kVAR, metered demand kW, and kWh/shift) for load centers over 100 kW. Based on this data, develop a power demand balance for the plant, under various operating conditions.

- Based on the results of the power demand survey, work together with process personnel to investigate ways to reschedule operations to reduce peak demand and to shift consumption from peak to off-peak hours.

- If motors with excessive reactance are identified, they should be taken out of service for rewinding or replacement, since kVAR charges paid by Oroshazi Uveggyar are substantial.

- Institute a monthly policy of motor maintenance. Check that bearings are getting proper lubrication. Electrical connections should be checked and tightened if necessary. The housing and ventilation air intake on all motors

should be cleaned to improve cooling and efficiency. Compressed air should be used to blow out dust and dirt from internal parts of the motor (air should be dry and less than 4 bar pressure to avoid damaging insulation). The motor and its drive system drive should be checked for proper alignment, proper belt tension, and proper lubrication. Insulation should be tested with a megohmeter, and a log should be kept of these readings so that comparisons can be made from month-to-month. Check for excessive vibration.

- As underloaded motors are identified by the survey, they should be changed for motors appropriately sized for the job. The inventory (developed above) should serve as the basis for moving motors from one location to another within the plant to match sizes to loads. If properly sized motors are available from spares or stocks, replacements of a given kW rating should prioritized on the basis of the possible efficiency improvement (degree of underloading and operating hours per year).

- If phase-to-phase voltage imbalance is found (over 2%), then adjustments should be made to correct the problem. For every 2% variation in phase-to-phase voltage, a motor loses about 1% in efficiency. For the 0.4 kV system, the phase voltages should be equal within ±5 volts, otherwise efficiency is reduced. Voltage imbalance can be caused by loose or corroded connections at bus bars, starter terminals, fuses, or the motor itself. If the problem is caused by single-phase loads which are attached one of the phases, these loads should be more equally distributed among the phases, or else the transformer should be retapped.

3.2 Existing Conditions

Oroshazi Uveggyar requires a high consumption of compressed air in the bottle-making machines and other process equipment. Electric motors are installed in the plant for air compressors, water pumping, material processing (grinding, mixing), ventilation (fans), and material handling. These motors are not all sized according to the capacity needed to do the job. There are also many motors operating in extremely dusty environments, such as raw material preparation.

3.3 Findings:

On May 7, 1991, the RCG/Hagler, Bailly team carried out a spot-check assessment of compressed air leaks, using an Alnor velometer

and a flow diverter tube. The air velocity readings obtained were converted to volume and cost, using the efficiency of the air compressor calculated by RCG/Hagler, Bailly based on measured performance parameters at the time. A number of leaks were measured, with the most notable being leaking valves on the raw material feed at the top of the furnaces and on the bottom of the compressed air receivers in the yard near the compressors. The most significant leaks had costs of $15,000 per year or more.

On May 3-4 the RCG/Hagler, Bailly provided a demonstration for Oroshazi Uveggyar staff of a spot-check on the Oroshazi Uveggyar electrical system at Furnace and bottle-making machine #1, using a strip-chart recording kW, kVAR meter.

3.2 Findings

The RCG/Hagler, Bailly team concludes that there is sufficient scope for improvement in reducing energy losses through leaks and underloaded motors at Oroshazi Uveggyar to justify an improvement project.

4. Benefits

4.1 Energy savings

The RCG/Hagler, Bailly team estimates that the potential savings of this program is 5% of electric energy and 0.15% of thermal energy, in the first year. Over time, as motors are replaced and maintenance is improved, the ultimate possible savings are about 8% of electric energy consumption.

4.2 Other benefits

The maintenance program will increase motor life, thereby reducing replacement and rewinding costs over the long run. The maintenance and monitoring program will also reduce the frequency of shutdowns in production operations because of motor failures, thereby having a productivity benefit. These benefits are not estimated in this report.

5. Implementation cost

Equipment required:

(1) Digital strobe tachometer
(1) Digital multimeter/megohmeter with current clamp and Power factor meter
(1) Velometer
(1) Digital thermocouple indicator and probes
(1) Fyrite combustion analysis kit
total estimated cost $5,000 (USAID)

Incidental equipment and repairs budget (additional maintenance) $50,000 per year

6. Financial analysis:

Payback period (including investments by both USAID and Oroshazi Uveggyar) = capital cost/net annual cost savings
$5,000/($180,000 - $50,000) = 0.04 year (2 weeks)

7. Implementation schedule

By RCG/Hagler, Bailly during U.S. Emergency Energy program:
Procure instruments and deliver to plant by 1 August 1991.

By Oroshazi Uveggyar:
Form leak teams as soon as possible, and implement programs by 10 September 1991.

8. Specification of equipment

(1) Digital tachometer (Transcat 7258FST-W or equivalent)

strobe-type, 0-15,000 rpm

digital display to 0.1 rpm

accuracy ± 2 rpm

50 Hz, 220 V

(1) Digital multimeter with integral current clamp (ITT or equivalent)

measure amps, volts, ohms, power factor

voltage probes suitable for 1000 volts

clamp-on current probe - 1000 amps, 2 inch diameter

rugged industrial case

(1) Velometer

Indicator (Alnor digital or equivalent), range 0-50 m/s
Pitot tube probe
Pressure probe

(1) Digital thermocouple indicator and probes

Indicator (Fluke dual-channel or equivalent), range -50C to 1000C

Piercing probe

Immersible probe

Air probe

Case

(1) Fyrite combustion analysis kit (Bacharach gas-burner or equivalent), including

Oxygen sample tester, range 0-21%

Carbon dioxide sample tester, range 0-15%

Thermometer, range 0-1000C

Sample pump

Case

B. LOW-COST SHORT-TERM IMPROVEMENTS

GLASS PRODUCTION
Oroshazi Uveggyar Action B.1.1 -
Install continuous oxygen and CO sensors on glass melting furnaces

1. Process Area

Glass-melting furnaces

2. Statement of Recommendation

RCG/Hagler, Bailly recommends that Oroshazi Uveggyar install continuous O2 and CO sensing on the glass melting furnaces in order to achieve optimum combustion. Two sets of sensors are required, one on the outlet of each side of the regenerator.

The sensors must be rugged enough to withstand the harsh, high-temperature environment found at the outlet of the glass furnace. The sensors must also have a fast response time, suitable for the dynamic conditions of the regenerator cycle.

3. Description/Rationale

3.1 Existing Conditions

Oroshazi Uveggyar makes measurements of combustion oxygen content on each burner port of each furnace on a periodic basis, about every 2 weeks, and uses the data to trim air to each row of burners. At the present time, there is often a situation of insufficient air at the burners (since the exhaust gas dampers are leaking and so some of the combustion air bypasses the regenerator, leaks through the damper and goes up the stack).

The furnace conditions are controlled by the Honeywell TDC-3000 control system. Many parameters are measured, but concentrations of combustion gases are not among them.

3.2 Findings:

The RCG/Hagler, Bailly team analyzed Oroshazi Uveggyar's data on manual readings of O2 in combustion gas, which indicate some degree of variability. From this analysis, it appears that combustion is not optimized across all burners, for all conditions of damper leakage. In particular, conditions on the right side of Furnace #1 indicated insufficient air, which required adjustment (corrected by April 30). During this period, incomplete combustion represented

a loss of energy. In other furnaces, excess air slightly above optimum was observed.

Installation of continuous control on oxygen, with alarm indication on CO, should enable the furnaces to run at 1.5% oxygen (7% excess air).

For April 15 (4/15/91), Oroshazi Uveggyar recorded:

Furnace	Port	O2 Left	O2 Right
1	1	3.6%	0.3% (4/30: 1.5%)
	2	2.6%	0.1% (4/30: 1.0%)
	3	1.4%	0.1% (4/30: 1.6%)
	4	0.5%	0.3% (4/30: 2.0%)
2	1	2.3%	1.7%
	2	2.6%	2.4%
	3	2.5%	2.0%
	4	2.9%	2.3%
3	1	1.3%	2.9%
	2	1.5%	2.1%
	3	3.4%	2.7%
	4	4.8%	2.9%
4	1	0.8%	2.0%
	2	2.7%	1.4%
	3	2.1%	1.8%
	4	1.8%	2.5%

4. Benefits

4.1 Energy savings

The RCG/Hagler, Bailly team estimates that the potential savings of the O2/CO control system is 2% of annual gas consumption.

Savings:
35 TJ, Ft 9.7 million/yr, $135,000/yr

4.2 Other benefits

The sensors will provide an indication of damper leakage, which can be used to increase maintenance, thereby reducing electrical energy consumption. This savings is not estimated in this report.

5. Implementation cost

Equipment required:
O2/CO sensors (8 - 2 for each furnace, 4 furnaces)
estimated cost $56,000 (1 set for 1 furnace to be procured by USAID, $16,000)

Installation cost: $ 10,000

Incidental equipment and repairs budget $16,000 per year

Total cost: $66,000 plus ongoing maintenance cost of $16,000 per year

6. Financial analysis

Payback period (including investments by both USAID and Oroshazi Uveggyar) = capital cost/net annual cost savings

$66,000/($135,000 - $16,000) = 0.6 year

7. Implementation schedule

By RCG/Hagler, Bailly during U.S. Emergency Energy program:
Procure sensors and deliver to plant by 1 August 1991.

By Oroshazi Uveggyar:
Install sensors and connect to TDC-3000 by 10 September 1991.

8. Technical risk

The sensors will measure bulk O2 and CO at the outlet of the regenerator. This reading will provide a gross indication of combustion conditions. Oroshazi Uveggyar must still carry out manual readings of O2 at each burner port in order to optimize combustion conditions.

9. Specification of equipment

Sensor for O2 and CO (or combustibles):
Environment - extremely harsh (outlet of glass melting furnace)
Operating ranges:
O2: 0-20%
CO: 0-5000 ppm
Maximum operating temperature: 800C
Response time: 1 minute to 95%
Accuracy: 1%
Output: 4-20 ma, 5 VDC, shielded twisted pair to TDC-3000

B. LOW-COST SHORT-TERM IMPROVEMENTS

GLASS PRODUCTION
Oroshazi Uveggyar Action B.1.2 - Optimize bottle-making to minimize waste

1. Process Area

Flint glass (clear) bottle-making machines

2. Statement of Recommendation

RCG/Hagler, Bailly recommends that Oroshazi Uveggyar reduce the percentage of waste generated for flint glass bottles by making greater use of machine #2 and by carrying out a study to identify ways to improve quality on machine #1. A budget of $100,000 appears warranted to upgrade/modernize machine #1.

3. Description/Rationale

3.1 Existing Conditions

Waste generation on bottle-making machine #1 is 22%, whereas the other machine making flint glass bottles, machine #2, has a waste rate of only 18%. This results from a combination of factors:

- Machine #2 has a more modern design, with enhanced electronic timing and 3 double-bed machines
- Machine #1 produces more of the smaller parts, which have an inherently higher breakage and reject rate
- Machine #1 is older and requires more maintenance

Oroshazi Uveggyar makes measurements of waste generation and reports these data on a daily basis, for each type of product, from each machine.

The melted glass input to Machine #2 is not limited to Furnace #2, connections are already in place to allow the feed from Furnace #1 or #3.

3.2 Findings:

The RCG/Hagler, Bailly team analyzed daily data for waste for all furnaces for the period January 1 - April 30, 1991. This data is provided in the Appendix.

RCG/Hagler, Bailly assumes that Furnace #2 will be retired. Therefore it should be possible to make a greater percentage of the clear glass products on Machine #2 and less on Machine #1. In order to do this, there may be some costs associated with new molds or other changeover parts.

4. Benefits

4.1 Energy savings

By reducing the scrap rate, there will be a reduced quantity of melt required for a given quantity of required good glass output. The RCG/Hagler, Bailly team estimates that the potential reduction of melt of 3% for Furnace #1, giving a savings of 3% of today's fuel consumption at Furnace #1.

Savings:
7 TJ, Ft 3.1 million/yr, $42,000/yr

4.2 Other benefits

Producing some of the smaller parts on machine #2 may improve quality and reduce breakage at later points in the delivery process, outside the factory. This savings is not estimated in this report.

5. Implementation cost

Modernization of machine #1: $100,000

6. Financial analysis

Payback period = capital cost/net annual cost savings

$100,000/($42,000) = 2.4 year

B. LOW-COST SHORT-TERM IMPROVEMENTS

MANAGEMENT AND CORPORATE PLANNING
Oroshazi Uveggyar Action B.1.3 - Long-term strategy to continue process improvements

1. Process Area

Management

2. Statement of Recommendation

RCG/Hagler, Bailly recommends that Oroshazi Uveggyar develop a corporate strategy by which the company can best adapt to the new demands of the market economy.

3. Description

Oroshazi Uveggyar has already identified a new furnace design which has a specific energy consumption approximately 30% less than their existing furnaces. These furnaces also improve productivity and product quality. Continued process improvement is the key not only to improved energy efficiency but also profitability, and in fact the company's ability to perform in a market-oriented economy.

RCG/Hagler, Bailly recommends that Oroshazi Uveggyar develop a long-term strategy and business plan for the company. In the first instance, this strategy would include two basic elements:

1. Development of a statement of corporate objectives. This would define the company's future product lines and markets. It would be based on an analysis of the profitability and competitiveness of Oroshazi Uveggyar's current products and the potential market for other similar glass container products. It would define the niche in which Oroshazi Uveggyar as a business enterprise will operate through the year 2000. This will represent the basis for corporate strategy.

2. Based on the corporate strategy, Oroshazi Uveggyar should develop specific business plans for the main functional areas of the company. Each business plan should cover the primary inputs required to execute the corporate strategy. The main functional areas are:

- <u>Marketing</u> - development of a marketing plan and improvements to the marketing department. This will include a system of pricing products, and a formal decision system for entering

and leaving markets.

- Production - identification of the process improvements required to manufacture the products required by the market at a cost which will enable the company to make a profit. This will include a plan for investments quality control, packaging, production capacity expansion, energy efficiency, and environmental control. It will also include development of a plan for improved labor productivity and safety.

- Finance - development of a plan to finance the operations of the company, through sales of products and capital investment from retained earnings, debt, joint ventures, and sales of shares.

- Management - improvements to the organizational and management system to maximize profit margins and return on shareholders' equity.

- Research and development - improvements to the company's R&D department to develop new products and to reduce production costs of existing products.

B. LOW-COST SHORT-TERM IMPROVEMENTS

ENERGY AND UTILITIES
Oroshazi Uveggyar Action B.2.1 -
Modify waste heat recovery system

1. Process Area

Boilers and steam heating systems

2. Statement of Recommendation

RCG/Hagler, Bailly recommends that Oroshazi Uveggyar modify its waste heat recovery systems to make better use of the waste heat available from the glass melting furnaces. There are two low-cost alternatives, either of which appears feasible:

- Connect the outlet of the HSRGs to the old (abandoned) stacks, so as to prevent short-circuiting which is currently causing fluctuating back pressure to the furnaces.

- Repair the by-pass dampers in order to solve the back-pressure problem, and downsize the HSRGs to meet the load.

3. Description/Rationale

3.1 Existing Conditions

Waste heat recovery has been included as an integral part of the design of the glass furnaces at Oroshazi Uveggyar, in two ways:

- Regenerators recover a large part of the heat available in the exhaust gas from combustion in the furnaces.

- Heat recovery steam generators (HSRG) were installed downstream in 1963-67 to generate hot water. In 1973 they were converted to steam to drive low pressure turbogenerators (about 2MW from 2 furnaces).

The HSRG/turbogenerator systems have fallen into disuse, for a number of reasons. First, the entire plant, including the heat recovery system, was designed when the plant was burning the local low-calorific-value "inert" gas. For these conditions, there was a far greater volume of exhaust gas flow, and hence heat available. In addition, the older furnace designs had smaller regenerators, so the temperature was higher, too (about 750C).

Subsequently, over the years, problems occurred with heat transfer and furnace life, so the furnaces were converted to natural gas. Newer furnaces had design improvements so that there was much less heat available for the HSRGs (550C, and much less flow). The design of the damper systems (cannot be closed for safety considerations) and backpressure from the HRSGs caused pressure fluctuations in the furnaces which made production difficult.

By 1987, the temperature at the HSRGs was reduced to 250C (leaks dilution from the exhaust gas dampers, and insulation had broken down), so auxiliary burners were installed, burning inert gas, and the waste heat was diverted to the stack. Substantial maintenance was required to the turbines, and so the power generation system was abandoned, also around 1987.

3.2 Findings:

Oroshazi Uveggyar has a plan to reconstruct the refractory duct on furnace #3, which is in the worst state of repair (it is in danger of falling). At the same time, the plan is to divert the exhaust to the old, abandoned stack, so as to solve the back-pressure problem, allowing waste heat to again be used. The RCG/Hagler, Bailly team supports Oroshazi Uveggyar's decision.

RCG/Hagler, Bailly also offers an alternative suggestion, which is to investigate different damper designs. If the damper can be corrected, then the back-pressure problem can be solved.

RCG/Hagler, Bailly also recommends that the system be modified to produce saturated steam, since the turbines are out of commission. This will reduce the pressure drop through the HSRG and reduce fan power requirements.

4. Benefits

4.1 Energy savings

The RCG/Hagler, Bailly team estimates that the potential reduction of inert gas consumption as 70% after each furnace is modified (some supplemental firing may still be required).

Inert gas savings:
14 TJ, Ft 21 million, $290,000

4.2 Other benefits (costs)

There will be increased energy consumption at the induced fan systems of the glass melting furnaces, because of the increased back pressure. However, the fans installed to provide draft to the

HRSGs can be switched off. If the superheaters are removed, there will be a net reduction in fan energy. This benefit is small, and is not estimated in this report.

5. Implementation cost

Conversion of each furnace: $50,000 ($150,000 total, assuming Furnace #2 retired)

Increased annual maintenance cost: $30,000 (3 systems)

6. Financial analysis

Payback period = capital cost/net annual cost savings

$150,000/($290,000 - $30,000) = 0.6 year

C. CAPITAL IMPROVEMENTS

The RCG/Hagler, Bailly team identified several other areas in which improvements to energy efficiency are possible. However, these areas require substantial investment.

