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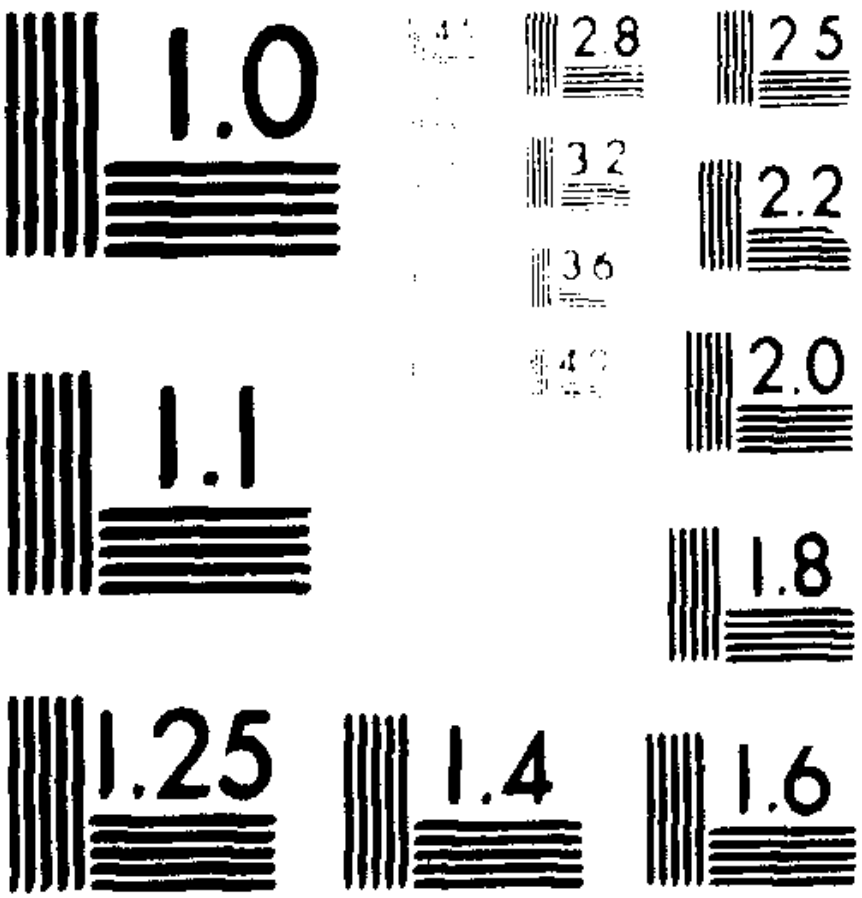

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FINAL REPORT

by chemical-engineer A.B.GENTOSH
and mechanical-engineer K.A.VEJLIVTSEV,
covering Phase II of Contract No. 70/75
between the United Nations Industrial
Development Organization and Technoprom-
export of January 14, 1971.

Mission to Ethiopia:
February 15, 1972 -
May 15, 1972

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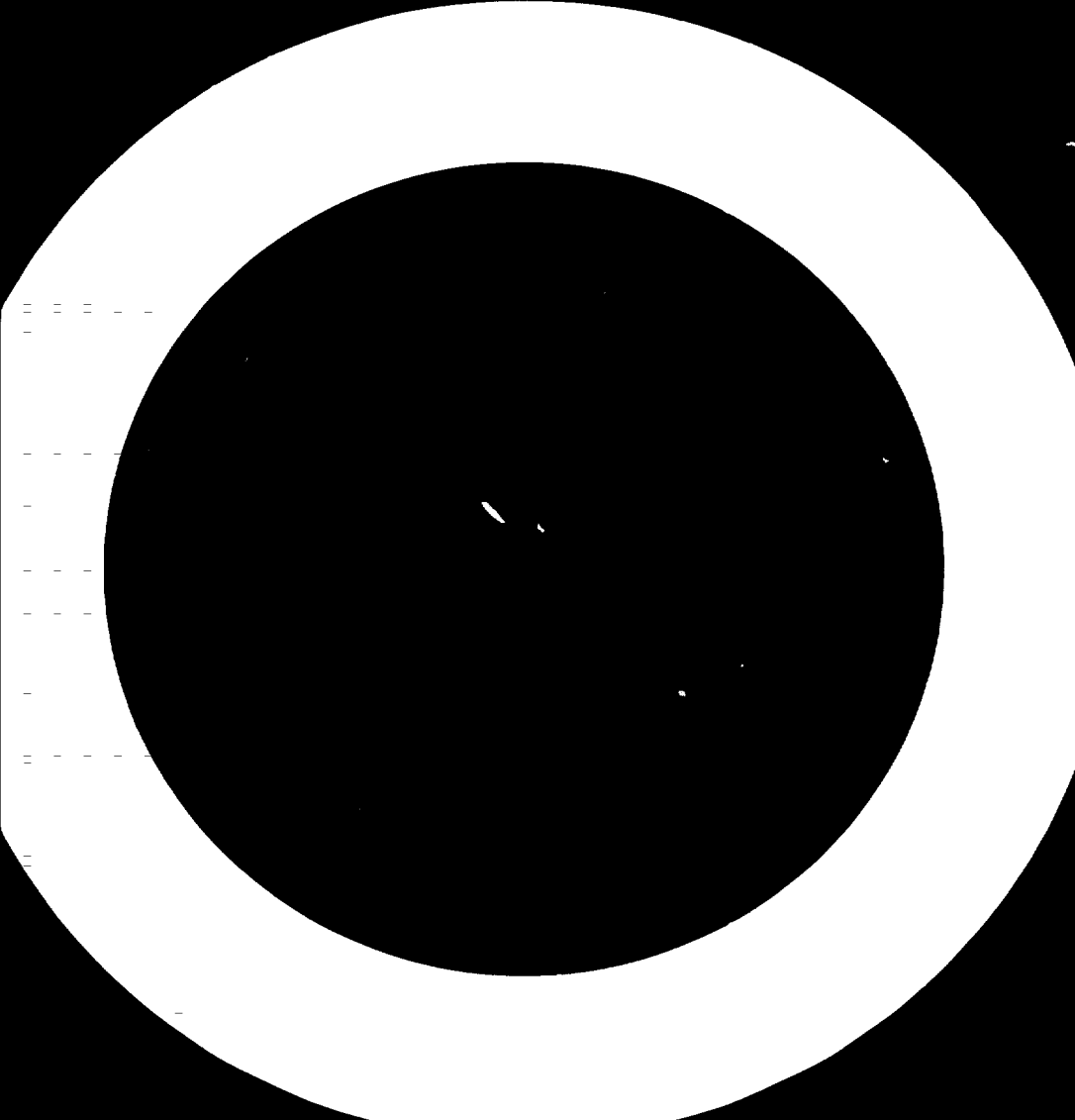

FINAL REPORT

by chemical-engineer A.B.GENTOSH,
covering Phase II of contract
No. 70/75

Technological part

INTRODUCTION

The present report covers the fulfillment of works on Phase II of Contract No.70/75 of January, 1971 concluded between United Nations Industrial Development Organization and Technopromexport with the aim of rendering technical assistance to the Ethiopian Cement Corporation.

Works on Phase II had been carrying out within three months - from February 15 to May 15, 1972.

By the time of Phase II recommendations of UNIDO expert on Phase I have been started to put into practice at the factory - the puzzolanic additive - purmice - was used when cement grinding and the third component (sandstone) was introduced into the mixture.

It was decided to perform works on Phase II only at the cement factory in Addis-Ababa which was caused by the following reasons:

1. short time for the fulfillment of works on Phase II;
2. the cement factory in Addis-Ababa is provided with more modern equipment and thus enables to increase the production of cement to a great extent as the result of the inculcation of new technology

The operation of the clinker and the work of the laboratory being the main weak points at the factory were the subject matter to my special attention. Improving of their work will permit to increase production and improve the quality of the cement produced.

Together with the engineers and technicians of the factory I revised the sampling charts and schedule of chemical analysis and carried out a number of other works described in the report.

Having studied the work of the factory I have proposed some recommendations with the aim of improving technological equipment. The recommendations in question after being discussed with the engineers at the meetings at the presence of General Director of the Ethiopian Cement Corporation have been accepted for implementation.

PART I

I THE WHEREABOUTS OF THE FACTORY

The cement factory is disposed in Addis Ababa. On the flat site of the factory in question there arranged also the production of the asbocement articles and concrete masonry blocks.

The railway and highway access to the factory.

The site is located at 2600 m above the sea level, the coordinates being as follows: 9° of northern latitude, 38° of eastern longitude. Temperate climate, two pronounced seasons: rainy and dry.

II SOURCE OF RAW MATERIALS

LIMESTONE

To the northwest of Addis Ababa in the region of the river Mugher there is a relatively large massif of limestone, nearly horizontally embedded and deeply intersected by the mentioned river. This limestone is partly covered with red sandstone, overlaid by basalt alluvions. Downstream towards the estuary of the river the strata of limestone grow thicker and thicker.

The seam on the left bank of the river Mugher, about 2 km downstream from the estuary of the river Dole into the Mugher, was surveyed in 1960. It is about 73 km from the factory and 17 km from the road connecting Addis Ababa

with Debra Markos.

The deposits have been explored by means of 8 boreholes, thus the depth of the useless overburden as well as the quantity of limestone determined. Some samples were taken for the chemical analysis. The deposits of limestone have been estimated at 2,432 tons. The quarry occupies the site covered with a maximum of 1.5 m overburden.

2. The CLAY QUARRY is disposed along the left bank of the Akaki river at a distance of 26 km from the factory by road. There was no geological survey, and the deposits have not been estimated.

3. GYPSUM AND SANDSTONE

The deposits are located close to the limestone quarry. There was no geological survey of the deposits and therefore they have not been estimated.

4. The PUMICE DEPOSIT is situated at a distance of 100-120 km from the factory in the area of three communities: Motosh-Cocatown and Nazareth. The quarry exploitation is effected by some out organisation which supplies the factory with pumice.

III MINING WORKS

A. LIMESTONE OUTPUT

1. STRIPPING

The stripping of overburden where the limestone layers are covered with humus patches or basalt alluvions is considered

as opening of the quarry. The jobs are executed by means of buldozers, Caterpiller D-8 type, 150 H.P., max stripping depth being 1.5 m.

2. DRILLING & BLASTING

The drilling is done by way of jackhammers with drills of 0.8, 1.6, 2.4, 3.2 and 4 m long. The weight of the hammer is 22 kgs. The majority of drillholes are inclined and up to 4 m deep with 30 mm diameter.

Compressed air, supplied by a stable compressor, is utilized for the jackhammers. The said compressor of EKZ-6 type with the electric drive, electromotor of 45 H.P, has a capacity of 6.2 m^3/min at 7 atm working pressure.

The boreholes are located in one row, the spacing being about 2m between the holes and 0.5 m - between the row and the berm rim. 20-30 boreholes are required for a blow. One blasthole rends approximately 7 m^3 of rock at the explosive (dynamite) consumption of 0.13 kg/t of limestone.

Since the jackhammers do not provide through-the-berm-height drilling (over 12 m) per one drill, the following procedure is applied. A row of blastholes (4 m deep) is blown up. The blasted rock comes down the slope of the working face. Then this area is cleaned manually to prepare space for secondary drilling and blasting and so on untill the footfall is reached.

3. EXCAVATION AND TRANSPORTATION OF LIMESTONE TO THE CRUSHING DEPARTMENT

The broken limestone is loaded on the dump trucks by a shovel excavator, Allis Chalmer type, or a bucket dredger, Duro Dakovic

type, with a bucket capacity of 1.3 m^3, 109 H.P.

Technical data of Allis Chalmer excavator.

1. Manufacturing plant	-	Allis Chalmer
2. Dipper capacity	-	1.3 m^3
3. Electric motor	-	Sever type
4. Motor power	-	80 Kw
5. Number of revol.	-	965 rpm
6. Voltage	-	380 V
7. Dredger weight in work	-	60 t
8. Dredger constructional weight	-	44 t
9. Speed of scoop lifting	-	0.37 m/s
10. Speed of travel	-	1.6 km/h

	30° beam	45 incl in.	60
11. Max scooping range	11.2	10.8	10.1
12. Max scoopin height	5.3	7.3	8.7

The transport of limestone to the crushing department is done by 4 dump trucks (4 m^3 each) with the diesel engine. The crushing department is situated at a distance of 150-200 m from the quarry face. In 1971 the limestone output was 88400 tons, i.e. ab. 380 t/day.

B. GYPSUM OUTPUT

Gypsum is quarried periodically, as required. The exploitation consists in drilling the small horizontally embedded holes by the jackhammers with the following blasting of the blocks. The gypsum is charged into the dump trucks (being used also for

the limestone transportation) by the bucket dredger, Duro Dakovic type. In 1971 the output of gypsum was 4,390 tons.

C.SANDSTONE DEPOSIT

Since the deposit in question just outcrops it is quarried by the dredger, Duro Dakovic type. In December 1971 one batch of sandstone was quarried in the quantity of 166 tons and conveyed to the factory first by the ropeway cars and then by trucks.

D.THE CLAY QUARRY

The quarrying facilities of the above quarry are as follows:

1 - shovel, Chaseside SL-900,shovel capacity being 1 m³
and
1 - buldozer, Caterpillar D-8, 150 H.P.

No blasting is used. The clay is transported from the quarry by trucks and trailers, FIAT 682/43, with a capacity of 23 tons each. The clay is quarried during 3 months (dry period). In 1971 the output of clay was 17,100tons.

IV. CRUSHING OF LIMESTONE AND GYPSUM

The crushing department is located close to the limestone quarry. The blasted limestone is discharged from the dump trucks into the receiving bin armoured with steel plated of 10-15 mm thick. A steel grate plate with the cells of 450x450 mm is provided on the top of the bin. The oversized material that would not come through the grate is crushed manually in addition.

The material from the bin is discharged on to the plate conveyor, 800x6500 mm which transports it further to the hammer crusher, Duro Dakovic type, 2CH-80 with a capacity of 80 t/h. The said crusher is driven by means of two electromotors, 2 AP4-407-6, 40 KW, 960 rpm, through V-belts. The rotor diameter in work is 1500 mm (with hammers), 285 rpm. 6 hammers are mounted on each rotor, spacing between the rotor axles being 1750 mm. Each grate comprises 17 trihedral grate bars.

The material crushed up to the size of less than 30 mm through the rubber conveyor, 500x4000 mm, is transported to the 2 bins with a holding capacity of 200 tons each.

Y. TRANSPORTATION OF LIMESTONE, GYPSUM AND SANDSTONE TO THE FACTORY

The above materials are transported first through the ropeway and then by trucks and trailers.

The crushed limestone or gypsum from the bins is charged into the ropeway cars. The ropeway covers 10000 m with a throughput of 25 t/h and 120 hauling units of 400 kgs each. The ropeway is driven by the electrical motor, 160 KW, 970 rpm through the gear-box and the open gear pair. It takes each car 55 min to cover the distance. At the acceptance station of the ropeway there is an open storage to keep the material in piles with a holding capacity of 6000 tons. The piling is effected when discharging the cars as well as by means of the bucket dredger, Duro Dakovic type, with a bucket of 1.5 m^3. The dredger in question is used also to charge the dump trucks which take the material to the factory being at a distance of 65 km by road.

The transport of the raw materials (limestone, gypsum, sandstone and clay) is done by 12 trucks and trailers, FIAT 682/n3, with a capacity of 22 tons each.

VI. POWER SUPPLY OF THE LIMESTONE QUARRY, CRUSHING DEPARTMENT AND ROPEWAY

The above objects are supplied with the electric energy from the power station located at the crushing department site.
The following diesel-generators are available at the said power station:

2 - diesel engine, BA6M528
generator, DI132-6, 388 KVA, 400 V, 560 a, 50 Hz, 750 rpm, $\cos\varphi = 0.8$

1 - diesel engine, M 6A3
generator, 551 type, 62.5 KVA, 440/240V, 90.2/52a, 1000 rpm, 50Hz, $\cos\varphi = 0.8$

1 - diesel engine, 12L514
generator, SYK 4-713 type, 20KVA, 400/231 V, 29 a, 1500 rpm, 50Hz, $\cos\varphi = 0.8$

The electrical energy is transmitted to the consumers through the transmission lines and cables. The upper station of the ropeway is secured with the power electrical supply through the transmission line (10 Km) from the above mentioned power station. Besides a provision was made of a diesel-generator, SYK 4-713 type, for lighting.

VII. THE MAIN SHOPS AND DEPARTMENTS OF THE FACTORY. STORAGE FOR THE MATERIAL

The General Store, the dimensions being 20x100 m, is foreseen to

keep the raw compononts as woll as clinker and additives. Tho deposit hall is made of the metal structures, the floor of asbocement plates resting on the metal trusses; tho reinforced walls are of 5 m high.

Tho Store is devided into the two parts with the length of 40 and 60 m.
The first part, a holding capacity being 6000 tons, is envisaged for the raw components; the second part with a holding capacity of 10000 tons - for clinker abd additives. Besides, the main stocks of clay and sandstone are kept in the open close to the General Store.

In the open the materials are handled by the bucket dredger, Duro Dakovic type, with a bucket of 1.5 m^3 and by the grab overhead crane - in the Store. Tho technical characterictics of the crane are as follows:

Type	: 5^t x 20 m
Carrying capacity	: 1.75
Bridge span	: 20 m
Crane capac.	: 5 tons
Lifting speed	: 40 m/min
Travelling crab speed	: 60 m/min
Bridge travel speed	: 100 m/min

The mixture ofc clay&sandstone and limestone are conveyed by the grab crane into tho raw mill bins whereas clinker, gypsum and pumice are charged into tho cement mill bins. Tho capacity of the bins is as follows:

Limestone bin	:	120 tons
Clay bin	:	40 tons
Clinker bin	:	100 tons
Gypsum bin	:	30 tons

All the bins are calculated for 8 hour operation of the mills.

