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BLAST FURNACE EXPERIENCE AND PRACTICE IN UAR

(Presented by the Government of
The United Arab Republic)

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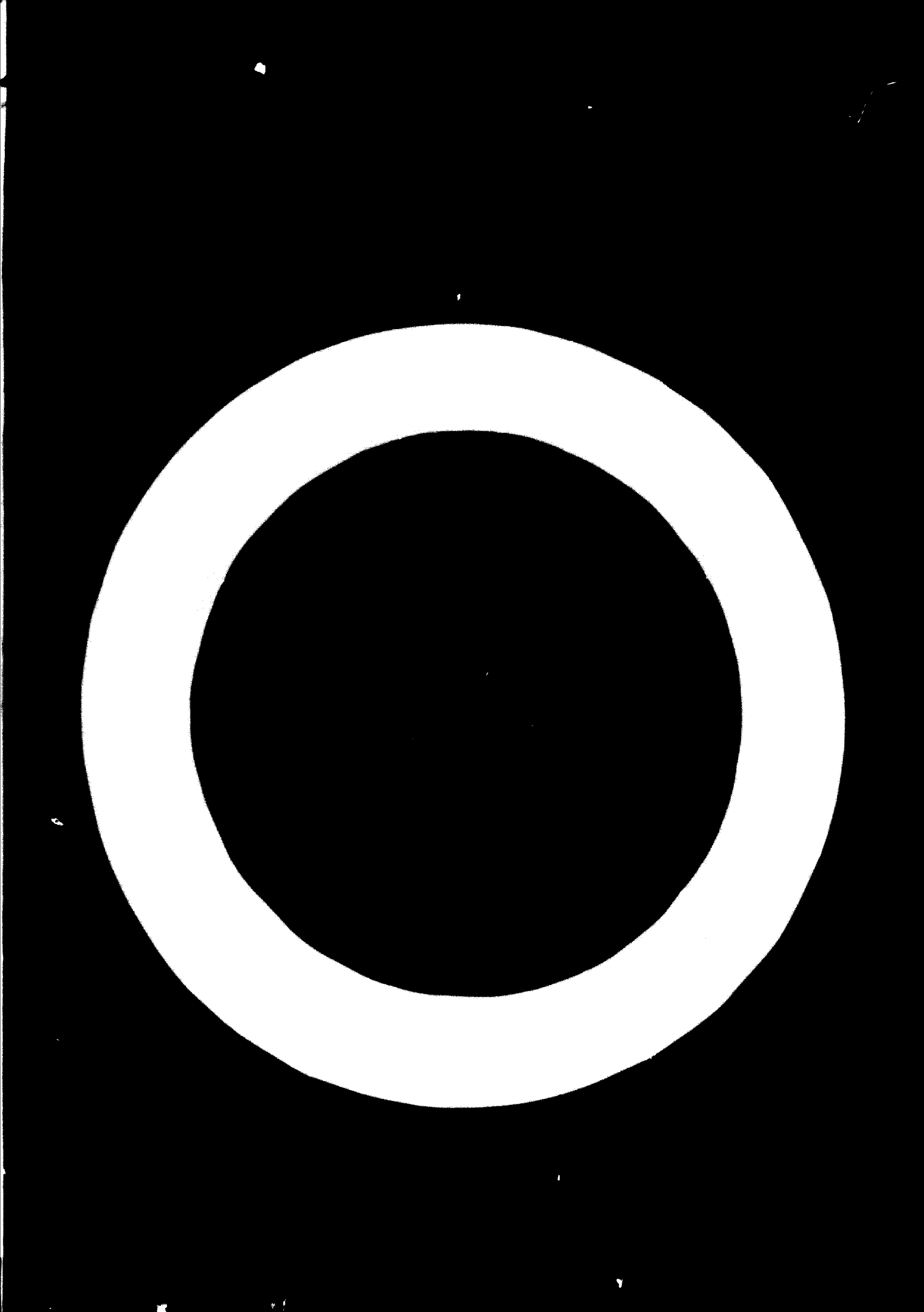

BLAST FURNACE EXPERIENCE AND PRACTICE IN UAR

SYNOPSIS

This paper deals with the technical experience and practice of ironmaking in the blast furnaces of the Egyptian Iron and Steel Company. Special attention is given to the characteristics of the iron ore used and the factors which affect the coke rate and the efforts directed towards the reduction of this figure as being the largest single item in the conversion cost for pig iron.

Local conditions will be taken into consideration and the paper concludes with a recommendation for the developing countries which intend to start up their own iron and steel industry.

I. INTRODUCTION

1- In February 1954, the UAR Government charged the West German Firm DEMAG with the establishment of a fully integrated iron and steel plant, except for a coke plant, with blast furnaces, Thomas converters, electric furnaces and rolling mills with an initial capacity of 265,000 tons of ingot steel per year.

The plant is situated in Helwen near Cairo.

2- The plant was based on the utilization of local ore deposits in Aswan Area with the use of imported coke.

3- The commissioning of the plant started gradually in June 1958 and since that time the plant facilities and the operating results were always under constant observation and analysis with the object of improving the over-all economy of the plant. The study has revealed certain deficiencies and bottle necks in plant equipment and production units. Continuous and successful efforts are being made to overcome those difficulties. Production levels consistent with the installed capacity are being reached almost regularly every month.

4- As a result of these studies two more production units were added to the original plant, one of them is the sintering plant and the other is a light section mill.

Those two units will improve the over-all economy of the plant. The sintering plant will enable us to use fine ores, flue dust, pyrite ashes, mill scale which otherwise could not be used in the blast furnace charge due to their physical nature.

The light section mill will enable us to roll all our steel ingot production into finished products.

Before the light section mill was put into operation an appreciable part of our production was sold as blooms to other local steel mills for re-rolling into concrete reinforcing bars.

5- Future expansion plans which will be carried out by the help of the Soviet Government includes the development of Baharia Ore deposits in the Western desert, coke ovens, blast furnaces, sintering plant, oxygen converters, continuous castings, hot and cold strip mill and additional structural shape mills. Production by 1970 is expected to be around 1.5 million tons of steel ingots per year.

II. DESCRIPTION OF EXISTING IRON AND STEEL PLANT

6- <u>Iron Making Plant</u>

The iron making plant of the Egyptian Iron and Steel Company consists of a blast furnace plant and a sintering plant.

6.1 The Blast Furnace Plant: comprising two furnaces having a hearth diameter of 5.1 metres and a useful volume of 500 m^3. Each furnace is designed on an approximate daily coke through-put of 400 tons. The first furnace was blown-in in June 1958 and the second two years later i.e. in June 1960.

The furnaces are of the self supporting type without stack carrying structures. The furnace shaft is lined with firebricks while the bottom, crucible and bosh are lined with carbon blocks. The furnaces are equipped with Mckee top for normal pressure operation.

The hot stoves consist of 5 stoves, two for each furnace and one serves as a standby unit arranged so that it can be connected to each furnace group. The stoves are capable of supplying each furnace with 60,000 Nm^3/hr air heated to 800°C. The incoming raw materials enter the plant in railway wagons either directly to the sintering plant or to the blast furnace bunker plant which is arranged with three tracks, one for dumping cars to the stock yard, one for dumping ores and fluxes directly to the bunkers, and one for dumping either coke directly to the coke bins or ores and fluxes to the bunkers.

The stock-yard is equipped with a single ore bridge having a 10-ton bucket. The bridge is used to spread the ores, fluxes and coke in the yard as well as to reclaim and transfer material from the yard to the bunkers through self-propelled transfer cars.

The furnaces are driven with electro-turbo blowers and the gas is cleaned by the wet method using spray washers and disintegrators and thence to a 30,000 cubic metre capacity gasholder.

The blast furnace slag is granulated in a granulation plant and the granulated slag is sold to a cement plant for the manufacture of blast furnace slag cement.

The slag which remains in the slag pot is disposed of at a dump. Trials have been made to make use of the dump slag for road construction and railway ballast, but till now no definite conclusion has been reached for the regular use of this slag.

Pig.iron is cast and transported to the steel-making shop in 35 ton capacity open top hot metal ladles and ladle cars.

6.2 The Sintering Plant: comprising of one machine with 50 square metre sintering area and an approximate daily capacity of 1200 tons of self fluxing sinter. The capacity depends to a large extent on the physical and chemical properties of the raw materials and the basicity of the sinter product. The sintering plant was put into operation in July 1964.

The plant produces one class of sinter screened over 10 mm screen, the screened sinter is delivered by belt conveyer to the blast furnace bunker plant where the self propelled distribution cars distribute the sinter to the storage bunkers.

6.3 Fuel Oil Injection System: a fuel oil injection system has been constructed and is expected to be put into operation in June 65. The system is capable of injecting up to 200 kg of fuel oil per ton of hot metal.

7- Steel Making Plant

The steelmaking plant of the Egyptian Iron and Steel Company consists of the following:

Thomas (Basic Bessemer) steel making plant with an annual capacity of 230,000 tons of Thomas steel ingots.

An electric steelmaking plant with an annual capacity of about 50,000 tons of electric steel ingots.

7.1 Thomas Steelmaking Plant

It consists of one hot metal mixer of 500 tons capacity, three converters 15 tons capacity with provisions for a fourth one. The plant comprises also of auxiliary facilities such as lime and additive handling and storage facilities, dolomite calcining and crushing plant, tar dolomite mixing, ramming machine and baking ovens for the manufacture of converter bottoms and brick press for the manufacture of converter lining.

The lime needed for the steel plant is provided by two vertical kilns fired with blast furnace gas and having a nominal capacity of 140 tons/day.

The Thomas slag produced is ground in a special slag grinding plant for the production of Thomas phosphate fertiliser.

Thomas steel is top poured into ingots weighing 3 to 4 tons. Moulds are stripped from the ingots and the ingots loaded into ingot transfer cars for transport to the soaking pits at the mills.

7.2 Electric Steel Plant

The electric steel plant comprises of two electric scrap melting furnaces each rated at 12 tons capacity.

The furnaces are fixed roof, movable shell type. The scrap buckets are moved from the scrap yard on a cross transportation self propelled waggon to the furnace bay.

The buckets are then hoisted and top charged into the furnace. After the heat is made, the furnaces are tilled and tapped into a bottom pouring ladle held in position by an overhead crane.

The electric furnace steel is normally bottom poured into slab ingots weighing one to two tons or square ingots weighing three to four tons.

The slab ingots are transferred to reheating furnace of the plate mill and the square ingots are transferred to the blooming mill soaking pits.

8- Rolling Mills

The rolling mills of the Egyptian Iron and Steel Company consists of the following:

8.1 Blooming Mill

The blooming mill is a 900 mms diameter, two-high reversing mill with an electrically operated manipulator at the entry and exit side with tilting hook at the entry side only.

The mill has a capacity of about 80 tons per hour and the initial material used is 3 to 4 ton ingots either from the Thomas plant or the electric furnaces.

Ingots are reduced on this mill to blooms measuring 140 to 225 mms square, and slab measuring 100 x 500 mm max. Blooms and slabs are cut to desired lengths on a 425 ton shear.

The soaking pits feeding the mill consist of six single hole, one way fired with a mixture of blast furnace gas and fuel oil. Each pit has a holding capacity of about 45 tons and the total output of the soaking pit plant is 60 tons per hr.

8.2 Heavy and Medium section Mill

The mill consists of three stands, one reversing two high roughing stand of 750 mm diameter and two reversing 750 mm two high finishing stand.

The blooms from the blooming mill could either be finished rolled in one heat or with intermediate heating depending on the section rolled and its weight per metre run.

The mill is provided with all necessary facilities such as cooling beds, shearing, sawing, straightening, punching, which are necessary to cover the requirements of the rolling programme of the mill.

The mill is capable of rolling sections having a weight of 7 up to 50 kg/metre run.

The capacity of the mill depends on the sections rolled and the product mix, chosen for its production programme. The average capacity of the mill is 20 tons/hr.

8.3 Three High Plate Mill

The mill consists of a single three high stand. The rolls are 750/600/750 mm body diameter and 1800 mm barrel length. The mill is serviced by a continuous pusher furnace.

The mill is capable of rolling plates of thickness varying from 5 to 25 mm.

The capacity of the mill depends on the thickness of the plate and its average capacity is about 15 tons per hr.

8.4 The Sheet Mill

The sheet mill is a single stand two high pull over mill, where the rolling operation is taking place in one direction only and the piece is returned over the top roll to be re-rolled in the next pass. The rolls have a diameter of 750 mm and a barrel length of 1250 mm.

The mill is capable of rolling sheets of thickness varying from 1 up to 3 mm.

The mill has an average capacity of 1.5 tons per hr.

8.5 Light Section Mill

The mill consists of the following:

(a) Primary roughing arrangement comprising two stands set side by side. The first stand which is the main roughing unit is a three high stand with a roll diameter of 550 mm and barrel length of 1800 mm.

The second roughing stand is two high with 550 mm roll diameter and 1800 mm barrel length.

(b) Semi-Continuous Mill

The primary roughing arrangement is followed by four continuous stands in tandem supplemented by a four stand finishing train.

The four tandem stands are all two high 360 mm roll diameter and 900 mm length. In the finishing train three stands are 360 roll diameter and 900 mm length and the fourth stand is 360 mm roll diameter and 700 mm length.

(c) Wire Mill

The wire mill consists of four Morgan stands with 275 mm roll diameter and 500 mm roll length.

The mill is capable of rolling wires from 6 to 13 mm and rounds from 16 to 38 mm, angles from 30 to 60 mm, tees from 30 to 60 mm. The mill is also capable of rolling flats and squares.

III. BASIC RAW MATERIAL DATA USED FOR DESIGNING OF PLANT EQUIPMENT

9- The blast furnaces were originally designed to produce 400 tons of Thomas pig-iron per day per furnace.

The iron analysis was expected to be within the following ranges:

C	3.5	-	3.8	%
Si	0.5	-	0.7	%
Mn	0.8	-	1.2	%
P	2.0	-	2.2	%
S	0.05	-	0.08	%

The calculations were based on using the following raw materials.

9.1 <u>Coke</u> to be imported from the Ruhr district of West Germany having the following analysis.

C	86	-	88	%
V.M	0.5	-	1.0	%
S	0.9	-	1.2	%
Ash	8.0	-	10.0	%

and the ash analysis having the following composition:

SiO_2	39	-	43	%
Al_2O_3	28	-	35	%
Fe_2O_3	13	-	19	%
CaO	2	-	6	%
MgO	1.5	-	2.5	%

9.2 Limestone will be delivered from the Company's own quarries which is situated about 20 kilometres north of the plant. The average analysis of the limestone is as follows:

CaO	52.0	-	53.0	%
MgO	1.0	-	1.3	%
R_2O_3	1.0	-	1.5	%
SiO_2	2.5	-	3.0	%
I.L.	42.0	-	42.5	%

The size of limestone will be from 25-80 mm.

9.3 <u>Aswan Ore</u>

The Aswan ore is an oolitic sedimentary hematite forming relatively thin beds varying in thickness between 0.2 and 2.0 metres, in Nubian sandstone with varying thickness of overburden. It is wildly distributed over a large area of approximately 800 square kilometres.

The ore deposits were first described geologically early in 1920. Before signing the contract for the establishment of the Iron and Steel Works with Messrs. Demag in

February 1954, several studies have been made on the Aswan ore deposits by specialized firms and individual experts. The results of their studies are given in Table (1) showing the average chemical analysis of the ore and its reserves.

TABLE 1

Name of investigator	Year	Fe	Mn	SiO_2	Al_2O_3	CaO	MgO	P	Reserves in tons
Vadasz	1932	52.32	0.58	10.94	5.58	1.88			344,000,000
Grocht-mann	1937	48.59	0.64	13.39	3.77	6.00	0.7	1.2	35,000,000
Schmidt	1937	51.18	0.28	10.37	3.04	4.2	0.9	1.26	270,000,000
Brassart	1939	47.4	0.5	11.4	6.08	3.6		1.2	13,500,000
Hassan Sadek	1940								400,000,000
Kipper	1949	44.87	0.56	14.2	6.39	3.35	0.57	1.41	300,000,000
Group of German firms	1950	47.0		13.5		4.0			
Eisen bau Essen	1950	50.19	0.53	11.32	4.41	4.56	0.89	1.2	
Egyptian mining administ-ration	1950								40,000,000
"	1952								158,000,000

A- Ore Analysis Basis

A thorough investigation of the figures given in Table (1) shows that the variation of Fe content of the ore according to different investigators ranges between 52.3 per cent and 44.87 per cent and the silica content varies between 10.94 per cent and 14.2 per cent.

The variation of the main components of the iron ore is, however not so serious as the variation of ore reserves calculated by the different investigators which varies between 13,500,000 and 400,000,000 tons.

The choice of the most reliable figures for the average analysis and the ore reserves from the available data was a very difficult job. It necessitated a very deep study of the different reports in order to find out which gives the most reliable figures. The factors which were taken into consideration while choosing the average analysis of the ore and the ore reserves are:

1- The volume of work done on the ore deposits and the number of samples taken and analysed.

2- The number of pits made to calculate the ore reserves.

According to these two main factors it was decided to use the figures of Brassert as the basis of calculation for the steel plant.

The ore reserves given by Brassert are very conservative and the lowest among all other investigators, yet it was sufficient to run the plant about 30 years and was considered adequate to justify the establishment of an iron and steel plant for the production of about 265,000 tons of ingot steel per year.

Brassert has also stated that further supplies may be revealed during the exploitation of the ore deposits.

Accordingly the following average analysis for Aswan ore was given to Messrs. Demag as basis for calculation of the size of the blast furnaces.

Fe	47.4	%
Mn	0.5	%
SiO_2	11.4	%
Al_2O_3	6.08	%
CaO	3.6	%
P	1.2	%

The ore is almost free from detrimental elements such as Pb, Cu, Zn, Vn, Ni, Cr, Sn, As, S and Cl.

IV. ORE CHARACTERISTICS AFTER ACTUAL MINING OPERATION STARTED

10- Before starting up the blast furnaces in June 1958 it was agreed with the mines that the ore should be crushed and classified as follows:

Coarse ore from	40 - 80 mm
Medium ore from	10 - 40 mm
Fine ore	below 10 mm

Both coarse and medium ore to be sent to the blast furnaces separately in self dumping railway wagons for the direct use in the furnace.

The fine ore of - 10 mm to be stored at the crusher in Aswan until the sintering plant is ready and as mentioned previously the sintering plant was put into operation in July 1964.

10.1 Ore Analysis

It was also agreed with the mines that the average analysis of both coarse and medium ore should be within the following composition.