Because the focus of the 1991 U.S. Emergency Energy Program for Hungary is on short-term, low-cost measures for energy efficiency, these projects are not described in detail. They are offered as possible ideas for the future.

C.1 PRODUCTION

C.1.1 Replace furnace #2 with improved design - consider offering this project to investors as part of a Joint Venture

C.2 ENERGY AND UTILITIES

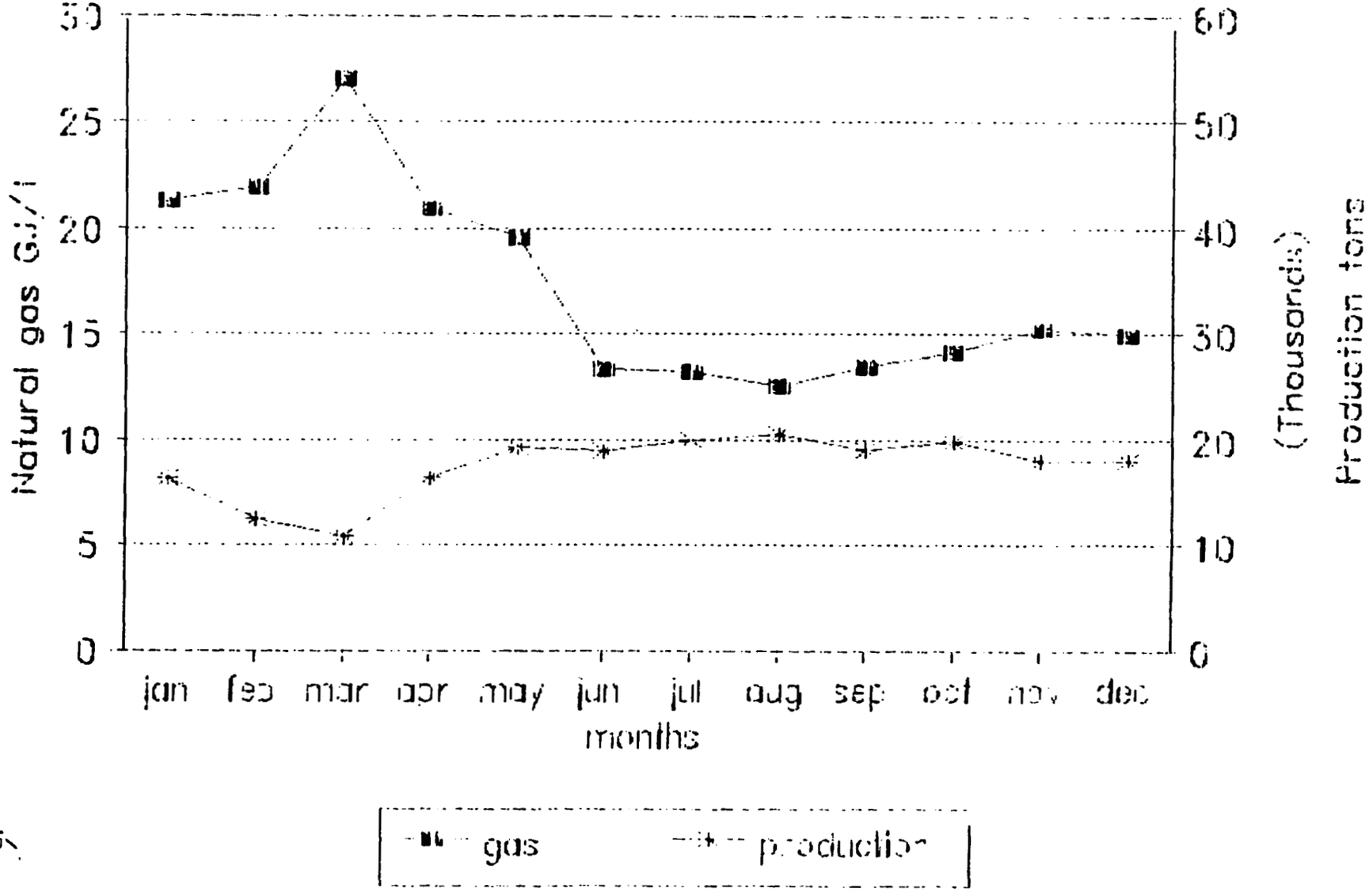
C.2.1 Install package boilers, specifically designed to fire inert gas (Type 2), one sized for winter and one sized for summer load. Either: (1) block off waste heat recovery system from furnace stack, or (2) divert exhaust gases to old stack to avoid back-pressure on furnaces.

C.2.2 Increase efficiency of compressed air supply - install smaller high-efficiency compressor to manage load, improve efficiency of existing machines.

C.2.3 Study feasibility of installing combined cycle electric power generation system - For each furnace install a gas turbine (about 2MW) specifically designed to burn inert gas (Type 2). Install a 40 bar superheated steam boiler/turbogenerator system (about 1.5 MW). Feed the exhaust gas from the turbine to the superheater. Feed mixed exhaust gas from furnace and turbine to evaporator section.