Not long ago a provision was made of a small metal bin for pumice to be charged into the cement mill.

GRINDING OF THE RAW MIXTURE

The grinding department of the raw mixture and cement adjoins the General Store of the materials. The two mills with the accessories, one being for the raw components grinding, the other - for the cement grinding, are installed in one and the same premise.

The raw feed is ground in the separator mill with simultaneous drying as per the closed cycle.

Technical characteristics of the raw mixture grinding facilities

RAW MILL

1. type - ball mill with simultaneous drying
2. dimensions - diameter : 2.6 meters
   length : 5.7 meters
3. Nos of chambers - 2
4. Chamber size-1st : 2.2 m
   2nd : 3.5 m
5. Grinding media distribution

Chambers	Grinding media distribution		Weight tons	Filling ratio
1 st	balls	φ 50	2.155	29.2
	"	φ 80	6.570	
	"	φ 60	3.920	
	Total		12.645	
2 nd	balls	φ 50	10.8	25.7
	"	φ 80	10.4	
	Total		21.2	

6. Drive of the mill

A.Main Drive - electromotor, 2 APZhn 1007-6
N=530 KW, n=975 rpm, V=6000 V
gear-box , Av-70-6; N=400, n=975/151 rpm

B.Auxiliary drive- electromotor, 2AS2092-4, N=1480rpm;
N=20 KW, V=220/380 V
gear-box , SMO-92.8a, N=14.7 KW
n=1450 rpm/15.6

C.Open Gear pair with a gear ratio of 7.9

7. Mill rev. speed - 19 rpm

The kiln is charged with the raw components by means of the plate feeders, the technical characteristics thereof being as follows:

Plate feeder for limestone:
plate diameter : 1250
electromotor : 2AZ 185-8, N=2KW, 700 rpm, 220/380 V
Plate feeder for clay:
plate diameter : 800
electromotor : 2AZ150-8, N=1.1 KW, n=690 rpm, 220/380 V

The coarse-grained material is taken by the bucket elevator (with the bucket width 630 mm, height - 19.58 m) driven by the electromotor, N=10 KW, to convey it to the air separator which separates the finely ground ,aterial (the fineness being 10-14 % on 4900 sieve) from the oversized material being returned to the mill for re-grounding.

Air Separator Technical data:

1. Type : SV-14'-90°, Sturtevant
2. Separator dia : 3250 mm
3. Capacity : 60 t/h
4. Separator drive
a) electromotor 2ADZ 467-6 type, N=72 KW, n=980 rpm, U=380 V

b) V-belt and taper closed gear
with the total ration - i=4.86

5. Dimensions : 4.85x4.85x6.39 m
6. Volume : 157 m^3

The oversized material separated in the air separator is taken to the mill by means of a screw conveyor of ϕ 500x6500 mm with the electromotor, N=5 KW, 950 rpm. A provision was made of an aspiration fan, VVS 9.75-383 type, Q=4.9 m^3/sec; head=200 mm WG, with the electromotor, 2AO2357-4G3 type (N=36 KW, n=1470 rpm, U=380 V) for vacuum creation in the mill system.

The aspiring air is cleaned in the bag filter, the technical characteristics being as follows:

1. Type : 6 RF-150-90°L
2. Dimensions : ϕ 2642x3500
3. Total filter area : 180 sq.m
4. Active filter area : 150 sq.m
5. Nos of chambers : 6
6. Nos of bags : 108 pieces
7. Distribution valve rpm : 0.2
8. Capacity : 28000 m^3/h of dust gas
9. Electromotor: N=0.8 KW, n=680 rpm.

The dust precipitated in the bag filter is conveyed through the overflow pipe to the elevator and then to the separator. A cell feeder of ϕ 200 mm with the electromotor N=2,2 KW, 1000 rpm.

The hot gases are supplied to the mill from the firing place to dry the raw materials. This furnace being a stationary double drum of ϕ 1500x4000, the inside surface lined with refractory bricks, is equipped with:

burner : Unitherm, A 100 P type,
output 150 kgs of fuel/hr
control range - 1:2.5

fan : SVB4/SP/180 type,
capacity - 2750 m^3/h
head - 160 mm WC

fan motor : 2 AZ 185-2 type with V-belt
N=4 KW, n=2870 rpm

The control facilities are provided to regulate the combustion process.

THE RAW MIXTURE SILO DEPARTMENT

GROUP A

Raw Mixture Transportation from the Mill to the Homogenisation Silos.

The raw feed from the separator is conveyed to the elevator through the air slide and further to the homogenisation silos through the system of air-slides.

1. Air Slide : B=200mm, L=17 m

2. High pressure fan : HSB 03500 type,
Q=10m^3/min; P=500 mm WC; n=2830 rpm
electromotor, OB 2-29n, n=2830 rpm;
N=2.2 KW, U=220/380 V

3. Bucket Elevator bucket width: B=315 mm, H=17.0 m
electromotor, 2AZ 235-6B5 type,
N=6.8 KW; n=940 rpm; U=380 V
gear-box, FBO 19.5-27.8 type, N=4.7 KW
n= 940/34.6 rpm

4. Three air slides of 3.0, 6.0 and 6.0 m long : B=200 mm

5. 1- HP fan per 3 air slides (the same type as in the above p.2)

GROUP B

Homogenisation silos

Correction and blending of the raw mixture is effected in the silos in question. The silos are of plate steel, welded design, the dimensions being ϕ 6.0x8.5 m, volume 150 tons, nos. - 2. The air plates with the airation system are provided at the silo bottom to supply compressed air. The automatic facilities with the electrical drives throw the supply in and out.

The compressed air is produced by:

1. Blower for active blending, GL 15.1K type — Q=35 m^3/min, P=8000 mm WC, n=1450 rpm
   electromotor, 2AOZ405-4 : N=72 KW, n=1470 rpm, U=380 V, i=129 a

2. Blower for passive blending, GL 14.8 K, Q=16.15 m^3/min — P=6000 mm WC, n=1450 rpm
   electromotor, 2AOZ405-4 : N=45 KW, n=1465 rpm, U=380 V, i=82 a

GROUP C

Transportation of the raw mixture from the homogenisation to the ready meal silos.

From the homogenisation silos the raw mixture through the rotary feeders comes into the air slides and then by means of the elevator

and air slides it is charged into the ready meal silos. The following facilities are available:

1. 3 air slides

   width : B=200
   length : L=4.5, 4.5m 6.5 m

2. 1- HP fan per 3 air slides : HEB 03500 type, Q=10 m^3/min, P=500 mm WC n=2830 rpm

   electromotor : OD2-89n, N=2.2 KW, n=2830 rpm, U=220/380 V

3. Bucket Elevator

   bucket width : B=400 mm
   H=21.5 m

   electromotor : 2AZ237-6S5, N=7 KW n=950 rpm, U=380 V

   gear-box : FDO24, N=7KW n=950/32 rpm, i=29.5

4. Air Slide

   width : B=400 mm
   length : L=12 m

5. HP fan, the same type as in above p.2

GROUP D

Ready Meal Silos

The silos in question are of plate steel, welded design, the dimensions being ϕ 6.5x15.0 m, capacity - 450 tons, Nos.-2. The bottom is equipped with the airation pipes to facilitate discharge of the raw mixture. The compressed air is produced by the blower, GL 13.7 type, Q=8.23 m^3/h, P=3500 mm WC, n=950 rpm. Electromotor, 2AZ265-6, n=955 rpm, N=10 KW, U=380 V, i=23 a

GROUP E

Raw Mixture Supply to the Kiln

The raw mixture through the rotary feeders enters the air slide (B=200, L=7.5) and then through the said air slide further on to the elevator.

One high pressure fan, HER 03500, is provided per 2 air slides, the technical characteristics of the former being as follows:

Q : 10 m^3/min
P : 500 mm WC
n : 2850 rpm

Electromotor

N = 2.2 KW
n = 2850 rpm
U = 220/380 V

GROUP F

Aspiration Facilities

for the homogenisation silos aspiration:

1. Bag Filter

Q = 80 nm^3/min

Nos of chambers 3
Nos of bags 40 (with mechanical knocking thereof)

2. Mean Pressure Fan

Q = 124.8 m^3/min
P = 160 mm WC

electromotor

N = 18 KW
n = 965 rpm
U = 380 V
i = 35 a

for the ready meal silos aspiration:

1. Bag Filter

Q	: 50 nm^3/min
Nos of chambers	: 4
Nos of bags	: 32 (with mechanical knocking thereo

2. Mean Pressure Fan

Type : SVN-6/7P160
Q : 78 m^3/min
P : 160 mm WC

electromotor, 354257-2

N : 15 KW
n : 2890 rpm
U : 380 V
i : 21 a

CLINKER BURNING

Burning of the clinker is effected in the rotary kiln being equipped with the cyclone heat exchangers.

Technical characteristics of the kiln unit facilities:

Dry-process Rotary Kiln (erected in 1964)

1. Manufacturer	-	Messrs. Humboldt
2. Type	-	Rotary kiln with the cyclone heat exchangers
3. Length	-	34 m
4. Diameter of		
-the shell	-	2.6 m
-cold end inlet section	-	1.6 m
5. Inclination	-	4 per cent
6. RPM	-	1.42 full speed 1.0 mean speed 0.47 low speed
7. Drive		
a) Main Drive	-	electromotor VEDN 165L-6 N=36 KW, n=1450 rpm, U=130 v, i=75 a

with a built in gear-box, NAINI/8 type, gear ration being 2.86;

gear-box C-100
N=47 KW
i=51.4

b) Auxiliary Drive : diesel engine, AR3N7-11
N=8 HP
gear-box, RF-725
N=10 KW
i=55.8

c) Open Gear Pair : i=6.38

The kiln housing consists of the steel rings. Thickness of plates is 18.2 and 22 mm, thickness of the under bandage rings - 40 mm and that of the under rim rings - 30 mm.

The kiln rests on two supports, the dimensions of the box section bandages being ϕ 3365/3723x350 mm; 4 carrying rollers of ϕ 1000x350 mm.

2 thrust rollers of ϕ 800x195 are provided on the cold support of the kiln to control and limit the axial travel of the latter.

The kiln is connected with a system of the cyclone heat exchangers by virtue of the admission chamber, a string-lever packing being in between. The admission chamber is connected also to the chimney stack and gas exhauster with a built-in gate.

System of the Cyclone Heat Exchangers

1. Type - Humboldt
2. No of arms - 1
3. No of stages- 4

4. Dimensions:

Stages	Nos of cyclones	Cylindrical part			Cone height mm
		Diameter, mm		height mm	
		external	internal		
IV	1	3400	3020	2550	2675
III	1	3400	3020	2550	2675
II	1	3400	3020	2550	2675
I	2	2060	1810	1970	2560

5. Gas Exhaustor cross section:

Description of the gas exhaustor	Linear dimensions mm	Square sq.m
from kiln to c No4	1220 x 1220	1.49
from c.4 to c. No3	1220 x 1220	1.49
from c.3 to c. No2	1090 x 1220	1.32
from c.2 to c. No1	1095 x 1220	1.34
	ϕ 1150	1.32

Burning of mazout (furnace oil) being used as fuel is effected by means of a burner device.

Burner Device:

Type	:	Ug 1503
Capacity	:	1200 kgs/h
Control range	:	1 : 2.5
Working Pressure	:	20 atm.
Outlet hole ϕ	:	3.8-4.2 mm
Air pipe	:	ϕ 110 mm, vertical design

2 furnace oil heaters are provided for mazout heating.

Furnace Oil Heater:

Type	: OE 6Pe3
Output	: 1500 kgs/h
Pressure	: 25 atm
Electric power consumption	: 65 KW/h
Nos	: 2

The primary air is conveyed into the kiln with a high pressure fan.

High Pressure Fan:

Type	: VVR 8B-540
Output	: 1892 m^3/h
Head	: 560 mm WC
El.motor	: 2H-237-2 type, N=11 KW, n=2890 rpm, U=380 V, i=21 a

The raw feed from the air slide (D=200mm, L=17.0m) enters the elevators which lift it to a height of 43 meters and charge into the bin.

The quantity if material in the bin is maintained constant by means of a valve built in the drain pipe. The surplus material is thrown out into one of the silos. Below the bin there is a cell feeder after which the raw mixture is taken to the weighing feeder. The raw meal is weighed and conveyed through the pipe with the cell feeder to the gas exhauster between the second and first cyclones.

Elevator:

Bucket width	: 315 mm
Height	: 22.65 m
Capacity	: 50 tons/h
Nos	: 2
Electromotor	: 2AZ237-6 type N= 7 KW, n=950 rpm, U=380V, i=17a

Gear-Box:

DN 2025; N=7 KW
i= 25.6
Nos.: 2

Cell Feeder:

Dimensions : ϕ 300 x 600 mm
Drive : motor-gear-box D486x/256W type
N=3 KW; n=690/43 rpm; U=380 V

Place of
installation - under the bin

Weighing Feeder:

Type : Schenk

Output : 20 t/h

Control range : 10 : 1

Cell Feeder:

Dimensions : ϕ 297x500
El.motor : AZ-135-6 type; N=0.6 KW
n=900 rpm; U=220/380 V
Gear-box : DN 1023, N=0.6 KW, n=900/39 rpm
Place of installation : in the pipe after the weighing feeder

Vacuum in the system Cooler-Kiln-Cyclone Heat Exchangers& Electrofilter is created by the two exhaust blowers, one of them being installed after the first stage cyclones, the second - after the electrofilter.

Gas Exhaust Blower:

Type : MPD 85-138
Capacity : 66 000 m^3
Head : 187 mm WC
El.motor : 2ADZ 355-453, N=28 KW; n=1470 rpm, U=380 V
V-belt : gear ration i=1.66

Gas Exhaust Blower: Type HK 85/197 placed after the 1 stage cyclone

Capacity : 60000 m^3/h at t°=350°C
Head : 570 mm WC
El.motor : RDN 316/16-6, N=160, n=1425 rpm with a phase rotor

The kiln flue gases are purified in the electrofilter, H15-5 type, with the degree of purification up to 0.5 g/m^3.

The dust precipitated by the electric filter is taken through the system of screw conveyors to the elevator and on mixing with the raw mixture further on for burning.

Screw Conveyor:

Dimensions : ϕ 250 x 3950 mm
El.motor : 2AZ 155-4 type, N=2.2 Kw, n=1410rpm
Gear-box : DN-1017 VHCA-331 type

Screw Conveyor:

Dimensions : ϕ 250x4500 mm
El.motor : 2AZ 155-4 type
N=2.2 Kw, n=1410 rpm
Gear-box : DN-1017 VHCA-331 type

Screw Conveyor:

Dimensions : ϕ 250 x 16560 mm
El.motor : 2 AZ157-4; N=3 Kw, n=1410 rpm
Gear-box : DN 1224 VHC A-360 type

Prior to being supplied into the electric filter the flue gases are cooled and moistened with water sprayed into the gas exhaustor under high pressure before the cyclones of the first stage. Water consumption - up to 2 m^3/h.

The gases purified in the electric filter are thrown out into the atmosphere through the chimney stack. The stack in question is made of steel, welded design, the inside surface being lined with refractory bricks. The dimensions - ϕ 1500x35.200 mm, the stack inner diameter - 1250 mm.

Fuller Cooler for the Clinker

Type	:	grate plate
Grate plate dimensions	:	width - 1200 mm length- 10250 mm
Grate angle of slope	:	20 per cent
Capacity	:	200÷210 tons/h
Cooler drive	:	electromotor, 2AZ-187-4 N=5.5 KW; n=1430 rpm U=380 V, i=12 a variator-gear-box, MSA4LB3 control range - 1:4 chain drive i = 3.45
Grate bar motion	:	110-115 mm

The clinker is cooled with the air injected under the grate plate by means of a high pressure fan. The air passing through the layer of clinker slowly mooving along the grate plate hets up and therefore is used for fuel burning in the kiln as secondary air. The surplus air is thrown out into the atmosphere through the exhaust pipe.

Fan

Type	:	34080 RW$_3$ III/80
Capacity	:	40000 nm^3/h
Head	:	210 mm wC
El.motor	:	2 ADZ 357-4 type N=36 KW n=1470 rpm V-belt, i=1.56

From the Fuller Cooler the clinker is transported to the deposit hall by the chain conveyor.

Chain Conveyor

Type	:	SKZ 30
Capacity	:	12 tons/h

Width : 300 mm
Length : 38.6 m
Drive : el.motor 3AZ-037
N=11 KW, n=1400 rpm
U=380 V, i=22 a
V-belt, i=3.75
gear-box, i=30
chain drive, i=2.92

Chain Conveyor for the split clinker

Type : SK 15
Width : 150 mm
Length : 10.05 m
Drive : Motor-gear-box , R10 3VD 54-6
N=3 KW
n=900/10 rpm
U=380 V
i=7.3 a
chain drive
i=1.91

Refractory Lining of Rotary Kiln

The Rotary Kiln inside surface is lined with refractory bricks whose properties vary depending upon the conditions. The first row (sometimes even up to 1.0 m from the kiln edge) is lined with Cromox 80 due to the close-to-exit sinter zone. The next 11 m of the kiln body, zones of calcination and cooling, are lined with Basal.

Due to Basal high transfer value there is a shamot layer (Nova 220); 40 mm thick between the shell and Basal. The thickness of the refractory lining together with shamot layer is 220 mm in the calcination zone.

Further on (from p.12.0 to 13;0) the surface is lined with Rubinal, the refractory lining thickness being 200 mm.

Previously the calcination zone at a distance of 19.0 to 26.5 from the kiln edge was lined with shamot; the alumina content being 45-50 per cent.