Fe	44	±	2 %
SiO_2	17	±	2 %

The ratio of coarse ore to medium ore delivered to the blast furnace at that time was approximately 2:1 and the average analysis of the two different classes of the ore were within the following range:

Coarse Ore Fe	45	±	2 %,	SiO_2	16	±	2 %
Medium Ore Fe	41	±	2 %,	SiO_2	19	±	2 %

It was agreed further with the mines that every train load will have about 1500 tons of ore and that the analysis of both coarse and medium ore should be cabled to the blast furnaces ahead of the arrival of the train.

10.2 <u>Blast Furnace Results</u>

The early practice was to dump the ore trains in the bunkers and in the stockyard in case the bunkers are full.

The furnace charge was calculated according to the average analysis for the coarse and medium ore as given before in paragraph 10-1.

Such practice does not enable the operators to attain the desired degree of control on blast furnace operation.

This leads to frequent marked fluctuations in both the physical and chemical characteristics of the hot metal.

Since the Thomas steelmaking process calls for maximum homogeneity in hot metal characteristics, such fluctuations tend to cause unsatisfactory results regarding material yield, state of deoxidation, teeming temperature and converter lining life.

The variation in the pig iron analysis could be summarized as follows:

C	3.4	-	3.8 %
Si	0.2	-	1.0 %
Mn	0.6	-	1.4 %
S	0.02	-	0.12 %

10.3 Statistical Study of the Ore Analysis

A statistical study has been made for the Fe and SiO_2 content of both coarse and medium ore delivered to the blast furnaces in the period from October 1958 until June 1959.

The iron content in the coarse ore varies between 41 per cent and 51 per cent Fe. A difference of 1 per cent Fe in the coarse ore may be associated with a difference of ± 2.5 per cent SiO_2. For instance it might be possible to get an ore train with 45 per cent Fe and 11.5 per cent SiO_2 and then followed by an ore train with 45 per cent Fe and 16.5 per cent SiO_2.

Sometimes there is a difference of 5 per cent SiO_2 for the same iron content e.g. the train No. 112 dated 25 May 1959 with 47.1 per cent Fe and 19.1 per cent SiO_2 and train No. 120 dated 3 June 1959 with 47.4 per cent Fe and 13.6 per cent SiO_2.

Such irregularities are very difficult to explain, one factor might be the fact that accurate sampling of such an irregular ore is a very difficult proposition.

Similar irregularities are to be found in the medium ore.

It should however be noted that the variation of SiO_2 for the same iron content becomes greater as the ore gets poorer in Fe content.

10.4 Modification of Blast Furnace Practice

As a result of the previous statistical analysis of the ore, it was decided to make two group of bunkers one for each furnace and each group is in sufficient number to hold a full train load of about 1500 tons. In case a train arrives and none of the bunker groups is empty, the train will be dumped in the stockyard.

The charge of the furnace will be calculated according to the analysis of the train which was dumped in its bunker group. The result of the charge calculation will appear after about 10-12 hrs., the furnace operator will start making corrections either by increasing or decreasing the amount of coke or limestone. The results of correcting the burden needs another 10-12 hrs. to materialise.

Twenty hours later the train load will be finished and the operator will have to start all over again using a new train load with different analysis going through the same steps once more. This practice has lead to the following:

(a) The furnaces have not maintained a stable state since they were put into operation for any appreciable length of time.

(b) Due to the frequent alteration in the furnaces burden and consequently the variation in the thermal load in the furnace it is not possible tc maintain the maximum blast temperature which will eventually lead to a minimum coke consumption.

As a result of this variation in the burden and thermal load in the furnace the blast temperature varies between 500-900°C.

Under the present condition it is also very dangerous to drive the furnace under the most economic condition due to the fluctuation and uncertainty of the ore analysis.

This forces the operator to keep a reasonable reserve in the blast temperature to cover any sudden increase in thermal load in order to avoid hearth chilling.

A chilled hearth is the most serious disorder which can happen to a blast furnace.

When it happened in our plant it took about 7 days of very hard work in order to put the furnace back into normal condition.

(c) It has previously been mentioned that train loads will be dumped in the stock yard in case the two bunker groups are full. The stock yard ore represents a special difficulty to the blast furnace operator because it is very difficult to get a representative sample from the yard especially because there is always a movement in the ore stocks.

The operator uses an approximate analysis for the stock yard ore. This practice will not help him to get homogeneous iron to the satisfaction of the steel plant operator.

(d) Inspite of this practice the regularity of the pig iron analysis was not very much improved due to the fluctuation of the analysis in the consecutive trains. The fluctuation in the thermal load of the furnace has also to be adjusted by alteration of the blast temperature and/or the amount of coke in the charge.

10.5 Working with one class of Ore

In order to make things easier it has been decided since May 1964 to work only with one class of ore having a size over 10 mm and up to about 80 mm.

In this case we will only have one analysis for the whole train.

The results obtained concerning the regularity of the pig iron analysis is still not satisfactory both to the blast furnace management and the steel plant management.

The analysis of the ore trains, with one class of ore which have arrived since the beginning of July 1964, varies approximately between 40.0-49.0 per cent Fe and 15-25 per cent SiO_2.

The same irregularities were also noted on the blast furnace ore after having it delivered in one class from 10-80 mm. The SiO_2 content might vary up to 4-5 per cent with the same Fe content.

10.6 Irregularities within the same train load

The ore bunkers of the crusher plant at Aswan are fed by a reciprocating belt conveyor which carries the ore from the crusher to the bunkers from which the ore train is loaded. The idea of making the belt reciprocating is to give the ore a chance to mix and to have a more or less homogeneous character.

During filling the loading bunkers by the reciprocating belt conveyer, 8 to 10 samples are taken from the belt representing the train load. Each sample is analysed for Fe and then all samples are mixed and quartered to get a representative sample for the whole train. This sample is analysed for Fe ans SiO_2 and the results are cabled to the blast furnaces at

Helwan. Table (2) shows the analysis of the individual samples for six trains during May 1965 and also the analysis of the representative sample of the whole train.

TABLE 2

Train No.	129	130	132	133	134	135
Fe % in first sample	41.4	51.0	47.8	41.0	46.8	47.0
" second "	41.1	40.9	50.2	46.4	44.8	48.1
" third "	42.1	45.1	41.9	41.7	44.3	42.6
" fourth "	42.4	43.9	42.1	40.9	47.2	43.8
" fifth "	46.1	43.3	39.2	43.4	46.7	46.0
" sixth "	48.9	43.3	40.7	44.4	45.3	44.0
" seventh "	43.6	44.9	43.3	44.8	46.6	43.7
" eighth "	46.4	41.1	41.8	48.0	42.3	45.1
" ninth "	44.8		42.6	45.8	44.6	47.9
" tenth "	45.8			46.8	41.3	44.0
Arithmetical average	44.2	44.2	44.4	44.4	44.9	45.2
Fe % in train sample	45.2	44.0	44.4	45.1	45.8	46.2
SiO_2 % in train "	17.9	20.0	22.6	18.6	17.2	18.6

From the above table it could be noted that the iron content of the train samples varies in Fe content from 8 to 10 per cent. The reciprocating action of the belt feeding the loading bunkers improves the homogeneity of the ore.

The extent of this improvement is very difficult to determine because there is no reliable means of sampling the train as it arrives at the blast furnaces in Helwan.

V. PIG-IRON QUALITY

11- Steelmaking, especially converter practice, demands hot metal with as much regularity in composition as possible. The use of an ore which varies in its properties as widely as has been shown for Aswan ore makes this a very difficult proposition.

In order to get low silicon, low sulphur Thomas iron, it will be necessary to work with a highly basic slags which is very dangerous unless you have a precise knowledge of the ore analysis.

Also it is very expensive because it means higher slag volume, higher coke consumption and lower furnace productivity.

VI. COKE CONSUMPTION

The blast furnace were started in June 1958 on imported coke from Germany and it kept on working on imported coke from different countries such as Germany, USSR and Poland until April 1964.

From that date the coking plant which was built south of the blast furnace plant started supplying the furnaces with coke. Now we are relying entirely on the production of this newly built coking plant. The coke produced is of excellent quality, both in chemical and physical properties. The coke analysis is homogeneous and has the following composition.

Ash	10.0 - 10.5 %
Sulphur	1.0 - 1.2 %
Volatile matter	0.4 - 0.6 %
Fixed carbon	89.0 - 89.5 %

12- Coke rate is the biggest single item in the conversion cost for pig-iron. It depends on many factors and the management of the Iron and Steel Company of Helwan is directing every effort possible towards a reduction of this figure.

The following are some of the main items effecting the coke rate:

12.1 - Burden preparation

12.2 - Chemical analysis of raw materials

12.3 - Physical properties of raw material

12.4 - Slag volume

12.5 - Hot blast temperature

12.6 - Distribution and charging system

12.7 - Top gas temperature and analysis

12.8 - Irregular movement of stock in furnace

12.9 - Supplementary fuel injection.

Table No. (3) shows the coke rate during the last three years together with the main indicators of the blast furnace operation.

TABLE 3

	61/62	62/63	63/64
Total production in tons	185,800	204,476	207,337
Coke rate/ton in kgs	118 7	114 3	111 9
Net burden/ton in "	304 0	305 3	295 8
Limestone/ton in "	960	965	787
Slag volume/ton in"	123 0	122 0	109 5
Slag basicity CaO/SiO_2	1.32	1.32	1.30

Table No. (4) shows the trend of variation in Aswan ore analysis during the last four years.

TABLE 4

	1960	1961	62/63	63/64
Fe %	44.8	45.0	43.46	43.99
SiO_2 %	16.3	17.9	19.46	20.36

Table (4) indicates that the trend of Aswan ore is towards lower Fe content and higher SiO_2 content.

The sure ore reserves in Aswan mines now is about 22 million tons. The whole area of the deposits is not yet fully investigated and the probable reserves are much more than the sure reserves stated previously.

13- Burden preparation

This is by far the most important item in reducing the coke rate. The striking records which appeared throughout the world for coke rate is mainly due to high burden preparation. The blast furnace burden should be rich in oron and low in silica, homogeneous in analysis, regular in size and free from fines. If this can be achieved, the slag volume will be reduced, it will be possible to blow with regular and maximum blast temperature, movement of stock will be regular, indirect reduction will be improved, more supplementary fuel could be injected and the coke rate will be highly reduced with consequent high furnace productivity.

In this line we are still lagging behind, but the management is fully aware of this fact and full attention is directed towards this goal.

A concentration and blending plant for the Aswan ore is planned to be put into operation within the second five year industrial plan of 1965-1970.

14- Slag Volume and acid smelting

One of the factors which affect the coke rate is the slag volume. In order to reduce the slag volume without concentrating the ore, acid smelting tests were carried out on the blast furnaces in December 1960 and January 1961.

In this process the blast furnace is considered to be essentially a plant for producing iron but not for refining it. The sulphur content of the iron is adjusted when the metal leaves the furnace by soda desulphurization.

The test was run under a slag basicity CaO/SiO_2 of 0.94. Table (5) compares the results of operation with the two different basicities of 0.94 and 1.22.

TABLE 5

	CaO/SiO_2 0.94		CaO/SiO_2 1.22	
Coke /ton	975	kg	1040	kg
Limestone /ton	401	"	776	"
Blast temp.	650	°C	715	°C
Pig iron analysis				
C	3.39	%	3.52	%
Si	1.15	%	0.75	%
Mn	0.61	%	1.03	%
P	2.21	%	2.27	%
S	0.28	%	0.07	%
Slag volume/ton	900	kg	1150	kg/ton

The figures given in Table (5) shows that there was a reduction in coke rate of 65 kg/ton of pig and slag volume was reduced by 250 kg.

Many objections and difficulties were raised by the Thomas plant management and the acid smelting tests were stopped due to the following:

(a) The variation in the pig iron analysis especially in connexion with Si and S has caused a lot of trouble. The Si content varied betwsen 0.82 and 1.89 per cent which caused excessive wear on the converter lining and higher metal losses due to spitting, in addition to longer blowing time.

(b) The sulphur content varied between 0.150 and 0.465 and since the soda desulphurization is an endothermic reaction, it cools the hot metal, affecting the yield and causing troubles in the casting pit due to the formation of heavy skulls in the casting ladles.

(c) Higher percentage of rejected ingots due to high sulphur content.

(d) Variation in the main components of the pig iron due to the irregularity of the iron ore was more pronounced with lower basicity as compared with normal slag basicity.

The final analysis of the test results indicated that better results could have been obtained if the ore were homogeneous.

The availability of local manganese ore containing about 21 per cent Mn, 35 per cent Fe and 3 per cent SiO_2 would have also helped in getting better results in the acid smelting practice because of the high desulphurising power of Mn. lower sulphur content would have been expected in the pig iron.

15- **Sintering**

The ore fines used in the sinter plant is - 10 mm size and of a relatively low quality, the iron content varies between 34-49 per cent Fe and the silica varies between 16-32 per cent.

The plant was started in July 1964 and sinter was produced with a basicity of about 0.7-0.8.

The use of rich Fe bearing materials such as pyrite ashes mill scale compensates for the quality of the iron ore fines and the iron content of the sinter is thus improved.

The analysis of the sinter produced during January, February and March 1965 are given in the following table.

Month	Fe	CaO	SiO_2	CaO/SiO_2 ratio
January	40.0	14.7	20.2	0.73
February	36.0	23.2	19.1	1.20
March	31.2	22.7	15.5	2.10

Due to the low quality of the ore fines, it was decided to raise the basicity of the sinter up to 2.0 in order to reduce the amount of ore fines going through the sintering plant. As a result of using this high basicity sinter, more limestone will be used in the sintering plant and less limestone will be charged into the blast furnace. The removal of limestone from the blast furnace charge improves its efficiency because limestone is a very substantial energy consumer.

It consumes heat for both decomposition and the endothermic reaction between carbon dioxide and the carbon of the coke according to the following equations:

$$CaCO_3 \text{ ----- } CaO + CO_2$$

$$CO_2 + C \text{ ----- } 2CO$$

Both reactions are endothermic and consumes a considerable amount of energy in the blast furnace. The second reaction which is known as the solution loss reaction besides being endothermic is a direct consumer of carbon from coke.

Consequently any removal of raw limestones from the furnace charge should reduce the coke rate. It is estimated that every 100 kg of limestone removed from the furnace charge reduces the coke rate by 35-40 kgs. It is much cheaper to decompose the fluxes on the sintering belt than decomposing it in the blast furnace.

16- Oil Injection

The oil injection system was erected and is expected to be put into operation in June 1965.

The present practice of smelting Aswan ore without blending does not allow the regular use of high blast temperature because of the heavy fluctuations in the thermal load of the blast furnace. The blast temperature now varies between 500 and 900°C with an average of about 600 to 650°C.

If the ore was homogeneous in analysis it would have been possible to drive the furnace under the most economic conditions with maximum blast temperature. This would enable us to inject more fuel and improve the replacement ratio and this would have resulted more reduction in the coke rate.

VII. FURNACE TROUBLES AND INVESTIGATION THEREOF

17- Scaffolds

Due to the lack of proper burden preparation and the variation in the ore analysis and the appreciable content of fine materials in the furnace burden there is always the possibility of scaffold formation in the furnace.

This is also aggravated by the fact that the ore is very silicious and needs a lot of limestone.

Limestone helps in the formation of scaffolds especially when it comes in contact with the furnace walls. Big variations in the blast temperatures alters the working zones in the furnace and adds an important factor to the formation of scaffolds.

Scaffolds may drop down suddenly by themselves with the furnace burden as it moves down or they may need dynamite to be removed. We have gone through both experience and both of them necessitate very hard work and constitute dangerous conditions.

Scaffolds have a basic character and the following shows the analysis of a sample of a scaffold removed from furnace No.1 during 1960. At that time the scaffold was removed by dynamite.

Analysis of a sample of scaffold

SiO_2	13 %	Mn	0.94 %
Fe_2O_3	50 %	P	0.7 %
Al_2O_3	6 %	C	1.5 %
CaO	22 %	S	2.0 %
MgO	2 %	Na_2OK_2O	6.1 %

The scaffolds were found to be built up in successive layers of fine raw materials and as shown from the analysis they contain mainly limestone and ore. Alkalies in the burden help the formation of scaffolds.

If the burden is properly screened and the fine constituents removed there will be slight possibility for scaffold formation.

Proper investigations should also be made to choose the most suitable charging system and stock level which will prevent fine raw materials and limestone from getting in contact with the walls of the furnace.

18- Hearth Break out

Blast furnace No. 1 was blown in on the 30th. of June 1958 and blown out for relining on the 8th. of September 1964.

The duration of its first campaign was six years and two months. During this campaign the furnace produced 590,987 tons of Thomas pig iron and consumed 650,268 tons of coke.

During the campaign one hearth break out occurred in the tap hole area in October 1963, almost five years after blowing in the furnace. The breakout was repaired by cutting a piece from the steel jacket around the tap hole area.

The lining in this area was removed and then rebuilt using high quality refractory blocks.

The part of the steel jacket which was stripped off was welded in its place and the furnace was put back on wind.

The time needed for this repair was about ten days. The maintenance of the tap hole area is one of the most important responsibilities of the blast furnace operator.

Measurement of the tap hole length should be made for each cast and recorded in the furnace daily report.

It should not be less than 130 cm., if it gets shorter one of the tuyères around the tap hole should be plugged off with clay. If it still gets shorter the other tuyère should be plugged off.

The plugged tuyères can only be opened after the situation improves.

Special attention should be given to the preparation of the clay gun mix. Different mixtures have been tried using coke, coal, pitch, clay and broken fire clay bricks. The one which we are using now has proved to be very satisfactory; it has the following composition.

Coal blend (For coking)	2	parts by volume
Sinai clay 40 % Al_2O_3	3	" " "
Aswan clay 28 % Al_2O_3	1	" " "
Broken fire clay bricks	1	" " "

In order to maintain a good tapping hole the furnaces should be absolutely dry after each cast. Plugging the furnace against slag and especially against iron is a very bad practice.

If this is repeated many times, the tap hole will be lost and consequently the furnace will be lost.

The clay gun should always be in good working condition and the operator must be sure that the clay goes into the tapping hole. The percentage of water in the clay mix is very important and must always be under constant observation.

19- Blast Furnace Investigation

Many attempts were made to make proper and scientific investigation on the blast furnace performance with the aim of reducing the coke rate to a minimum figure. The following are some of the points which we have tried to investigate:

19.1 - Ore size
19.2 - Limestone size
19.3 - Burden distribution
19.4 - Blast temperature
19.5 - Sinter composition and basicity
19.6 - Slag basicity
19.7 - Percentage of indirect reduction
19.8 - Optimum driving rate.