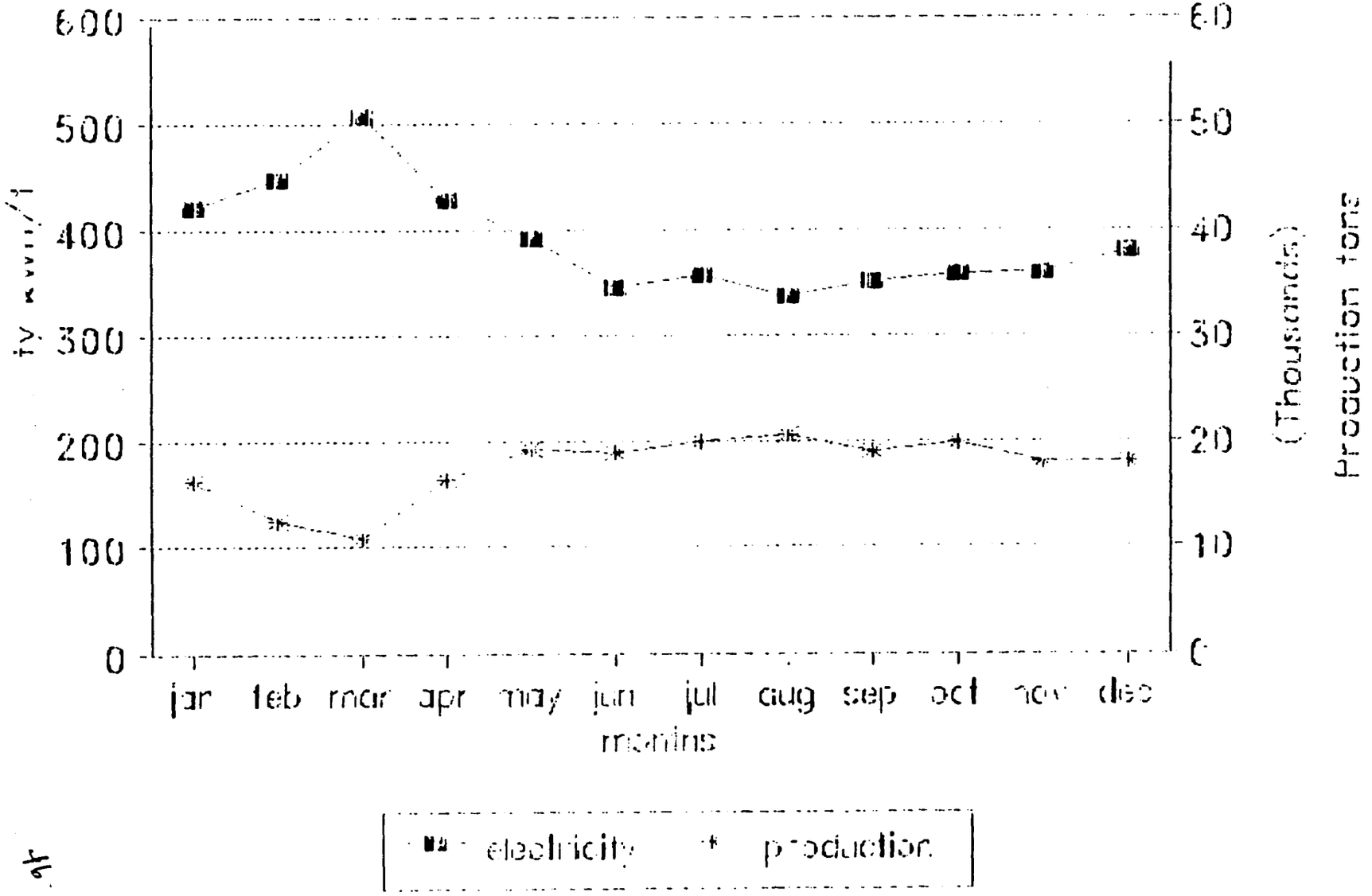
OROSHAZI UVEGGYAR – YEAR 1990

Natural gas consumption



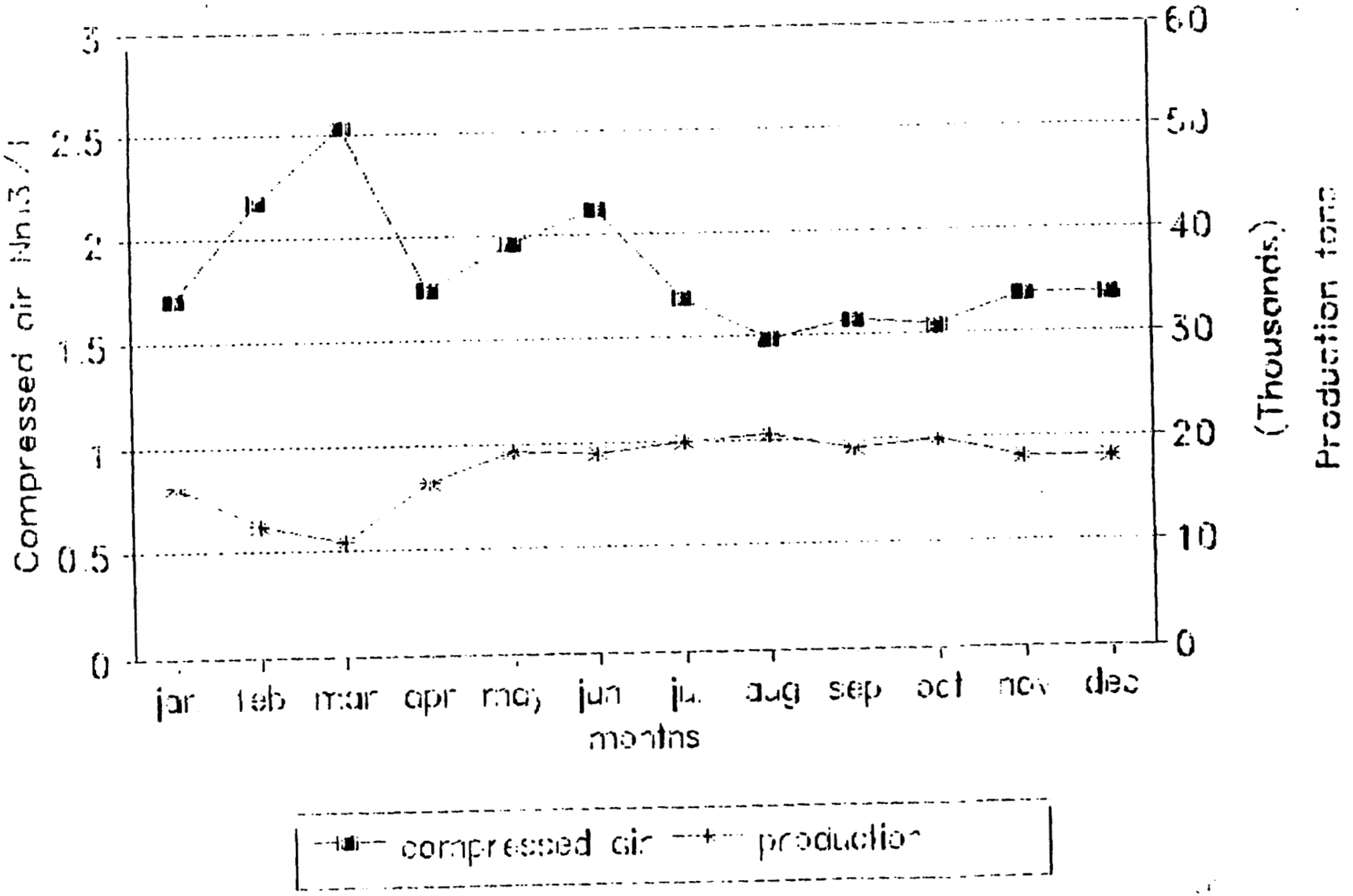
OROSHAZI UVEGGYAR – YEAR 1990

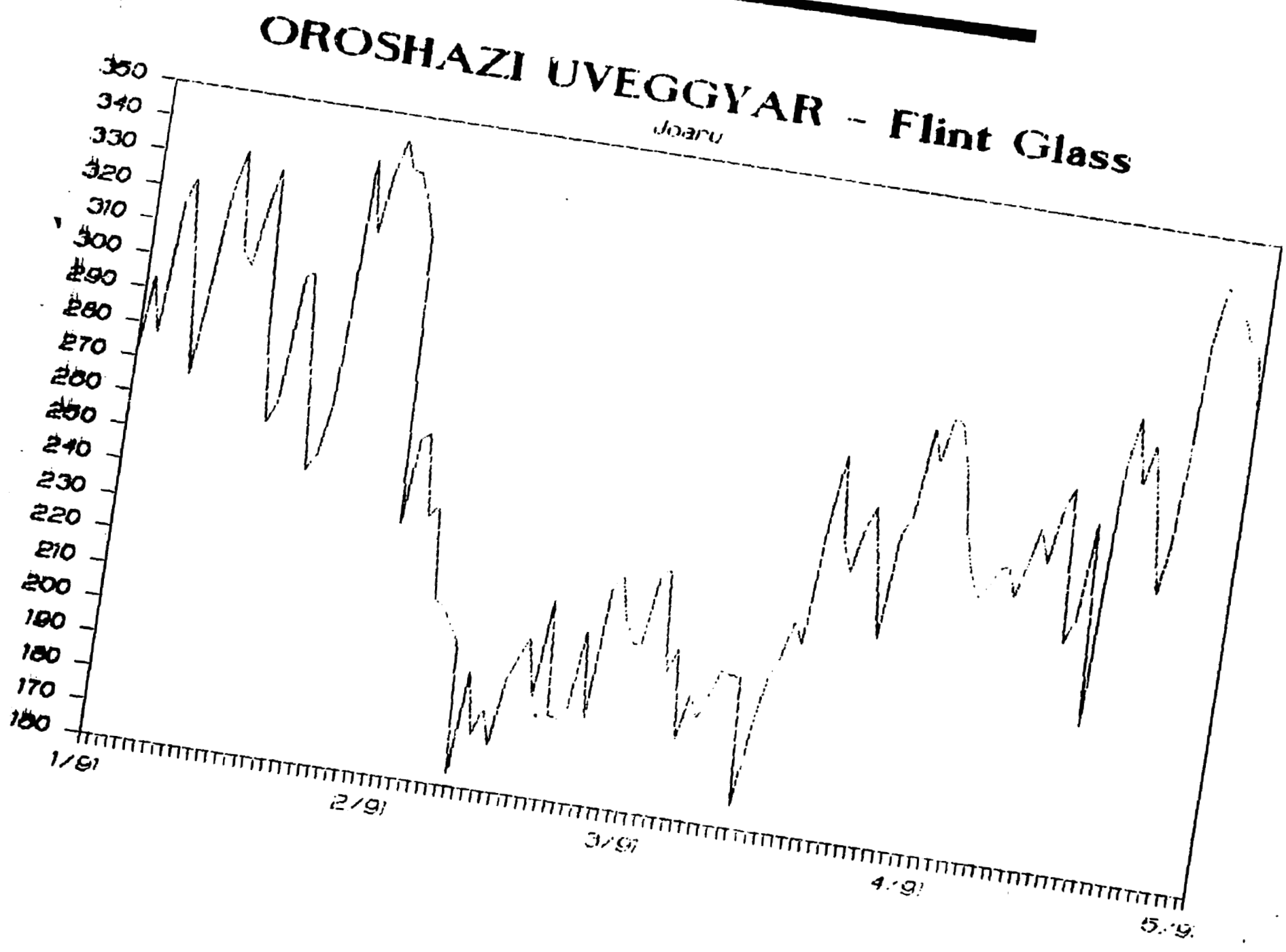
Electricity consumption



OROSHAZI UVEGGYAR – YEAR 1990

Compressed air consumption




OROSHAZI UVEGGYAR - Flint Glass
Joaru
350
340
330
320
310
300
290
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270
260
250
240
230
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190
180
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160
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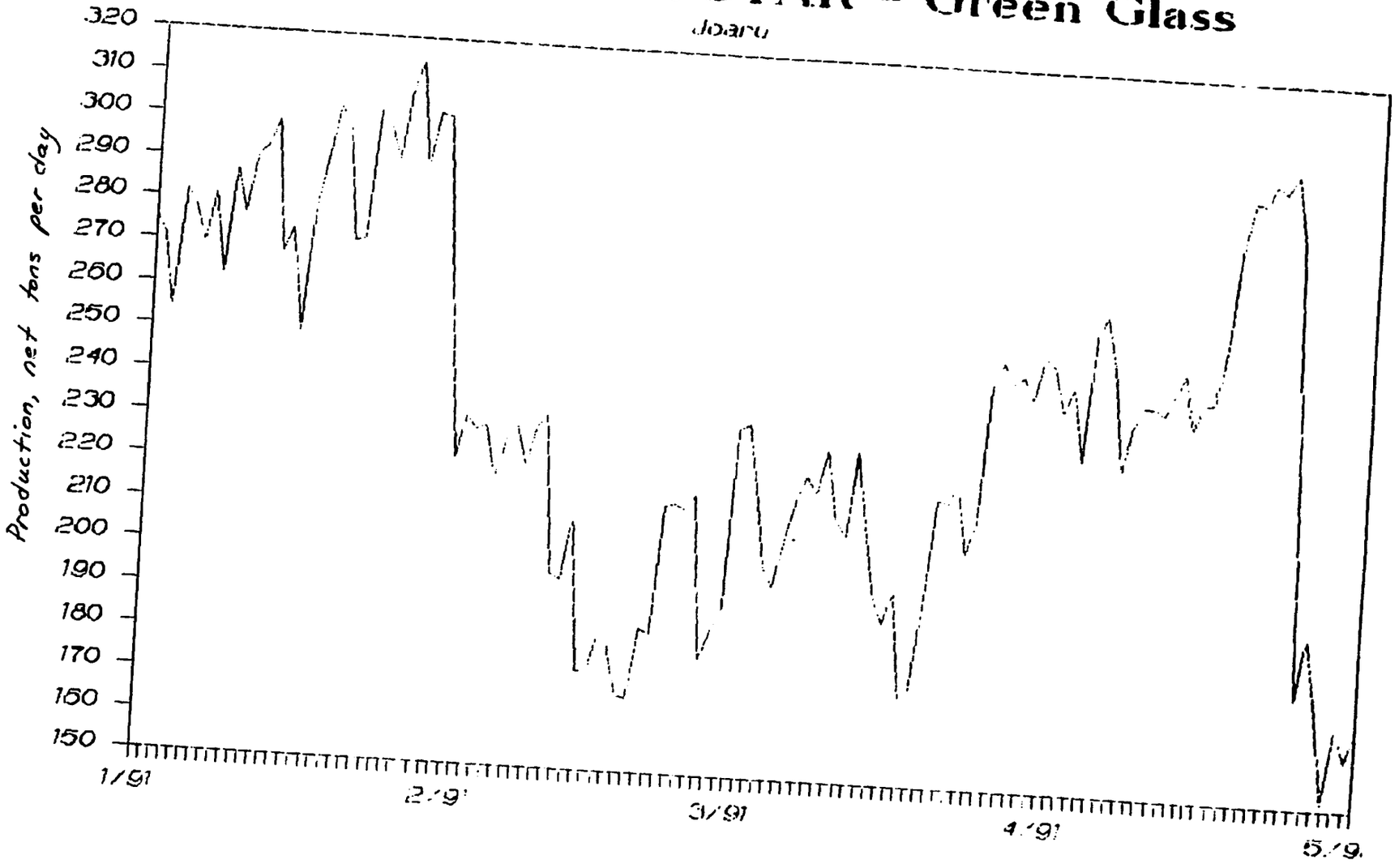
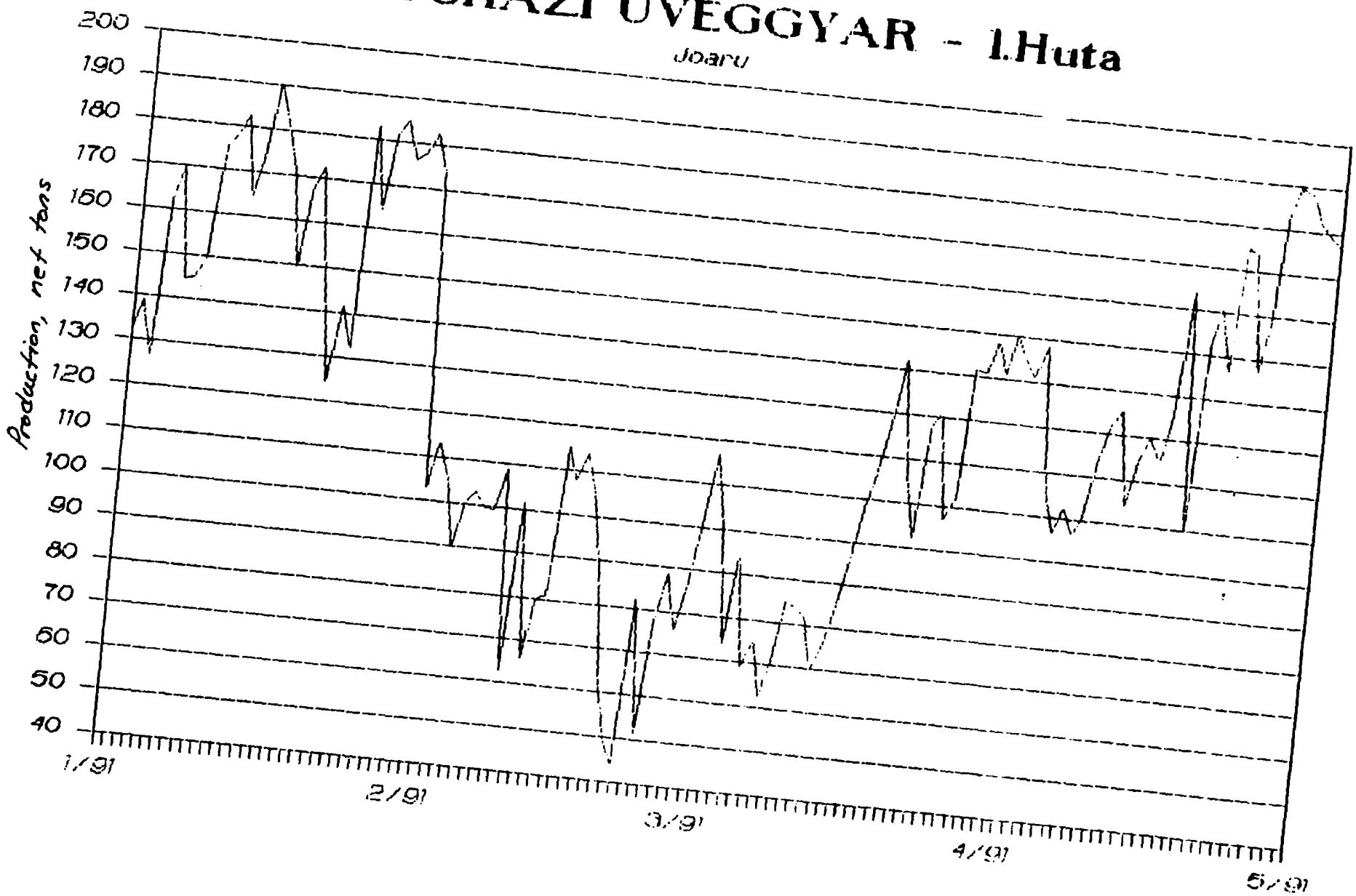
3/91
4/91
5/91

OROSHAZI UVEGGYAR -- Green Glass



OROSHAZI UVEGGYAR - I.Huta



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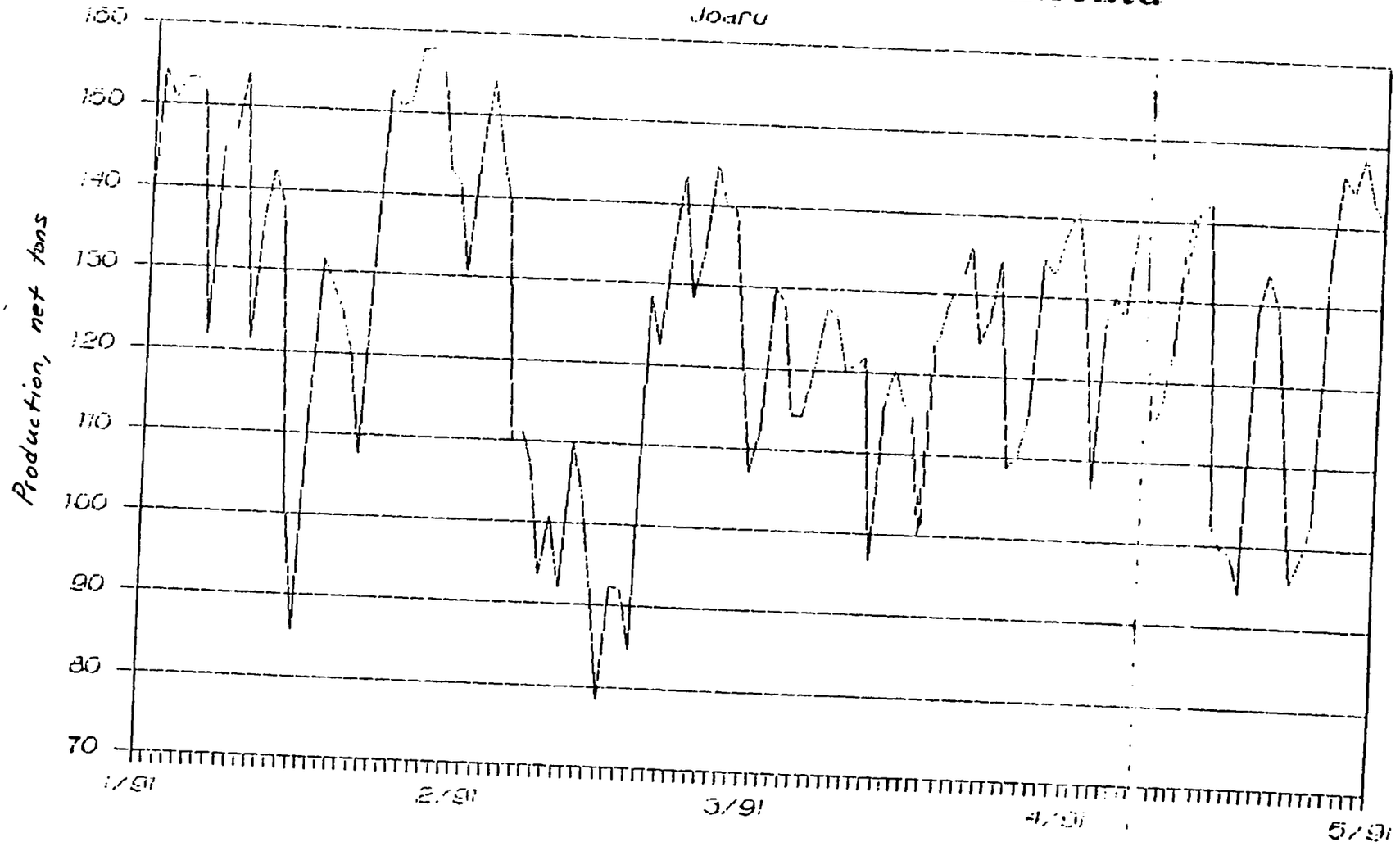

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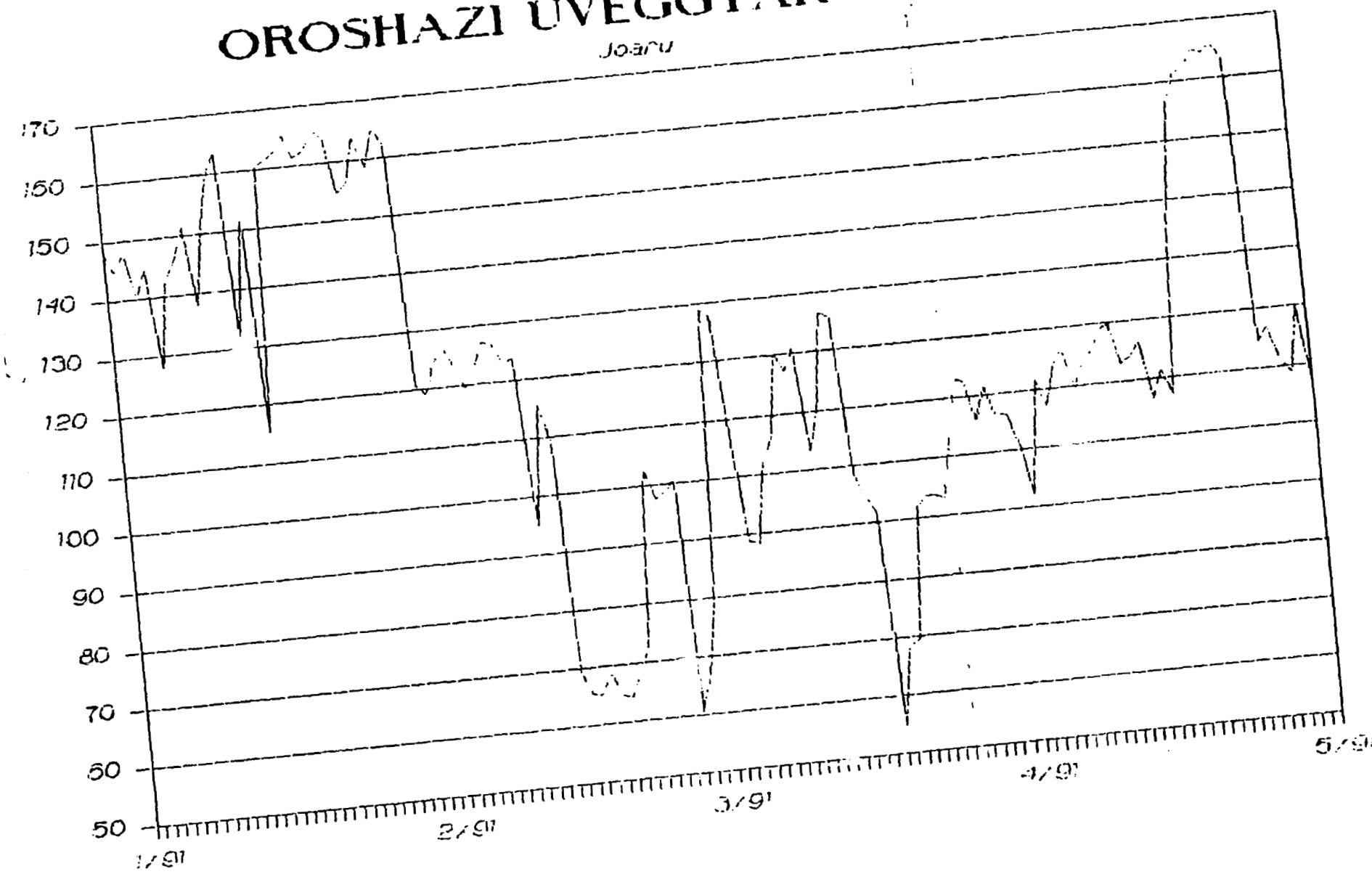

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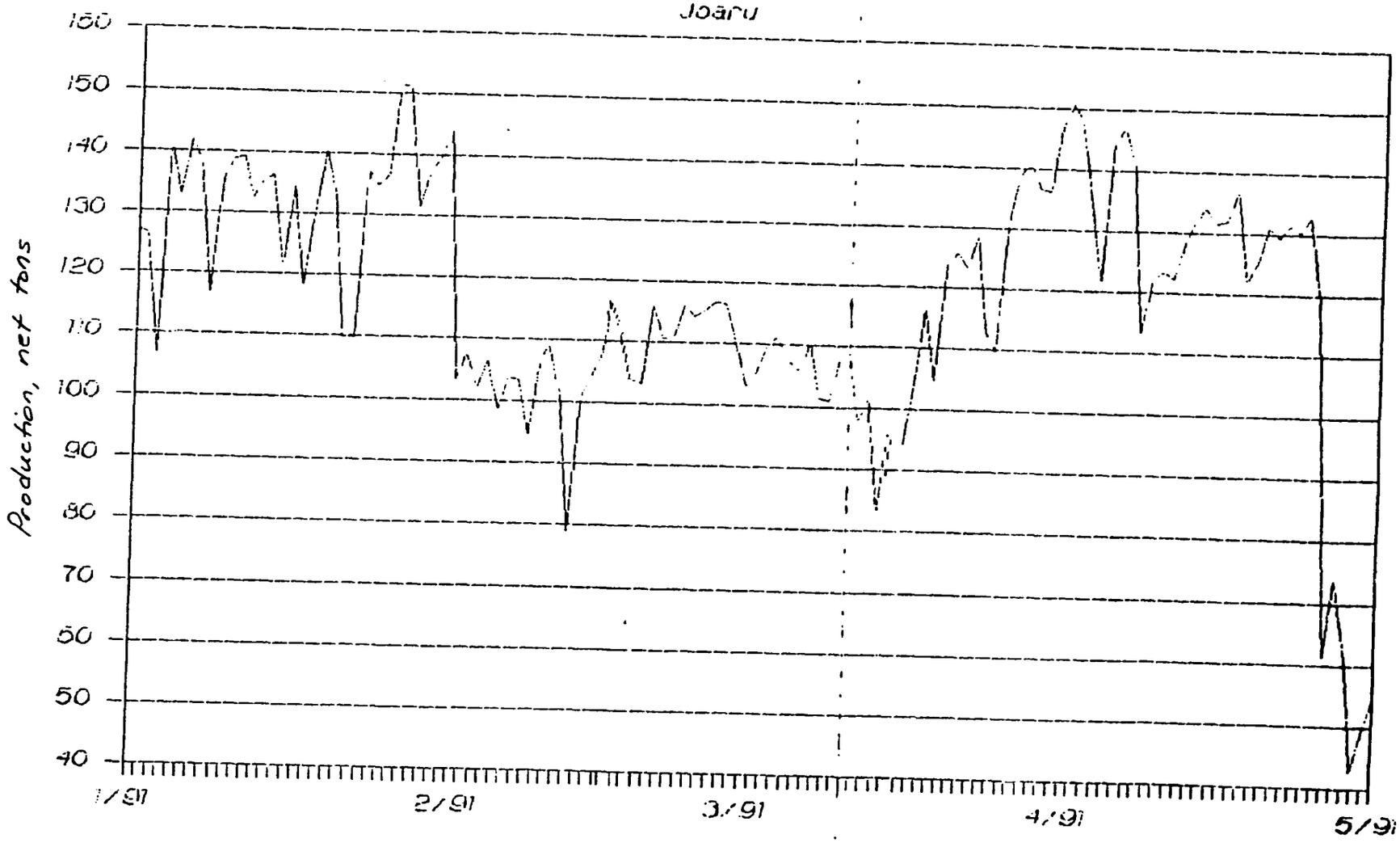