In January 1971 the area from p. 19.5 to 26.5 m was lined with shamot, Maxial 320, from p.26.5 to 34 m - with shamot Cl III, Al_2O_3 content being 32-35 %.

The magnezite chrome bricks are bound by a special mortar or underlaid with metal sheets; shamot brickwork is done with a brick mortar.

The cyclone heat exchangers (of 4 stages) and the connecting flue gas pipes are lined with the profile shamot, BIIIT and A III H, 125 mm thick.

Vaults of heat exchangers and flue gas pipes are lined with the overhead shamot bricks. There is an insulation layer, 67-70 mm thick, between the refractory brickwork and shells of flue gas pipes as well as heat exchangers.

Walls, vault, pit of the cooler and hot head of the kiln are lined with the profile shamot bricks.

Durability of the refractory lining during the last campaign amounted to 15 months in the high temperature zone and 18-20

months - in the zones with lower temperature.

The refractory ring lifetime is 2-3 months.

The refractory lining in the calcination zone has been in operation for 7 years and that of the rest zones - since putting the kiln into operation.

Rotary Kiln Refractories

Physicochemical Data

Nos	Description	Content of Al_2O_3 per cent	MgO per cent	Refractoriness °C	Melting point °C	Compressive strength kg/cm²	Bulk Density kg/dm³	Porosity %	Thermal shock resis
1.	Cronox 80 bauxite-corundum	80		1375	1550 - 1700	>450	2.30	18	>50
2.	Basal		60-55		1500 - 1600		3.0-3.1	17-21	
3.	Rubinal FZ		80		1550 - 1700	400-600	2.95-3.0	21	
4.	Shamot	45-50				200-300	2.0-2.1	24-26	
5.	Shamot Cl III	32-35				300-400	2.05	21-23	
6.	Shamot, Maxial	39-42		1730	1450	300-400		20-22	
7.	Nova 220 (Lower layer)	39-42		1730	1400	200-300	2.0	21-23	
8.	Shamot A IIIII	32-35			1300	180-220	1.95	25	
9.	Shamot BMT	25-30			1320	180-220	1.95	25	

CEMENT GRINDING

Grinding of cement is effected in a two-chambered separator mill.

Technical characteristics of the facilities to grind cement

Cement Mill:

1. Type : Ball Mill
2. Dimensions : diameter - 2.4 meters
   length - 6.0 meters
3. Nos of chambers: 2
4. Chamber dimensions : 1 st chamber - 2.2 meters
   2 nd chamber - 3.8 meters

5. Grinding Media Filling

Chambers	Grinding media description	Weight tons	Filling ratio %
1 st	balls ϕ 90	2.3	30
	" ϕ 80	3.7	
	" ϕ 60	6.0	
	Total	12.0	
2 nd	balls ϕ 50	11.0	29
	" 40	7.0	
	" 30	3.5	
	Total	21.5	

6. Mill Drive

A. Main Drive

a) electromotor : the same type as that of the raw mill
b) gear-box : Av70-5.15c
N=400 KW
n=975/158.5 rpm

B. Auxiliary Drive

a) electromotor : the same type as that of the raw mill

b) gear-box : SB60-92.3 V
N= 14.7 KW
n= 1450/15.8 rpm

C. Open Gear Pair

gear ratio : 7.6

7. Mill rpm : 20.8

The material is charged into the mill by way of the feeders, the technical characteristics thereof being as follows:

Plate feeder for clinker:

Plate ⌀ : 1250 mm
Plate rpm : 9
el.motor : AZ 157-8, N=1.5 KW, n=690 rpm

Belt weighing feeder for pumice:

Type : Liebhart
el.motor : GG6/12 type
N=0.55 KW, n=1500 rpm
gear-box : G112/27.54 , N=0.58 KW, n=1400/51 rpm
chain drive with a gear ratio being 3.56

Belt weighing feeder for gypsum:

Type : Liebhart
el.motor : the same type as above
gear-box : G112/31.13 type
N=0.58 KW
n=1400/45 rpm
2 chain drives with a total gear ratio i=30.91

The crushed material is charged into the elevator with a

bucket width of 500 mm, height 19.3 m driven by way of the electromotor, N=10 KW. From the elevator the material is conveyed to the separator with the technical characteristics being analogous to those of the raw mill separator.

The separated oversized material through the screw conveyor, ø 500x6500, is returned to the mill to be re-ground.

The mill unit aspiration is effected by means of the fan, SVS-12 type, capacity Q=6.4 m^3/sec, head-160 mmWC, with the electromotor, 2AZ 357-6 type, N=28 KW, n=975 rpm.

The aspirating air is purified in the bag filter (the same type as that of the raw mill).

SILOS FOR CEMENT

Group A

Cement transportation from the mill to cement silos

From the separator cement through the air-slide is conveyed to the elevator and further on distributed between the silos by means of the air-slides system.

1. Air-slide : B=200; L=21.5 m
2. High pressure fan : MEB 04300 type
   Q=16 m^3/min
   P=500 mm WC, n=2860 rpm
   el.motor : OD 2-375n
   N=3.0 KW
   n=2860 rpm
   U=380 V
3. Elevator
   bucket width : B=315
   H=24.5
   el.motor : 2AZ235-6B5
   N=6,3 KW
   n=970 rpm
   U=380 V

gear-box : FPO 19.5-27.8
N=4.7 KW
n=940/34.6 rpm

4. 4 air-slides : B=200
L=15.0, 15.0, 5.5, 5.5 m

5. 1-HP fan per 4 air-slides, the same type as in p.2

Group B

Silos for cement:

The silos in question are made from plate steel, welded design.

Dimensions : ø 7.0x15.0 m
Capacity : 750 tons each
Nos : 6

In order to provide discharging of cement the silo botton is equipped with the air pipes for the compressed air supply.

Two blowers are available to produce the compressed air:

Type : GL 13.7
Q=13.7 m^3/min
P=5000 mm WC
n=1450 rpm
el.motor : 2A3267-4 type
N=19.8 KW
n=1455 rpm
U=380 V
i=40 a

Aspiration of the silos is effected by way of the two exhaust pipes with prior purification of dusty air.

Group C

Transportation of cement to the Packing Plant

After the silos cement through the side pneumatic discharge devices is transported to the screw conveyor which takes it

to the elevator and further on to the packing machine bin.

Screw conveyor	-	ϕ 500x29.300 mm Nos; 2
electromotor	-	2AZ 267-6B5 type N=12.5 KW U=380 V n=960 rpm il29a
gear-box	-	FBO 27-17.9 type n=960/54 rpm

CEMENT PACKING

As a rule cement is delivered in bags, one bag weight with cement being 50 kgs.

Packing of cement is effected by means of one semi-automatic four-sprout machine, Euro Dakovic type, with a capacity of 50 tons/h. Packed cement by a system of belt conveyors is taken to the places of loading the trucks, wagons ot transported to the covered store for the tared cement. The most part of cement is delivered by trucks.

Belt Conveyor

1 st	Belt width	:	B=650 mm
	length	:	L=7000 mm
electromotor		:	2AZ 185-6 N=2,5 KW n=930 rpm
gear-box		:	DN 1224 type N=2.5 KW n=930/25 rpm
2 nd	Belt width	:	B=650 mm
	length	:	L=35500 mm
Driving drum with a built in motor-gear-box		:	DT 546/10A type N=3.7 KW

Charging of cement into the packing machine bin is effected by the elevator whereupon cement is taken to the vibration screen and then to the bin of 8 m^3.

Elevator

bucket width	B = 500 mm
height	H = 15.650 mm
el.motor	2AZ 237-6
	N=7 KW, n=950 rpm
gear-box	DN 3034, N=7 KW, n=950/28 rpm

Aspiration of the system is made by means of a fan.

Fan SVS 8P180
Q=11600 m^3/h
H=180 mm WC
n=1450 rpm

el.motor 2AZ 265-4
N=14.8 KW
n=1450 rpm

The aspirating air is cleaned in a bag filter.

Bag Filter

Capacity	: 10000 m^3/h
Nos of chambers	: 5
Nos of bags	: 40 with the mechanical knocking thereof

Cement spilt during packing is collected to the bin under the packing machine from which it is returned to the elevator through the screw conveyors, ⌀ 250 , L=4.0, 7.5 m.

The dust precipitated in the bag filter is taken to the elevator as well.

Bulk cement is loaded on trucks through the air-slide.

VIII ELECTRICAL SUPPLY OF THE FACTORY

The electrical energy is supplied by the EEL & PA (Ethiopian Electric Light & Power Authority) with the voltage of 15,000 V.

For the electrical energy transformation and distribution a provision is made of a transformer sub-station with the following transformers:

1. Three-phase power oil transformer with the output of 630 KVA, transformation ratio being 15,000±4%/6,300 V — pcs 2

2. Three-phase power oil transformer of 1000 KVa, transformation ratio 15,000±4%/400/231 V — pcs 2

3. Three-phase oil transformer output of 250 KVA, transformation ratio 15,000±4%/400/231V — pcs 1

The main motors of the cement and raw mills are supplied with the energy from the transformers of 630 KVA mentioned in item 1 above; the rest motors (380 V) - from the transformer of 1000 KVA in item 2 (one of the transformers is stand-by).

Factory lightning (one-phase, 220 V) is effected from the transformer of 250 KVA, mentioned in item 3.

The total output of the transformer sub-station is 3510 KVA, $\cos\varphi = 0.8$.

The condenser batteries (N=50kVar, 380 V, Nos;-10) serve for the power factor raising.

IX. MAZOUT SUPPLY

Two gear pumps, Z-30 type, Q=205 l/min, P=6kg/cm^2, are provided at the factory to discharge mazout from cisterns and pump it into the tank; the electromotor 2AZ 237-6, N=7 KW, n=960 rpm, U=380 V, i=17a being a drive of the pumps.

The required stock of mazout is kept in the metal tank of 600 m^3. Supply of mazout into the kiln and raw mill burner device is effected by means of the pumps, DKI75 type, Q=60 l/min, P=25 kg/cm^2, Nos:-2. The pump electrical motor, 2AZ 187-4 type, N=5.5 KW, n=1420 rpm, U=380 V, i=12 a.

PART II

I. OPERATION OF THE MAIN TECHNOLOGICAL EQUIPMENT OF THE FACTORY.

The main indices of operation of the Rotary kiln, raw and cement mills are given in Tables 1,2 and 3.

Table 1

Year	Month	Clinker output t	Kiln capacity t/h	Calendar hours	Working hours	Stand-still hours	Usage factor %	Heat specific consumption Kcal/kg	Energy specific consump KWH/t
70	Jan.	4942	9.9	744	484	260	65	1040	17.6
	Feb.	4437	9.9	672	443	229	66	1030	17.7
	Mar.	6537	9.3	744	685	59	92	1045	17.6
	Apr.	6107	9.8	720	620	100	86	1060	17.6
	May	6875	9.7	744	703	36	95	1091	19.5
	Jun.	4723	9.5	720	500	220	70	1063	21.4
	Jul.	7207	10.0	744	720	24	97	1030	21.2
	Aug.	6915	10.0	744	692	52	96	1049	21.3
	Sep.	5729	9.7	720	582	138	81	1047	22.3
	Oct.	6983	10.0	744	695	49	93	988	20.9
	Nov.	6132	9.9	720	617	103	86	1022	22.1
	Dec.	3653	5.7	744	641	103	86	1580	37.2
PER YEAR		70240	9.5	8760	7387	1373	84.3	1072	20.7
1971	Jan.	6570	9.8	744	691	53	93	995	22.5
	Feb.	5200	8.8	672	590	82	88	1130	24.2
	Mar.	5000	9.4	744	531	213	71	1265	22.4
	Apr.	5333	8.3	720	641	79	89	1141	25.4
	May	6516	9.2	744	710	34	95	1082	22.2
	Jun.	6016	9;0	720	666	54	93	1118	23.0
	Jul.	6098	9.2	744	665	79	89	1088	23.0
	Aug.	3117	7.7	744	405	339	54	1262	28.6
	Sep.	5335	8.5	720	628	92	87	1240	23.8
	Oct.	6307	9.2	744	688	56	92	1004	21.6
	Nov.	6007	9.3	720	643	77	89	1050	21.5
	Dec.	6110	9.5	744	641	103	86	1040	21.4
PER YEAR		67794	9.0	8760	7499	1261	85.5	1105	23.0

TABLE No. 3

Operation of the Cement Mill

Year	Month	Cement produced t	Mill capacity t/h	Calendar hours	Working hours	Stand still hours	Usage factor %	Energy specific consumption KWH/t
1970	Jan.	7539	11.8	744	634	110	85	42.8
	Feb.	7082	11.9	672	595	77	88	40.8
	Mar.	7620	10.7	744	713	31	96	42.8
	Apr.	7405	11.0	720	672	48	93	40.5
	May	8292	12.2	744	682	62	92	39.9
	Jun.	9363	18.9	720	493	227	68	26.6
	Jul.	5309	9.1	744	532	162	72	53.9
	Aug.	4409	9.7	744	452	292	61	51.1
	Sep.	5634	10.7	720	523	197	73	45.7
	Oct.	6811	14.3	744	475	269	64	35.3
	Nov.	6271	13.9	720	451	269	63	37.1
	Dec.	8059	13.7	744	586	158	79	33.0
Per year		33794	12.2	8760	6859	1902	78	40.2
1971	Jan.	9712	16.4	744	590	154	79	30.7
	Feb.	6331	14.2	672	446	226	66	34.3
	Mar.	5567	12.9	744	431	313	58	36.9
	Apr.	7781	11.7	720	660	60	92	39.4
	May	7559	12.8	744	590	154	79	36.9
	Jun.	8586	12.5	720	690	30	96	36.0
	Jul.	6263	13.0	744	481	263	65	34.0
	Aug.	4461	10.7	744	414	330	56	43.7
	Sep.	7631	11.9	720	639	81	89	37.8
	Oct.	7234	14.2	744	509	235	68	33.6
	Nov.	7604	13.5	720	561	159	78	35.3
	Dec.	8000	12.3	744	648	96	87	36.1
Per year		86834	13.0	8760	6659	2101	76	35.9
1972	Jan.	6291	14.7	744	428	316	58	34.0
	Feb.	7712	15.2	696	507	189	73	26.7
	Mar.	7414	13.3	744	539	205	72	

Note: Some part of clinker from the Dire Dawa cement factory is used for the cement production.

1972	Jan.	4165	9.2	744	453	291	61	1377	22.1
	Feb.	5377	9.4	696	626	70	90	887	17.9
	Mar.	6102	8.8	744	692	52	93	1162	

TABLE No. 2

Operation of the Raw Mill

Year	Month	Raw Mix output t	Mill capacity t/h	Calendar hours	Working hours	Stand still hrs	Usage factor %	Heat specific cons. for drying Kcal/kg	Energy specific consump. kWh/t
1970	Jan.	8056	23.7	744	343	401	46	33.6	23.6
	Feb.	7327	24.5	672	302	370	45	31.7	23.7
	Mar.	10747	21.2	744	515	229	69	36.5	27.4
	Apr.	10020	21.6	720	469	251	64	34.6	27.4
	May	11616	21.1	744	548	196	74	34.6	27.2
	Jun.	7668	21.5	720	357	363	50	35.5	26.6
	Jul.	11364	17.7	744	668	76	90	43.2	32.2
	Aug.	11148	16.2	744	686	58	92	48.0	34.5
	Sep.	9444	17.7	720	540	180	75	43.2	32.3
	Oct.	11955	21.2	744	534	210	72	33.6	27.0
	Nov.	8543	21.1	720	483	237	67	39.4	27.0
	Dec.	6067	21.5	744	487	257	65	57.6	27.1
Per year		120047	20.2	8760	5932	2828	70	37.4	28.2
1971	Jan.	11163	21.2	744	525	219	70	29.9	27.6
	Feb.	9883	19.7	672	500	172	74	35.5	28.4
	Mar.	7925	19.0	744	417	327	56	37.4	30.2
	Apr.	9840	19.0	720	544	176	75	38.4	30.5
	May	9330	18.1	744	609	135	82	46.1	31.9
	Jun.	10743	18.6	720	576	144	80	41.3	43.2
	Jul.	10749	15.3	744	683	61	92	49.9	38.0
	Aug.	4415	13.0	744	425	319	57	92.2	42.4
	Sep.	9892	15.0	720	659	61	91	53.8	37.4
	Oct.	10617	17.8	744	606	138	81	35.5	32.6
	Nov.	10099	18.2	720	529	191	73	25.9	31.3
	Dec.	10139	18.1	744	559	185	75	43.2	33.1
Per year		117582	17.7	8760	6632	2128	75	39.4	34.0
1972	Jan.	7125	16.0	744	446	298	60	47.1	37.2
	Feb.	8933	16.6	696	540	156	78	41.8	42.6
	Mar.	10103	17.3	744	602	142	81	39.1	

Operation of the kiln is not stable. The average monthly hour's output of the kiln varied from 9.3 to 10.0 t/h in 1970 and from 7.7 to 9.3 t/h in 1971; One could observe even greater fluctuations in the average daily hour's output: from 6.7 to 10.7 t/h in 1970 and from 7.2 to 11.8 t/h in 1971;

The kiln usage factor is low. The significant standstill of the kiln takes place due to the technological, mechanical and electrical faults.

The main reasons of the kiln shut down

Year	Total number of standstill hours	I N C L U D I N G				
		repair and relining of the refractory	Technological faults		F a u l t s	
			ring formation	Total	mechanical	electrical
1970	1373	806	213	271	110	136
1971	1261	634	218	296	181	150

The analysis of the technological equipment operation reveals that the possibilities of the equipment are not used in full.

Improvement of the technological process, organisation of repair, elimination of the material ring formation will permit to raise the kiln output up to 10 t/h as well as the usage factor up to 90-92 %. The improvement in question in its turn means the additional production of clinker in the quantity of 10-11 thousand tons per year in comparison with 1971. There exist some reserves in the grinding department of raw mixture and cement.