In order to investigate the individual effect of each of the previous items on the coke rate you have to keep the other factors constant. Under the present circumstance of the fluctuations in the ore analysis and the consequent changes in furnace burden it is almost impossible to carry out any sound investigation on the furnace performance. Too many variables are changing everyday and at the same time which makes it very difficult to correlate the variation of the coke rate with those variables.

The Thomas steel plant is also facing the same difficulties. Due to the variation in the pig-iron analysis no systematic studies could be made on the factors affecting the quality of the steel ingots, the yield, the amount of dioxidisers needed the temperature of steel and the other casting pit problems.

VIII. FOREIGN TECHNICAL ASSISTANT

20- This is one of the most important points which faces the developing countries which start their own iron and steel industry.

It is definitely advisable that those countries should get technical help and consultation from the highly industrialised countries which have long years of experience in this field.

20.1 Another important point in this field is that the developing countries which started their own iron and steel industry starts usually with one plant only which means that there is no possibility of exchanging experience within the country. We have only one blast furnace plant in our country and whenever we meet any furnace trouble for the first time, we will have to rely entirely upon ourselves. To overcome such trouble, without the help and experience of others who have successfully worried through that particular trouble, will take much longer time and greater effort. It must be emphasised that there are few situations in life where the experience and example of others are so needed as around a blast furnace when a new kind of trouble is met.

20.2 This clearly indicates that one iron and steel plant in the country cannot operate successfully and economically if it remains isolated from the other iron and steel plants in the world.

20.3 The iron and steel industry is progressing very fast and it is probably no exaggeration to say that we are in the midst of a revolution and technical explosion in the field of iron and steelmaking practice. The highly industrialized countries are exchanging their experience on local levels in local conferences and on international levels in international conferences. Developing countries should make use of those conferences at least by sending observers to follow up the new and modern trends which are continually developing in this industry.

20.4 The writer also believes that the developing countries have common problems which do not exist any more in the highly developed countries. It will be, therefore, advisable for the developing countries to exchange visits of their staff and to hold their own conferences in which all common problems could be discussed and their experience mutually exchanged.

20.5 It is also the opinion of the writer that the developing countries which started their own iron and steel industry should employ a group of specialists from the highly industrialized countries. Those experts will be available for direct consultation and will act as link between the plant in which they are working and the plants in their own countries.

20.6 It should, however, be bornein mind that every country has its own school of practice and experience.

Since our plant was put into operation we had the chance to work with specialists from different countries such as Germany, USA, USSR, England, Austria, Czechoslovakia and France.

This definitely has a serious drawback because every expert advocates the practice of his own country which sometimes is quite different from that of the other country. If the operator keeps changing from one practice to the other he will never have the chance to master any practice which is against the benefit of the industry.

20.7 As previously mentioned each country has its own school of practice and experience depending mainly on scientific principles and taking local conditions into consideration. For example, it is scientifically and practically approved that oil injection can replace part of the coke in the blast furnace, but the economy of this operation depends to a great extent on the relative price of oil and coke and this is a local factor which varies from one country to the other.

20.8 In the blast furnace operation some experts have strongly recommended the use of dolomite together with limestone as a flux, others declared that for our ores and our local conditions there is no need at all for dolomite in the blast furnace charge. Some experts have also recommended that due to the heavy fluctuation of the Aswan ore analysis, a blending plant should be immediately installed. Others said that blending could be made by the ore bridge in the stockyard.

Experts from a third country said that their experiences have proved that blending in the stockyard is a mere loss of time and effort. Some experts have strongly recommended to follow the acid smelting practice in the blast furnaces, others have stated that our local conditions do not permit the use of such practice.

Some experts recommend that blast furnaces should not be driven hard unless the burden is fully prepared, others do not agree with such recommendation.

Such conflicting ideas make it difficult for the management to take sharp and decisive actions.

20.9 The same also happened in steelmaking operation and rolling mill practice. For example, in steelmaking some experts recommended the production of rimming steel, others advocate the production of semi-killed steel.

20.10 So it is the opinion of the writer that the experts should be chosen from the country who delivered the plant equipment and that they should not be changed by others from another country until a certain practice has been reasonably established and stablized.

This does not mean that we should ignore the practice in the other countries completely. This could be covered by sending our engineers and technicians to the iron and steel plants of the different countries to get acquainted with their practice. Also through the participation in the international conferences, an effective contact could be realized in order to follow up the activities of the iron and steel plants throughout the world.

IX. CONCLUSIONS

21- The iron and steel industry is a highly developed industry and very efficient. All industrial countries are directing great effort towards the production of cheaper steel and better quality. The object of this policy is to make steel more competitive with other metals and with other steel producers in other countries.

22- Developing countries which intend to start up their own iron and steel industry must bear in mind that this industry involves a great number of difficult problems.

The most important of these problems is that of raw materials. The iron ore deposits should be studied very carefully in order to have a clear and accurate picture of the ore characteristics. In case of developing a new ore mine it is advisable to run a large scale mining test.

The homogeneity of the ore is an absolute necessity, the Fe and SiO_2 content should vary within a very narrow limit of $\pm$ 0.5 per cent, phosphorus content of the ore is very important as it decides the steelmaking process.

A thorough investigation should be made for the detrimental elements of the ore such as As, Cu, Pb, Ni, S, Sn, Cl etc.

There are well known ore deposits in the world which are rich in Fe and low in silica but their economic value is low because they contain high percentage of detrimental elements, e.g. the Conakry ore of Guinea contains 1 per cent Cr. In Tunis one of the iron ore mines produces ore containing 55 per cent Fe and 3 per cent SiO_2 but due to its relatively high content of Zn 0.58 per cent pb 0.33 per cent. As 0.26 per cent its economic value is seriously affected.

23- Ore concentration is an economic problem governed by the production cost of pig-iron, but it must be deeply studied. Ores containing 55 per cent Fe are being concentrated in some plants to 65 per cent Fe.

24- Investment on burden preparation used to be considered as a luxury in the old practice. Now it is becoming a necessity especially in the countries which rely on imported coal or coke for their industry. Although coke is available at a relatively cheap price in USA, yet it has been recently reported that at the present

present time between 80 to 90 per cent of their domestically produced iron ore is treated, i.e. either heated, crushed, screened or concentrated in advance.

25- Although it is possible to calculate the expected iron analysis if the ore analysis is known, yet it might be advisable to run an actual smelting test in a commercial furnace to make sure of the analysis of the pig iron produced.

This is very important because the analysis of the pig iron decides the most suitable steelmaking process for that iron.

26- The maximum elimination of limestone from the blast furnace charge improves its effeciency and raises its productivity.

27- High blast temperature and fuel injections should also be the aim to save coke and to enable the furnace to be driven at faster rate.

28- If the country has its own coal mines and intends to produce its own coke, the coal deposits should be thoroughly studied in order to make sure that good quality metallurgical coke will be produced. The coke should also be homogeneous in analysis. The same also applied to other raw materials such as limestone and dolomite.

29- If the raw materials picture is absolutely clear a lot of difficulties in the new industry will be avoided.

30- It is not advisable for developing countries to start with highly automatic equipment and machinery. Such equipment need great skill for operation and maintenance.

31- Maintenance facilities should be given high consideration and should be planned in such a way that the plant can rely on them for the manufacture of the spare parts needed to the greatest possible and reasonable extent.

32- It should also be borne in mind that a new iron and steel industry produces an appreciable amount of scrap and waste containing a high percentage of Fe units. A plant for the preparation of scrap and the recovery of the Fe units from the plant waste is a very economical proposition.

It will pay for itself in a few years. The product of this plant could either be charged back into the blast furnaces or in the steelmaking units or both.

This will improve the economy of the blast furnace and reduce the coke rate. In general, such a plant will improve the over-all economy of the industry.

33- Full utilisation of the plant by-products such as coke, oven gas, blast furnace gas, blast furnace slag etc, improves the economy of the plant to a great extent.

34- A new steel plant cannot live isolated from the experience and practice of the other iron and steel plants in the world. It must have some sort of connexion with other plants in other countries. The employment of a team of experts from a highly industrial country can provide this contact very effectively.

The participation in international conferences provides another means to follow up the new and modern trends which are continually developing in this industry.

Developing countries have common problems which do not exist in the highly developed countries. They must find a way to get together to discuss their common problems and exchange their experience.

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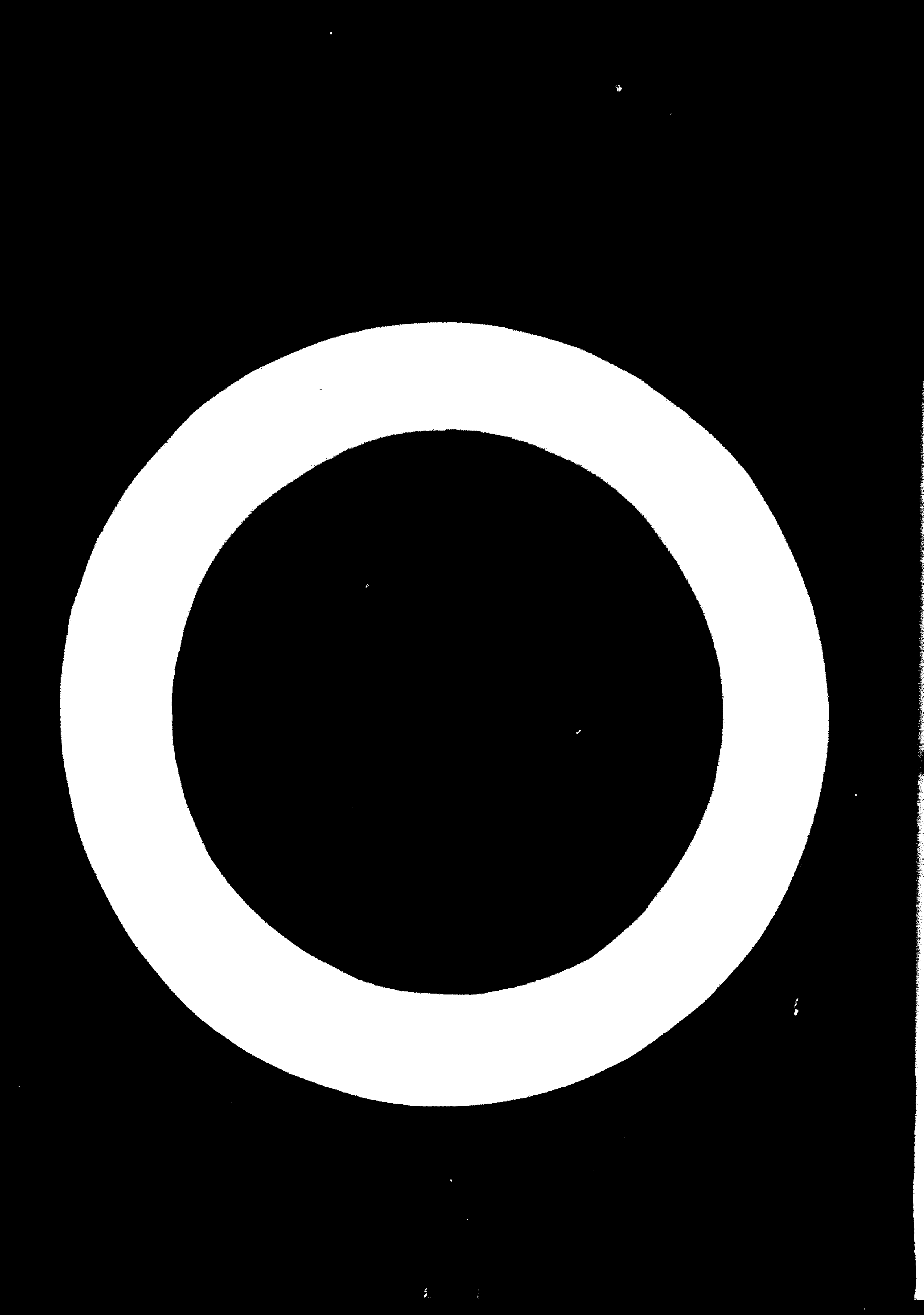

HADI SOLB

EGYPT

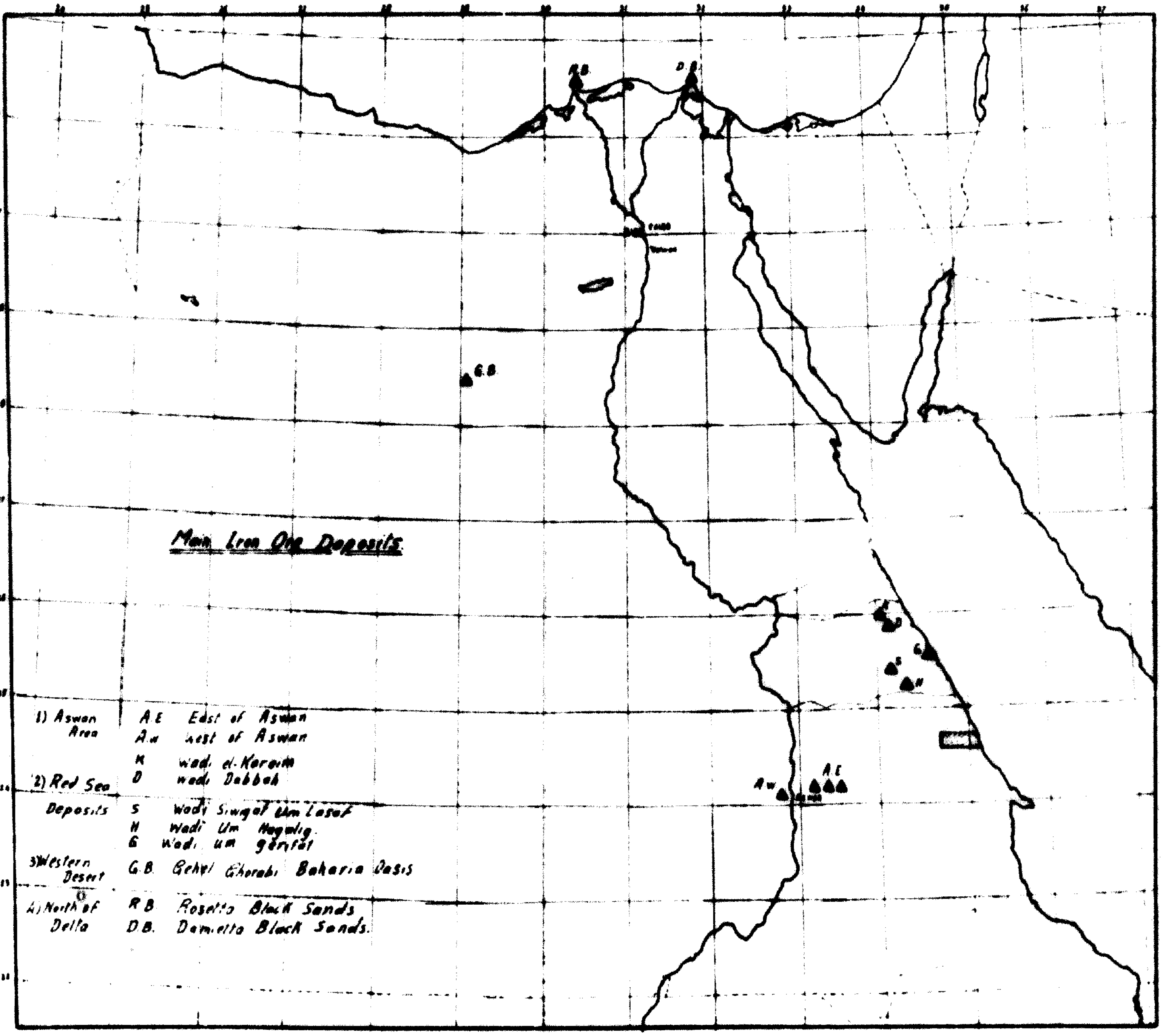

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Fig. (1)