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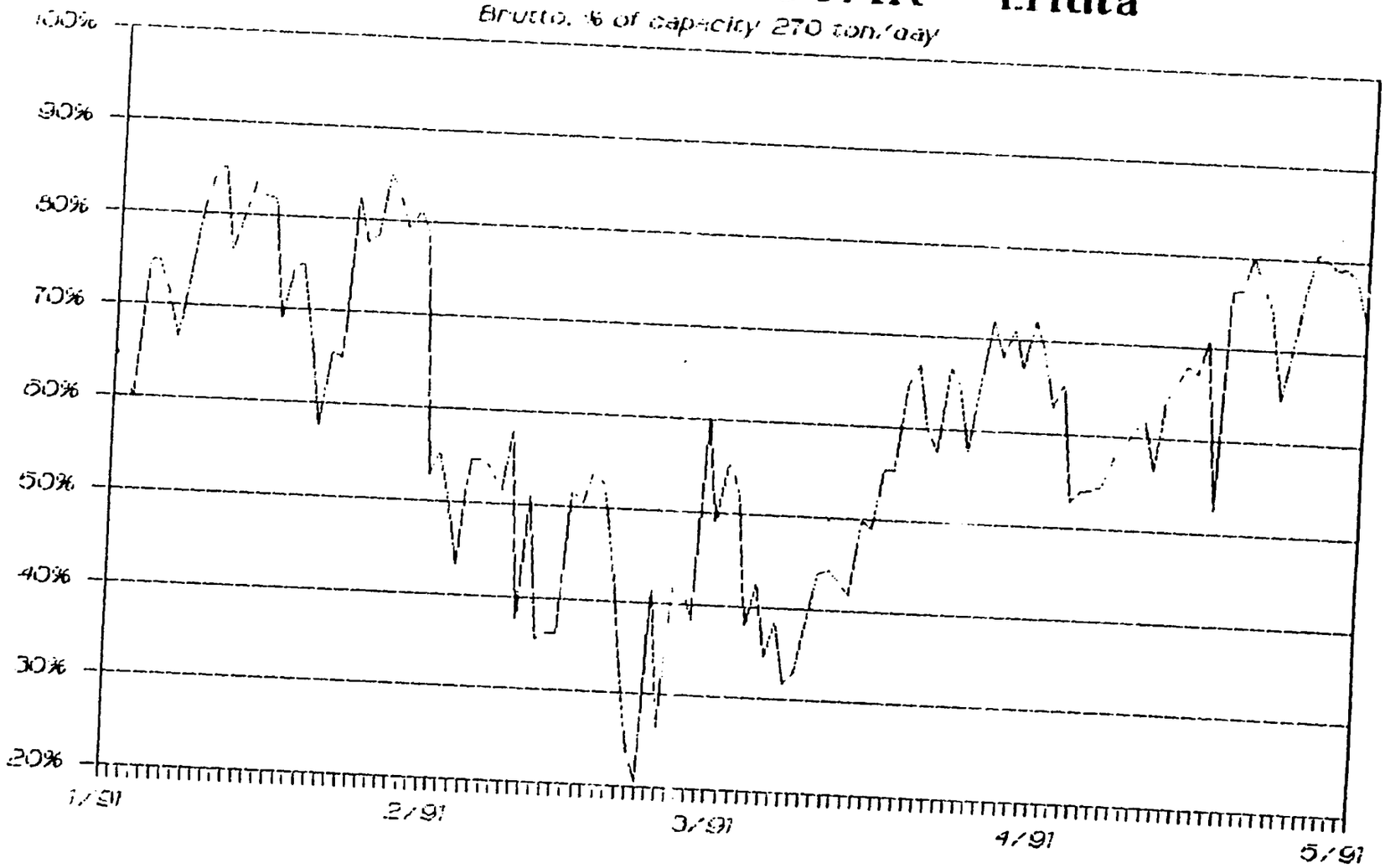

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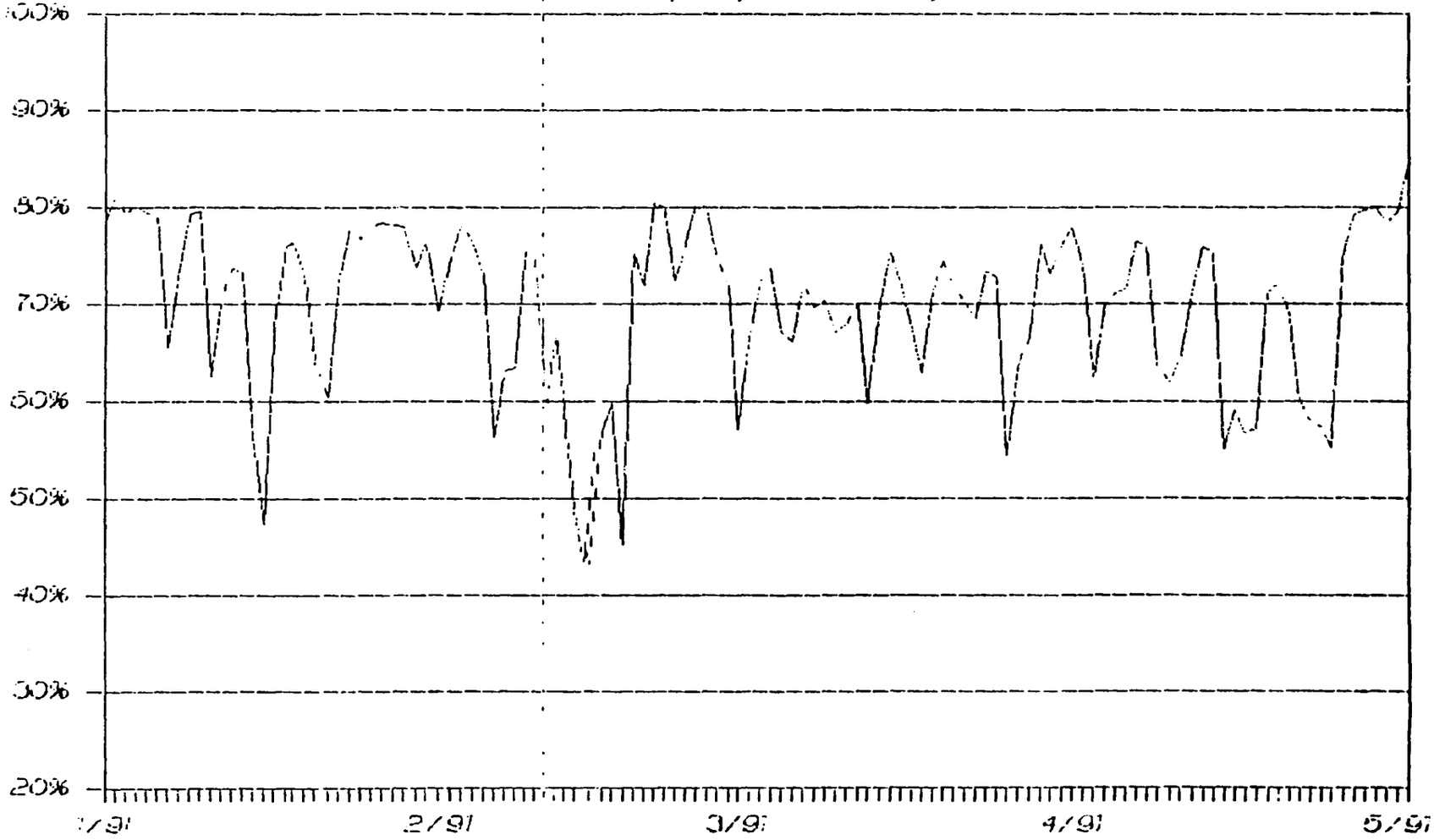
Brutto, % of capacity 220 ton/day



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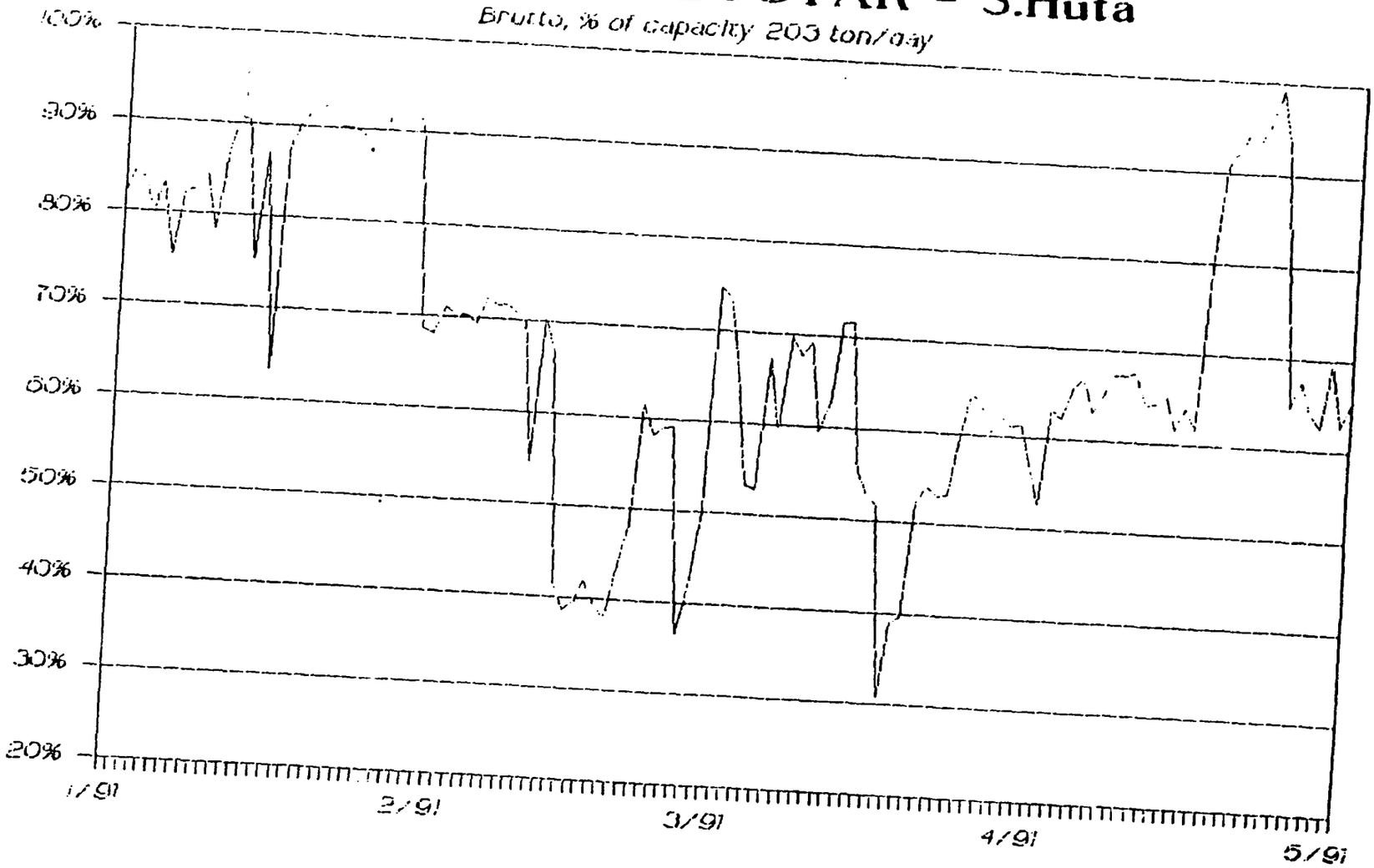

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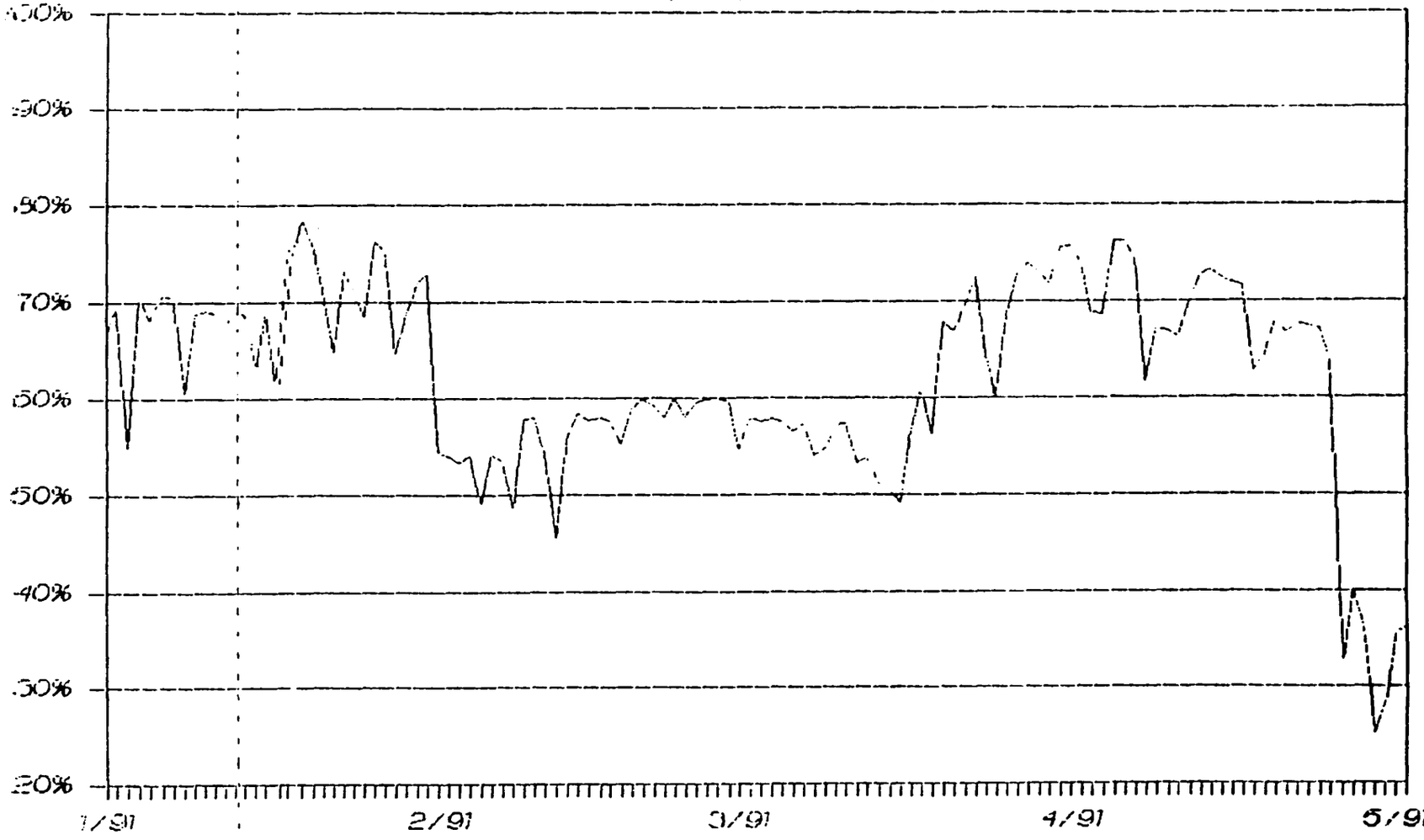
Brutto, % of capacity 220 ton/day



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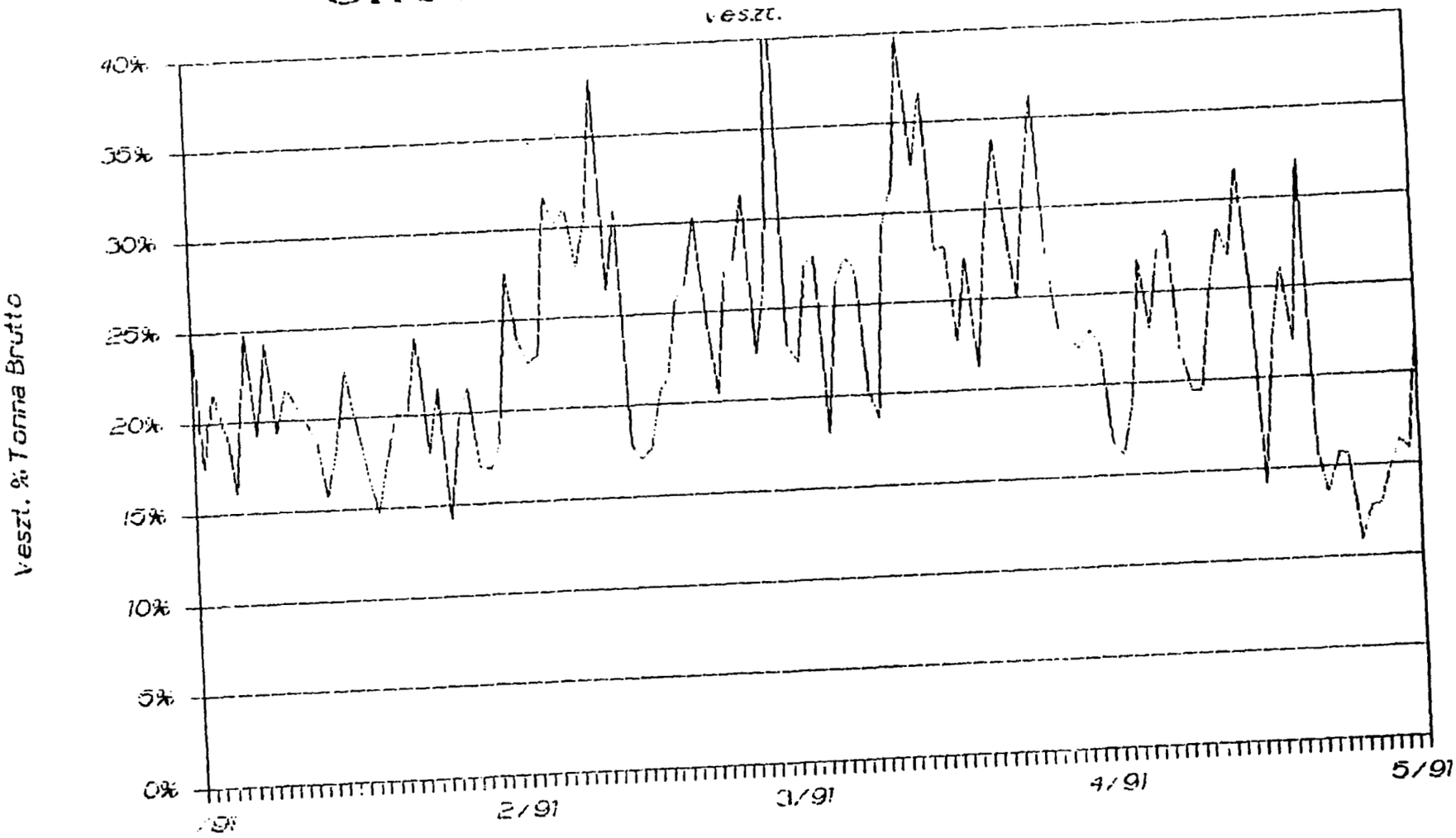