The data on the material movement in 1972 for production of the raw mixture, clinker and cement are given below.

Raw Mixture Production

Month	C O N S U M P T I O N of						Raw Mix total output	L O S S	
	limestone		clay		sandstone			t	%
	t	%	t	%	t	%	t		
January	5353	73.09	1600	21.33	42	0.58	7500	375	5
February	7106	76.1	2175	23.0	25	0.9	9465	473	5
March	7241	75.25	2.575	23.58	131	1.20	10921	547	5

Raw mixture consumption for clinker production

Month	Raw mixture consumption	Clinker produced	Raw mixture specific c. t/t of clink.	Clinker Loss	
				t	%
January	7086	4294	1.65	129	3
February	9752	5910	1.65	177	3
March	10331	6291	1.65	189	3

Materials consumption for cement production

Month	C O N S U M P T I O N						Output of cement t	L O S S	
	Clinker		Ashes		Gypsum			t	%
	t	%	t	%	t	%			
January	5580	87.8	496	7.8	279	4.4	6354	63	1
February	6809	87.4	655	8.4	327	4.2	7791	78	1
March	6503	86.9	674	9.0	307	4.1	7489	75	1

II. ANALYSIS OF THE LAB WORK AND CONTROL OF THE PRODUCTION TECHNOLOGICAL PROCESS.

1. CURRENT CONTROL OF PRODUCTION

A. Quality control of the raw materials

Clay and Limestone

The samples of clay and limestone are taken from the plate feeders, deposit hall and from each truck arriving at the factory with a view to determining the content of moisture and $CaCO_3$. The average sample is compounded from the said samples for the chemical analysis, which is made one per week.

B. Quality control and correction of the raw mixture

Correction of the raw mixture is effected according to the content of $CaCO_3$. In compliance with the recommendation of Mr. Ferens, UNIDO expert on phase I of the Project, sandstone is used as a correction admixture in order to raise the silica module. Clay and sandstone are mixed outside of the deposit hall by means of a buldozer. First one bucket of sandstone is mixed with nine buckets of clay. After that the obtained mixture is mixed again with clay in the following ratio: 1 bucket of mixture - 5 buckets of clay.

The mixture prepared in such a way, the content of sandstone being 1.67%, is pushed into the deposit hall. The raw mill is equipped with the two bins. One of them is charged with limestone, the other - with the mixture of clay and sandstone. The mill is supplied with these two components by means of the plate feeders. Prior to being fed into the homogenisation silo the raw mixture is sampled one per 1/2 h in order to determine the content of $CaCO_3$. Moisture content and fineness of the raw mixture are defined once per hour.

The ground raw mill is fed into the homogenisation silo up to 2/3 of its volume, whereupon the meal feeding is switched over into the second homogenisation silo. The silo being filled up to 2/3 of the volume, contains the raw meal of a very variegated chemical composition since the two plate feeders of the mill cannot secure the proper accuracy of the proportioning.

The raw meal in the homogenisation silo is blended with the compressed air. After blending two samples (top - bottom) are taken to determine the content of $CaCO_3$. If this content is not adequate the silo is supplied with the additional quantity of the raw mixture, $CaCO_3$ being low or high, which mixture is blended once again and the content of $CaCO_3$ (top - bottom of the silo) is determined. On getting the adequate content of CaCO the raw mixture is pumped into the raw meal silo for storage. The raw mixture on the way from the homogenisation silo to the ready meal silo is exposed to the control on the $CaCO_3$ content. If the latter does not correspond to the norm they stop pumping of the raw mixture.

The raw mixture is sampled once per hour when being conveyed from the raw meal silo into the kiln. One sample is compounded from the above samples for the weekly chemical analysis. The content of $CaCO_3$ in the raw mixture supplied for burning is defined once/hour.

It is gratifying to note that the factory usually achieves a high degree of uniformiti of the raw mixture as far as the content of $CaCO_3$ is concerned, tolerances deom the norm being insignificant.

C. Fuel quality control

The furnace oil (mazout) with a net calorific value of 9600 Kcal/kg is utilized at the factory for the clinker burning as well as RM drying. The sample of mazout from each vehicle or cistern is exposed to the analysis with a view to determining the sulphur and moisture content as well as its calorific value. If so required the mazout can be sampled when being injected into the kiln from the tank.

D. Clinker quality control

The sample of clinker is taken from the Cooler every half an hour by means of a spade. The clinker taken is sieved through two sieves, the sizes of cells being 7 and 3 mm respectively. The sample, containing particles of 3-7 mm, is exposed to the weekly chemical analysis. The clinker litre weight is defined every half an hour. The physicomechanical tests of the clinker are performed one/week. The content of free lime in clinker is not determined. The clinker litre weight is characterized by a high degree tolerance to the low values, as a rule.

E. Gypsum quality control

Gypsum is sampled 3 times/day from the mill feeder is order to determine the content of SO_3. The representative of these samples is exposed to the chemical analysis which takes place one/week.

F. Quality control of the puzzolan additive

In compliance with the recommendations of Mr. Ferenz, UNIDO expert on phase I, the puzzolanic additive - pumice - is used when cement grinding. 8 per cent of pumice are introduced.

Samples of pumice are taken from each dump car for the definition of moisture content. The representative of these samples is analized one per week.

G. Quality control of cement and preparation of the charge to be ground.

In order to have a possibility of the three components proportioning (clinker, gypsum, pumice) a provision was made of a small metal bin as well as a third additional feeder for the cement mill. But at present one of the weighing feeders is idle, hence clinker is mixed with pumice in the deposit hall by spades. This mixture of clinker and pumice is charged into the bin being equipped with a plate feeder whilst gypsum is conveyed from the new bin through the belt weighing feeder.

When being fed into the silo cement is sampled for the definition of its fineness. The content of SO_3 is determined once/shift. The average sample made of the hour's samples is analised once per 2-3 days (for each silo).

The physicomechanical tests are carried out daily (milled and packed cement separately).

2. RESULTS OF THE CHEMICAL ANALYSES OF THE RAW MATERIALS CLINKER AND CEMENT

are presented in Tables 4434 attached hereto.

With a view to improving the production technological process I suggested reconsidering of the charts of sampling and chemical analyses (see Appendix 1).

Formely the chemical analyses of the raw mixture, clinker and raw materials were made once/week. I suggested performing the analyses of the raw mixture and clinker once/day and those of the raw materials - once/month.

In this way it became possible to make correction of the raw mixture once/day since the emphasis was concentrated on preparation and quality control of the raw mixture and clinker. At the same time the lab was released from less importatrt jobs.

The lab did not make the analysis on the free lime content. The clinker particles of 3-7 mm were exposed to the analysis and therefore there was misrepresentation of the results.

In March 1972 the new charts of sampling and analyses were approved by the Management of the Corporation and put into execution.

Since the analysists of the lab mastered the chemical analysis on determination of the free lime content it became possible to judge the degree of the raw mixture sinterability and characterize more correctly the mineralogical composition of clinker.

The limestone chemical analysis is presented in Tables 4-7.

The analysis implies good quality of limestone and high content of $CaCO_3$. At the same time the silica and iron modules vary within the broad range: from 0.53 to 1.37 and from 1.08 to 5.00 respectively. But due to the midget content of SiO_2, Al_2O_3 and Fe_2O_3 in limestone the influence of the latter over the SM and IM is insignificant.

The chemical analysis of clay is given in Tables 8-11.

Thanks to the high content of Fe_2O_3 in clay the factory can operate without the correction additive rich in Fe.

The silica module of clay lies within the range of 1.70 - 2.10, the iron module - 1.70 - 2.10.

The chemical analysis of sandstone is shown in Tables 12 and 35.

Only one chemical analysis of sandstone has been made at the factory up to now. The analysis of sample 373 has been made in the Cement Research Institute, Moscow, USSR. The content of silica is high, the content of alkali being insignificant.

Tables 13-17 attached hereto present the chemical composition of the raw mixture.

The chemical analysis of the raw mixture shown that the latter is uniform as far as the content of $CaCO_3$ is concerned, the fluctuations of the silica module as well as the iron module are quite midget. The silica module is low, but at the same time the lime saturation factor varies within the broad range - from 0.94 to 1.01.

Tables 14 and 15 show the fluctuations of the LSF, SM, IM of the raw mixture within the short periods of time.

The raw mixture chemical composition as it is clear from the average weekly data is not stable. LSF varies from 0.92 to 1.03; SM - from 1.71 to 1.95 and IM - from 1.40 to 2.29, whilst the fluctuations of $CaCO_3$ content are insignificant - from 76.90 to 75.37.

The above mentioned chemical analyses imply that the raw mixture correction being applied at the factory does not provide its chemical uniformity.

Since March the lab performs the raw mixture chemical analysis daily (see Tables 16 and 17).

As before the correction of the raw mixture is effected according to the content of $CaCO_3$ but now the lab controls the LSF daily and, if necessary, changes it by way of raising or decreasing the content of $CaCO_3$ in the raw mixture. Also once per day it's possible to change the proportioning of sandstone into clay depending upon the raw mixture silica module.

The method of the raw mixture correction proposed by myself provides more operative influence over its quality but still it does not settle completely the problem of preparation of the raw mixture with the homogenous chemical composition.

The lime saturation factor of Tables 13-17 was calculated as per the formula of Prof. V.KIND and V.YOUNG:

$$LSF' = \frac{CaO - (1.65.Al_2O_3 + 0.35Fe_2O_3)}{2.8SiO_2}$$

LSF - as per the formula of Lea and Parker being applied at the factory:

$$LSF = \frac{CaO - 0.7SO_3}{2.8SiO_2 + 1.2Al_2O_3 + 0.65\ Fe_2O_3}$$

The clinker chemical analysis is given in Tables 18-22 attached hereto.

The LSF as well as the clinker minerals are calculated according to the formula applied in the USSR:

$$LSF' = \frac{(CaO_t - CaO_{fr}) - (1.65\ Al_2O_3 + 0.35\ Fe_2O_3 + 0.7SO_3)}{2.8\ (SiO_{2t} - SiO_{2ins})}$$

$C_3S = 3.8\ SiO_2\ (3LSF' - 2)$

$C_2S = 8.6\ SiO_2\ (1 - LSF')$

$C_3A = 2.65Al_2O_3 - 1.7\ Fe_2O_3$

$C_4AF = 3.04Fe_2O_3$

LSF - as per the formula of Lea and Parker given above.

It was assumed that the content of free lime in clinker was 1.0%. Since April 20, 1972 they use the values determined by the lab.

As it can be seen from the analyses the mineralogical composition of clinker is nonuniform due to the chemical heterogeneity of the raw mixture. It should be noted that with the daily analyses the clinker composition has been improved a little - the increased and more constant content of C_3S is observed.

The residue-on-the-sieve (No.900,4900 see Table 36) analyses of the raw mixture performed in April showed that sandstone was ground perfectly whilst limestone turned out to be the most difficult component to grind in the mixture of limestone-clay-sandstone. That is why it was decided to increase the quantity of sandstone in the charge and raise in this way the silica module, what can be seen from the clinker analyses in April.

Tables 23-25 enclosed herewith present the chemical composition of gypsum. The quality of gypsum is good.

The chemical composition of pumice - see Tables 26-29.

The tests of pumice which have been carried out in the Cement Research Institute, Moscow, USSR, show that the pumice meets the standard on the puzzolanic reactivity :
1 g of pumice absorbs 61.51 mg of CaO from the saturated limy solution at the norm being equal to 50 mg.

The cement chemical composition is given in Tables 30-34.

When cement grinding 8-9 per cent of pumice have been introduced since December 1971.

3. PHYSICOMECHANICAL TESTS: CEMENT & CLIKER

The results of the above tests of clinker are given in Tables §7-41, those of ground cement - in Tables 42-46, packed cement - Tables 47-51.

The physicomechanical tests of cement show that the latter meets the requirements of the British Standard. At that it's necessary to note that the strength of cement varies within the extensive limits due to the nonuniform mineralogical composition and fineness.

Improvement of the production technological process will give a possibility to improve the cement quality and, therefore, reduce consumption of cement in the civil engineering.

Note: When making samples to be tested in the lab they use sand from Dire Dawa, which sand gives less strength than the British one. The latter is used as required.

When using the D.D. sand it was found out that the compressive strength of cement after 3 days should be not less that 143 kg/cm^2 instead of 194 kg/cm^2 according to the British Standard, and after 7 days - 191 kg/cm^2 instead of 239 kg/cm^2.

4. TESTS ON THE PHYSICOMECHANICAL PROPERTIES OF CEMENT DEPENDING UPON THE QUANTITY OF PUMICE INTRODUCED

A series of the cement samples was prepared at the lab with a view to determining the pumice influence over the cement properties. Table 52 presents the results of tests of 11 pairs of samples. Each pair is made of one and the same clinker, one of them being without pimice, the other - with 20% of pumice.

The tests performed showed that all samples observe the requirements of the British Standard on strength, setting time and other indices. But it should be noted that introduction of 20% of pumice decreases the cement strength by 59 kg/cm^2 after 3 days and by 72 kg/cm^2 after 7 days.

The results of the physicomechanical tests of 2 ser. of the cement samples are given in Table 53. Each series of samples is made of the same clinker with the pumice introduction being as follows: 0, 10, 15, 20, 25, 30, 35 per cent.

The tests were carried out after 7, 28 days and after 6 months from the moment of cement *mastering*.
In the first series (samples 1-7) samples 1-5 with the pumice content up to 25 % meet the standard. The strength of samples 6 and 7 with the pumice additive of 30 and 35 % was 130 and 131 kg/cm^2 after 7 days setting time, i.e. lower than the norm (143 kg/cm^2).

All samples (8-14) of the second series observe the requirements of the standard.

At it can be seen from the tests the additive influence over the cement strength becomes less after 28 days and especially after 6 months, when the strength of samples is almost levelled (excluding samples 6 and 7 which did not observe the standards).

Some Comments concerning Applying of the British Standard at the Factory.

The factory lab is equippmed with the equipment for the tests to be carried out according to the British Standard and also has the experience in pplying of the latter.

But as it's clear now the requirements of this standard hinder the further developement of production.

Thus, The British Standards prohibit using of any additives but clinker, gypsum and water when cement grinding. This provision is specified in the standard and besides there is a requirement to the incoluble residue - it should be not more than 1.5 % - which also restricts using of additives.

At the same time in the area of Addis Ababa there are deposits of puzzolan additives of the vulcanic origin.

Experience of the USSR, Italy and some other countries has prooved that the puzzolan additives are the good and cheap *raw materials*

for production of the cement since they improve its technical properties.

The British Standard subdevides cement according to its strength into Ordinary Portland and Rapid-hardening Cement.

The Standards of the USSR, Yugoslavia, Germany and some other countries provide for the subdivision pf cement into classes (according to its strength) and secure in this way more rational consumption of cement in the civil engineering. depending upon the required rigidity of the erecting structures

At present the Ethiopian Standards Institution has started elaboration of the standard on cement for Ethiopia. It would be beneficial to take into account the experience of other countries.

7. CONCLUSIONS ABOUT THE EXISTING SYSTEM OF THE PRODUCTION CONTROL

The lab of the factory applies the classical methods of the chemical analysis which require much time. For example, determination of the four oxides CaO, SiO_2, Al_2O_3 and Fe_2O_3 takes 5-6 hours whilst the result of MgO content can be obtained the next day only.

That is why the current control can be effected only according to the content of $CaCO_3$ which cannot characterize the chemical composition of the raw mixture in full.

With the help of the raw mixture and clinker daily chemical analyses it became possible to make correction of the raw mixture once/day. But even this correction is late though it is more operative in comparison with the previous one effected once/week.

The photocolorimetric methods of the analysis are used for the current control of SiO_2, $Al2O_3$, Fe_2O_3, MnO, TiO_2 being performed with the aid of a photoelectrocolorimeter. The method in question is based on the dependence of the solution optical densiti on its concentration. The definition of the above oxides takes 1 hour.

The trilonometric titration is used for the determination of CaO and MgO. The said method is based on the formation of calsium and magnium intra-complex soluble compoands with the so-called trilon B. The method is very simple and takes one hour.

Automatic roentgenospectral analysers are widely used in the cement industry. By means of the above analysers it's possible to determine the content of the four main oxides (CaO, SiO_2, Al_2O_3 and Fe_2O_3) within a few minutes. With the help of the analysers in question and the weighing feeders one can obtain the raw mixture of the required chemical composition just from the mill.

The correction admixture is proportioned into the raw mixture by means of a buldozer and it prevents from the operative interference into the process.
At such a proportioning it's not possible to influence the silica module untill the mixture of clay and sandstone being prepared for 24 h working has been completely used.

The more exact and controllable proportioning of sandstone can be obtained by way of supplying the raw mill with the additional bin and weighing feeder for this component.

Mastering of the express methods of the analysis in combination with the sandstone proportioning into the raw mill by means of a separate weighing feeder will give a possibility to get the raw mixture of a uniform chemical composition on the LSF and SM.

The analysts of the lab have mastered the methods on determination of the free lime content in clinker and pumice quantity in cement.

The method of the pumice content definition in cement by way of the hydrochloric acid surplus titration permits its using for the current control.

The content of free lime in clinker is determined only once per day sitnce the analysis iscomplicated and takes much time.

For the current control of the clinker quality its necessary to assimilate the method on the free lime content under the microscope.

III OPERATION OF THE ROTARY KILN

The usage factor of the kiln is low: 84.3 % - 1970, 85.5 % - 1971. The technological, mechanical and electrical faults are the main reasons of the kiln standstill.

Frequent ring formation results in the shut-downs of the kiln to remove the ring. The total standstill of the kiln due to the above reasons amounted to 213 hours in 1970 and 218 hours in 1971. The ring formation affects the kiln output and leads to the production of the poor quality clinker.