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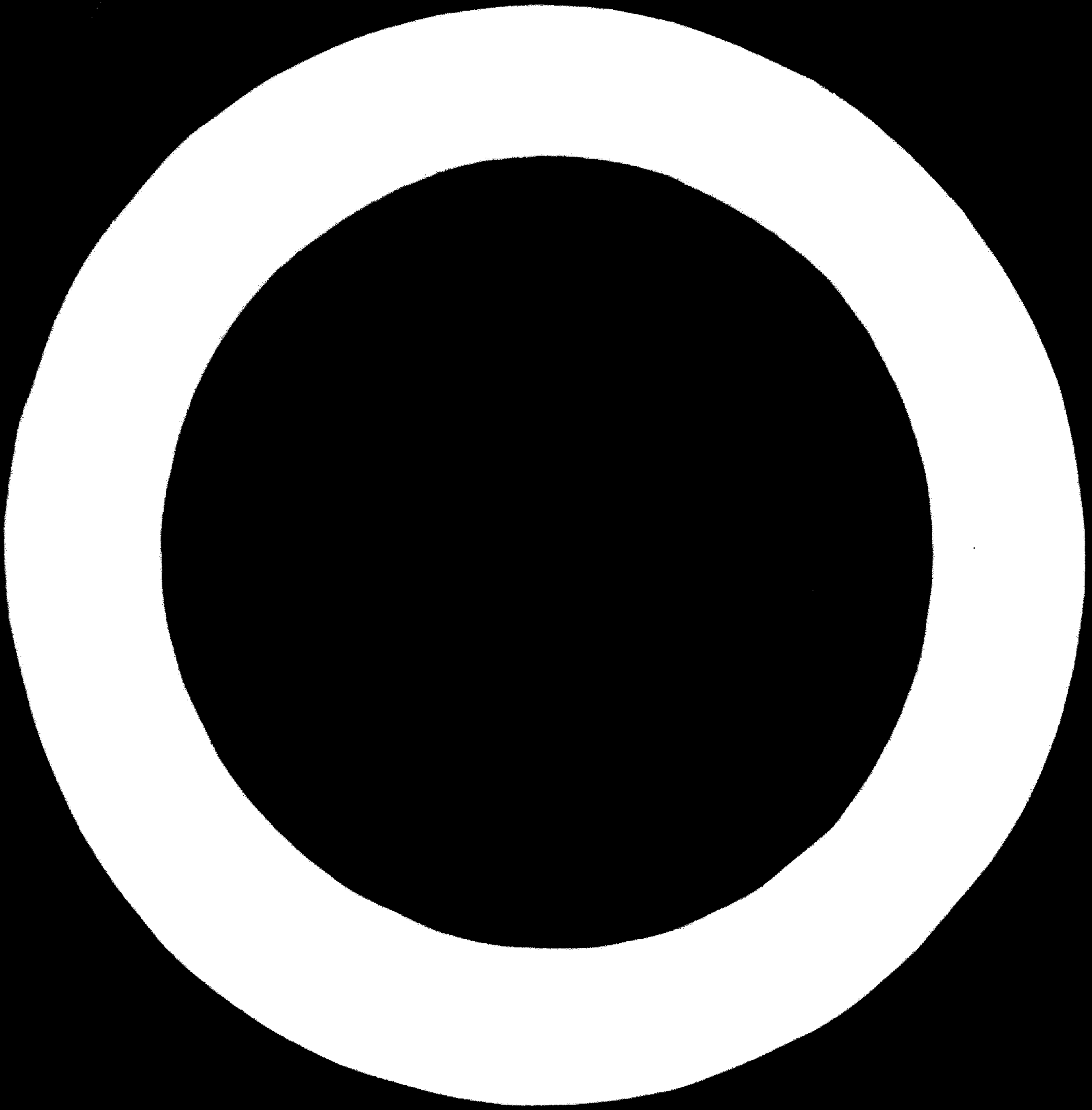
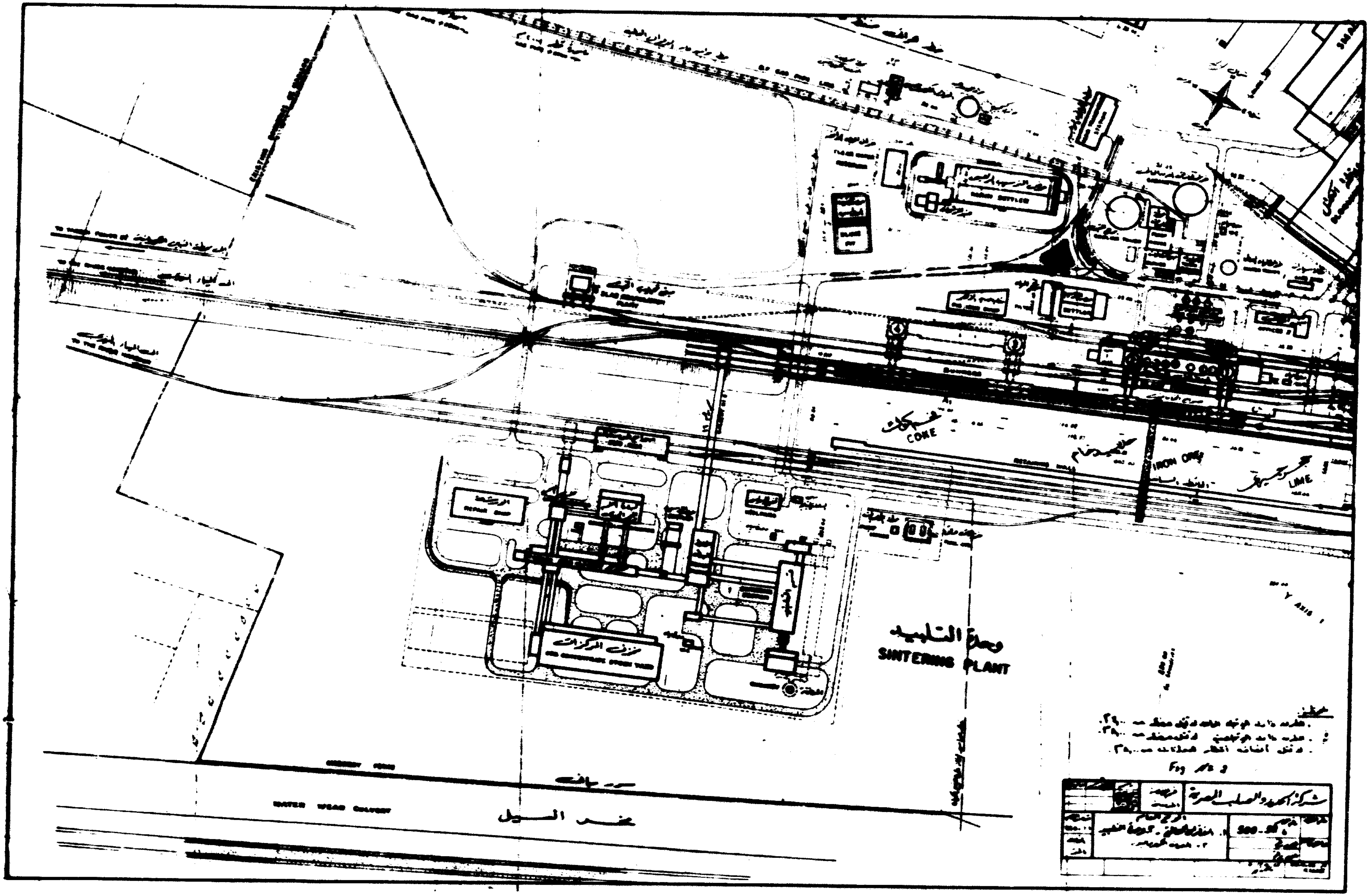
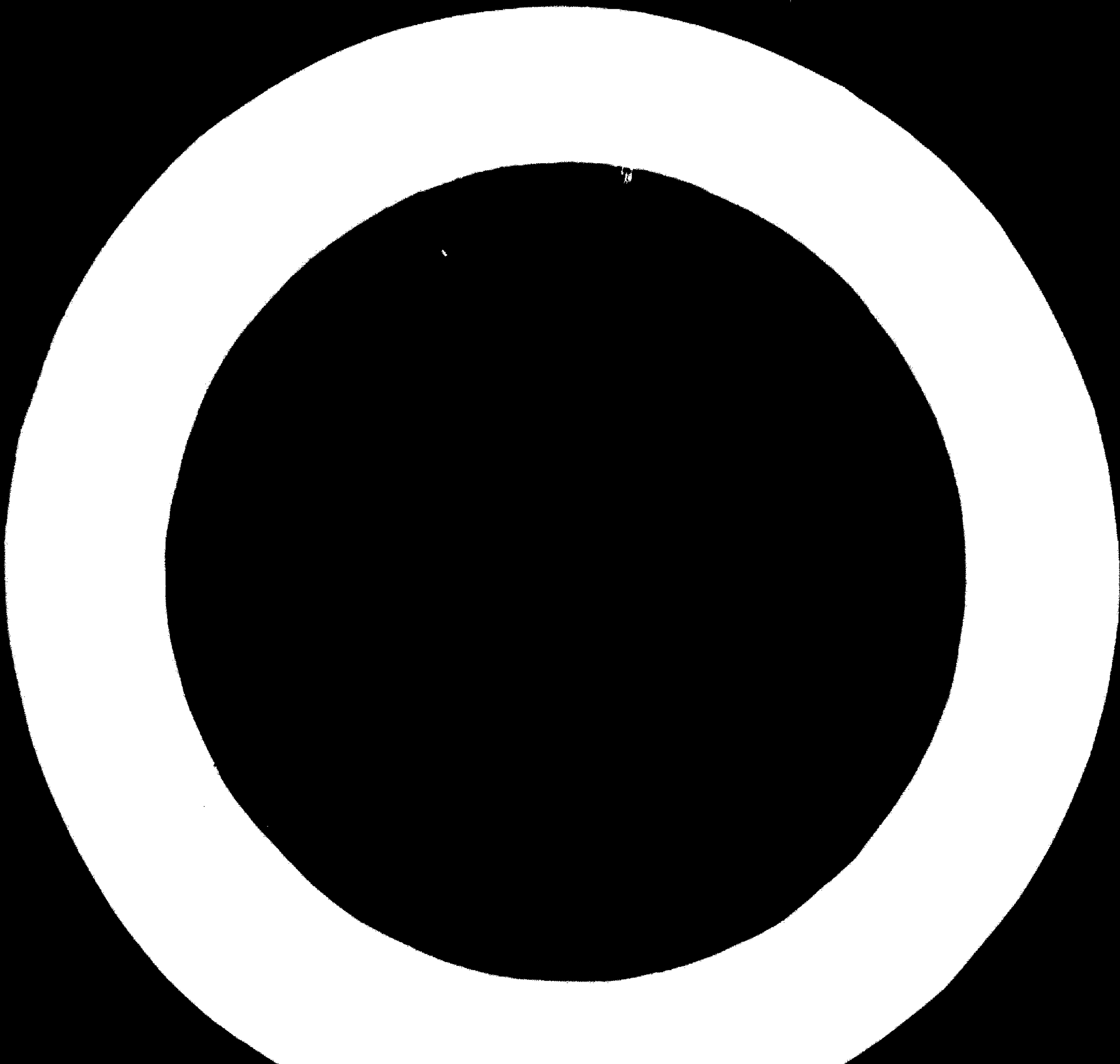




وحدة التلبيد
SINTERING PLANT
CONE
IRON ORE
LIME
Fig No 3
شركة الحديد والصلب المصرية



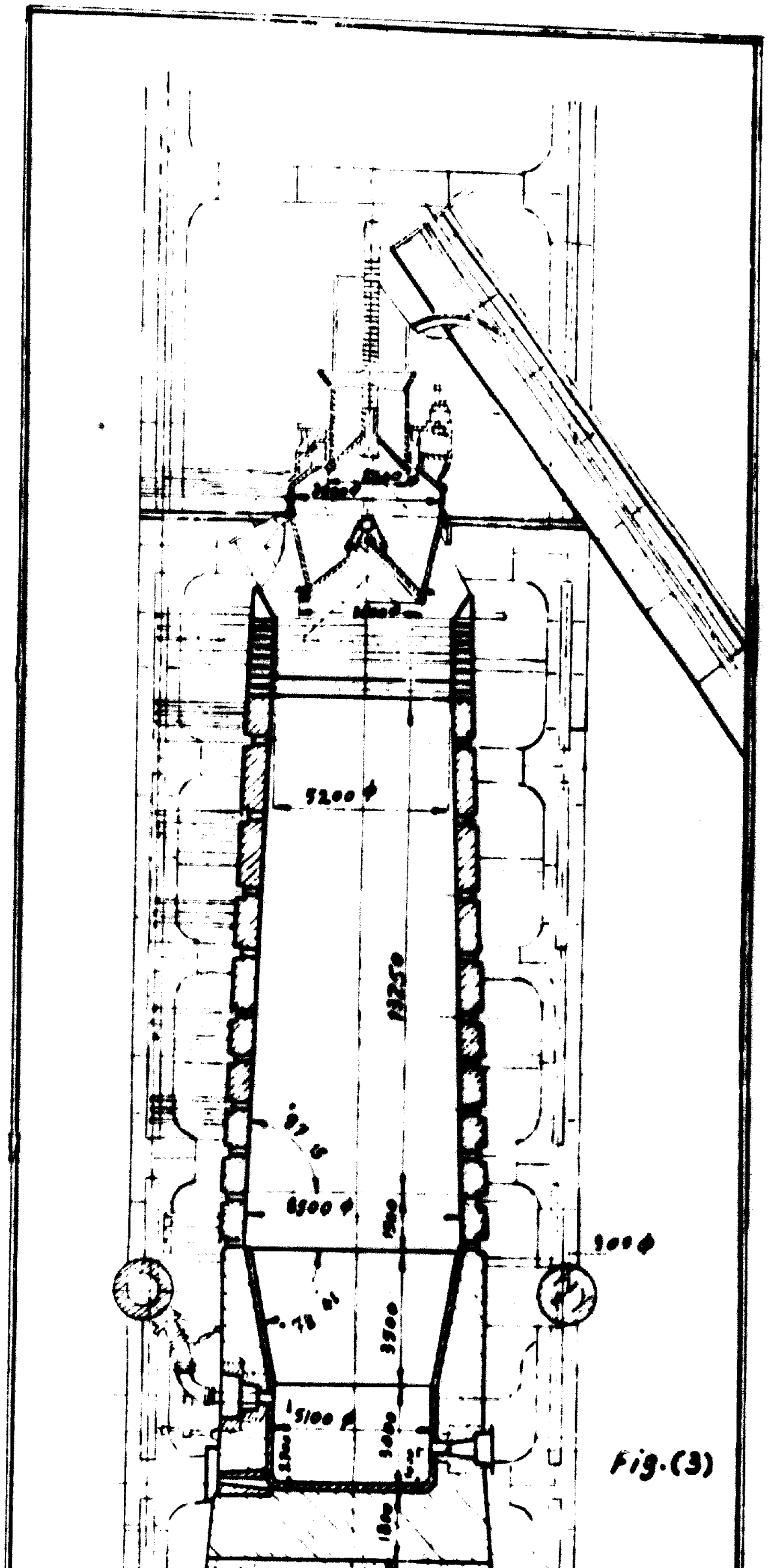
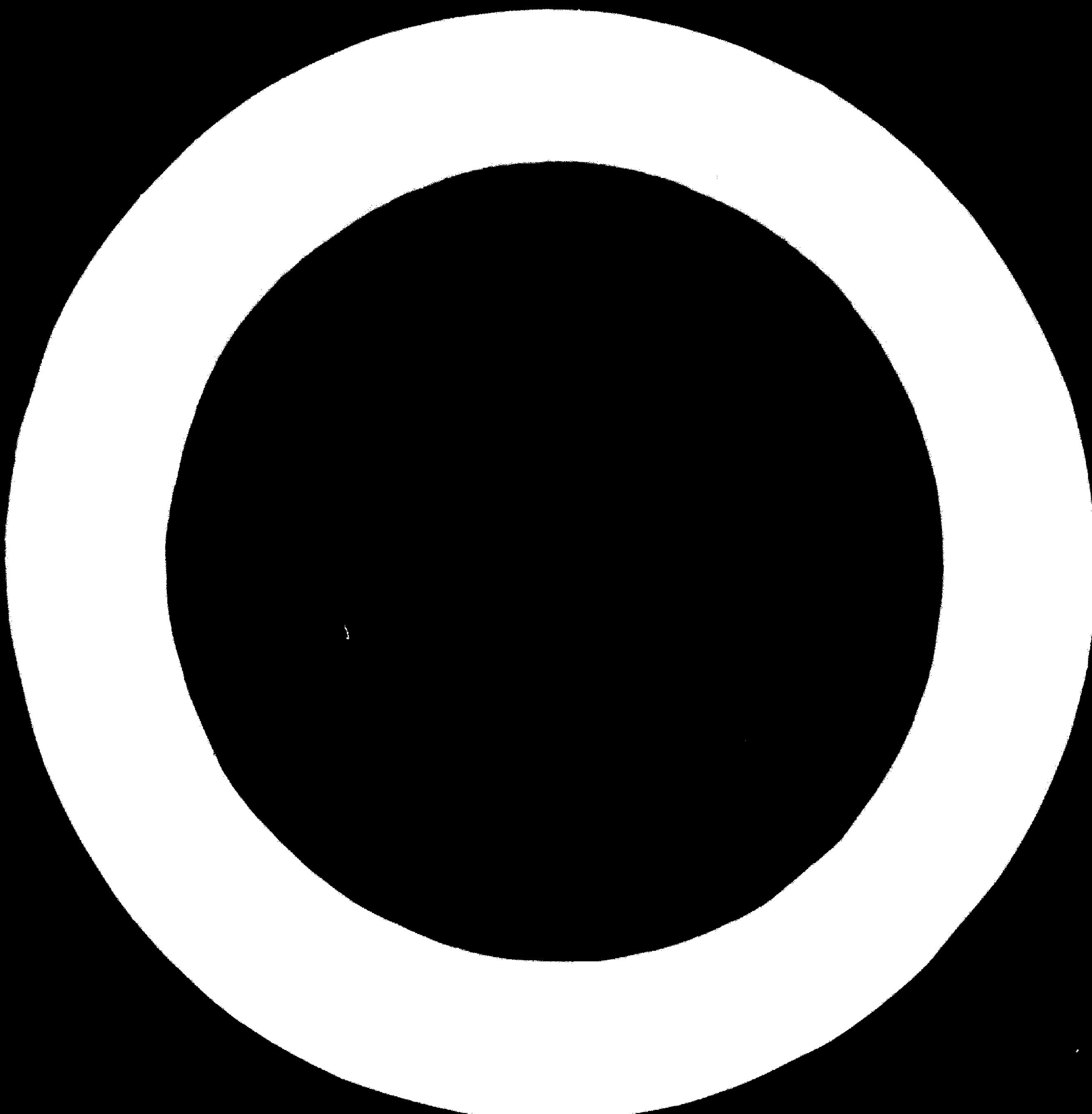


Fig.(3)