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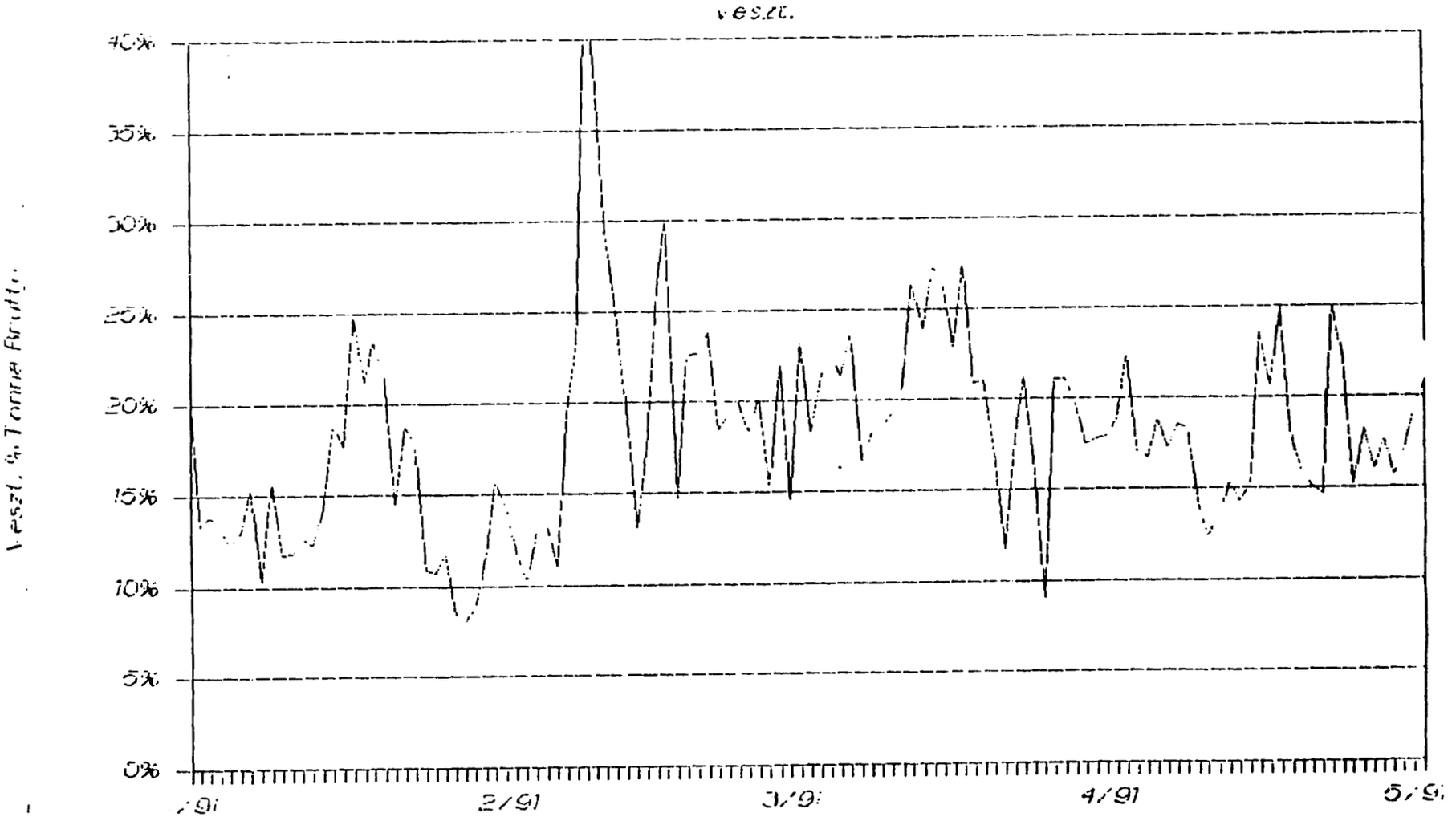

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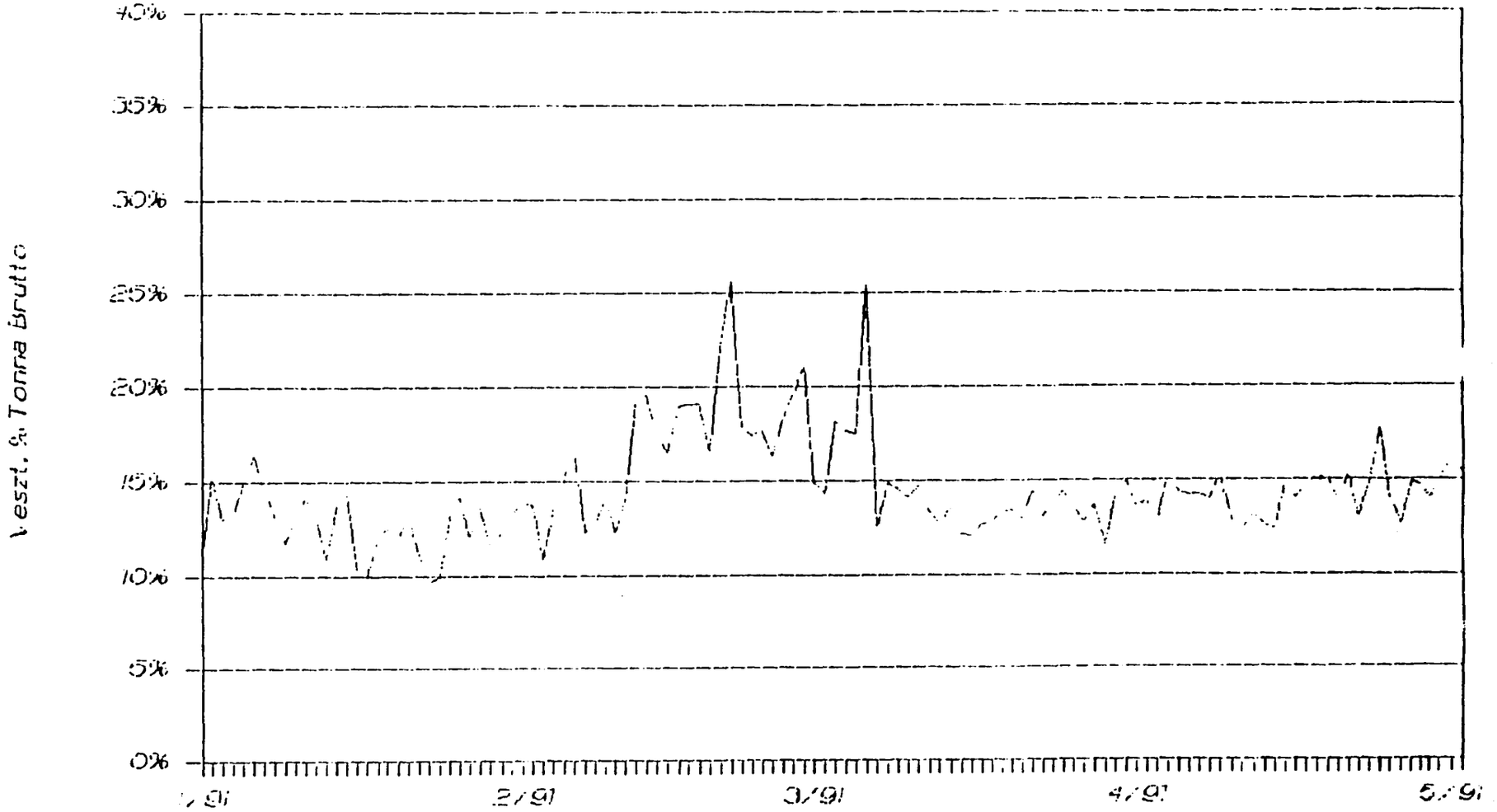

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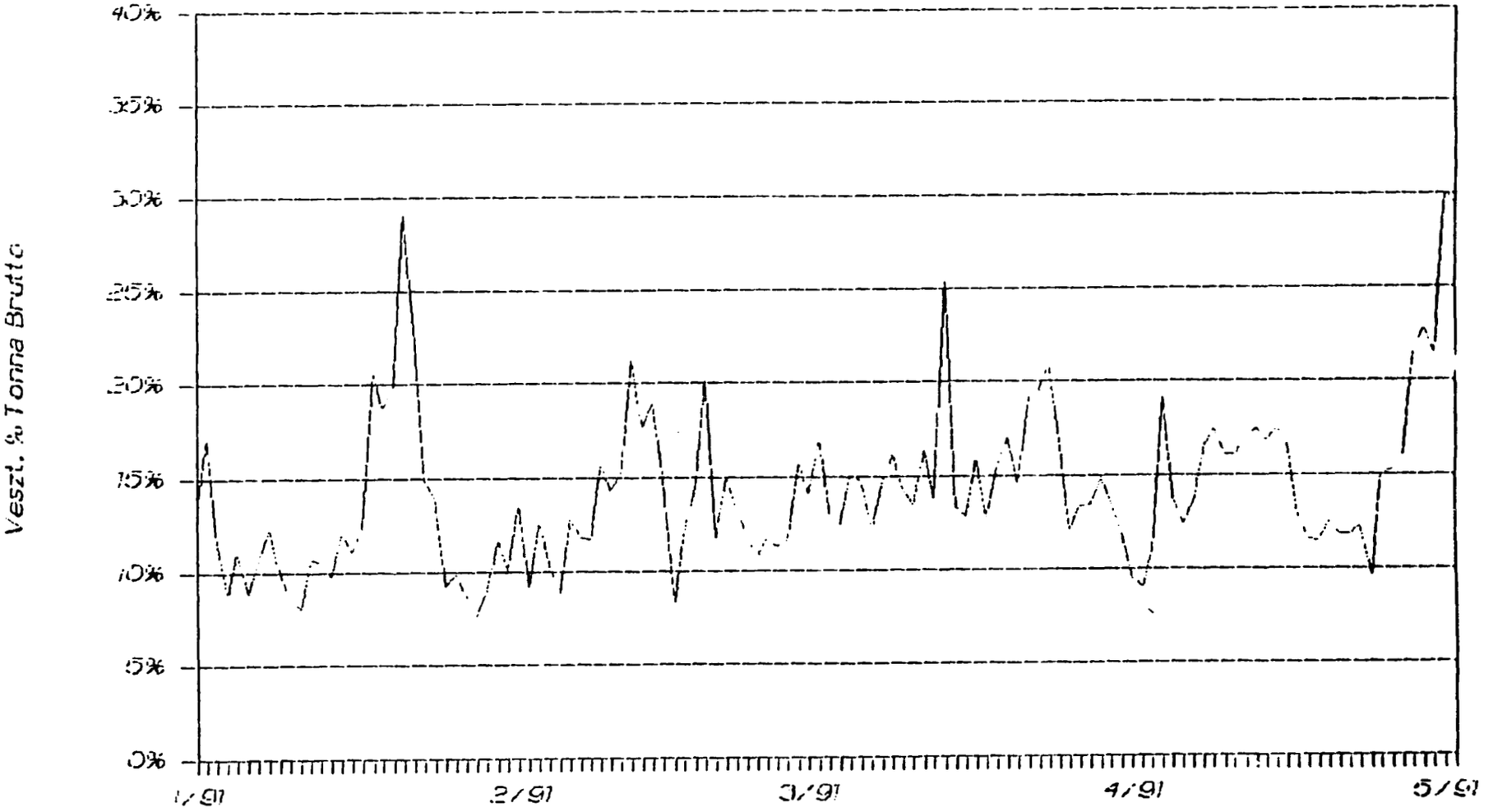

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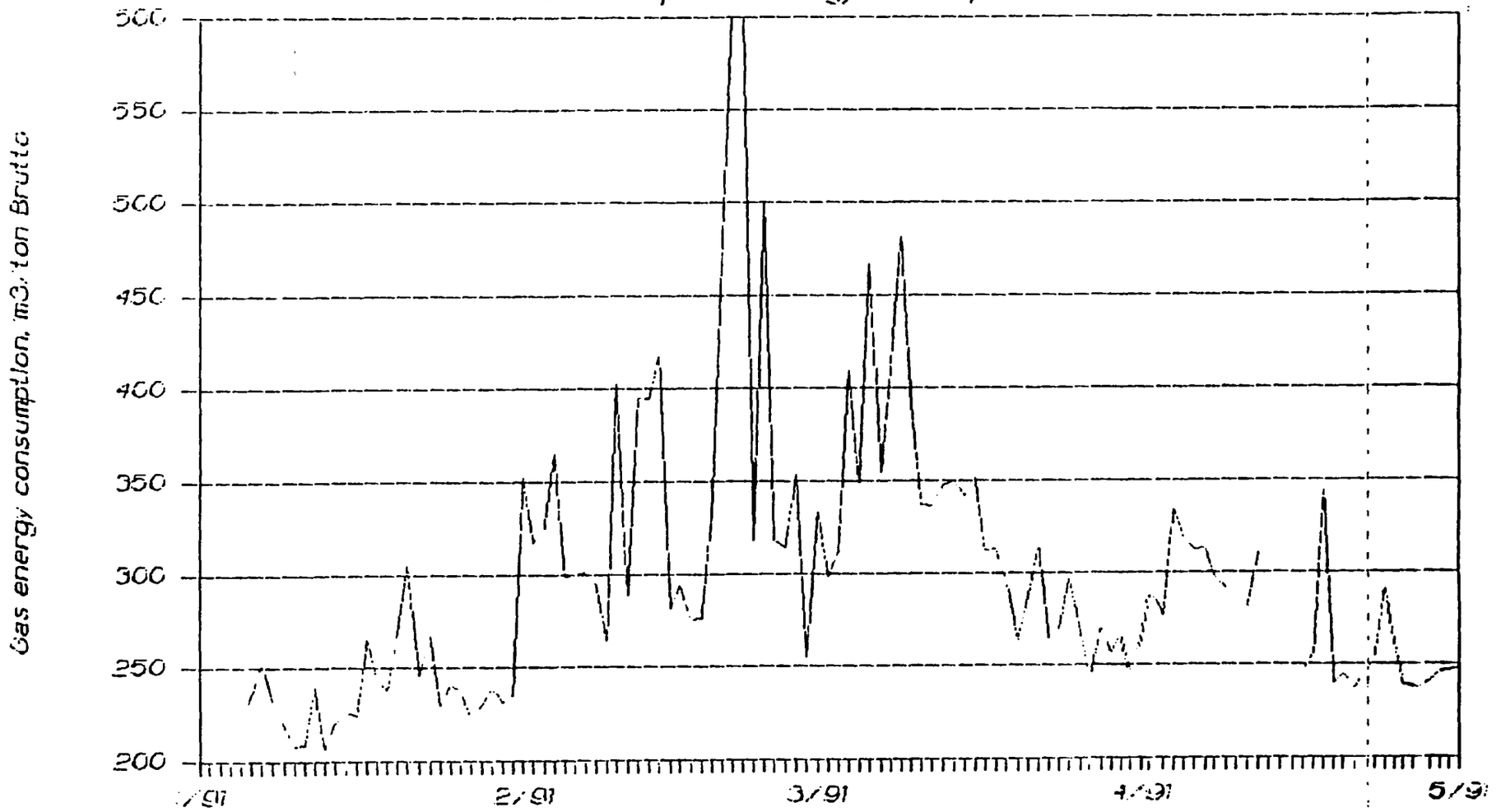
OROSHAZI UVEGGYAR - I.Kemence

Furnace Specific Energy Consumption



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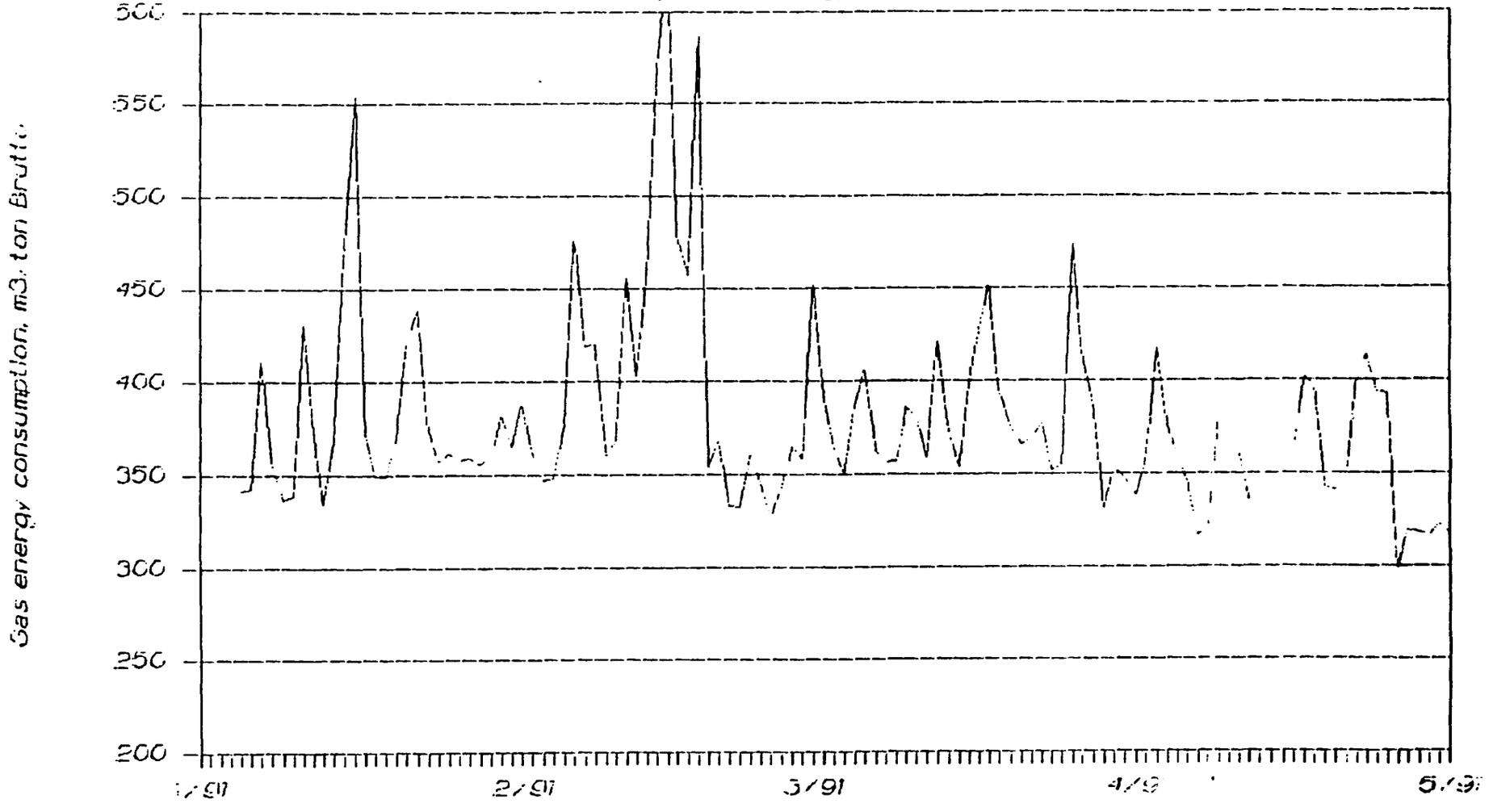
Furnace Specific Energy Consumption