Breaking of the ring is effected by means of water under pressure provided that the ring was formed near to the exit cone end of the kiln. Hence, the kiln operates with the close-to-exit sinter zone. The operation with the close-to-exit sinter zone causes overheating of the cooler and the end segment of the kiln, which overheating increases stoppage time being necessary for the repair of the said equipment. The reduced temperature of the gases coming out from the kiln into the cyclone heat exchangers leads to the insufficient preparation of the material in the cyclones.

The specific heat consumption for the clinker burning is high, it is equal to 1050-1100 Kcal/kg of clinker. So, elimination of the material ring formation is the main target with a view to improving the kiln operation.

The analysis of the kiln operation shows that the main reasons of the ring formation are as follows:

1. Non-stable chemical composition and low silica module of the raw mixture being charged for burning.

2. Irregular feeding of the kiln with the material.

3. Reducing gas medium in the kiln.

The previous part of the presenr report was devoted to the way of improving the raw mixture chemical composition, that's why here I shall dwell on the lat two reasons of the material ring formation.

One of the main reasons of the ring formation is partially decarbonized material coming into the sinter zone which cools the refractory surface and adheres to it. Under the high temperature the adhered material is being mild and undertakes a new portion of the material. The formed ring in it's turn facilitates further growth of the material.

The irregular feeding of the kiln and heterogenous chemical composition of the raw mixture create ground for overheating of the refractory lining surface and contacting of the unprepared material with the latter.

The above-mentioned phenomenon takes palce at the factory. Though the kiln is equipped with a good weighing feeder, Schenk type, the feeding of the former with the material is utterly irregular. The kiln is charged with the equal quantity of the material irrespective of the rotation speed. For instance, 17 tons of the raw mixture are charged into the kiln at 1.3 rpm. If the temperature in the kiln decreases they slow down the speed of the kiln (say to 0.7 rpm), at that 17 tons/h still being conveyed to the kiln. It shows that the quantity of the material is not regulated in compliance with rpm.

As a result one can observe a non-uniform bed of the material and its wavy movement, both affecting the temperature regime.

At low speed the kiln is so overloaded that proper burning of the material is quite impossible. Poorly burnt clinker with low litre weight is the outcome, the figures being as follows:

January 1972 - 28.5 %
FEBRUARY 1972 - 25 %
March 1972 - 30 %

Due to the non-stable temperature conditions created in the kiln the clinker litre weight varies within the broad limits - from 750 to 1570 g, the secondary air temperature - from 640°C to 1200°C, the cooler grate bars temperature - from 40° to 320°C, the temperature of the gases after the kiln - from 400° to 940°C and so on through the whole system of the kiln unit.

The non-stable temperature conditions in the kiln facilitate the fuel incomplete combustion as well as creation of the reducing gas medium in the kiln.

The burners of the kiln are not efficient enough to control a number of performances exercising over the regilar process of the clinker burning - and this is also one of the reasons of the irregular heat engineering conditions in the kiln.

Elimination of the material ring formation requires the uniform heat engineering operating conditions for the sufficient and uniform preparation of the material for burning.

With this in view it's necessary:

1. To stabilize the heat conditions in the kiln (neither cooling, not overheating of the material is allowable), to take timely steps for keeping of the normal temperature.

2. To have max working hours of the kiln at the normal speed.

3. To slow down, if necessary, the kiln rpm preventing from the discard production.

4. To exclude the production of clinker with litre weight being less than 1300 g/l.

5. When changing the speed of the kiln the quantity of the raw mixture being fed into the kiln should be changed accordingly in order to provide the uniform bed of the material.

6. Simultaneously with changing of the fuel supply it is necessary to change the air supply to get complete combustion.

The above measures will raise not only the output of the kiln and its usage factor but also provide production of the higher quality clinker (at present there are 25-30 % of poorly burnt clinker).

CONCLUSIONS AND RECOMMENDATIONS

1. The Cement Factory in Addis Ababa is provided with one technological line of the complete production cycle. The design capacity of the factory is 70,000 tons of cement per year.

   84,000 tons and 87,000 tons of cement were produced at the factory in 1970 and 1971 respectively. At that some part of clinker was brought from Dire Dawa. The output of the rotary kiln was 9.5 and 9.0 t/h, the usage factor - 84.3 and 85.5 percentages respectively. Asfar as the cement quality is concerned the Standard is observed.

2. Analysis of the factory operation shows that there is a possibility to improve the quality and raise the output of the cement produced.

   The raw material quarry as well as grinding departement completely satisfy the factory needs and can secure the additional production of cement.

   The operation of the rotary kiln and work of the laboratory being the main weak points at the factory were the subject matter to my special attention.

3. The kiln operation is not stable: its daily average output varied from 6.7 to 10.7 t/h in 1970 and from 7.2 to 11.8 t/h in 1971.

   The main drawback of the kiln running is the intensive material ring formation in the sinter zone.

   With a view to eliminating the ring formation UNIDO expert on phase I of the Contract suggested raising of the raw mixture silica module by way of the third component (sandstone) introduction into the mixture.

   By the time of Phase II the factory has started to introduce sandstone as an additive in the quantity of 1.67 % to clay for the silica module correction. Further raising of the silica module was rejected due to the opinion it would affect the clinker burning.

On the basis of the residue-on-the-sieve (No.900,4900) chemical analyses performed by the laboratory in April 1972 it was de ided to raise dandstone quantoty being introduced into the raw charge.

The proportioning of the raw charge has been changed accordingly so that the clinker silica module would be within the range of 2.0-2.2.

Survey of the kiln operation being charged with the mixture of a raised silica module testifies to reducing of the material ring formation but not complete elimination.

4. The proportioning of the additive by means of a buldozer is not precise and prevents from the operative interference into the process. Consequently in order to improve the raw mixture quality it's necessary to provide the raw mill with an additional bin and weighing feeder for the sandstone proportioning when grinding.

5. It has been found out that one of the main reasons of the material ring formation is the utterly non-stable heat engineering conditions in the kiln due to the irregular feeding of the kiln with the material and also due to the fact that the burners are not keen on the up-to-date methods of the kiln operation.

In order to rule out the ring formation and stabilize the clinker quality it's necessary to create the uniform temperature regime in the kiln providing thereby the sufficient and uniform flow of the process.

In my opinion it is urgent and necessary to train the factory burners so that they would master some modern methods of the kiln operation. From my point of view the individual training is the most effective one.

For the above purpose it would be desirable that the technological engineer with a group of 4 skilled operators should be sent to Addis Ababa, the stay being about 12 months. The burners with the experience of work at the kiln with the cyclone heat exchangers would arrange the uniform temperature conditions of

the kiln and train the indigenous personnel.

6. The main shortcoming in the factory lab work is that it applies the out-of-date, so-called classical methods of the chemical analysis which require much time and work.

Some recommendations of mine suggested with a view to improving the lab work have been realized already:

- The chemical analyses of the raw mixture and clinker are performed daily;
- The lab has mastered the method on definition of the pumice quantity in cement and free lime content in clinker.

Daily analysis of the raw mixture and clinker permits to correct the proportioningof the raw charge once per day, besides the interference into the process of production became more effecti in comparison with the time when such analyses were conducted once per week.

For further improvement of the lab functions and raising its role in the process of production I would considet it feasible to transfer the lab on the express methods of the chemical analysis of the raw materials, raw mixture and clinker.

In order to master the above methods of the analysis it's necessary to buy the equipment & reagents and send to the USSR 2 or 3 analysts for training (about 6 months) where they they would master not only the methods metnoned above but some others being indispensable for the cement production, for instance, definition of the free lime content under the microscope.

7. To raise the output of the factory and improve the technical properties of cement UNIDO expert on phase I suggested using of the puzzolan additive (pumice) for the cement production.

Since December 1971 eight per cent of pumice have been introduced when cement grinding. The introduction in question permits to produce monthly about 500 tons of cement in addition.

The lab tests of pumice performed by S.P.A. SAUTI (Italy)

showed that the pumice under study could be used for the manufacture of cement without any disadvantages being revealed. The samples exposed to the tests contained 65 % of clinker, 32% of pumice and 5 % of gypsum. Hence there is a possibility to increase the scope of production by way of using more quantity of pumice when cement grinding. The quantity of pumice will depend mainly upon the clinker quality and requirements of the standard.

8. It should be noted that the Ethiopian Standards Institution has started elaboration of standards for cement.

These standards with the account of the local conditions are based on the British Standard, and it is true since the laboratories of the Cement Corporation are provided with the corresponding equipment and have experience in applying of the British Standard.

But in the Ethiopian standard it is necessary to make a provision of a possibility to use the puzzolan additives as well as division of cement into classes according to its strength. From the requirements of the future standard it is feasible to exclude the limitation on the insoluble residue and stipulate the number of additives to be introduced in cement.

Division of cement into classes according to its strength will provide more rational using of cement in the civil engineering but distinction of price depending upon the class will create the incentive of improving the quality of the cement produced.

Execution of the work provided for by the Contract between UNIDO and Technopromexport of January 1971 secured some positive results in operation of the Addis Ababa cement factory:

1. Raising of the silica module by way of using a third component - sandstone - in the raw charge reduced the material ring formation in the kiln.

2. Utilization of the puzzolan additive - pumice - in production of cement secured raising of the output by 5-6 th. tons of cement per year.

3. Revision of the sampling chart shifted the emphasis of the raw mixture as well as the clinker quality.

Proceeding from the findings of my work, Phase II of the Contract, I consider it expedient to continue rendering of assistance to the Addis Ababa Cement Factory. For phase III I would recommend the following:

1. With a view to eliminating the material ring formation in the kiln and improving the quality of the clinker burning it's necessary to create the uniform heat engineering operating conditions. For this purpose it's mandatory to teach the indigenous personnel of the up-to-date methods of the kiln control by way of deputing to Addis Ababa the technological engineer with a group of the efficient operators (burners) of the kiln.

2. The laboratory of the factory should master the express methods of the chemical analysis for which purpose it's necessary to buy the relevant equipment and reagents and send the analysts (chemists) of the lab for training to the USSR.

3. In the Ethiopian Standards for cement being elaborated by the Ethiopian Standards Institution a provision should be made of the following:

   - Division of cement into classes depending upon its strength;
   - Possibility to introduce the puzzolan additives.

A. GENTOSH
UNIDO expert on phase II

Addis Ababa, May 3, 1972

Translated from the Russian by Svetlana Efimova

APPENDIX No. 1

MAINTENANCE & REPAIR OF THE EQUIPMENT

MONTHLY MAINTENANCE

1. Monthly maintenance is conducted by the workers of the adequate occupation (burners, operators of the mills, crushers, excavators etc), duty locksmiths and electricians, being well aware of the operating manuals, by means of inspection of the equipment conditions and elimination of the minor faults. All the jobs are executed during the working shift.

2. Monthly maintenance comprises the following jobs:

- cleaning, checking of the machine and elimination of the minor faults;
- checking of the bracing details (being eccessible for inspection), spline joints, thrust rings as well as some details replacement;
- checking of the lubricating devices operation, oil piping, cooling systems, sealings and instrumentation conditions as well as ckecking of frictional faces heating degree;
- checking of the motors operation, starting up and braking devices and the control system as well;
- checking of the running parts, connecting couplings, protecting parts;
- checking on oil and water presence in the lubricating and cooling systems;
- checking of the separate details and units regulation.

3. In order to maintain the equipment availability it is necessary to follow all the evnts laid down in the operating manuals for the relevant machines.

4. On revealing any defects which can not be eliminated during this shift the operator should inform the duty engineer about the defects and put them down in the logbook or list of the shift acceptance and passing.

5. The shift engineer is responsible for the jobs of the Monthly maintenance and provides due and qualicative implementation thereof. If necessary, he may resort to the duty engineer.

PERIODIC MAINTENANCE

1. PM is carried out by the repair team together with the maintenance personnel, if necessary (duty locksmiths, electricians, operators and thir assistants etc.) with a view to checking the technical condition of the equipment, revealing and elimination of the faults as well as preventing from the accidents.

2. During the maintenance in question the following jobs are to be implemented:

   - Cleaning of the equipment and working places from dust, impurities and production waists.
   - Outside inspection (without dismantling) to reveal faults of the equipment and its separate units.
   - Opening of the units covers for inspection and checking of the mechanisms condition, replacement of the worn out or damaged details.
   - Defectation of the details being in need of replacement or restoration during the coming planned repair.
   - Clarification of the details and units lifetime.
   - Control of clearances of the main units.

- Control of the frictional couplings and tightning of brakes.
- Control of smoothness of the units and separate elements of the machine.
- Checking of the rolling and frictional surfaces, cleaning of stratches and the similar.
- Repair and control of strings tension and that of belt drives, gear drives, belt conveyors.
- Checking of supports, limiters and switches.
- Checking and tightening of glands, collars, packings and joints (for leakages elimination).
- Checking and tightning of bolt connections, bracing and fixing details.
- Checking and minor repair of the cooling, lubricating and hydraulic systems; oil refilling, if necessary.
- Checking of automatic and protective devices.
- Checking and minor repair of casings, landings, barriers, stairs and passages.

3. The mechanical (electrical) engineer effects supervision over the work. The results of the periodic maintenance & repair are put down into the logbooks on the periodical maintenance & repair of the equipment.

REPAIRS

1. Repair of the equipment is envisaged for the restoration of the equipment availability by means of replacement of the worn out details and units by the repaired or new ones, alignment of the details interrelation.

2. The repair is subdevided into the current, mean and general overhaul according to the scope and nature of jobs.

3. Periods for repairs are defined according to the number of working hours being set for different kinds of equipment, conditions of work and degree of the details and units wearing.

MAINTENANCE

1. By this maintenance is meant such a minimum (as regards its scope) kind of repair during which replacement or restoration of some details (lifetime thereof being equal /or less/ to the period between the repairs) should be executed; regulation providing normal operation of the machine up to the next planned repair should take ppace as well.

2. Scope of the maintenance is to be set in advance, the results of the previous periodic maintenance being taken into account.

During the maintenance the following jobs should be executed:

- Cleaning of the machine, inspection and washing of the dismantled units details, as well as of rolling and friction faces.
- Partial dismantling of the machine; dismantling of the units exposed to greater wear and impurity.
- Clarification of the list of faults found earlier and revealing of the details to be replaced or repaired during the next planned repair (minor repair or general overhaul).
- Repair or replacement of the worn out details which can hot go on operation till the next planned repair.
- Inspection of rolling bearings, replacement of the worn out.
- Adding of friction discs, scraping of bevels, re-riveting of brake belts.
- Replacement of the worn out or damaged bracing details of glands, collars and packings.
- Scraping or cleaning of the warming frictional faces and cleaning of scratces, barbs of the tooth gears; replacement of the damaged hubs or bushes.
- Checking and testing of the repaired details and units.
- Cleaning of oil chambers, repair of the lubricating, cooling and hydraulic systems; oil refilling in compliance with the chart.

- Repair of casings, landings, barriers, stairs, passages, devices for the protection of the machined surfaces from impurity and abrasive dust.

- Works on the electrical equipment and instrumentation in accordance with the classification of the maintenance.

The maintenance comprises also all the jobs frovided for by the periodic technical maintenance.

3. The repair team carries out maintenance of the equipment together with the maintenance personnel, if necessary. The mechanical (electrical) engineer directs the jobs on the repair of the equipment. The results of the work done are put down in the locbook on the periodical technical meintenance & repair of the equipment.

MEAN REPAIR

1; During the above repair the accuracy, power and capacity of the equipment should be restored by means of replacement or restoration of the worn out details and units for the period up to the next planned mean repair or general overhaul. During the repair in question faulty details (lifetime thereof being equal /less/ to the interrepait period or to that between the two mean repairs.

2. Scope of jobs should be set in advance with the account of the previous current repair results. The jobs to be executed during the mean repair are as follows:

- Dismantling of the units excluding the basic ones (beds, stands and foundation frames).

- Inspection and defectation of the dismantled details and units. Clarification of the preliminary faults list for the mean repair; details and units to be replaced or repaired during the nearest planned general overhaul.

- Repair or replacement of the worn out details which can not go on operation till the next mean repair or general overhaul.

- Repair or replacement of the worn out or damaged shafts, axles and hubs.

- Replacement of the friction discs, reboring of bevels, replacement of brake belts.

- Replacement of worn out or damaged chain and gear drives as well as worm pairs.

- Checking, cleaning and repair of the details which are not to be replaced during this repair.

- Repair of pumps, lubricating, cooling and hydraulic systems; oil refilling according to the chart.

- Refilling and scraping of the slide bearing brasses and scraping of the guide surfaces of the slide block and those of other details.

- Partial replacement of springs, nuts and check-nuts, fixing of separate units and details.

- Assembly of the repaired units, checking of the units and mechanisms interaction.

- Alignment of axles and co-ordinates; regulation of units and mechanisms of the machine.

- Painting of the external non-working surfaces of the machine.

- Checking for noise and heating of the friction surfaces. Testing of the machine under load following the conditions of the normal technological process.

- Works on the electrical equipment and instrumentation in compliance with the classification for the mean repairs.

The mean repair comprises also all the jobs provided for by the maintenance.

3. The mean repair is executed by the repair team together with the personnel of the workshop, operating personnel and /maybe/ repair team of the quarry.

4. The senior mechanical (electrical) engineers supervise the work and bear responsibility for the timely preparation of the repair, execution of the set scope of jobs and quality thereof.

The results of the work done are put down into the logbook on the periodic maintenance & repair of the equipment.

GENERAL OVERHAUL

1. The period between the two exceeds a year. During the general overhaul all performances of the equipment are restored completely (initial strength, accuracy, power and capacity provided for by the technical terms but lost in the course of operation).