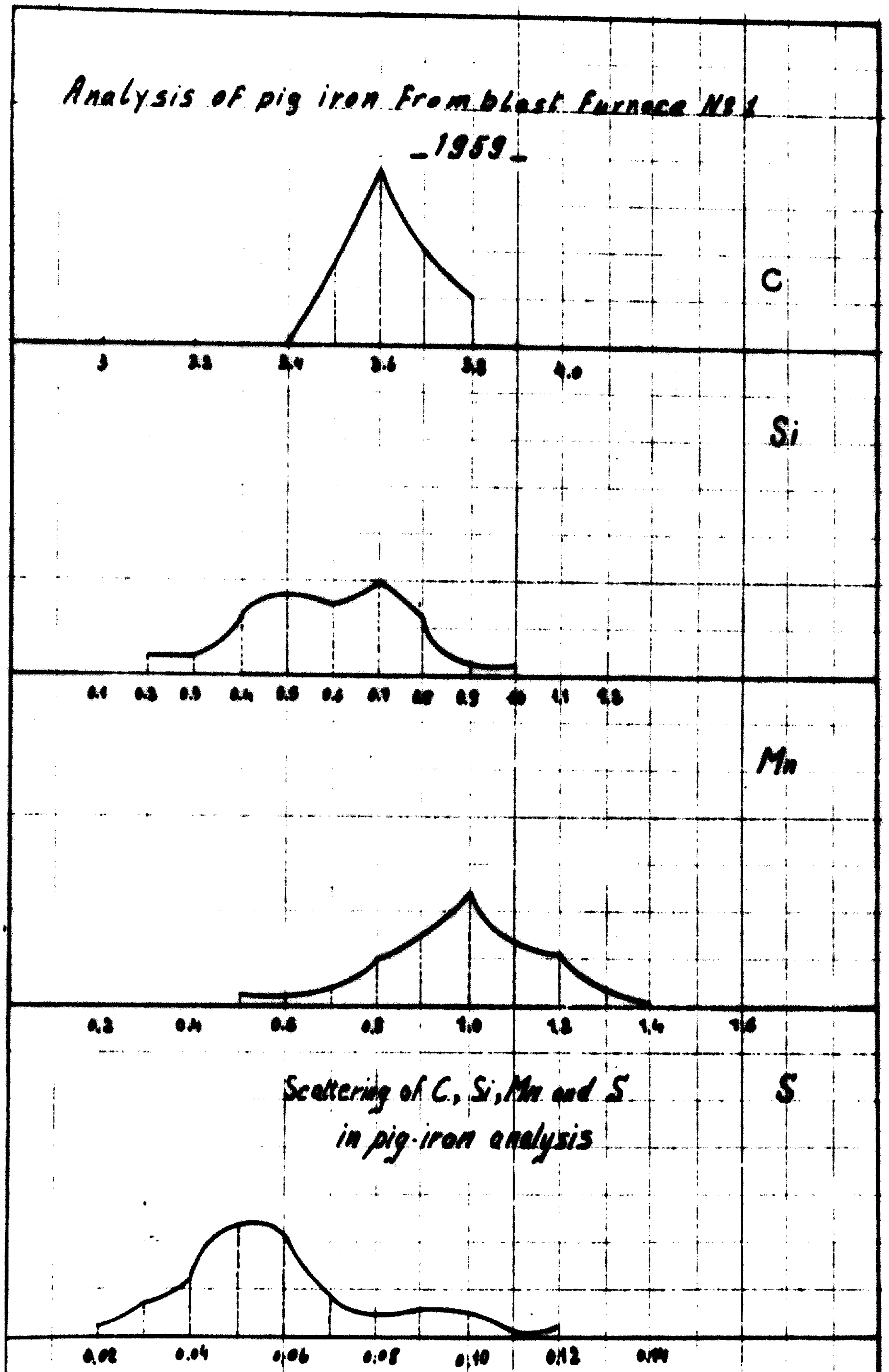
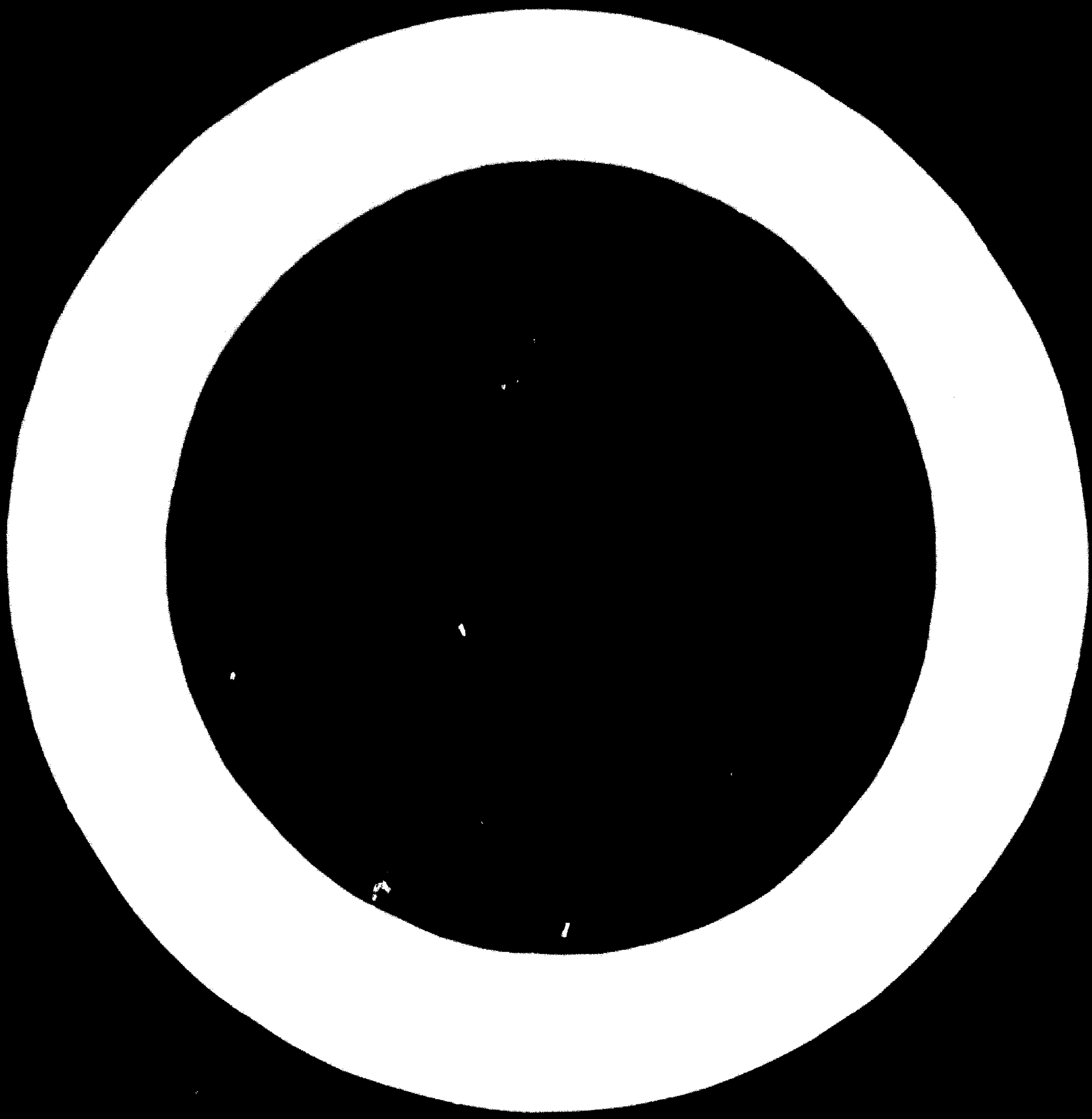

Analysis of pig iron From blast Furnace № 1
_1959_
C
3
3.4
3.6
3.8
4.0
Si
Mn
0.6
0.8
1.0
1.2
1.4
S
Scattering of C, Si, Mn and S
in pig-iron analysis
0,02
0,04
0,06
0,08
0,10
0,12

Fig. 4



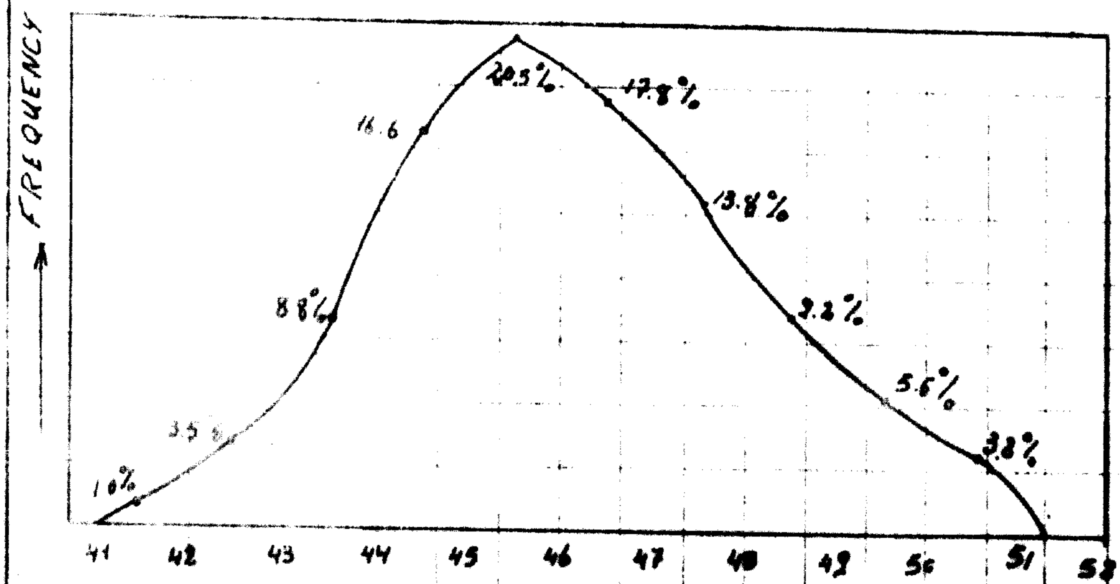


Fig. 5 Variation in Fe Content of the Coarse Ore (40-80 mm)

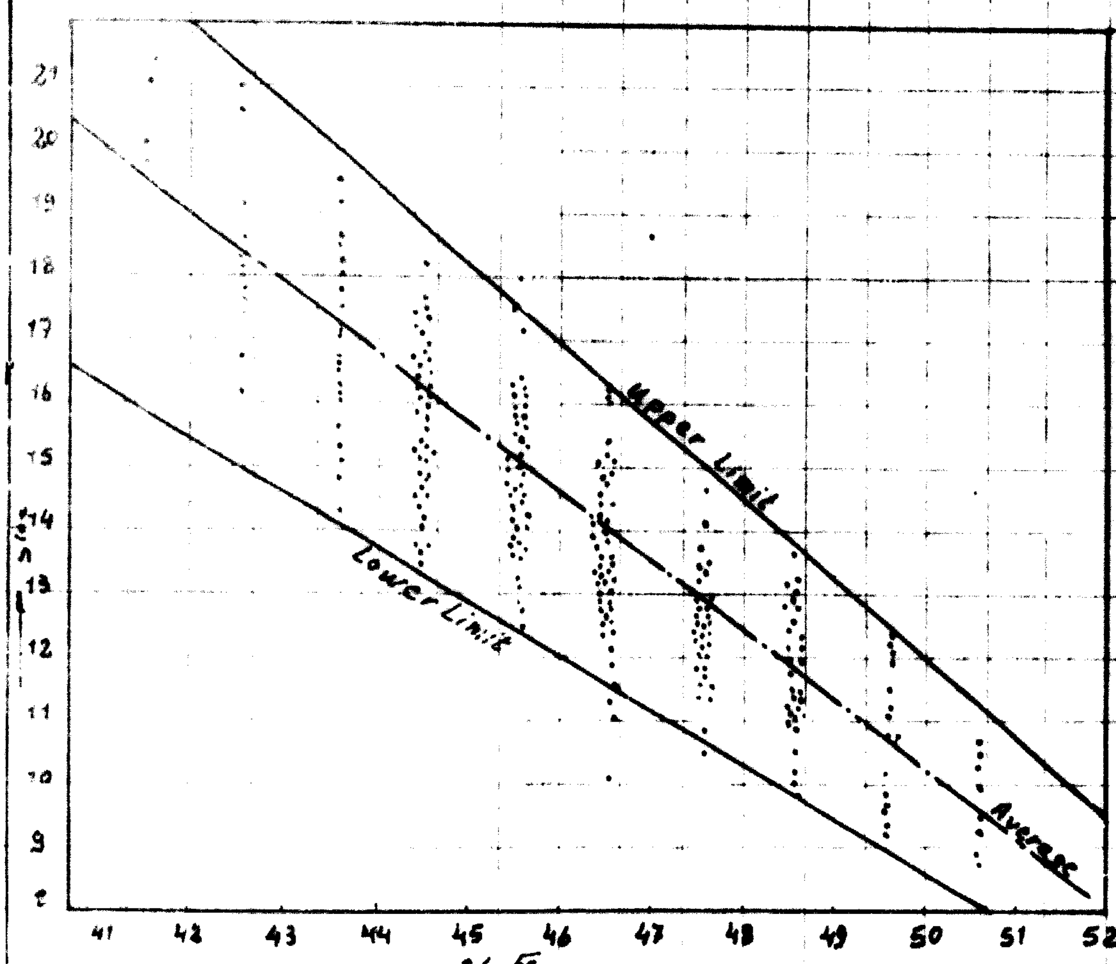
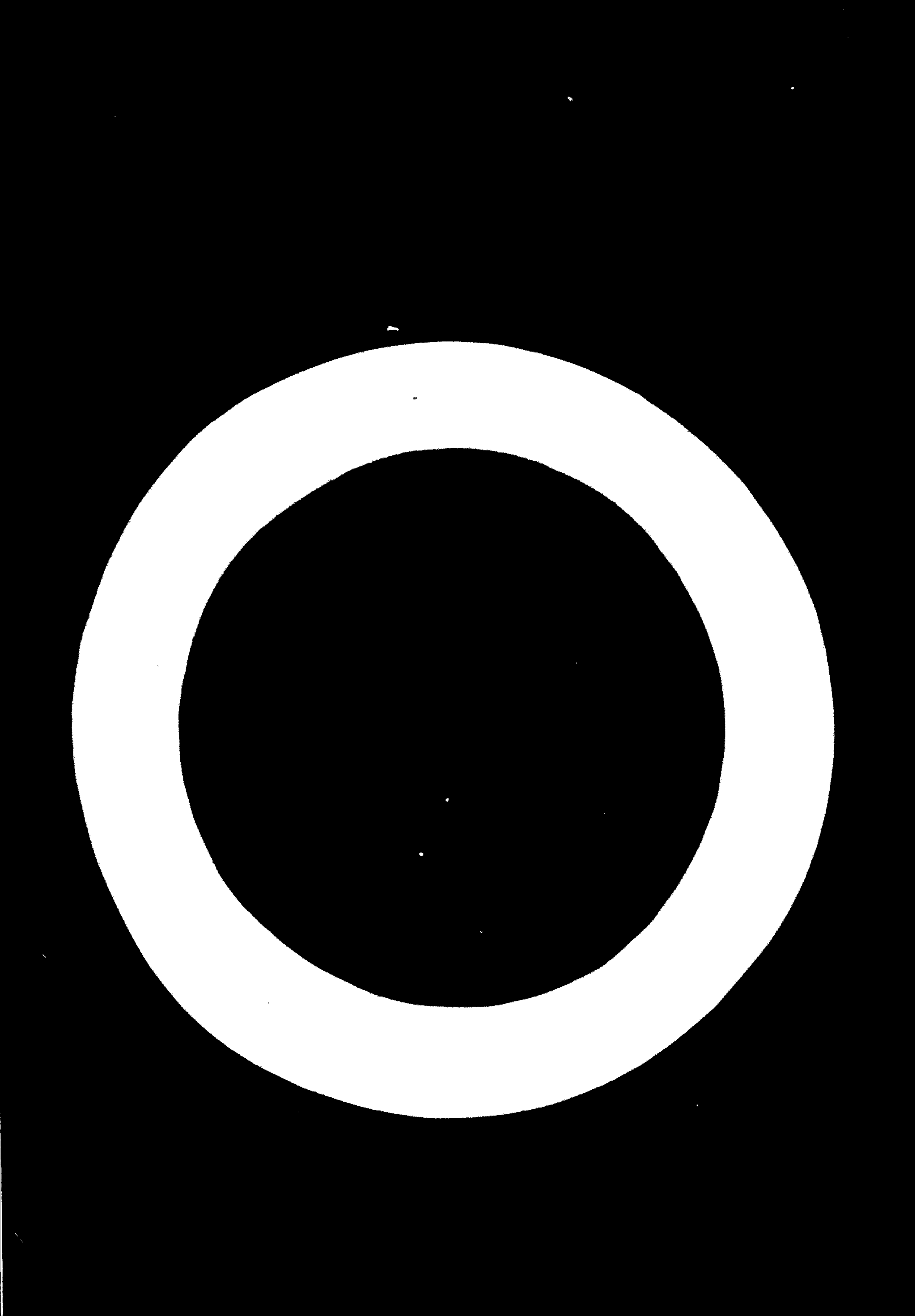


Fig. 6 Relation ship between Fe content and silica Content of the coarse ore (40-80mm)



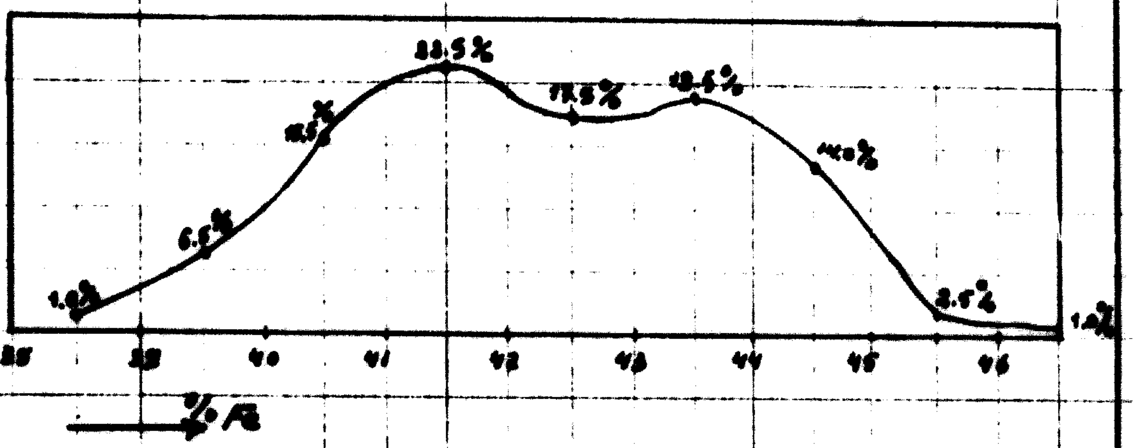


Fig. 7 Variation in Fe content of medium ores (10_40 mm.)

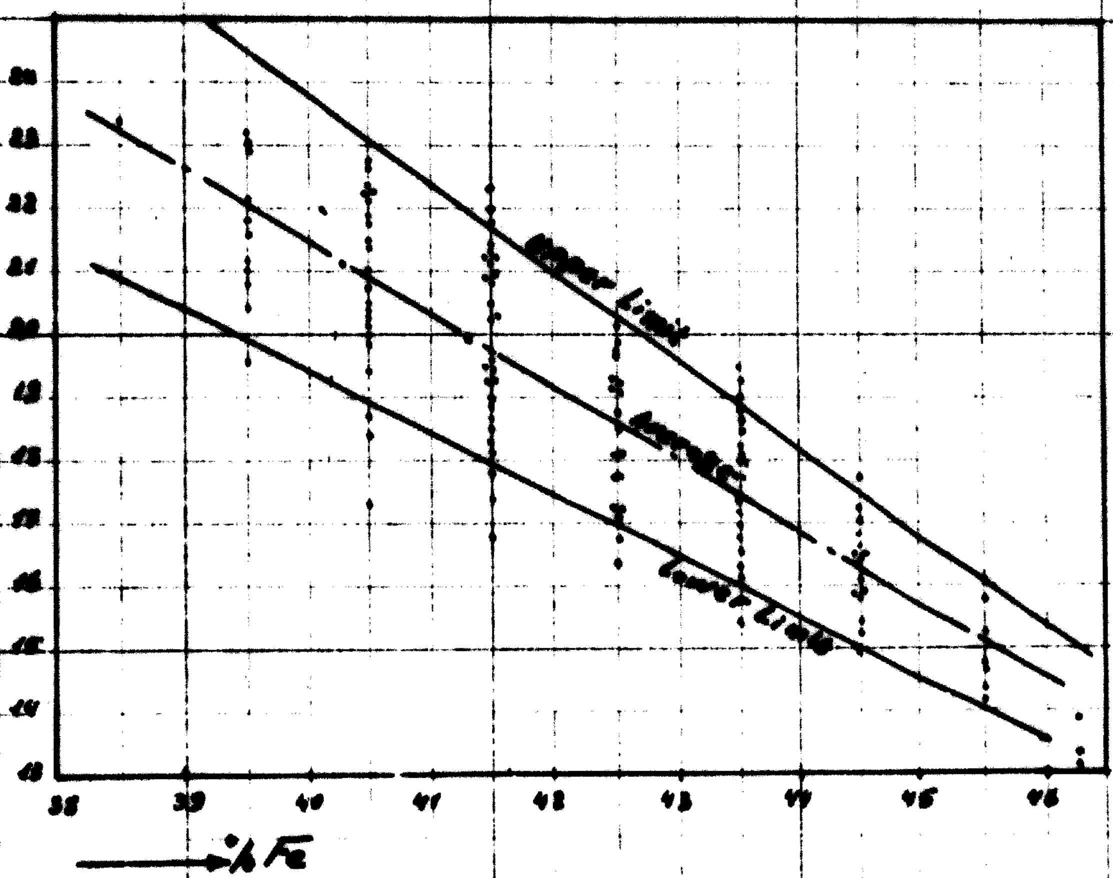


Fig. 8 Relation ship between Fe content and SiO_2 content of the medium ore (10_40 mm.)