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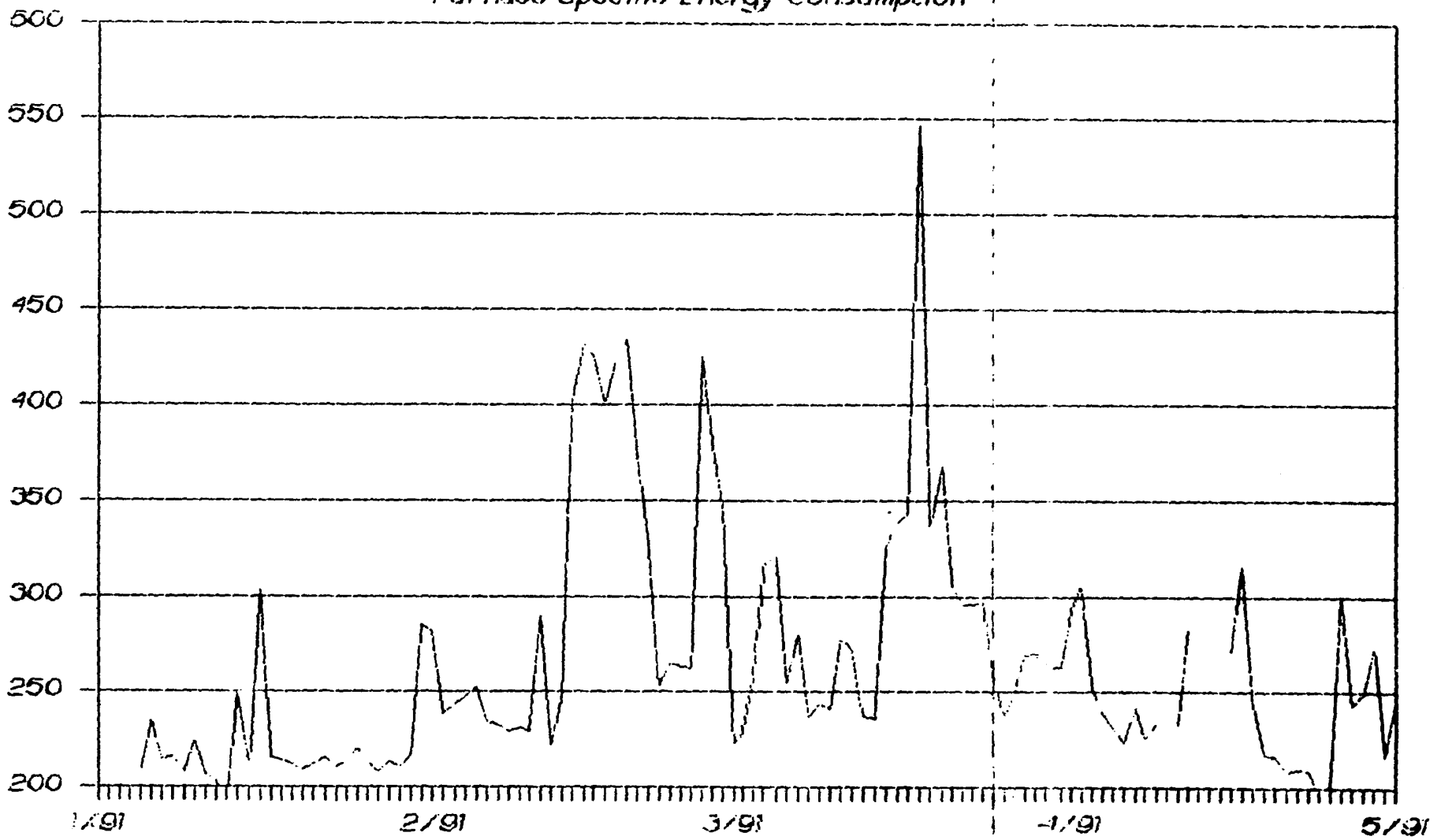
OROSHAZI UVEGGYAR - 3.Kemence

Furnace Specific Energy Consumption



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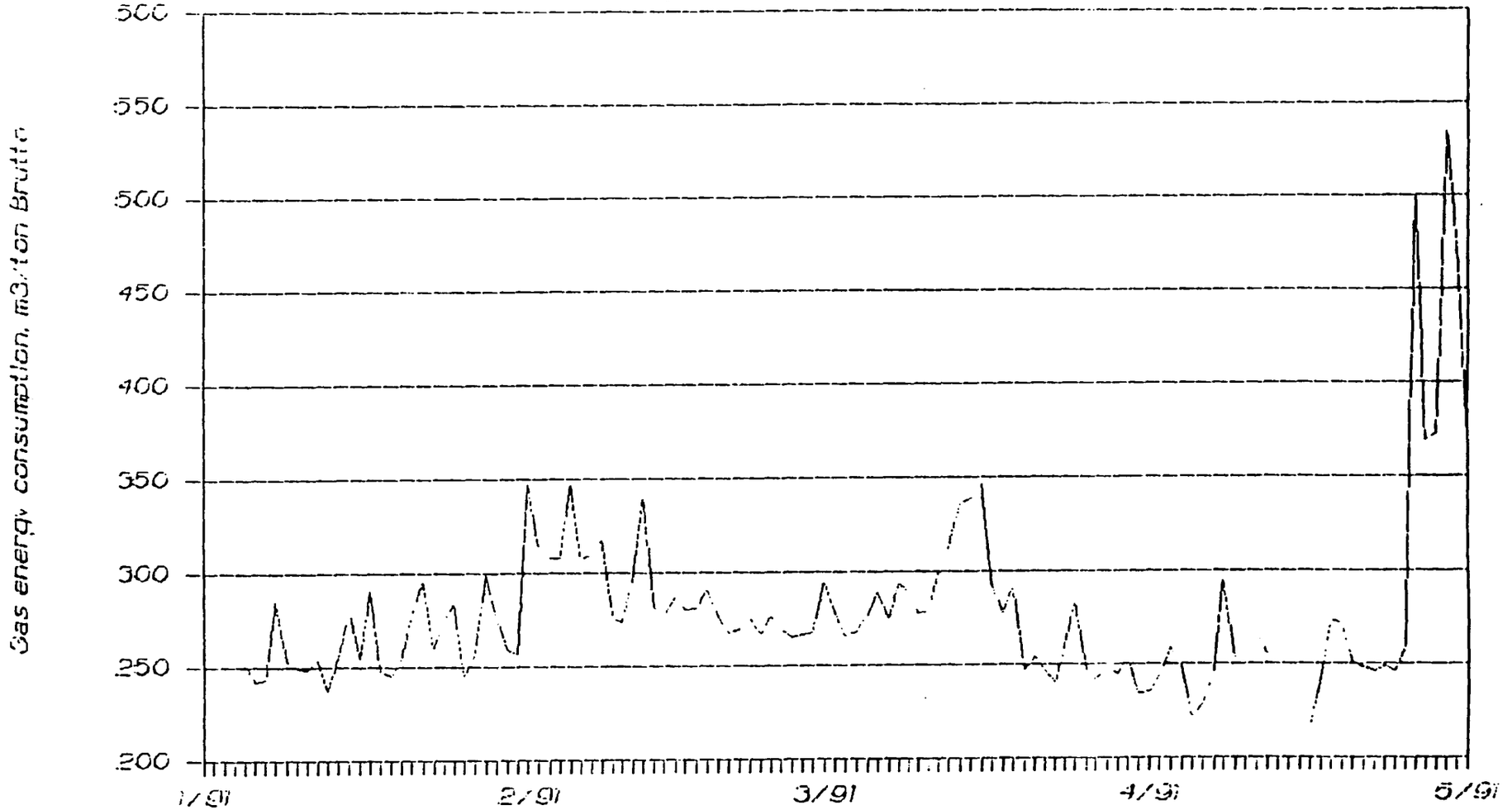
Furnace Specific Energy Consumption



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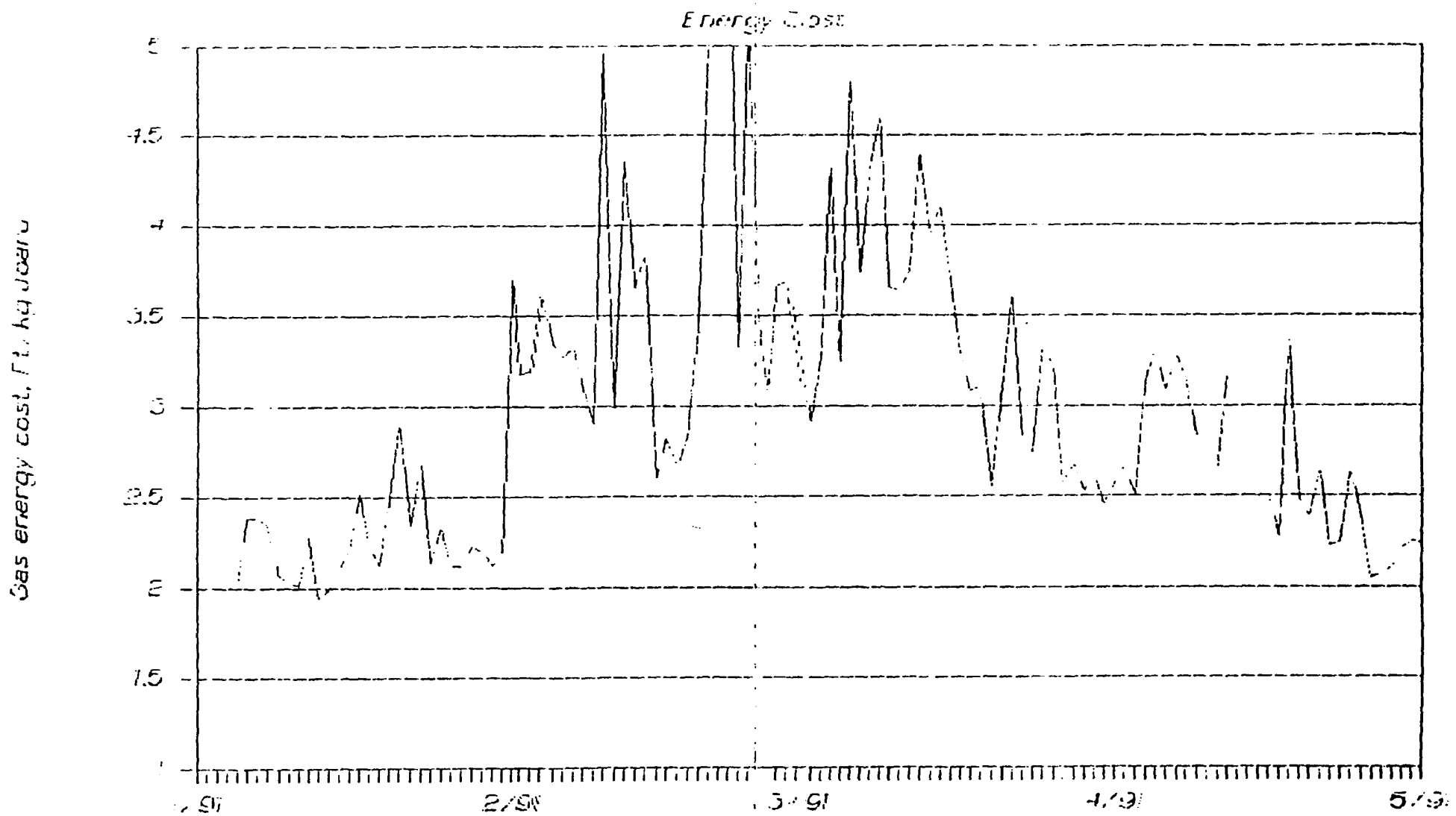

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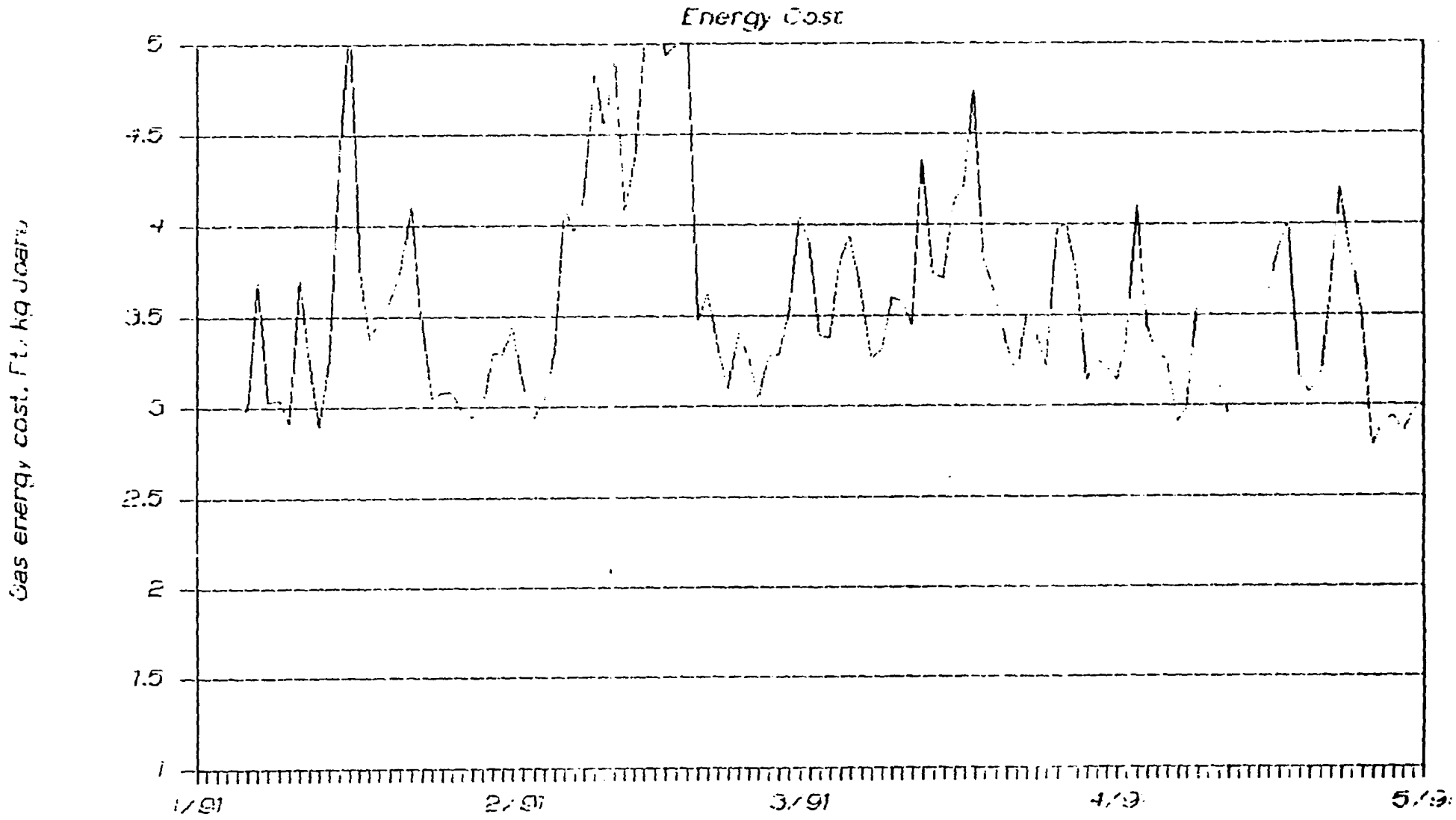