2. During the overhaul the equipment is dismantled in full, restored; worn out details and units are replaced. Assembling and checking being in accordance with the following list:

   - Complete dismantling of the machine and all its parts.
   - Inspection and defectation of the dismantled units and details. Clarification of the faults record which has been made earlier for the general overhaul.
   - Replacement or repair of all the worn out details.
   - Replacement or machining and scraping of the slide bearings brasses (being in need of repair), friction and guide surfaces.
   - Replacement (if necessary) of gear-boxes, electromotors, oil pumps and cooling pumps and other outfit.
   - Replacement and repair of the ventilation and aspiration systems.
   - Assembly of all the units, testing of interaction of all the units and mechanisms of the machine.
   - Checking and repair of the foundations, checking of supporting frames.bracings and bracing of the machines. Repair of burners, dust chambers etc.
   - Filling and painting of all non-machined surfaces.
   - Testing of the machine at idle running, testing for noise and heating of the frictional surfaces.Testing of the machine under load according to the conditions of the normal technological process.

- Jobs on the electrical equipment and instrumentation in compliance with the classification for the general overhaul.

3. The general overhaul depending on the local conditions (power reserve, spare parts, materials, labour force etc) can be carried out simultaneously or by means of a dispersed method (per units).

4; The general overhaul is executed by the joint repair forces together with the operating personnel.

5. The senior mechanical (electrical) engineer conducts implementation of the work. He is responsible for the timely prepatation of the repair, execution of the planned scope of jobs and quality thereof. The results of all the main jobs are put down into the technical passport or the logbook on the periodic maintenance & repair of the equipment.

Note: In order to determine the necessity of the preventive maintenance it is necessary before shut down of the equipment to inspect and make a list of faults. If it turns out to be that the equipment is in order or it is possible to replace the planned repair by some other being less in scope, the decision on such a replacement can be made by the senior mechanical (electrical) engineer upon the agreement with the management of the corporation (factory).

Appendix No. 2

APPROXIMATE LIST OF SPECIFIC JOBS TO BE EXECUTED WHEN REPAIR OF THE TECHNOLOGICAL EQUIPMENT

ROTARY KILN

Maintenance

1. Inspection and partial replacement of the refractory lining in the kiln and cyclone heat exchangers.

2. Replacement or bracing of segments of the kiln discharge end.

3. Welding of cracks, cutting out of faulty sections and welding of the new parts of the kiln housing and cyclone heat exchangers.

4. Welding of under bandage linings and supports, replacement up to 20 per cent of underbandage control linings, cleaning and welding of the bandage holes and cracks.

5. Inspection and elimination of faults of the thrust rollers heating bearings, partial replacement of bushes.

6. Inspection of rest roller tilting bearings.

7. Opening and inspection of the pinion shaft bearings.

8. Revision of the kiln drive connection.

9. Revision of the toothing bracing.

10. Inspection and, if necessary, replacement of the main gear-box bearings. Inspection of all the gear-box gears through the eye manhole.

11. Elimination of the gear-box oil leakage.

Mean Repair

1. Changing of the refractory lining in the sinter zone at the discharge end as well as in the cyclone heat exchangers.

2. Replacement of one-two rings including the discharge end ring.

3. Instrumental checking of the axle position of the kiln in the horizontal and vertical planes.

4. Replacement up to 40 per cent of the under bandage linings.

5. Lathing of the bandage working face.

6. Revision of the radial bearings, washing of casings, determination of the normal butt end plays, cleaning and partial replacement of brusses.

7. Replacement of radial bearings, grinding or lathing of the rollers working faces and axle journals.

8. Replacement of thrust roller axles and bearings, working surface overmelting and lathing.

9. Pinion turn by 180°;

10. Replacement of the pinion shaft bearings.

11. Replacement of the kiln drive high-speed connectors.

12. Check of bracing and centering of the gear-rim.

13. Revision of the main and auxiliary gear-boxes. Replacement of the main gear-box high-speed shaft-gear and bearings.

14. Centering check of the main gear-box with the pinion shaft, electromotor with auxiliary gear-box.

General Overhaul

1. Replacement of the refractory lining in the kiln, hot head and cyclone heat exchangers.

2. Replacement of 1-2 cyclones and heat exchanger flue gas pipes.

3. Partial replacement of the kiln housing, charge and discharge ends.

4. Replacement of faulty bandages and under-bandage linings.

5. Replacement of radial bearings with brasses and bearing casings.

6. Changing of rest rollers.

7. Changing of the pinion.

8. Replacement of the kiln drive low-speed coupling.

9. Replacement or turning by 180° of the gear-rim.

10. Changing of the main gear-box blocks and bearings.

GRATE PLATE COOLER

Maintenance

1. Repair of the cooler pit refractory lining.

2. Bracing and replacement of 3-4 raws of grate bars.

3. Revision of bracing of carrying grate plates, movable frames and side armour plates.

4. Revision of rest rollers, brusses driving axle necks and journals.

5. Revision of drag chains with partial changing of scrapers and connecting pins.

Mean Repair

1. Repair of the cooler pit and vault lining.

2. Replacement of the hot chamber grate bars and partial changing of the grate plate supports.

3. Bracing and partial replacement of the cold chamber grate bars.

4. Partial replacement of the side armour plates.

5. Replacement of rest rollers.

6. Changing of the eccentric yokes and brusses of all axles.

7. Check of parallelity and horizontality of the shaft axles and journals.

8. Revision of the variator-gear-box; replacement if necessary of the worn out details and bearings.

9. Replacement of chain drive chain gears.

10. Selective replacement of scrapers bearing rollers and drag chain guides.

11. Revision of the drag chain drives.

12. Revision of the forcing fan bearings.

General Overhaul

1. Replacement of the cooler lining.

2. Complete replacement of grate bars, carrying grates, side plates and armours.

3. Changing of the mobile frame transverse and longitudinal beams.

4. Replacement of the eccentric and driving shafts, journals, connecting rods and all bearing brasses.

5. Replacement of rest rollers and guides thereof.

6. Replacement of shafts, bearings and variator-gear-box worn out details.

7. Replacement of chain drive chain gears.

8. Complete replacement of scrapers and pins of drag chains.

9. Replacement of driving chain gears, pull drums, bearing rollers and drag chain guides.

10. Replacement of details and bearings of drag chain guides.

11. Cooler metal structures repair.

12. Replacement of the forcing fan runner and carrier.

SEPARATOR BALL MILLS

Maintenance

1. Partial replacement of the plate liners, partitions and outlet grates.

2. Tightning of bolts of the liners, partitions and outlet grates.

3. Inspection of the charge end and replacement of the discharge screen.

4. Tightning of the pinion bolts.

5. Opening of the intermediate shaft bearings; revision of brasses and washing of the bearing casings.

6. Checking of the pinion fit and toothing.

7. Connectors revision.

8. Oil leakage elimination from gear-boxes, oil piping and journal bearings.

9. Revision of filters, coolers, oil pumps and cooling system.

10. Revision of the distribution plate, fan blades, centrifugal separator shutters and gates.

11. Revision and repair of the plate and belt feeders.

Mean Repair

1. Changing of the plate liners, partitions and outlet grates.

2. Replacement or repair of the charge and discharge devices.

3. Bracing of the end plate.

4. Measurement of babbit layer in the journal bearing brasses, thir re-pouring or replacement, if necessary.

5. Turning of the pinion by 180°, repouring of the intermediate shaft brasses, replacement of connectors.

6. Checking of the mill axle as well as intermediate shaft parallelity.

7. Revision of the main gear-box and changing of the high-speed shaft-gear, replacement or re-pouring of brasses.

8. Repair of the gear-box oil and cooling systems. Changing of the oil pump gears.

9. Changing of the distribution plate, centrifugal separator fan blades.

10. Revision of gear-box, changing of bearings of the separator vertical shaft.

11. Changing of the separator housing lining.

12. Repair of the plate and belt feeders. Revision of the gear-boxes and changing of the worn out details.

General Overhaul

1. Changing of the end plates.

2. Partial or complete changing of the mill shell and discharge housing.

3. Changing of liners, partitions, outlet grates, charge and discharge devices.

4. Changing of the pinion and intermediate shaft with bearings.

5. Turning by 180° or replacement of the gear-rim.

6. Changing of the gear-box gears, shafts and bearings.

7. Changing of the oil filter, cooler and oil pump.

8. Changing of the journal bearing brasses.

9. Separator general overhaul. Replacement of the gear-box gears, vertical shaft fans, distribution plate and body armour.

10. Plate and belt feeders general overhaul. Changing of plates, shafts, gear-box gears, bearings. Repair of the feeder body.

GRAB OVERHEAD CRANE

Maintenance

1. Revision and change of the bridge and trolley wheels.

2. Checking of bearings, shaft necks, connectors, bucket lifting and closing drum.

3. Checking of the rail bracing.

4. Changing of ropes.

5. Revision of the rope wheel bearings.

6. Revision of the bucket articulation with rods. Bucket jaws overmelting.

7. Regulation of brakes and terminal switch of lifting, bridge and trolley travel.

8. Revision of all the gear-boxes, elimination of defects.

Mean Repair

1; Change of the bridge and trolley wheels.

2. Partial change of rails; instrumental chack of the crane rails.

3. Revision of all the gear-boxes, change of the high-speed shaft-gears.

4. Change of bridge travel mechanism and open gears. Revision of the bridge transmission bearings.

5. Lathing of the brake pulley.

6. Repair of the bucket. Change of the rope blocks with axles.

General Overhaul

1. Change of drums with shafts.

2. Change of the brake pulleys.

3. Change of the gears, shafts and gear-box bearings.

4. Change of the transmission shafts of the bridge and trolley travel mechanism.

5. Change of the bridge and trolley wheels.

6. Trolley replacement.

7. Complete change of the rails.

HAMMER CRUSHER WITH PLATE FEEDERS

Maintenance

1. Overmelting of the hammers, grate bars and crusher body liners.

2. Revision of the crucher shaft bearings.

3. Revision of the driving and drag chain gears, shaft necks and feeder bearings.

4. Checking of the rails bracing .

5. Repait of the bin above the feeder and pipes.

Mean Repair

1. Change of the hammers, grate bars, crusher body liners.
2. Change of the shaft bearings.
3. Change of the hammer holders.
4. Revision of the flywheel bracing.
5. Revision of the driving and drag chain gears.
6. Revision of the feeder drive gear-box; change of the high-speed shaft and bearings.
7. Checking of the rails parallelity; partial change of the rails.
8. Partial change of the axles, planks, rollers and buckets.
9. Replacement of the bin section above the feeder and pipes.

General Overhaul

1. Change of the gear-boxes.
2. Change of the grate plate and liners.
3. Change of the flywheels and pulleys.
4. Change of the shafts, gears and feeder drive bearings. Connectors replacement.
5. Change of the rail-way line, frame repair.
6. Complete change of the feeder canvas.
7. Change of the driving and drag chain gears with the axles and bearings.
8. Change of the bin grate.
9. Change of the bin and pipes.

ROPEWAY

Maintenance

1. Drive revision (gears, shafts, bearings, grooved pulleys).
2. Revision of the rest (support) rollers.

3. Revision of the drag devices.
4. Revision of the pulley and carrying ropes.
5. Revision and small repair of waggons.
6. Hangers (rollers, bearings, axles) and waggon locks revision.
7. Repair of the charging device.

Mean Repair

1. Changing and repair of the drive details.
2. Waggon repair, changing of the locks and hangers.
3. Changing of the rest rollers.
4. Changing of the support elements (some of them).
5. Replacement of the pull rope.
6. Checking and re-tightening of the carrying rope line couplings.
7. Bracing and dressing of the waggon siding track.

General Overhaul

1. Waggon changing.
2. Support changing.
3. Carrying rope changing.
4. Grooved pulley changing.
5. Drive changing.

ALLOWABLE CLEARANCE EXPANSION BETWEEN THE SHAFT AND A HUB
(for the cast iron and bronze)

2 mm	at the shaft	ϕ 50 mm
3 mm	"	ϕ up to 100 mm
4 mm	"	200 mm
5 mm	"	300 mm
6 mm	"	400 mm
7 mm	"	500 mm

Allowable clearances in the unit - shaft-bearing)
(bearings with the babbit pouring)

0.5 mm	at the shaft diameter	50-80 mm
0.8 mm	"	80-120 mm
1.2 mm	"	120-180 mm
1.6 mm	"	180-260 mm
2.0 mm	"	260-360 mm

The gar-box bearing brasses are to be babbitted at the clearance expansion up to:

0.003	of the diameter	at 200 rpm
0.002	"	at 200-1000 rpm

The driving shaft bearing brasses should be babbitted or replaced at the expansion of the upper clearances up to 0.01 of the diameter and 0.005 of the diameter at the constant and variable loads respectively.

The babbit allowance of the journal bearing brasses is up to 4-5 mm of the remained thickness.

4-5 times expansion (against the nominal) of the thrust bearing end plays is allowable whereupon it is necessary to overmelt the butt ends.

Allowable clearances in the roller bearings.

2 times expansion of the initial clearance is allowable in the main units and 3-4 times expansion - in the marginal and

slow-speed units.

In the bearing units with the high requirements, for example, in the metal cutting machine spindles, the clearance expansion should not exceed 25 % of the initial value.

The allowable tooth wearing on thickness as per the pitch circle.

Type of the gear drive	Tear-andwear %
Open deives with the steel and cast iron wheels including the gears of the kiln and mills.	30 %
Gear wheels of the gear-boxes and other main drives running at the peripheral speed of 5 m/sec, including the wheels of the crane motion mechanism.	20
Gear wheels of the crane lifting mechanism as well as the drive gear wheels running at the peripheral speed of 5-10 m/sec and gear wheels running at the peripheral speed of 5-15 m/sec.	15
Worms and worm wheels	
Pinions with the cemented teeth should be replaced is the cemented layer consumption is ab.80% as well as when painting or restoration.	

APPENDIX No. 3

NOMENCLATURE OF THE SPARE PARTS OF THE MAIN TECHNOLOGICAL EQUIPMENT

R O T A R Y K I L N 2,6x34 m ø

Description of the details, short characteristics thereof	Drw.Nos	Material	Amount	Weight unit	Weight total	Lifetime
Gear rim 4080x330 ø, m=30, Z=134	7070-1/1	atg 52.81	1	6500	6500	
Gear rim spring with loops 460x820x20	7070-2/2	St 37	12		874	
Joint pin 55x480 ø	7070-2/4	St 50	12		108	
Gear pinion 690x360 ø m=30, Z=21	7071-06/1	25CrMo4	1	920	920	
Gear pinion shaft 220x1490 ø	7071-05/1	St60.11	1	318	318	
Gear pinion shaft thrust bearing casing 340 ø (560x260x440)	7071-20	composite	1	230	230	
Gear pinion shaft roller bearing casing 340 ø	7071-10	composite	1	200	200	
Bandage 3365/2723 x 580/350 ø	7075-1	Stg 52	2			
Rest roller 1000x450 ø	0932-23-I	Stg 60.81S	4		6800	
with axis 330x1590 ø and	0932-26-I/1	St 50.11	4		3800	
locking rings	0932-26/4	St 42.21	8		108	

1	2	3	4	5	6	7
Rest roller insert 300/340/450x x400 ø	0932-27/2	gBz14	8		400	
Rest roller bearing casing	0932-24	Gg22	8		4000	
510x740x800 with a face cover	0932-25/1	Gg22	8		360	
and packing rings	0932-28/1	Gg22	8		60	
Thrust roller 800-195 ø	0932-32-I	Stg60	2		760	
with axis 260x692 ø	0932-34-I/1	St50.11	2		360	
Thrust roller bed 598x510x500	0932-33-I	Gg22	2		660	
Forging ring 1200x 2600/2680ø	7072-0	HI DIN	2		3786	
= 40	Pos.1	17155				
with straps	Pos.5				330	
Discharge end			1		4315	
Discharge end segment	7072-1		24			
Sinter zone forging ring	7072-0	HI DIN	3		8772	
1900xø2600/2644 =22	Pos.10	17155				
Forging ring = 30	7072-0	HI DIN	2		5508	
1300xø2600/2660	Pos.3	17155				

FULLER COOLER

C OOLER

Eccentric shaft	KO.400-28.01.02D	St 50.11	1	455	455
Driving chain gear Z=11, t=63.5			1		
Driven chain gear Z=38, t=63.5	Ko.000-11.10.02A/1	St	1	80	80
Bush-roller chain t=63.6	DIN 8180				
Connecting rod two-part bushing from the eccentric side	KO.000-28.02.04A		2	12.5	25
Connecting rod boss from the driving shaft side	KO.000-28.02.06.A/1		2	7.5	15
Eccentric shaft bearing two-part bushing ϕ 125 DIN 506			2	13.5	27
Driven shaft	KO.400-29.01.01 B/1	St 50.11	1	207	207
Roller boss			4		
Rest roller LR3	KO.000-33.01.04 C/1	Kokel casting	4	42	168
Roller guide SPS 2	KO.000-33.02.02C	Mn casting	4	15.5	62
Sealing frame	KO.000-34.10.02 B/1	Ge12.91	4	16	64
Driving shaft sealing pressure plate	KO.000-34.18.02 B/1	St0021	2	12	24
Journal sealing pressure plate	KO.000-34.19.02 B/1	St.00.21	2	12	24