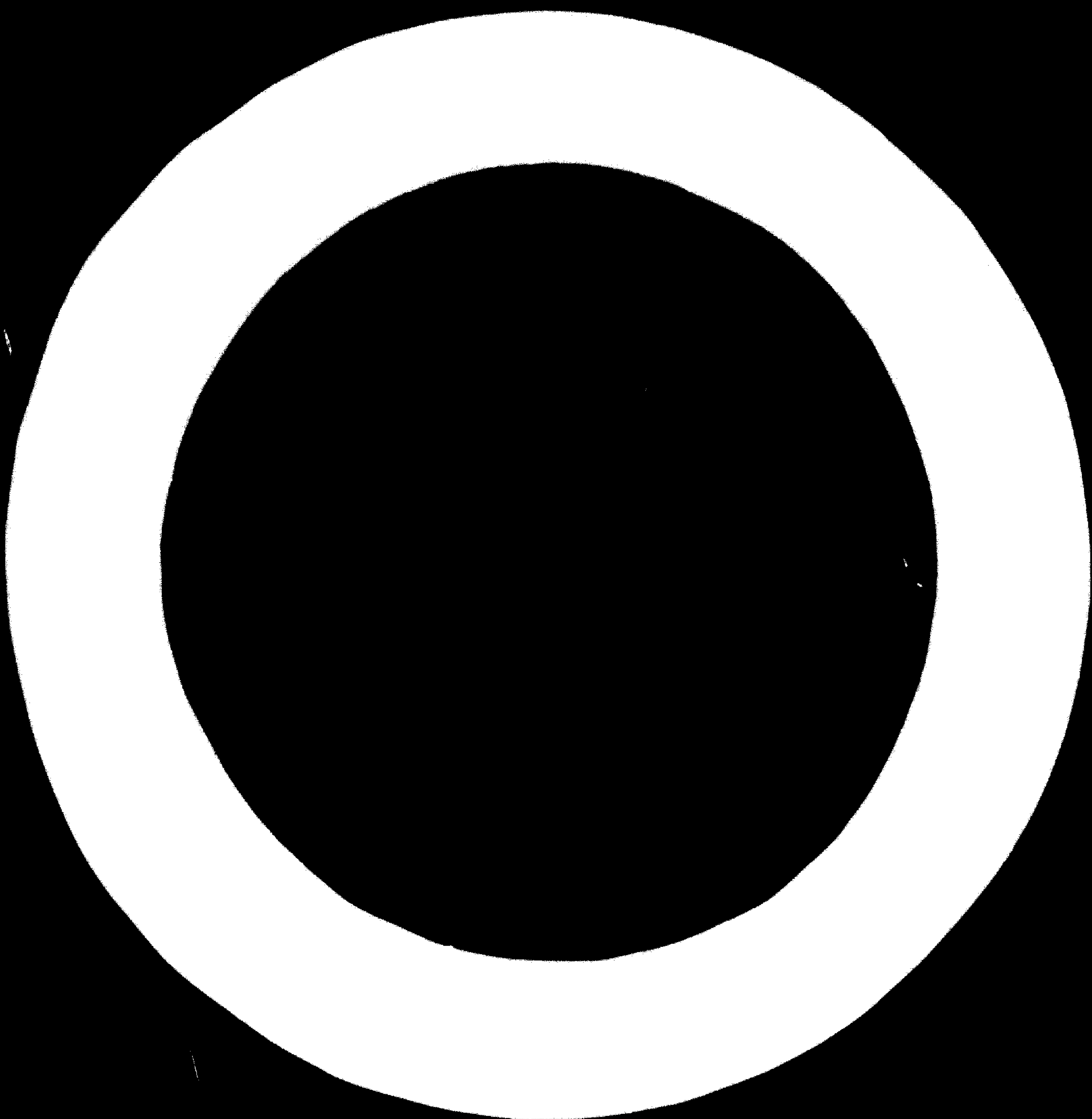
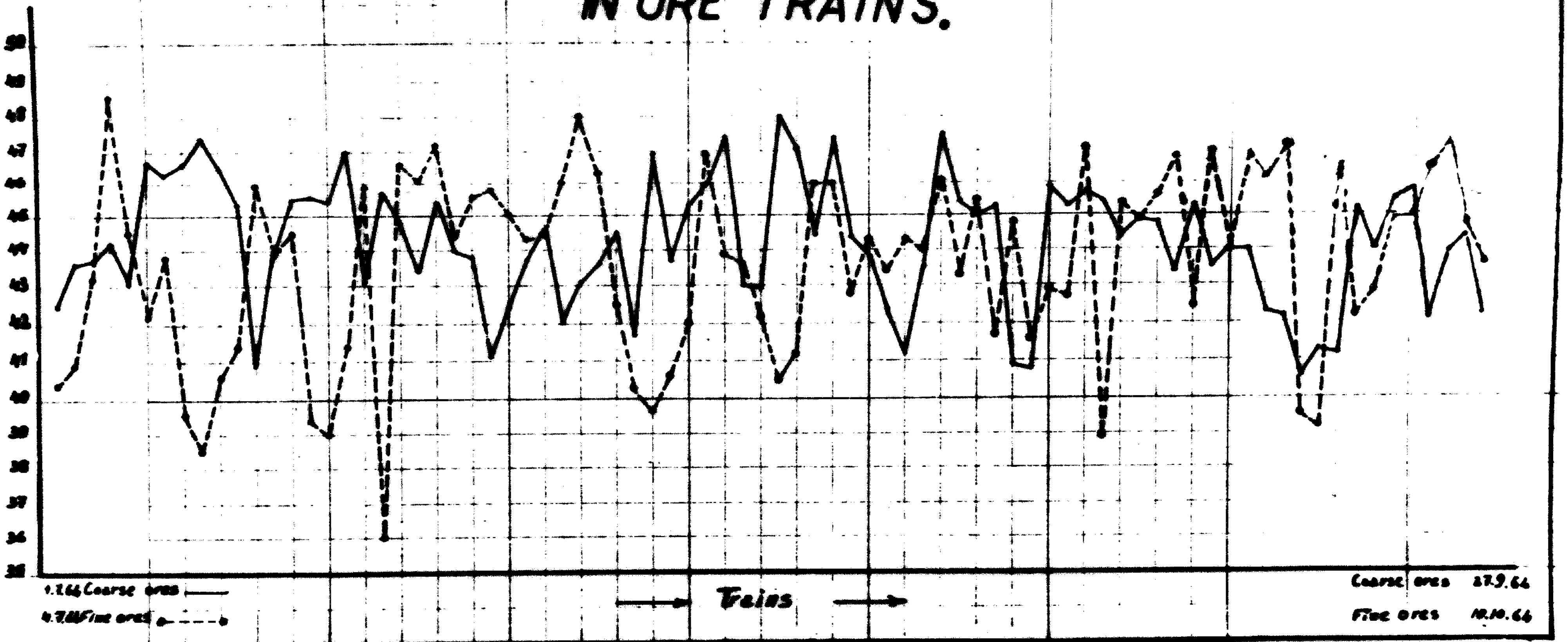


Fig 9 VARIATION OF Fe CONTENT IN ORE TRAINS.



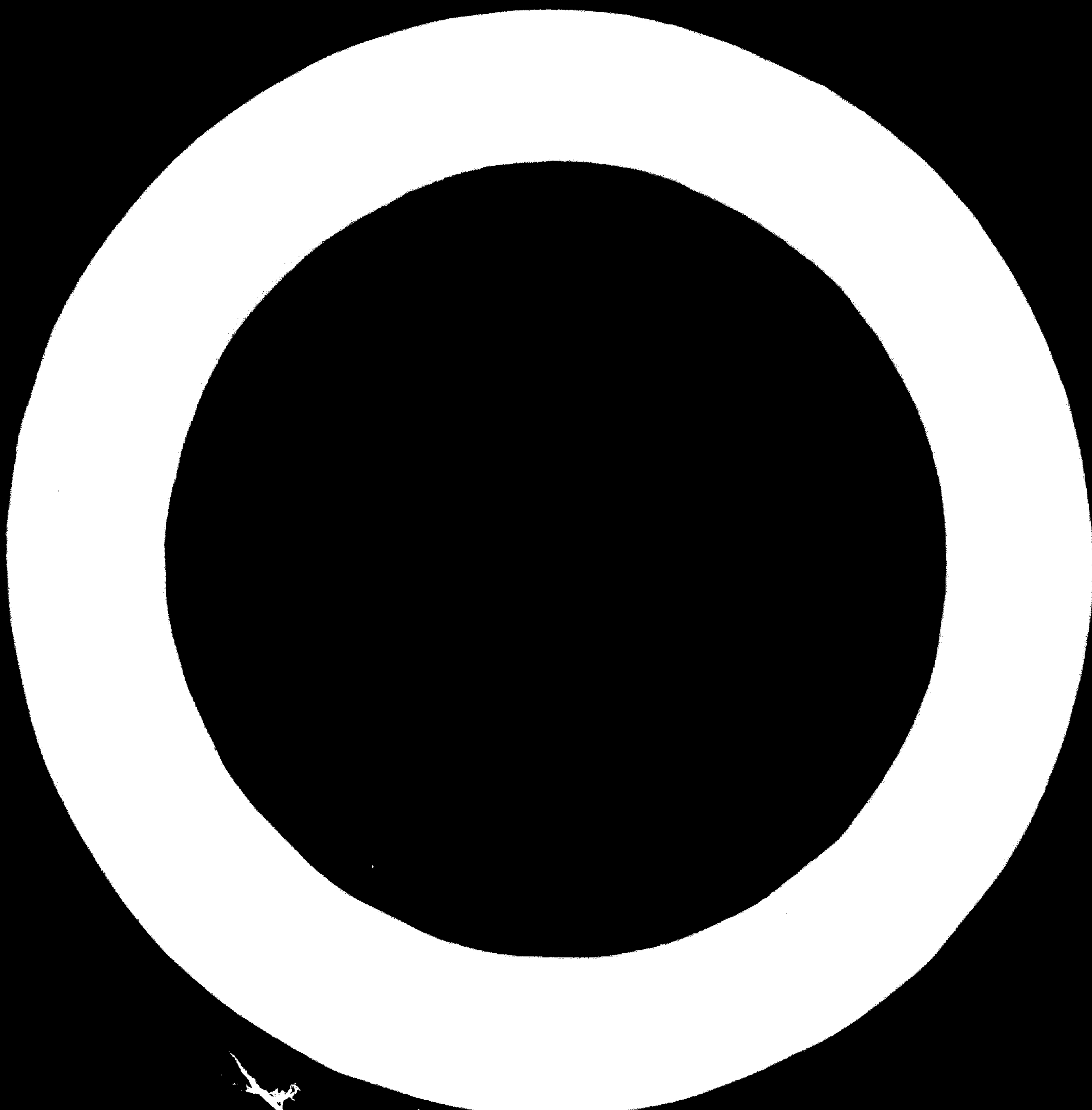
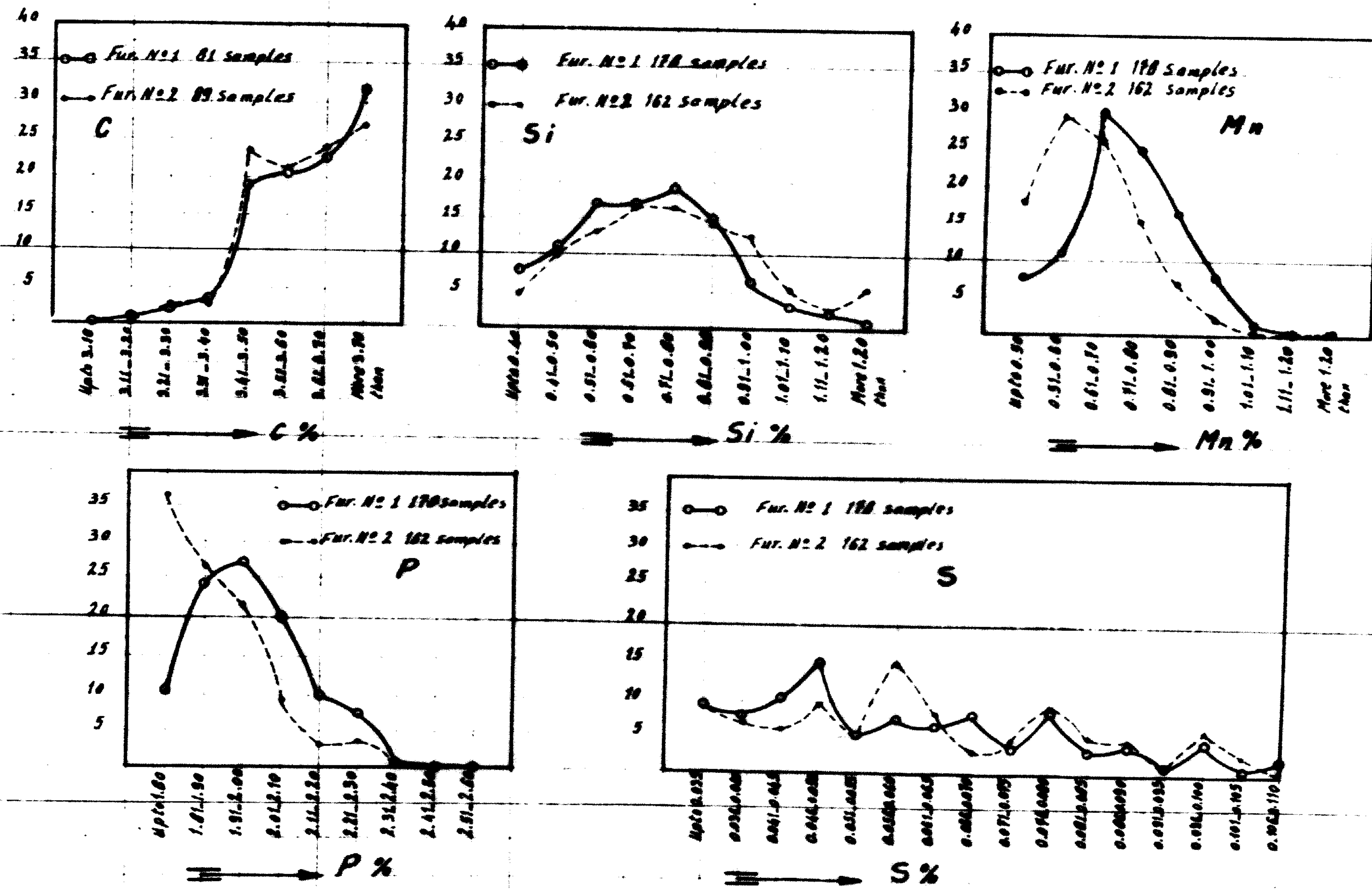
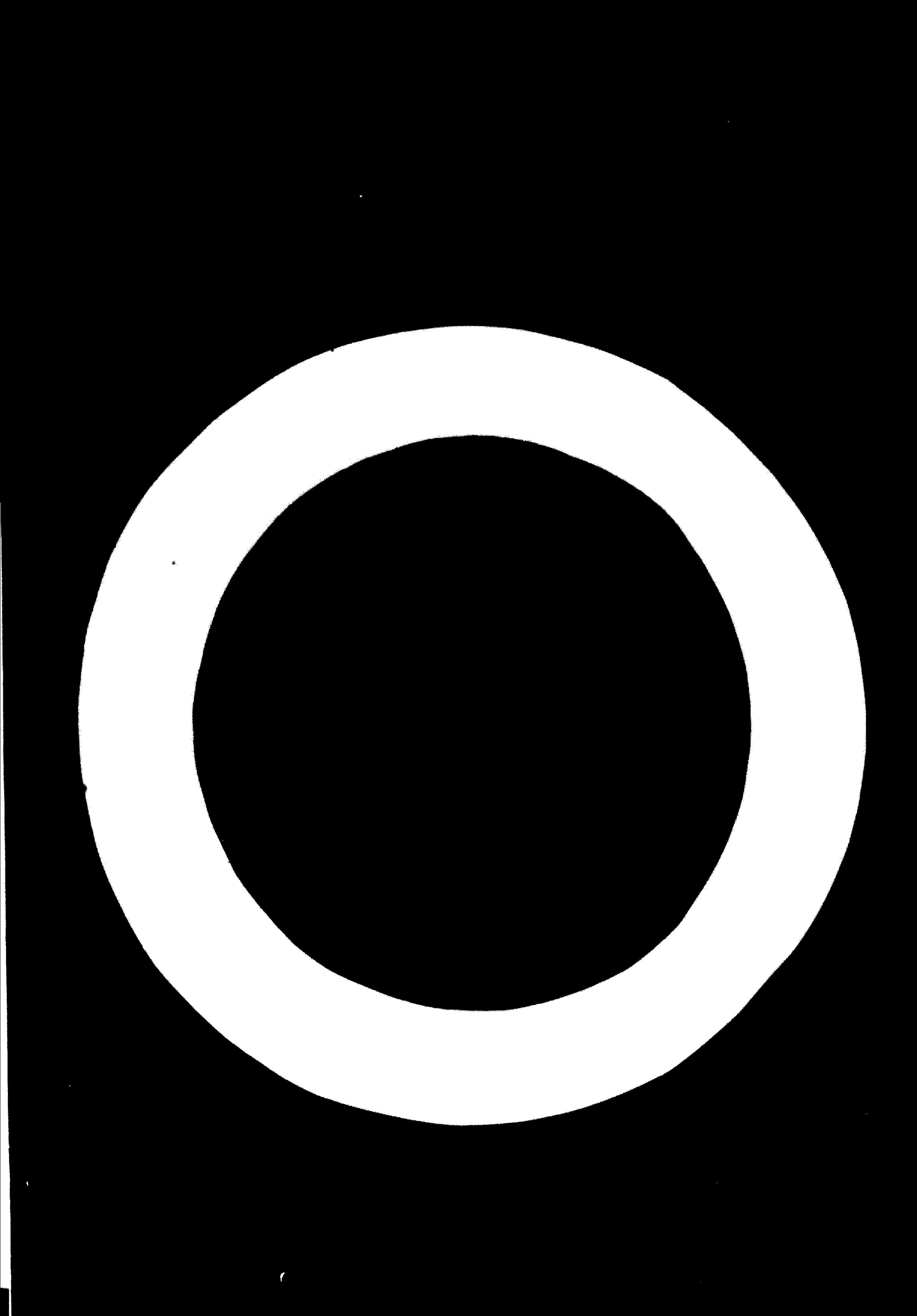