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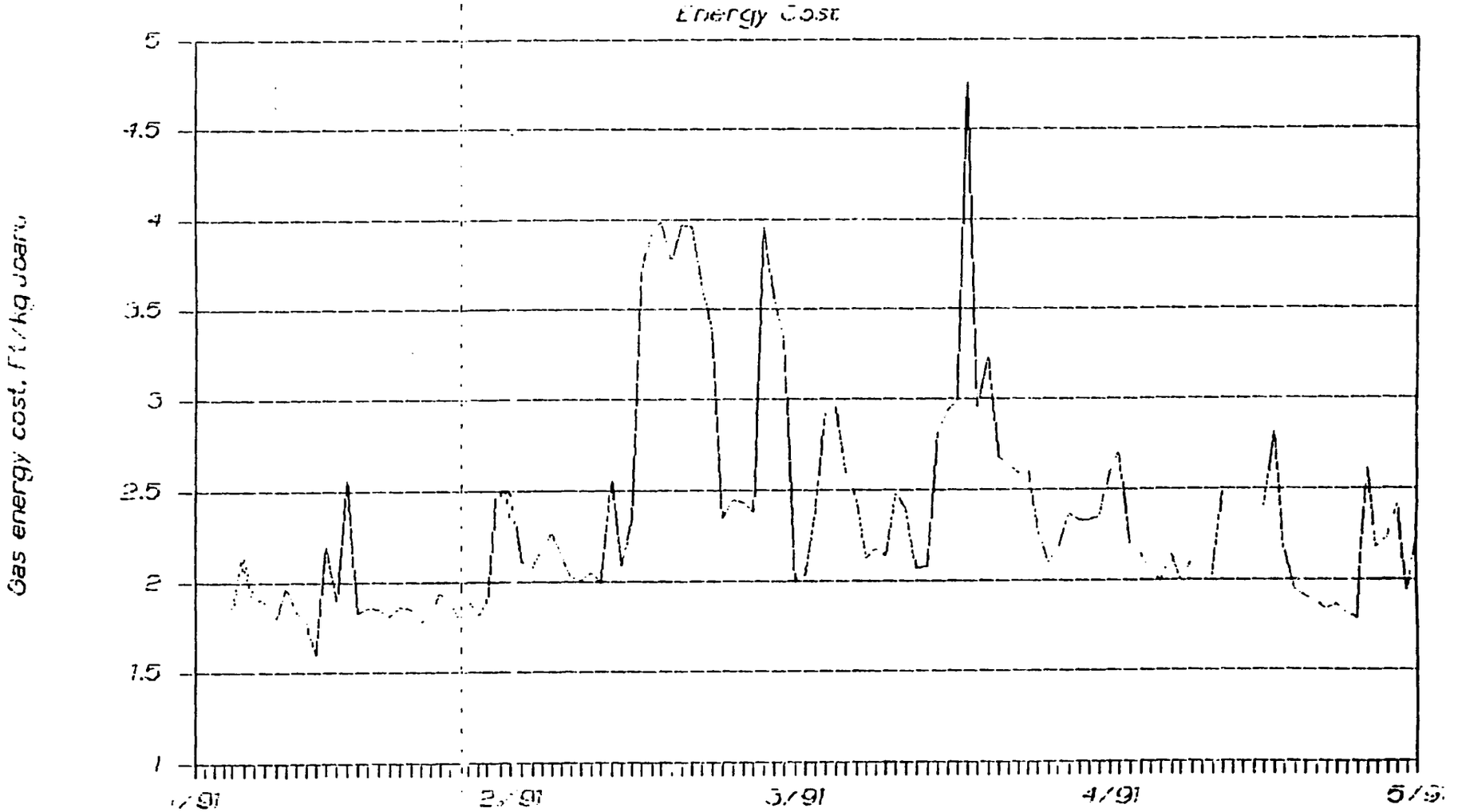

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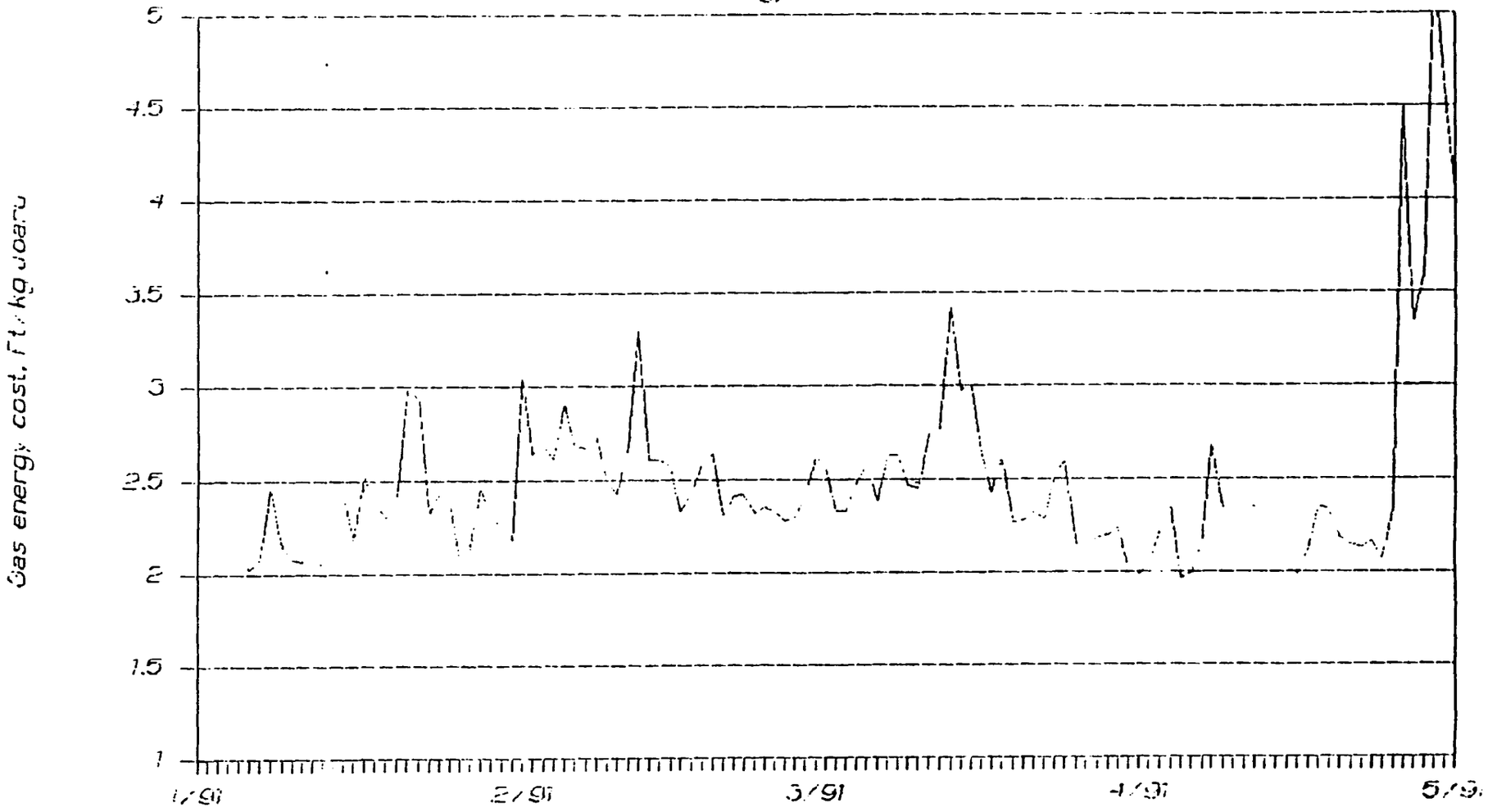
Energy Cost



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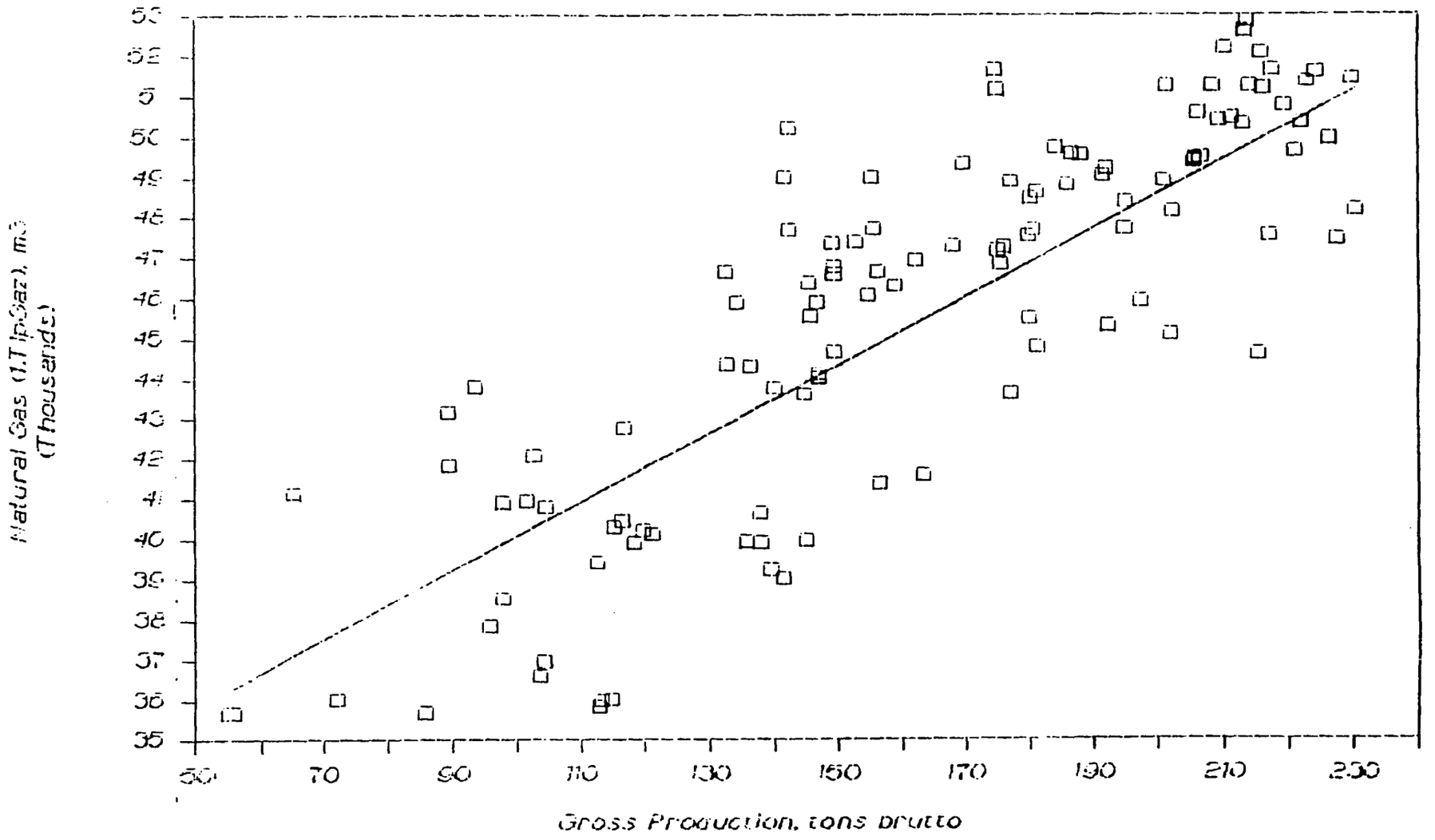

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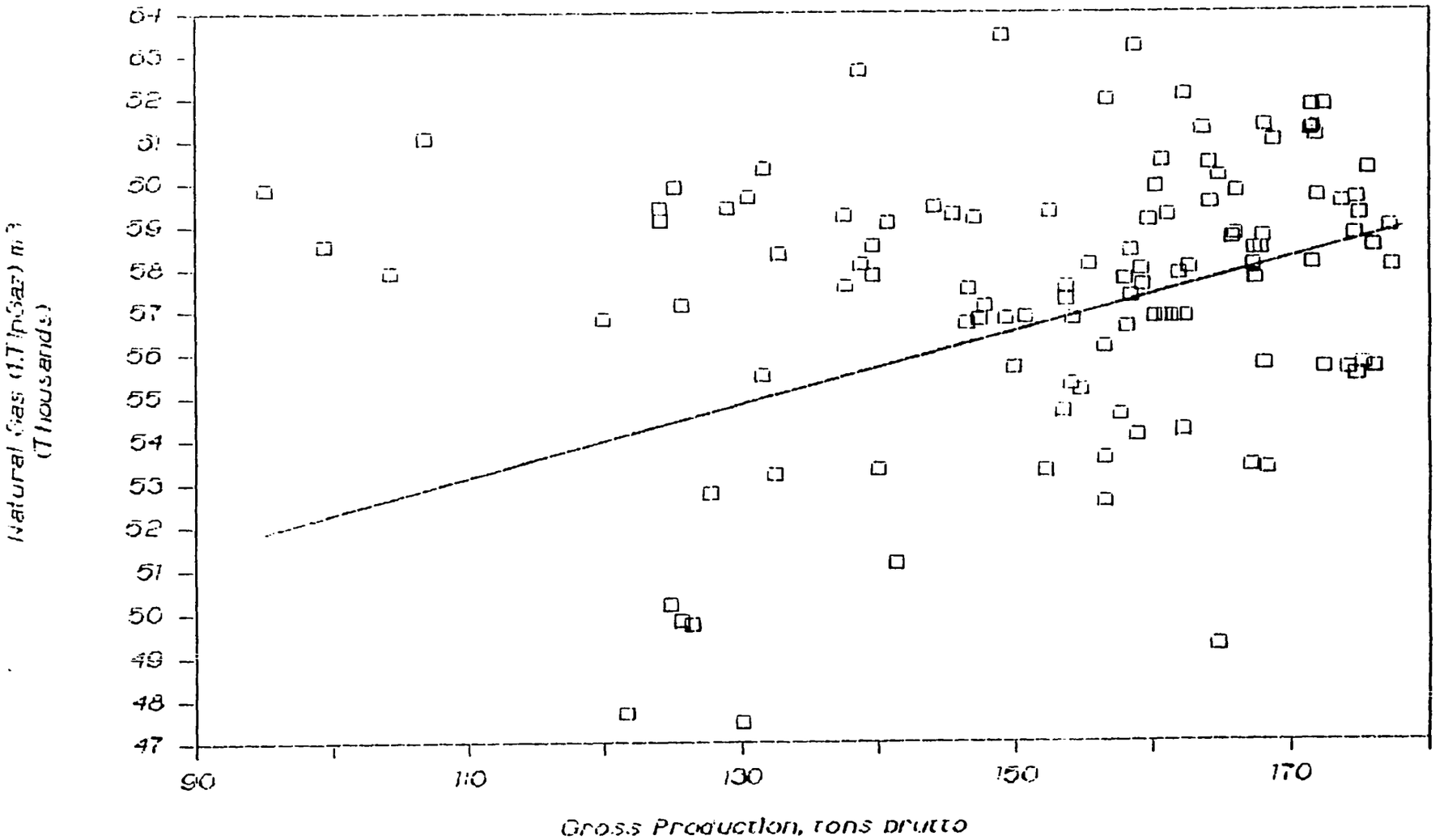

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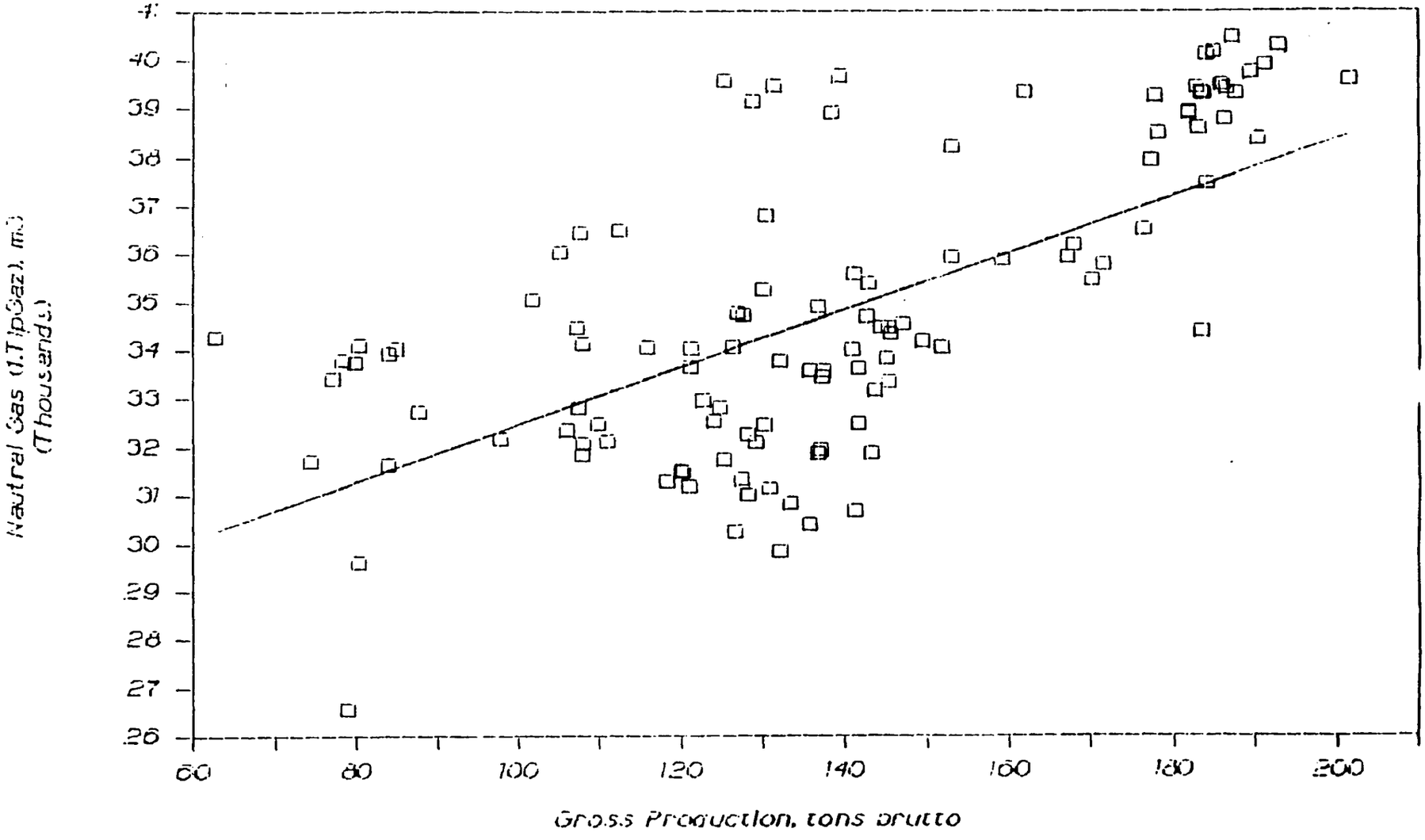