Sealing spring 2.5x50	KO.000-34.17.02A	Spring steel	12	0.02	0.24
Rest roller journal	KO.000-30.01.02B	St 50.11	2	42	84
Grate plate support LT48	KO.000-35.11.11D2	Stg Cr-Ni Mo	9	85	765
Grate plate support LT4	KO.000-35.11.12D2	Stg	14	64	896
Wedge end grate plate,left PG2214KL	32/1965	G22/14 Heat res. steel	7	16	112
Wedge end grate plate, right PG 2214KR	31/1965	"	7	16	112
Wedge grate plate PG 2214KM	30/1965	"	14	16	224
Wedge end grate plate,left PG 6KL		Steel G6	15	16	240
Wedge end grate plate, right PG6KR		"	15	16	240
Wedge grate plate PG6KM	33/1965	"	30	16	480
Flat end grate plate, left PG6FL	KO.000-35.02.10C2	"	1	14	14
Flat end grate plate, right PG6FR	"	"	1	14	14
Flat grate plate PG6FM	"	"	2	14	28
Top wear plate BS1	KO.000-35.07.13C1	Heat res. steel G22/14	2	11	22
Top wear plate BS2	KO.000-35.07.14C1	"	6	13	78
Top wear plate BS3	KO.000-35.07.15C	"	12	14	168
Wear plate, left KGSNL	KO.000-35.08.09B		8	23	184
Wear plate, right KGSNR	"		8	23	184

Top -side casting, left OLS	KO.000-35.05.12D1	Heat res. steel G6	1	110	110
Top-side casting,right ORS	"	"	1	110	110
Tp-side casting, lest NSL	"	"	2	75	150
Top-side casting, right NSR	"	"	2	75	150
Square tile hanger HH-6-1	KO.000-35.04.07B1	"	4	22	88
Side-casting, left GENL	KO.000-35.06.10D6		4	130	520
Side-casting, right GENR	"		4	130	520
<u>Bolts for grate support</u>					
with rectangular head					
2 - nuts M20x100			50	0.6	30
1 - washer M20x540			45	1.4	63
M20x430			6	1.37	8.22
with countersunk head					
M16x90			53	0.28	14.84
<u>T-Bolts for grate plates</u>					
2-nuts, m16x220			103	0.8	82.4
2-washers					
1-spring					
<u>T-Bolts for wear plates</u>					
1-nut M16x85			35	0.25	8.75
1-washer M16x220			32	0.76	16.72
<u>Square head bolts for side-castings</u>					
1-nut M20x60			50	0.4	20
2-washers M20x90			4	0.5	2

DRAG CHAIN SK 15

Driving shaft	K15SK-91.01B4	St50.11	1	32	32
Driving chain gear	K15SK-91.04.01D3	Stg	1	50	50
Drag drum with axle	K15SK-92.01.01B1	St	1	100	100
Support roller with axle	K15SK-93.01.01C1	St	4	25	100
Low guide S15	K15SK-94.02.01A	St	11	7	77
Scraper	K15SK-95.01.01C1	Stg	155	3	465
Connecting pin	K15SK-95.01.01C1		155	0.4	62
Driving chain gear Z=11, t=63.5		St	1	13	13
Driven chain Z=21;t=63.5	KO.000-11.10.07C2	St	1	45	45
Hub-roller chain t=63.5	DIN 8180	St			

DRAG CHAIN SK 30

Driving shaft			1		
Driven chain gear			1		
Drag drum with axle			1		
Support roller with axle			15		
Low guide SN 30			31		
Scraper					
Driving chain gear Z=13, t=63.5					
Driven chain gear Z=38; t=63.5			1		
Hub-roller chain t=63.5; L=3429 mm	DIN 8180		1		

R A W M I L L 2,6[redacted]7 m ø

Description of the details, short characteristics thereof	Nos drw.	Material	Amount	Weight unit	Weight total	Lifetime
1	2	3	4	5	6	7
Mill body with flanges	7065-6.4	HI	1		8800	
	7065-15.2	St42.11	2		1120	
Outlet end with journal	7065-1	Stg45.3	1		4560	
Inlet end with journal	7065-2	Stg45.3	1		3880	
Gear rim 4032x470 ø; m=24; Z=164	7065-4/I	Stg 52	1		5100	
Gear pinion 552x370 ø; m=24; Z=21	7065-5.2	1.25CrMo4	1		470	
Gear pinion shaft 240x3500 ø	7065-5.1	St 60.11	1		1020	
Gear pinion shaft bearing brass lower 200x350 ø£	7021-4.1	composite	3	49		
Gear pinion shaft bearing brass upper 200x350 ø	7021-3.1	composite	3	58		
Brass of journal 950x380 ø	7016-102.1	"	2			
Charge pipe 990x731 ø	7081-100	"	1		392	
Discharge device	7035-100	"	11			
	7035-300	"	1			

1	2	3	4	5	6	7
Inlet end external liner	7065-3.1	12Mn	14	58,5	819	
Inlet end internal liner	7065-3.2	12Mn	14	44	616	
External liner plate fixing bolt M30x2x125	7065-16.5	D5	28		20,2	
Internal liner plate fixing bolt M30x2x140	7065-16.5	D5	14		11,2	
Internal liner plate fixing bolt M30x2x155	7065-16,5	D5	14		12,5	
First chamber liner plate 305x494x... 50	7065-9/1-1	12Mn	91	56,7	5159	
First chamber small liner plate 305x244x...50	7065-9/1-2	12Mn	26	28,35	737	
Fixing bolt of 1st and 2nd chambers liner plates M30x 2x120	7065-16.5	D5	552		386,4	
Fixing bolt of the liner plates abutting to manholes M30x2x 140	7065-16.5	D5	20		16	
Second chamber liner plate 305x494x..50	7065-10/1-1	12Mn	169	42	7138	
Second chamber small liner plate 305x244x...50	7065-10/1-2	12Mn	26	21	546	

1	2	3	4	5	6	7
Partition slotted sector	7065-6.1	12Mn	16	90,67	1450	
PARTITION solid sector	7065-6.2	12Mn	16	80,52	1288	
Partition double semi-ring 730x180 ø	7065-7.1	GS52	2	92	184	
Partition semi-ring 730x60 ø	7065-7.2	GS52	2	45	90	
Lining for the partition	7065-9.1 7065-9.2	St 37 St 37	16 48		468 28,32	
Slotted sector fixing bolt to the body M24x1,5x165	7065-16.5	D 5	32		19,2	
Fixing bolt for the sectors M24x1,5x185	7065-16,5	D5	48		32,4	
Fixing bolt for the semi-rings M24x1,5x115	7065-16,5	D5	8		3,5	
Discharge grate external sector	7065-8.1	12Mn	14	66	918	
Discharge grate internal sector	7065-8.2	12Mn	14	54	756	
External sector fixing bolt M30x2x170	7065-16.5	D5	28		27,2	

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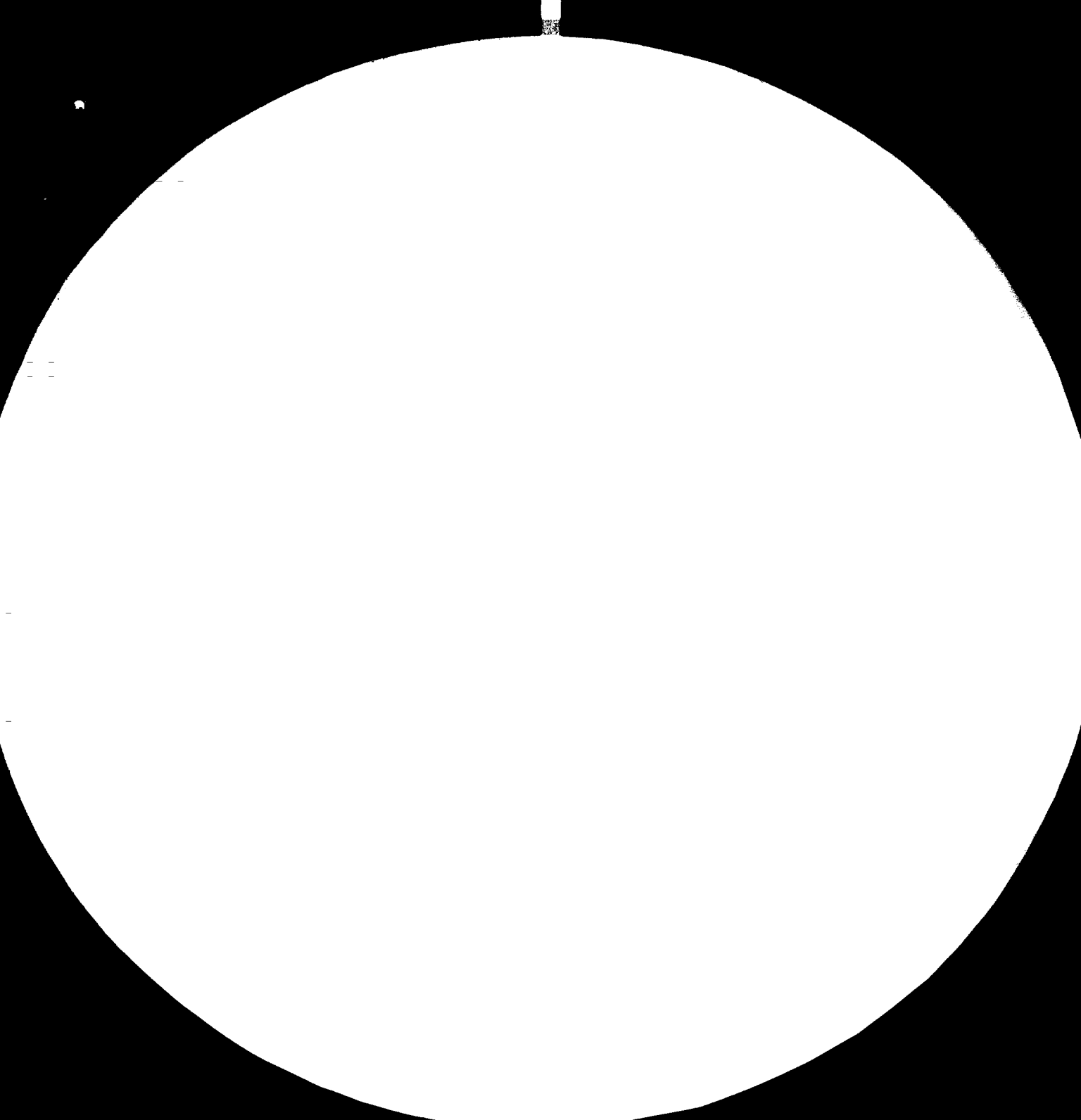
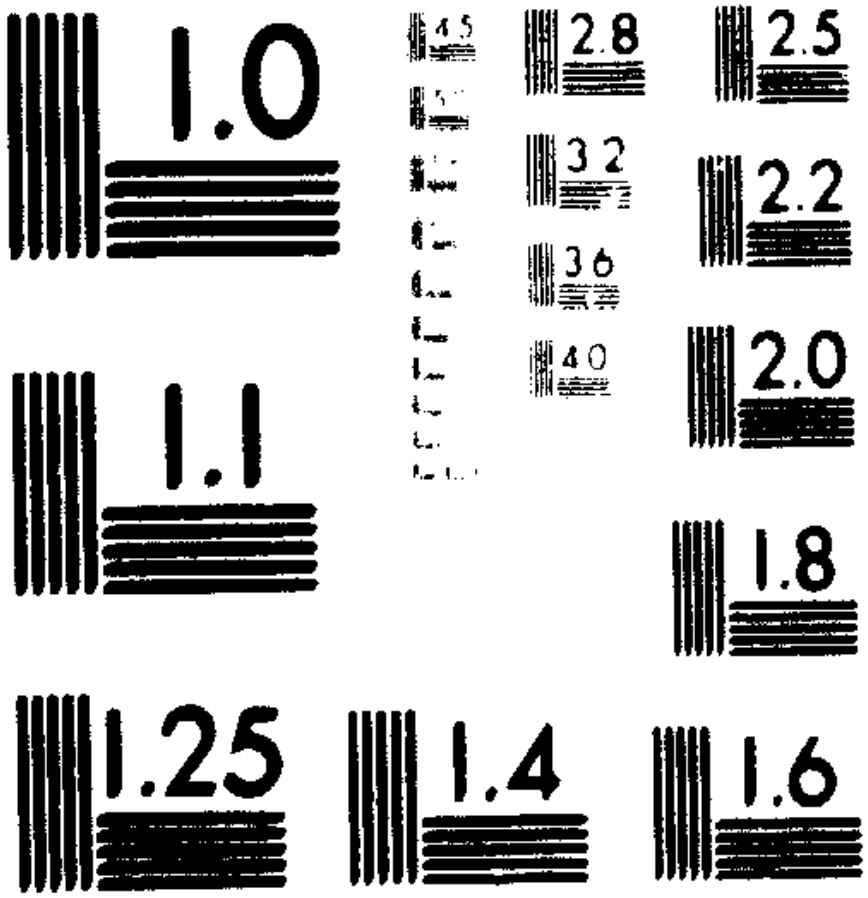
1	2	3	4	5	6	7
Internal sector fixing bolt M30x2x240	7065-16.5	D5	14		19	
Internal sector fixing bolt M30x2x315	7065-16.5	D5	14		25	





C E M E N T M I L 2,4x6 m ø

Description of the details, characteristics thereof	Nos drw.	Material	Amount	Weight unit	Weight total	Lifetime
1	2		4	5	6	7
Mill body	7015-103A	composite	1		10643	
Inlet end with journal	7015-101.2	GS-45.3	1		3370	
Outlet end with journal	7015-101.1	GS-45.3	1		3650	
Gear rim ø3888x450 ; m=24; Z=160	7015-104	GS-52	1		4880	
Gear pinion ø552x370 ;m=24; Z=21	7015-105.2	25CrMo4	1		470	
Gear pinion shaft ø240x4300	7015-105.1	St60	1		1295	
Gear pinion shaft bearing brass lower ø200x350	7021-4.1	composite	3	49		
Gear pinion shaft bearing brass upper ø200x350	7021-3.1	"	3	58		
Journal bearing brass ø950x380	7016-102.1	"	2			
Gear pinion shaft bearing casing 7021		"	3	642,6		
Charge device		"	1			

1	2	3	4	5	6	7
Discharge device		composite	1			
Inlet end external liner plate	Pos. 17 7015-108.1	12 Mn	12	53	635	
Inlet end internal liner plate	7015-108.1 Pos. 18	12 Mn	12	41	492	
External liner plate fixing bolt M30x2x130	7015-112.6	St 37	24		18	
Internal liner fixing bolt M 30x2x140	7015-112.6	St 37	12		9,6	
Internal liner fixing bolt M 30x2x150	7015-112.6	St 37	12		10,2	
First chamber liner plate 308x494x...50	7015-110A2	12 Mn	84	60	5040	
First chamber small liner plate 308x244x...50	7015-110A1	12 Mn	24	30	720	
Second chamber liner plate 308x494x...50	7015-111A2	12 Mn	168	45	7560	
Second chamber small liner plate 308x244x...50	7015-111A1	12 Mn	24	22	528	
Liner plate fixing bolt of the 1st and 2nd chambers M 30x2x105	7015-112.6	St 37	532		266	

1	2	3	4	5	6	7
Fixing bolts of the liner plates abutting to the manholes M 30 x 2 x 130	7015-112.6	St 37	20		12	
Partition slotted sector	7015-106.2	12 Mn	16	82	982	
Partition solid sector	7015-106.1	12 Mn	16	72	862	
Partition double semi-ring ø 700x180	7015-107.1	GS-52	2	87	174	
Partition semi-ring ø 700x60	7015-107.2	GS-52	2	43	86	
Slotted sector fixing bolt to the body M24x1,5x165	7015-112.6	St 37	32		20,8	
Fixing bolt of the sectors M 24x1,5x185	7015-112.6	St 37	48		36	
Fixing bolt of the semi-rings M24x1,5x115	7015-112.6	St 37	8		3,6	
Discharge drate external sector	7015-109.1 Pos. 19	12 Mn	12	60	720	
Discharge grate internal sector	7015-109.1 Pos. 20	12 Mn	12	50	600	
External sector fixing bolt M 30x2x175	7015-112.6	St 37	24		24	

1	2	3	4	5	6	7
Internal sector fixing bolt M30x2x235	7015-112.6 St 37		12		16,2	
Internal sector fixing bolt M30x2x295	7015-112.6 St 37		12		20,4	

CENTRIFUGAL SEPARATOR (No. - 2)

Driving shaft	3551695-2		1		
Bevel driving gear z=19, m=10	3551673-2		1		
Driven bevel rim Z=54; m=10	3551673		1		
Driven wheel boss	3551673-3		1		
Driven shaft	3551695-1		1		
Driven shaft upper nut	3551695-10		1		
Driven shaft low nut	3551838-1		1		
Scattering plate boss	3551677-2		1		
Scattering plate	3551679-17		1		
Selective ventilator disc	3552401-1		1		
Selective ventilator blade	3551680-3		48		
Circulating ventilator disc	3551679-18		1		
Circulating ventilator blade	3551680-1		6		
Circulating ventilator small blade	3551680-2		6		
Cylindrical wear plate	3551697-8		1		
Taper wear plate	3551700-6		1		
Wear plate bracing bolt M12x35	Lis 60	c 35	168	0.046	7.728
Wear plate bracing bolt M12x30	"	"	152	0.04	6.56
Nut M12	Lis 18	St38.13	320	0.016	5.12
Control valve plate	3552 341-1		16		

ELEVATOR B=630

Driving shaft ϕ130x1300	A156/1	St 50	1	135	135
Half of driving block ϕ 900/130	A 155	Stg42	4	132	528
Distance bush ϕ200/130x160	A 156/2	GG18	1	23	23
Connecting pin ϕ20x610	A 156/3	St 42	12	1.53	18.4
with rings ϕ40/20x20	"	"	24	0.02	4.8
Nut M20	DIN 934	St38.13	24		
Splint pin	DIN	St.00	24		
Spline 32x18x240	DIN 6885	St60.11	2		
Spline 28x16c125	DIN 6886	"	1		
Drag block axle ϕ100x1046	A 161/1	St 50	1	68	68
Drag block half ϕ900/100	A 155	Stg 42	4	132	528
Distance bush ϕ170/100x 160	A 161/3	GG 18	1	20	20
Spline 28x16x240	DIN 6885	St 60	2		
Bucket 630	A 154	St.00	59	42.9	2531.1
7-linked chain AC 26	DIN 764	St.35.13k	118	18	2124
Clamp 105	DIN 745	"	118	4.8	566.4
Locking plate 1x48x155		St.00	118	0.12	14.16
Nut M24		St.38.13	236	0.097	22.9

ELEVATOR B=500 (Nos-2el.)