FIG. 10

Analysis Of Pig Iron In Blast Furnaces In March 1965





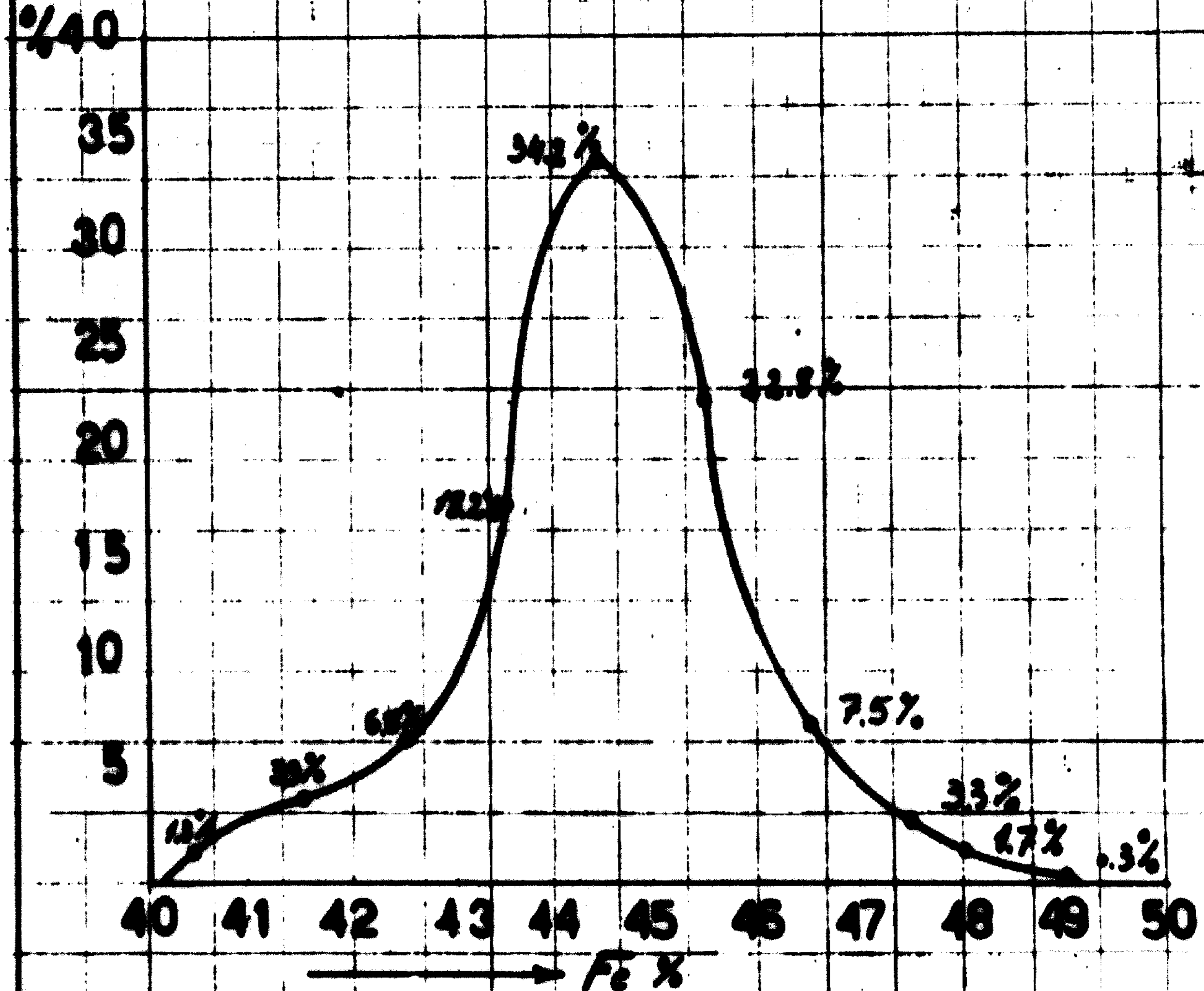


Fig. 11 Frequency of the Fe content of the Aswan One class ore (10-80mm.)

- 307 Samples -

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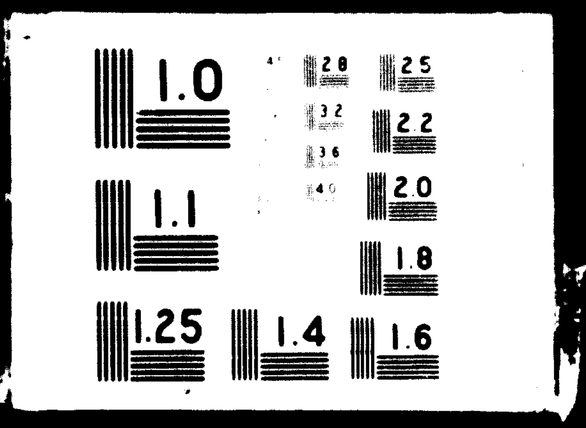
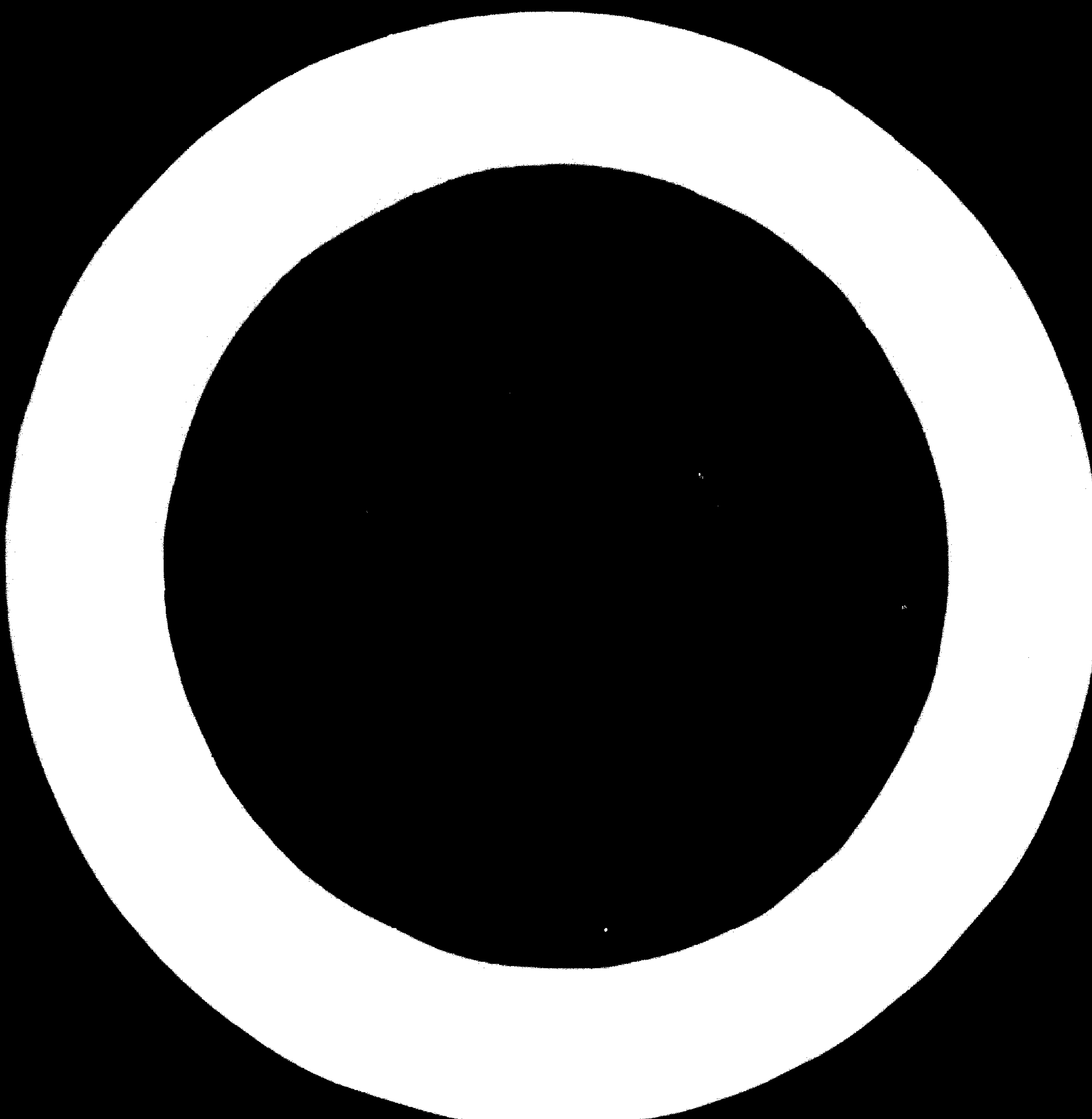




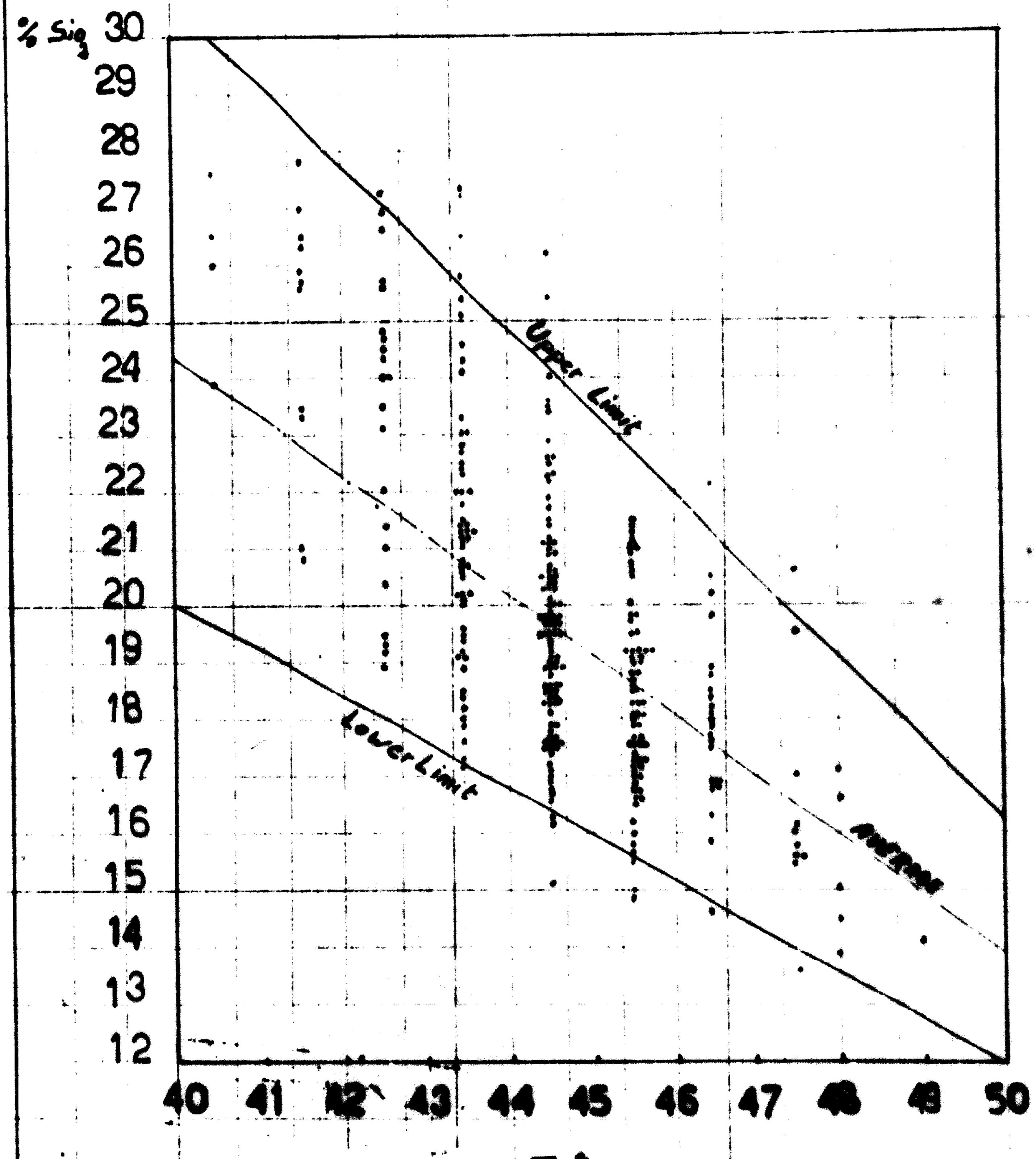
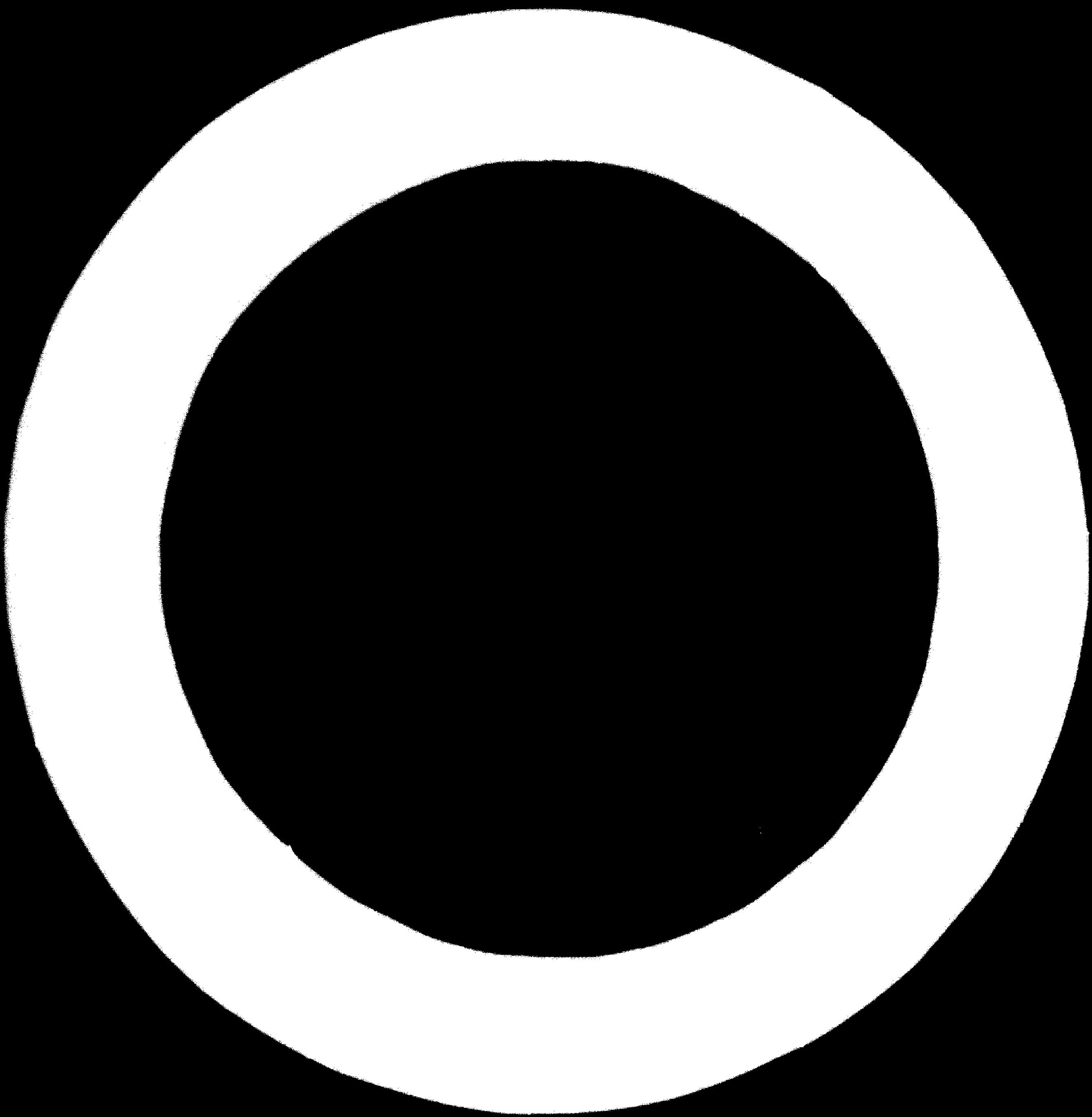


Fig.12 RELATIONSHIP BETWEEN Fe CONTENT AND SiO_2 CONTENT IN THE ONE CLASS ORES (40 - 80 mm)