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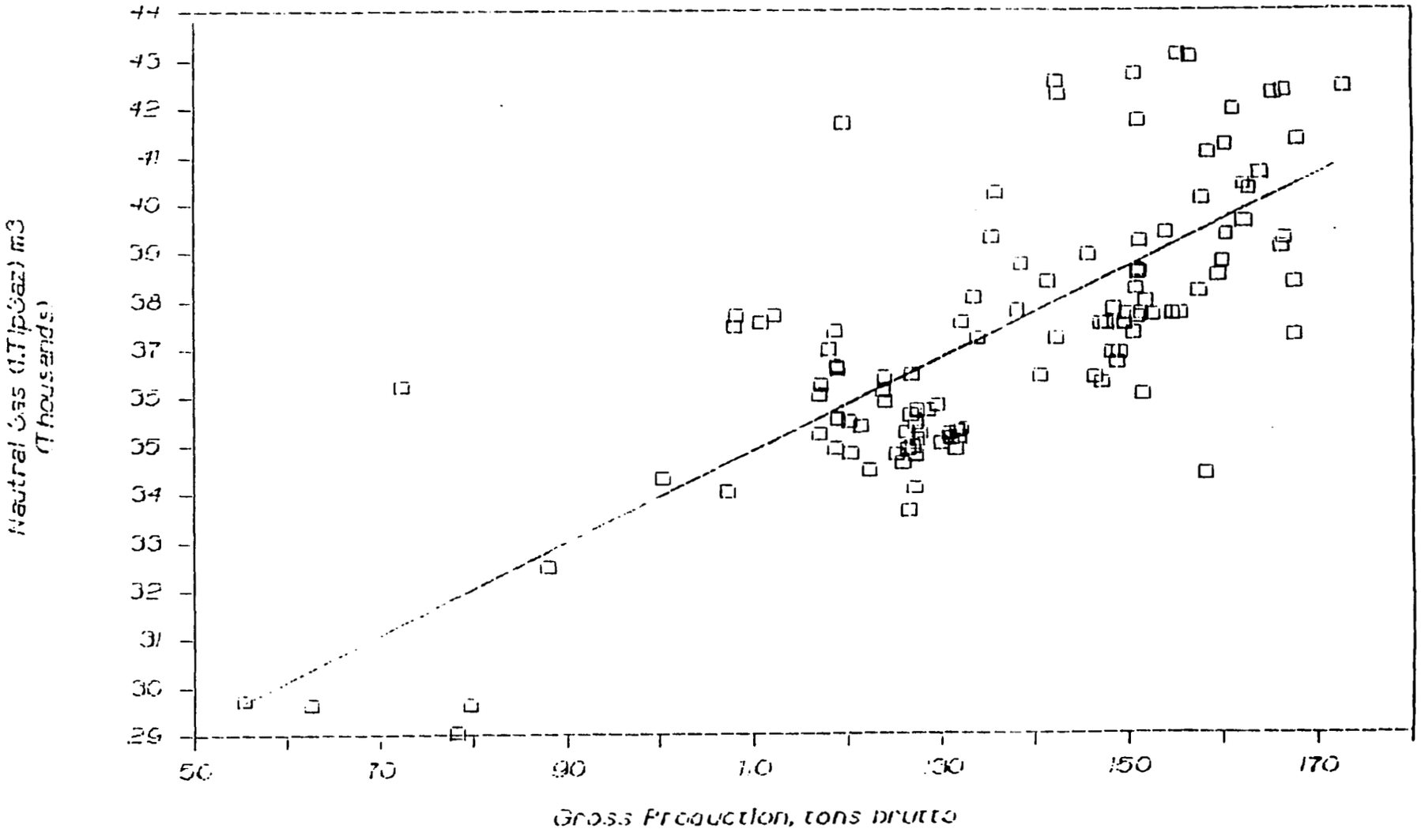

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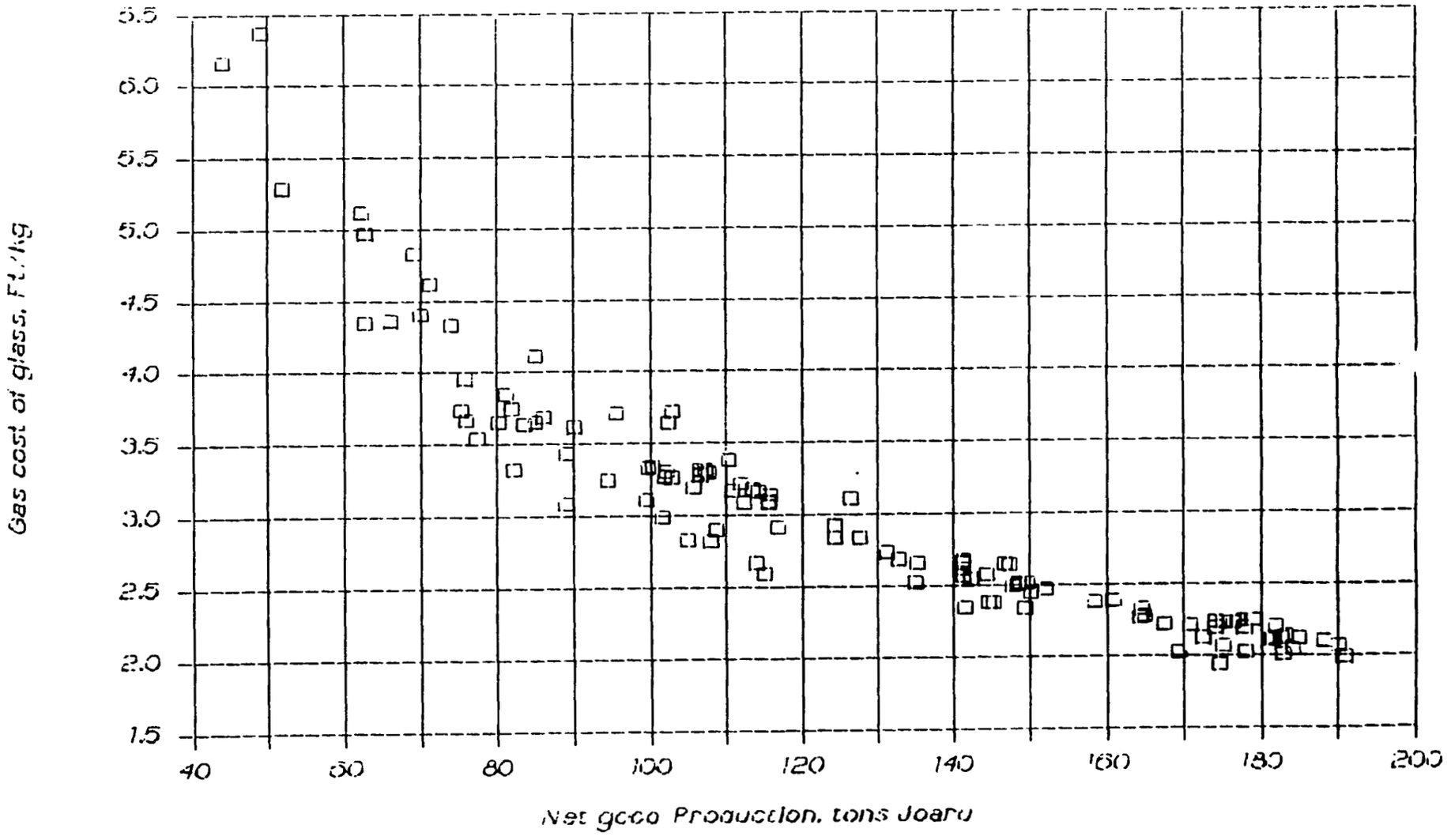

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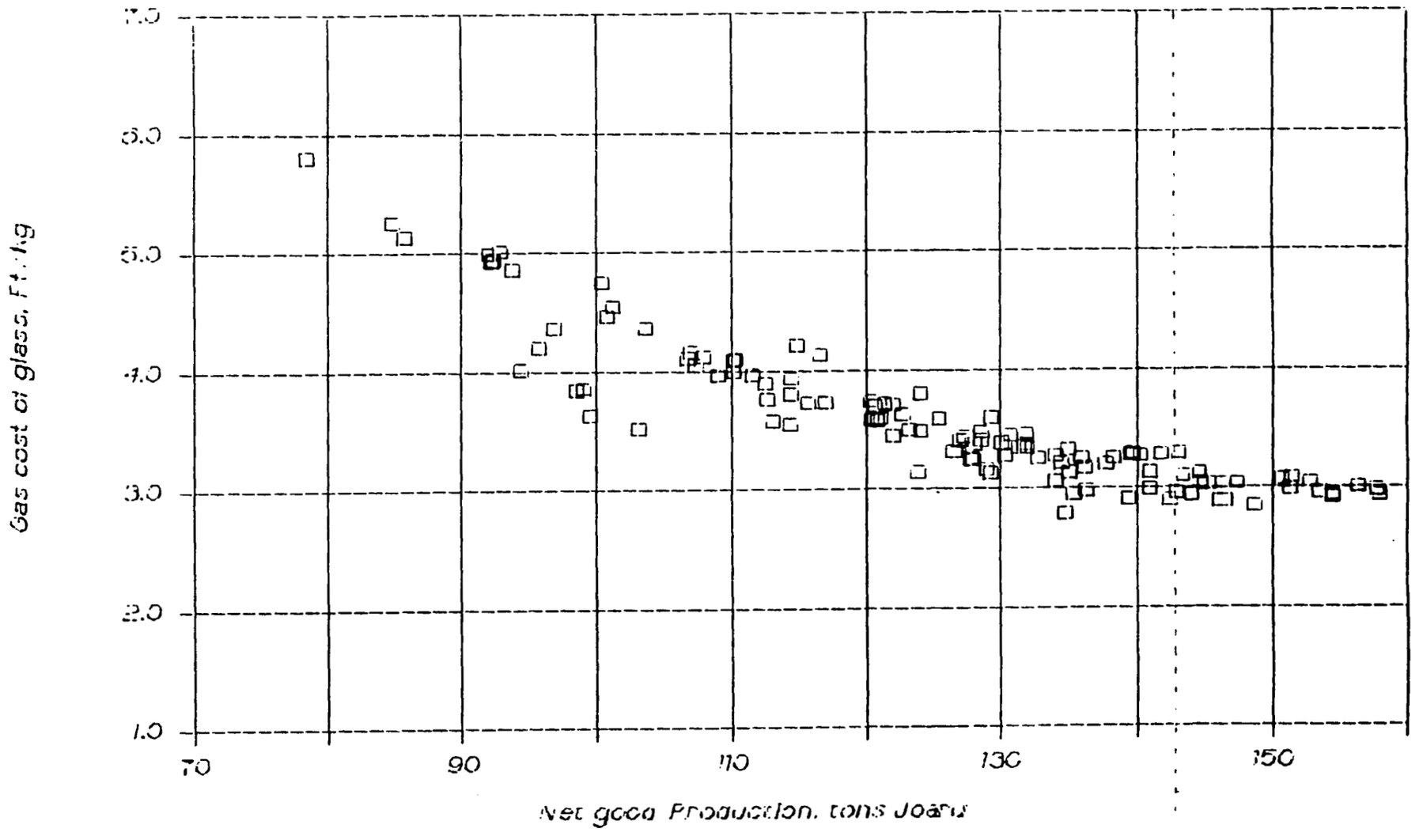

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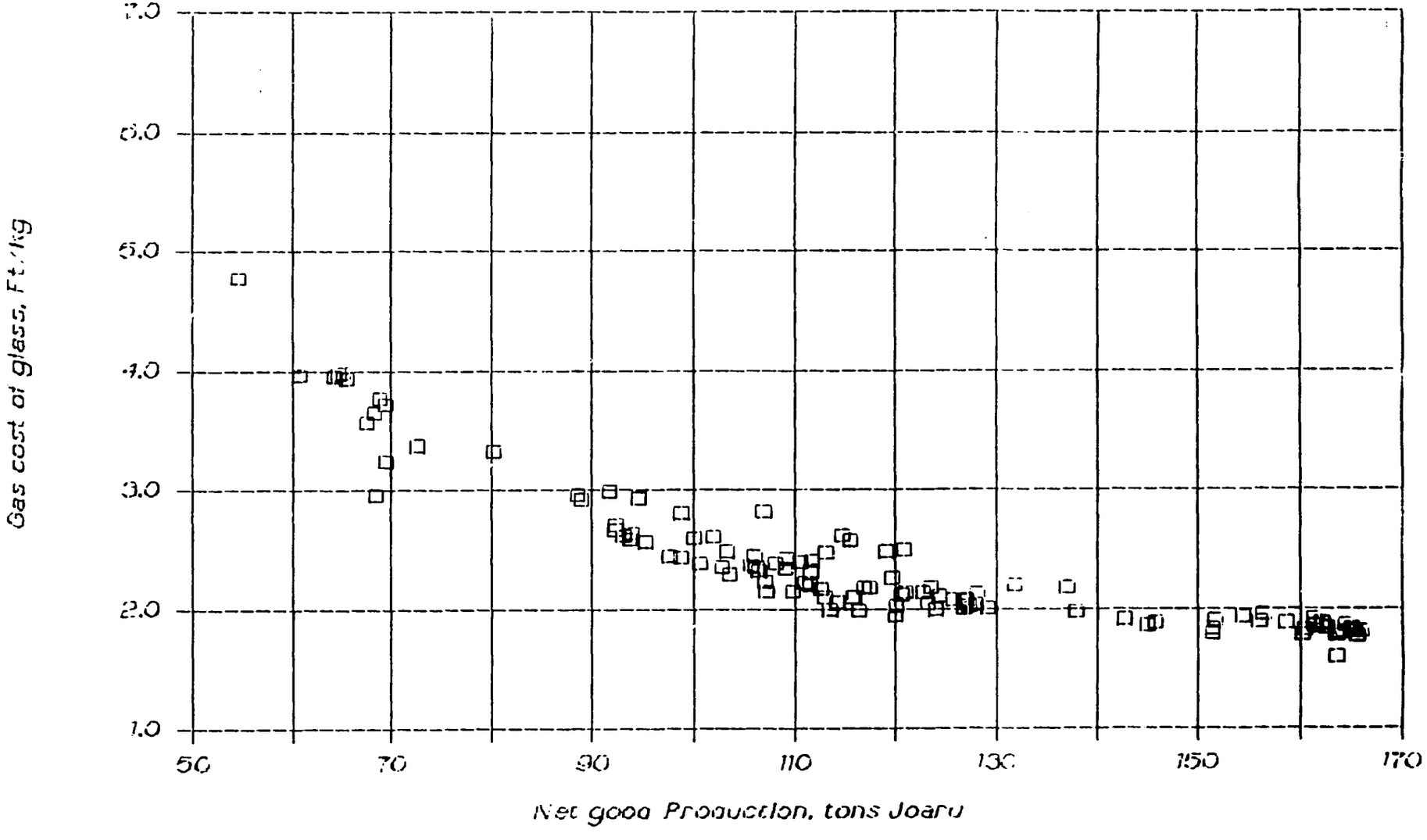
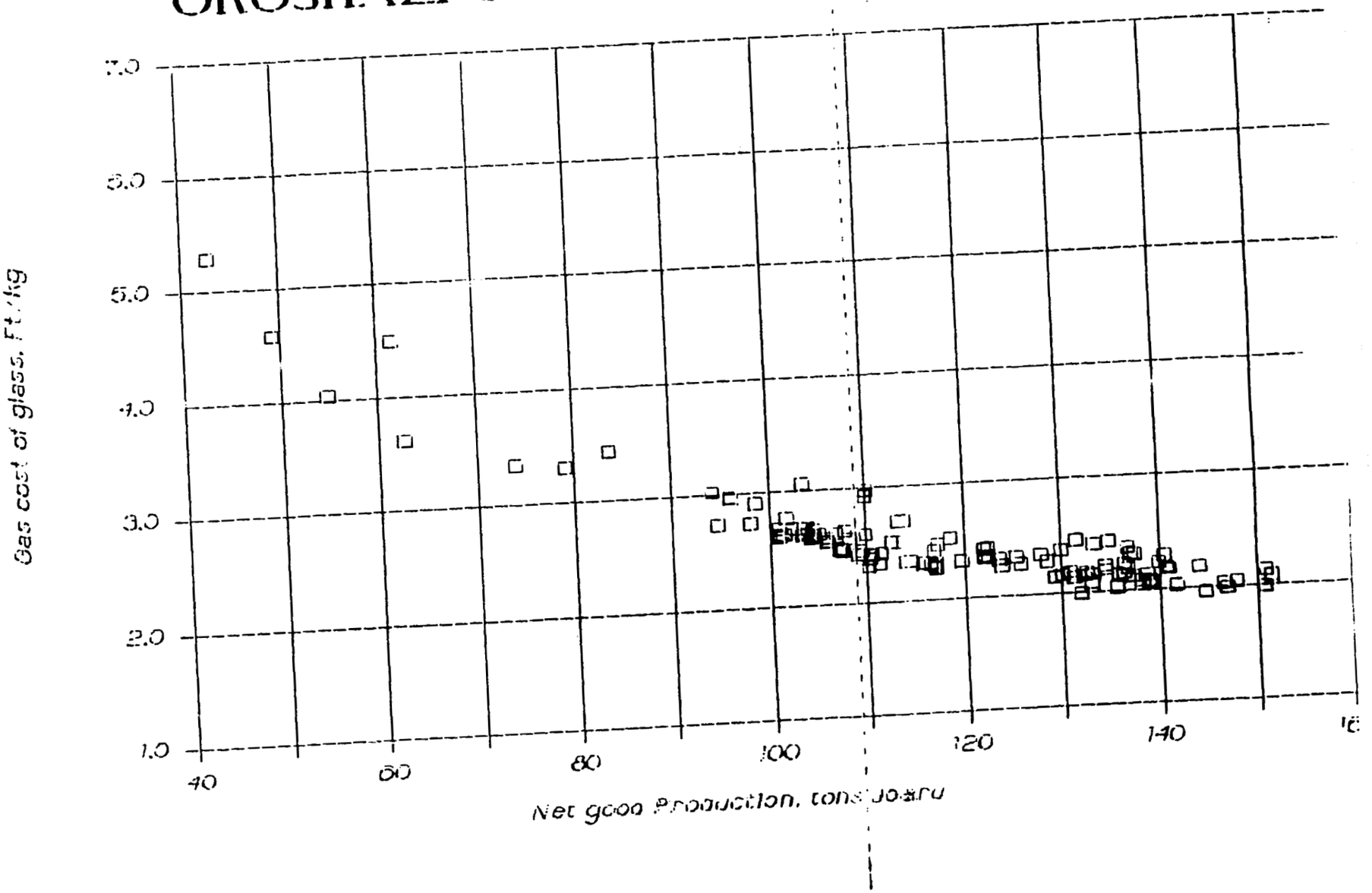
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