RELATION BETWEEN THE COKE CONSUMPTION & THE BURDEN OUTPUT

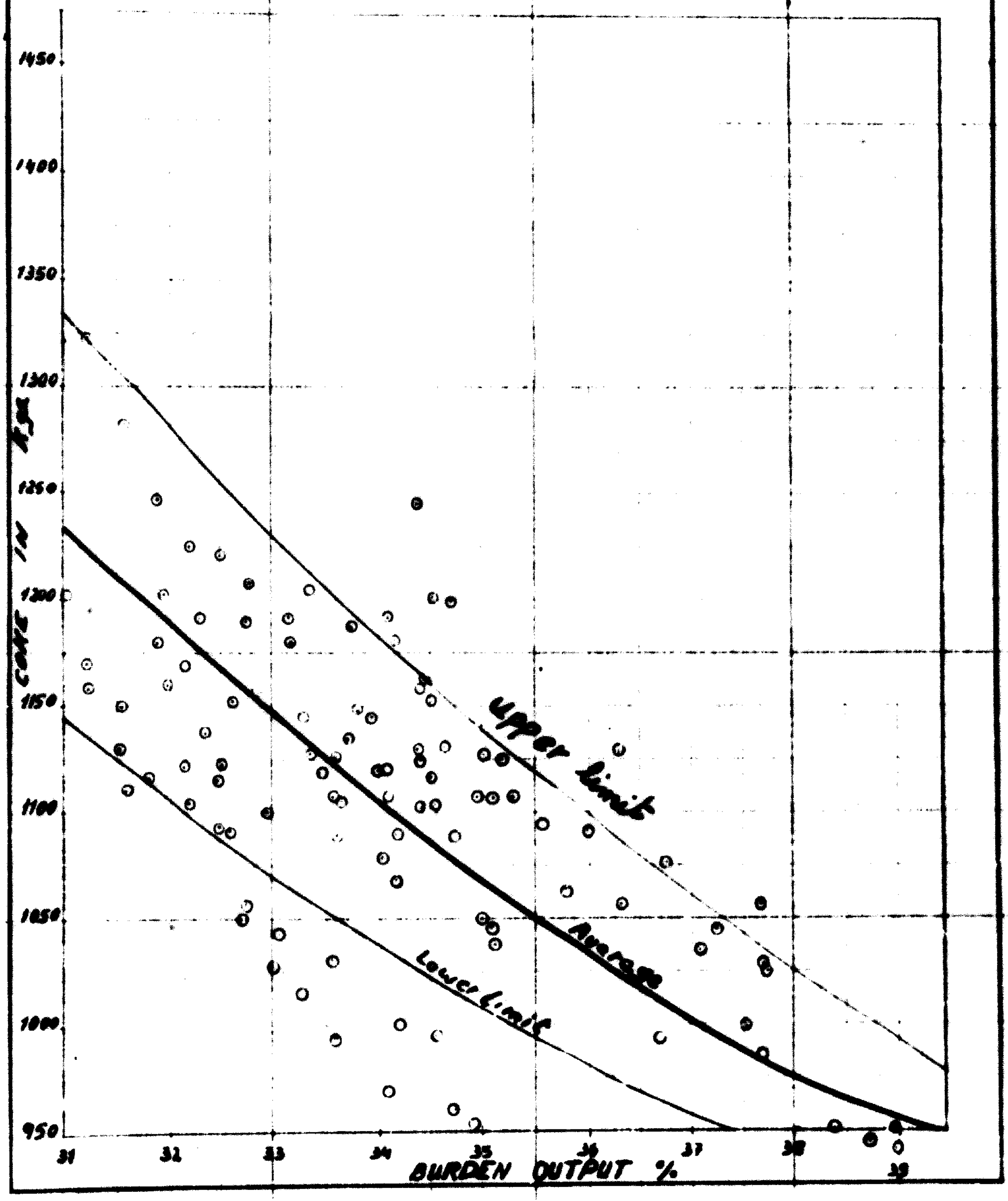
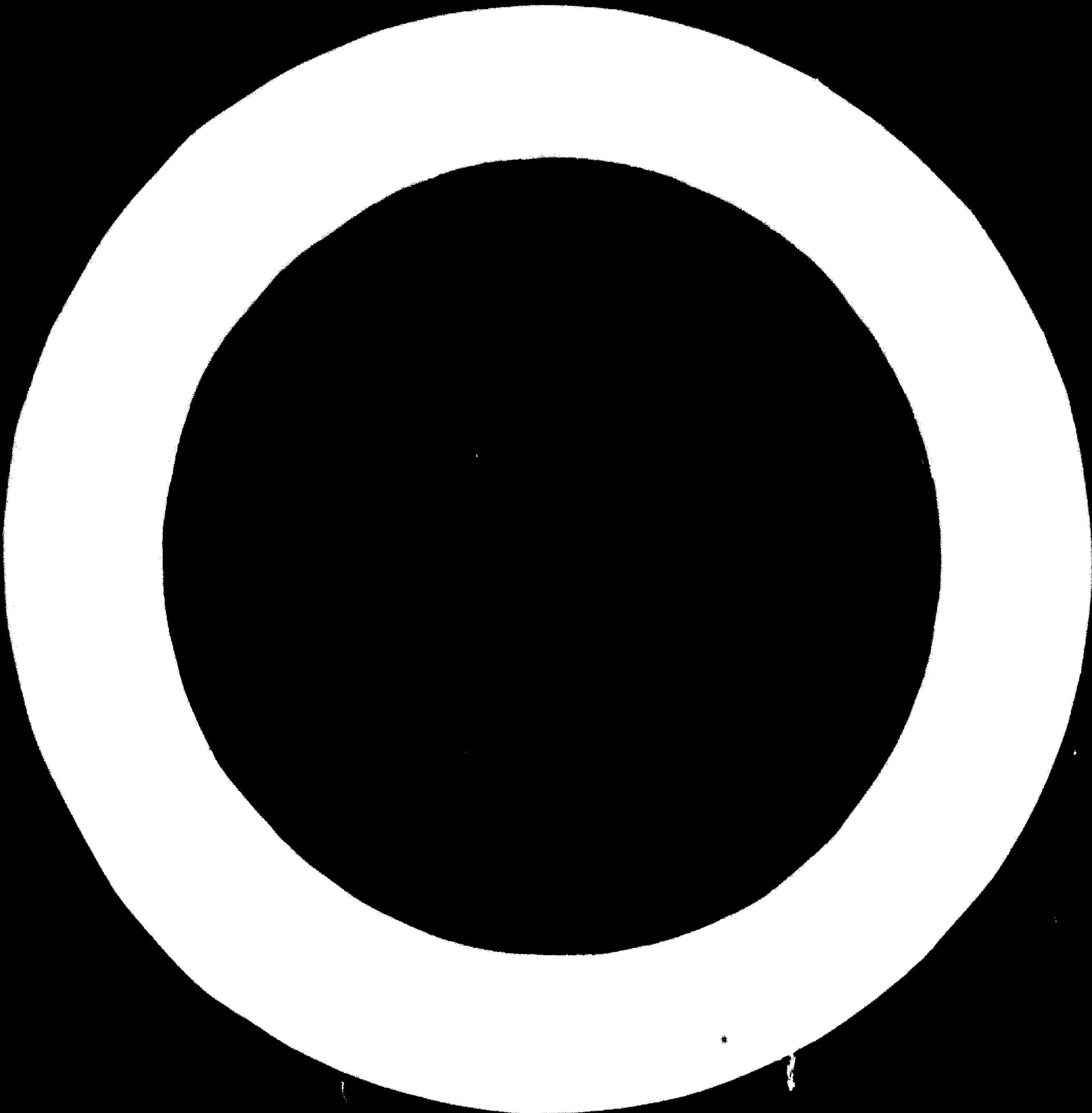


Fig. 23



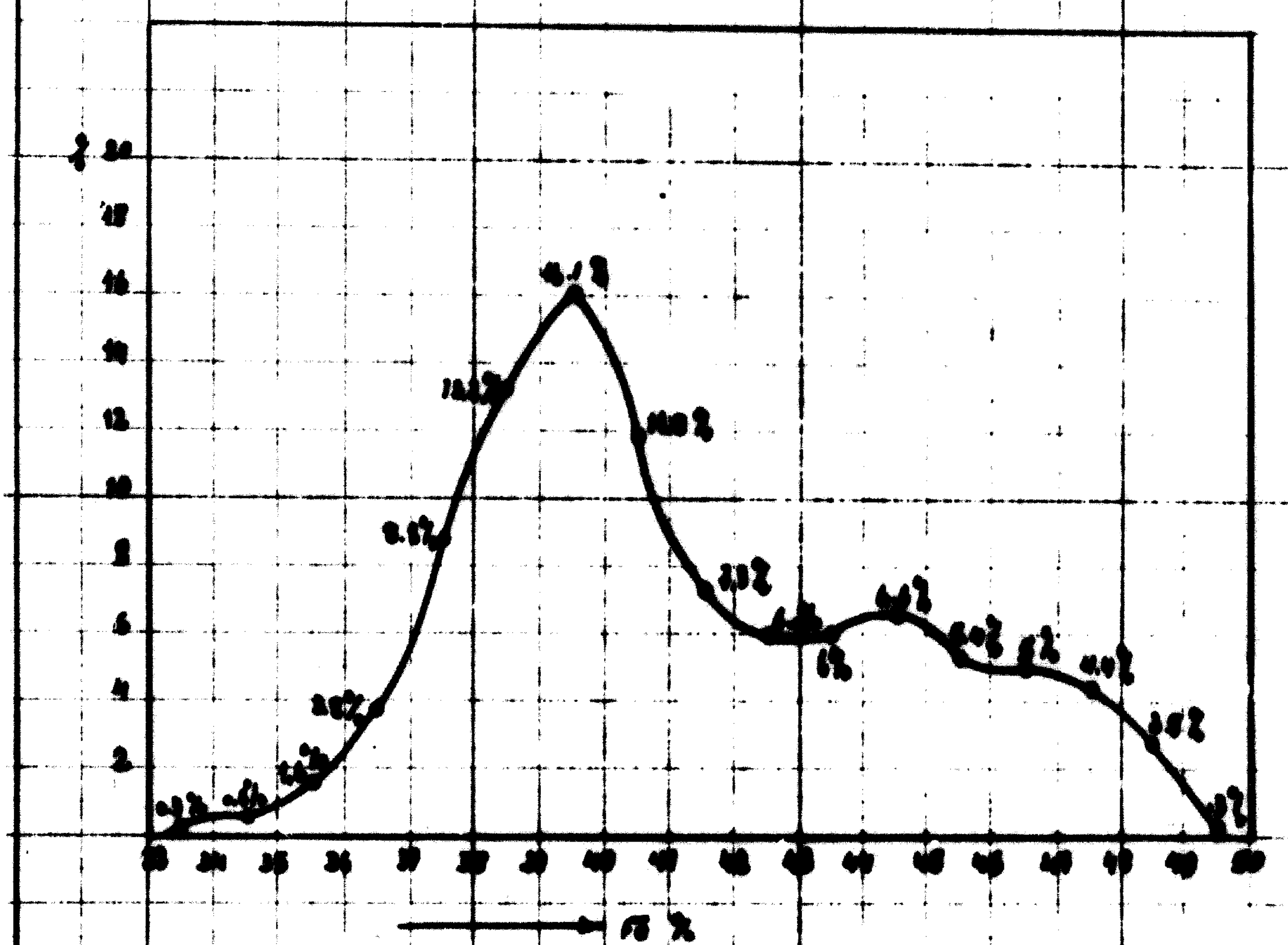
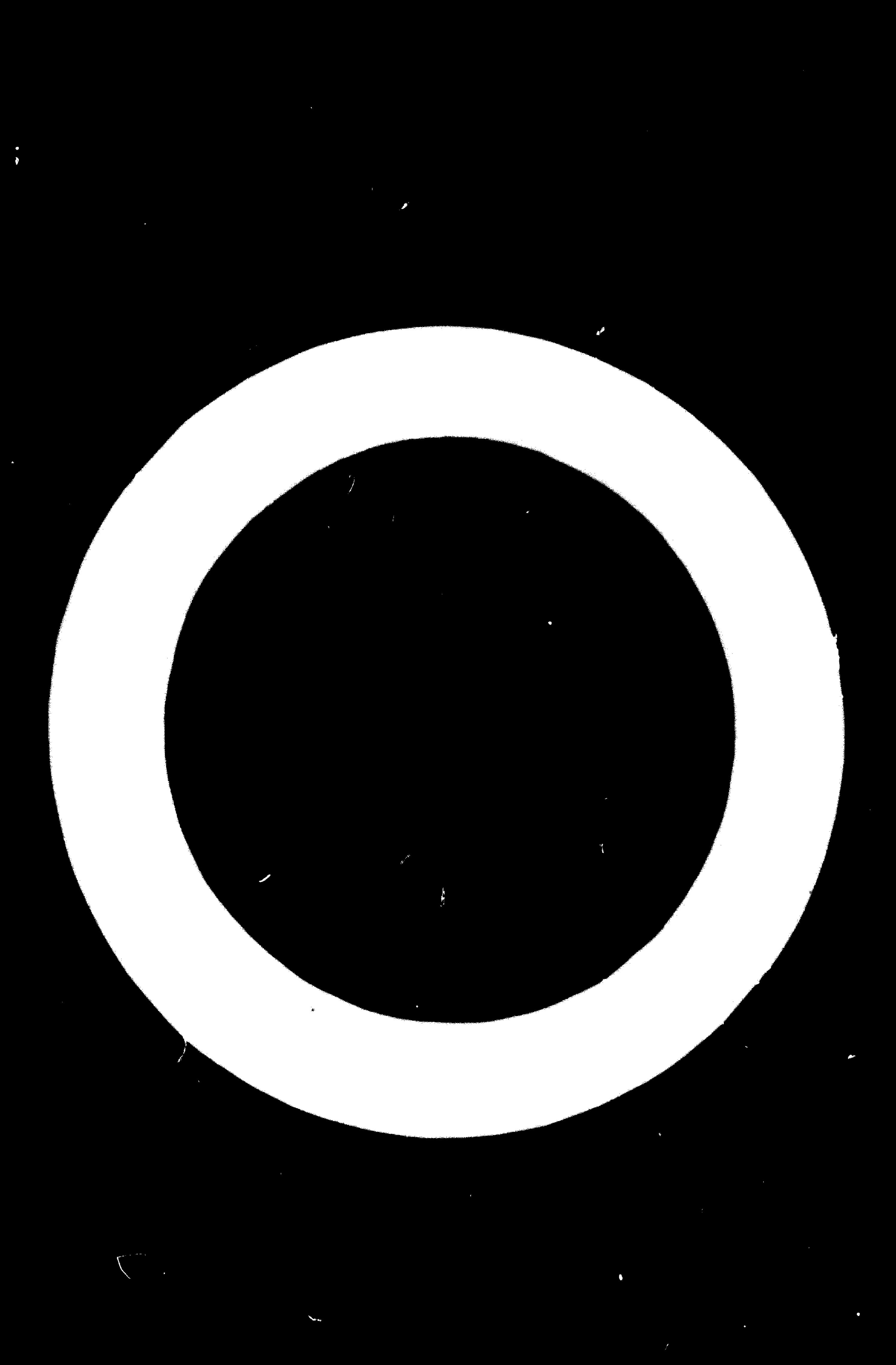
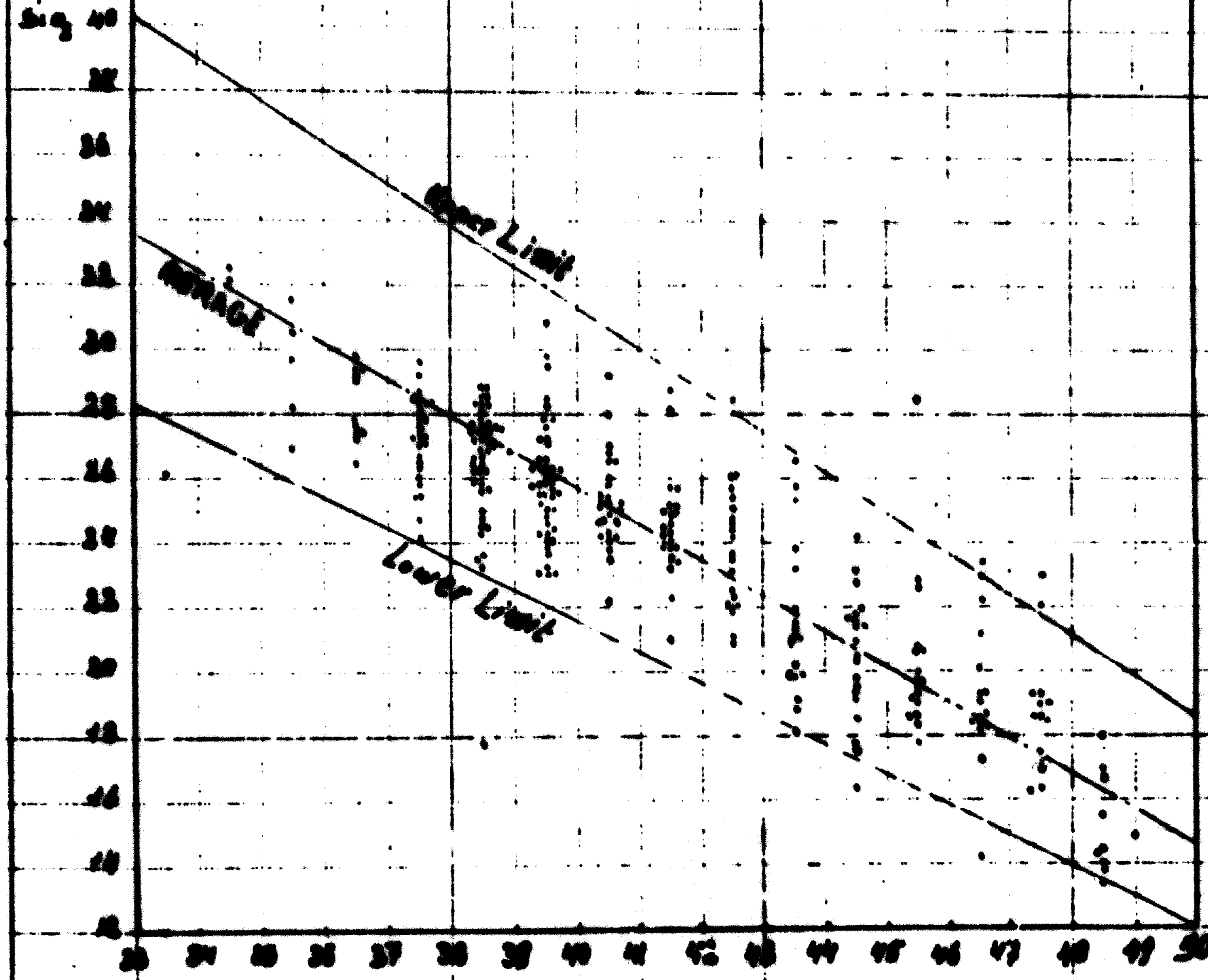


Fig. 14 FREQUENCY OF THE Fe CONTENT OF THE ASSUAN FINE ORES [317 Samples]
(_ 10 mm.) For sintering





Fig(15) AVERAGE OF THE SiO_2 CONTENT IN FINE ORES AND ITS SCATTERING
(– 10mm.) For Sintering

22.3. 74