Driving shaft ϕ120x1335	A 139/1	St 50	1	113	113
Driving block half ϕ800/120	A140/1	GG22	4	90	360
Distance bush ϕ200/120x115	A139/2	"	1	18	18
Connecting pin ϕ20x510	A139/3	St42	12	1.25	15
with rings ϕ40/20x20	A139/3	St42	24	0.15	3.6
Nut M20	DIN 934	St38.13	24	0.064	1.54
Splint pin ϕ4x40	DIN 94	St37.12	24	0.044	0.1
Spline 32x18x200	DIN 6885	St60.11	2	0.6	1.2
Spline 25x14x120	DIN 6886	St60.11	1	0.3	0.3
Spline		St60.11	1		
Drag blocks axle ϕ100x 916	A 143/1	St50.11	1	57	57
Drag block half ϕ800/100	A 140	GG22	4	90	360
Distance bush ϕ170/100x 115	A 143/3	"	1	13.5	13.5
Spline 28/16x200	DIN 6885	St60.11	2	0.6	1.2
Bucket 500	A 149	St.00		23.85	
for elevator H=19.3			66		1574.1
" H=15.65			54		1287.9
7-linked"chain AC23	DIN 764	St35.13K		12.1	
for elevator H=19.3			132		1597.2
" H=15.65			108		1306.8
Clamp 91	DIN 745	"		3.65	
for elevator H=19.3			132		481.8
" H=15.65			108		394.2
Locking plate 1x48x140		St.00		0.11	
for elevator H=19.3			132		13.53
" H=15.65			108		11.88
Nut M24				0.097	
for elevator H=19.3			264		25.6
" H=15.65			216		20.95

ELEVATOR B=400

Driving shaft			1		
Driving block half ϕ 710		GG22	4	66.25	265
Distance bush		"	1		
Connecting pin ϕ 20x440	A 107/4	St42.12	12	1.03	12.4
with rings ϕ40/20x20	A 107/5	St.42.12	24	0.15	3.6
Nut M 20	DIN 934	St38.13	24		
Spline		St60.11	2		
Spline		St60.11	1		
Drag blocks axle ϕ 80x688	A 107/1	St 50.11	1	27	27
Drag block half ϕ 710/80	A 104	GG22	4	66.25	265
Distance bush ϕ140/80x70	A 107/3	"	1	5.7	5.7
Spline 22x14x180	DIN 6885	St60.11	2	0.475	0.95
Bearing casing 175x210x ϕ125	A 107/2	GG22	2	7	14
Labyrinth ϕ130/70x45	A 107/6	"	2	2.2	2.2
Bucket 400 DIN 15234	A 106	St.00	80	16.3	1304
7-linked chain AC 20	DIN 764		160	9.2	1472
Clamp 80	DIN 7451555		160	2.3	368
Locking plate					
1x45x125		St.00	160		
Nut M20			320		

ELEVATOR B=315 (Nos. - 4 el.)

Driving shaft ϕ 85x875	A 127/1	St50.11	1	39	39
Driving wheel half ϕ630/85	A 122	GG22	4	55	220
Distance bush ϕ140/85x40	a 127/2	GG22	1	6	6
Connecting pin ϕ20x370	A 127/3	St42.12	12	1	12
with rings ϕ40/20x20	A 127/4	St42.12	24	0.15	3.6
Nut M 20	DIN 934	St38.13	24		
Spline 22x14x160	DIN 6885	St60.11	2		
Spline 20x12x105	DIN 6885	St60.11	1		
Drag blocks axle ϕ70x593	A 121/1	St50.11	1	18.2	18.2
Drag block half ϕ630/70	A 122	GG22	4	55	220
Distance bush ϕ 130/70x40	A 121/3	GG22	1	3	3
Spline 20x12x160	DIN 6885	St60.11	2		
Bearing casing 160x200xϕ110	A 121/2	GG22	2	7	14
Labyrinth ϕ118/60x43	A 121/6	"	2	2	4
Bucket 315 DIN 15234	A 136	St.oo		11.92	
for elevator H=17			62		739.04
" H=21.5			82		977.44
" H=22.85			90		1072.8
" H=22.85			90		1072.8
9-linked chain AC 16	DIN 764			5.2	
for elevator H=17			124		644.8
" H=21.5			164		852.8
" H=22.85			180		936.0
" H=22.85			180		936.0
Clamp 63	DIN 7451555			1.2	
for elevator H=17			124		148.8
" H=21.5			164		196.8
" H=22.85			180		216.0

for elevator H=22.85		180	216.0
Locking plate 1x35x100	St 60		
for elevator H=17		124	
" H=21.5		164	
" H=22.85		180	
" H=22.85		180	
Nut M 16			
for elevator H=17		248	
" H=21.5		328	
" H=22.85		360	
" H=22.85		360	

GRAB CRANE, 5t x 20 m

Bridge travel mechanism				
Driving wheel ϕ 500 with end face caps	Z217.25-2		2	320.3
Driven wheel ϕ500 with end face caps	Z217.29-2		2	225.18
Wheel axle ϕ70x325	3-45620		4	38.4
Driving wheel rim m=10, Z=50	28.001-00.3	St52.81	2	
Gear-pinion m=10,Z=19	4-45368	C 45	2	31.6
Transmission shaft end section			2	
Transmission shaft section ϕ 50x			2	
Transmission shaft section ϕ 50x			2	
Transmission shaft section ϕ 50x			2	
Transmission shaft coupling ϕ 50	23.002.00-2		8	71.76
Transmission shaft bearing casing with cap	Z217.31-1		12	200.76
Gear-box gear pinion m=5, Z=17	3-44757	C 60	1	
Gear-box driving gear axle			1	
Gear-box driven wheel m=5, Z=96	3-44758	C 45	1	
Gear-box driven wheel axle			1	
Brake pulley			1	
Semi-coupling			1	
Coupling pin			4	

Trolley travel mechanism

Trolley wheel			4		
Trolley driving wheel shaft			2		
Trolley wheel axle			2		
Trolley wheel bearing axle box with caps			8		
Trolley transmission section ϕ 55x505	Z345-75-3		1	10.5	10.5
Trolley transmission section ϕ 55x705	Z345-77-3		1	15	15
Trolley transmission coupling ϕ 55	Z345-04-2		4		69
1 stage driving shaft-pinion m=2, Z=34	Z345-31-3	VMS135	1		
1 stage driven wheel m=2, Z=88	Z345-32-3	St60.11	1		
II stage driving shaft-pinion m=3, Z=34	Z345-33-3	St70.11	1		
II stage driven wheel m=3, Z=80	Z345-34-3	St60.11	1		
III stage driving sgaft-pinion m=5, Z=23	Z345-35-3	St70.11	1		
III stage driven wheel m=5, Z=46	Z345-36-3	St60.11	1		
III stage driven wheel shaft			1		
Brake pulley			1		
Semi-coupling driving			1		
Driving coupling pin			4		

Lifting and closing mechanism

Drum ϕ 400 B			1		
Drum ϕ 400 A			1		
Drum toothed clutch			2		
Bearing casing with end face cap			2		
1 stage driving shaft-gear m=4, Z=24	Z345-07-3a+ 3-44537	VMS135	2		
1 stage driven wheel m=4, Z=72	Z 345-09-3	St60.11	2		
II stage driving shaft-gear m=6, Z=19	Z345-06-2	VMS135	2		
II stage driven wheel m=6, Z=58	Z345-08-3	St70.11	2		
III stage driving shaft-gear m=8, Z=15	Z341-105-2	VCMO150	2		
III stage driven wheel m=8, Z=50	Z341-108-3	VMS135	2		
III stage driven wheel shaft			2		
Brake pulley			2		
Driving semi-coupling			2		
Coupling pin			12		
Hydropusher	MD6-315	SSW	2	32	64
Differential		1M393 SSW	1	36	36
Chain gear t=9.525, Z=8	3-45550		2	0.16	0.32
Chain gear t=9.525, Z=40	3-45549		1	2.15	2.15
Chain gear t=9.525, Z=40	3-45548		1	0.73	0.73
Chain 1x9.525x3.2x6			1.8m	0.39	0.39

G R A B 1.75 m^3

Wire rope wheel ϕ 400	6
Rod axle bracing to the bucket	4
Rod axle bracing to the bucket traverse	
Traverse block axle	1
Bucket head block axle	1
Closing rope bracing thimble	2
Bucket parts axle bracing to head	4
Tothed sector	4
Lifting rope rocker jaw	2
Rocker bracing axle to traverse	1
Lifting rope bracing axle to rocker	2
Wire rope guide	2

CRUSHER 2DD-80

Shaft ϕ 580x2385	7004.301.2	St 60.11	2	730	1460
Hammer holder 1160x450x120	7004.303.4	gSt52.81	12	225	2700
Hammer 235x260x385.5	7004.302.2	St KHS	12	76.6	920
Flywheel ϕ1650x400	7004.310.3	Ge18.91	2	2700	5400
Shearing pin ϕ30x85	7004.316.5	St42.11	4	0.6	2.4
Bearing casing 770x330x515	7004.300.8	composite	2	213	426
Bearing casing 510x240x325	7004.300.9	composite	2	65	130
Grate bar △100x850	7004.201.2	St12Mn	34	33.5	1139
Armour plate 430x200x175	7004.457.2	gSt12MnCr	4	28	112
Armour plate 430x150x340	7004.458.2	gSr12MnCr	4	52.5	210
Armour plate of the manhole 375x100x50	7004.459.2	gSr12MnCr	8	11	88

Appendix 4

OBLIGATORY STOCK OF THE CONSUMABLE AND MOST IMPORTANT DETAILS OF THE MAIN TECHNOLOGICAL EQUIPMENT

Nos.	Description of units & details	Unit of measur.	Appr. life time	Nos of details per unit	Nos of obligat. stock det.	Remarks
1	2	3	4	5	6	7
	ROTARY KILN					
1.	Pinion shaft rolling bearings	pcs		2	2	
2.	Rest rollers	"		4	1	
3.	Rest roller inserts	"		8	2	
4.	Thrust roller rolling bearings	set		2	1	
5.	Sinter zone ring	run m			4	
6.	Discharge end segments	set	12 months	1	1	
	KILN MAIN DRIVE GEAR-BOX					
7.	Driving shaft-gear	pcs		1	1	
8.	Driving shaft-gear rolling bearings	set		1	1	
	FULLER COOLER					
1.	Eccentric shaft bearing brasses	pair		2	2	
2.	Connecting rod	pcs		2	1	
3.	Driving shaft	pcs		1	1	
4.	Rest rollers	"		4	2	
5.	Connecting rod bushing from the driving shaft side	"		2	2	

1	2	3	4	5	6	7
Roller bushing		pcs	6 months	4	4	
7.	Rest roller journal	"		2	2	
8.	First chamber grate bars	set	3 months	1	1	
9.	2 nd chamber grate bars	"		1	0.5	
10.	1st chamber grate plate supports	"	6 months	7	7	
11.	Top wear plate BS-1	"	"	2	2	
12.	Top wear plate BS-2	"	"	6	6	
13.	Top wear plate BS-3	"	12 months	12	6	
	COOLER DRIVE GEAR-BOX					
14.	High-speed shaft-gear					
15.	High-speed shaft rolling bearings	set		1	1	
	DRAG CHAIN SK-15					
16.	Scraper	set		1	0.25	
17.	Connecting pin	"		1	0.25	
	DRAG CHAIN SK-30					
1.	Guide support, lower	pcs	6 months	31	15	
2.	Scraper	set		1	0.25	
	Conveyor drive					
3.	Gear-box high-speed shaft-gear	pcs		1	1	
4.	High-speed shaft gear-box bearings	set		1	1	
	RAW MILL & CEMENT MILL					
1.	Inlet plate liners	set per mill	10 m cement mill	1	1	lifetime is given for cement mill only

1	2	3	4	5	6	7
2.	1st chamber plate liners	set	8 m	1	1	lifetime for cement mill only
3.	2nd chamber plate liners	"	18 m	1	1	"
4.	Partition					
	a) solid dector	"	8	1	1	"
	b) slotted sector	"	15	1	1	"
5.	Journal bearing brasses	pcs		4	1	lifetime for both m.
6.	Pinion	"		2	1	"
7.	Pinion bearing brass	pair		6	2	"
8.	Discharge screen	set	48 m	2	1	"
	Mill drive					
9.	Gear-box driving shaft-gear	pcs		1	1	one per each mill
10.	Shaft-gear bearing brasses	pair		4	2	for both mills
11.	Driven shaft-gearbox bearing bushings	"		4	2	"
12.	Toothed clutch	pcs		2	1	"
	HAMMER CRUSHER					
1.	Shaft	pcs		2	1	
2.	Hammers	set	48 m	1	1	
3.	Hammer holders	"	"	1	0.5	
4.	Fire bars	"		1	1	
5.	Liners	"		1	1	
6.	Shaft rolling beqrings	pcs		4	2	one of each size

1	2	3	4	5	6	7
	GRAB OVERHEAD CRANE					
1.	Bridge driving and driven wheels	set	3 m	1	1	two of each
2.	Trolley driving & driven wheels	"	12 m	1	1	
3.	Bridge transmission	"		1	0.5	
4.	Rope wheel	"		1	1	
	Bridge travel mechanism gear-box					
5.	Pinion	pcs		1	1	
6.	Pinion shaft rolling bearings	"		2	2	
	Trolley travel mechanism gear-box					
7.	Driving shaft-gear	"		1	1	
8.	Driving shaft-gear rolling bearings	"		2	2	
	Lifting&closing mechanism gear-box					
9.	Driving shaft-gear	"		2	2	
10.	1st stage gear-wheel	"		2	1	
11.	Driving shaft-gear rolling bearings	"		4	2	
12.	Second shaft rolling bearings	"		4	2	
13.	Third shaft rolling bearings	"		4	2	
	ROPEWAY					
1.	Line couplings	set		1	0.25	1 set for the ropeway
2.	End couplings	"		1	0.25	"
3.	Divert, line and turn shoes	"		1	0.25	"
4.	Rest rollers	"		1	0.5	"
5.	Waggon locks	"		1	0.5	"
6.	Waggon hangers	"		1	0.5	"
7.	Waggon running rollers	"		1	0.5	"

APPENDIX No. 5

LIST OF FAULTS

determining the necessity of repairs of the details and unfitness thereof (by means of measurement and out inspection)

Details	DEFECTS	
	to be eliminated	determ. unfitness of detail
1	2	3
SHAFTS AND AXLES	1. Residual destortions due to bending	1. Cracks
	2. Separate scratches and the similar on working faces	2. Residual destortions due to twisting
	3. Longitudinal cracks with the length being not more than 10 % of the length and depth being not more than 10 % of the marginal shaft diameter.	3. Tear-and-wear of working surfaces exceeds 5 % of the normal diameter at the impact load and 10 % at the normal one.
	4. Ovality and taper of necks exceed 0,0002 of the diameter.	4. Tear-and-wear of slit faces.
	5. Tear-and-wear of key-grooves being not more than 15 %.	
	6. Hollow chamfers damage.	
	7. Damage of different threads.	
	8. Centre holes damage.	
HUBS	1. Oil groove damage.	1. Through cracks and shears.
	2. Slight scratches on working faces.	2. Clearance expansion between the shaft and hub due to abnormal tear-

../.2

1	2	3
		and-wear.
SLIDE BEARINGS	1. White metal pouring damage (cracks, scratches, overflow, untight adjustment).	1. Cracks in bronze and cast iron brasses.
	2. Abnormal tear-and-wear of the white metal pouring	2. Abnormal tear-and-wear of bronze and cast iron brasses (upper clearances).
	3. Lack of lateral clearances.	
TOOTH WHEELS including GEARS	1. Cracks in the rim, spokes and spider of marginal drives.	1. Cracks in the rim, spokes and spider of main drives (including hoisting mechanisms).
	2. Break of not more than 2 teeth in turn (in the marginal drives).	2. Break of two and more teeth (along more than 50 % of the length). in the main drives.
	3. Break of 2-3 teeth in the main drives (50 % of the length).	3. Abnormal tear-and-wear of the teeth thickness.
KEY JOINTS	1. Clearance between the spider and shaft exceeds the tolerance for the slide fit.	
	2. Spline loose fit.	
	3. Availability of linings under the spline.	
	4. Keygroove width expansion exceeds 15 %.	
WHEELS AND DRUMS FOR ROPES	1. More than 2 mm expansion of the keygroove width against the normal one.	1. Cracks in cast iron details.
	2. Spider fitting orifice. expansion.	2. Through cracks in metal detail rims or spiders.

../.3

1	2	3
	3. Groove surface tear-and-wear exceeds 3 mm.	3. Tear-and-wear of slits, spider orifice expansion.
	4. Thread holes damage.	4. Tear-and-wear of the drum wall exceeds 0,1 of the initial thickness.
BRAKE BELTS AND SHOES	1. Tear-and-wear of frictional linings exceeds 30%	1. Cracks
	2. Tear-and-wear of rivet heads (being submerged less than 25% of the initial thickness of linings).	2. Sharp overbending and tears.
	3. Clearances in fixing of frictional lining to the belt and shoes.	
	4. Loosening of support loops fixing to the belt.	
	5. Oiled frictional linings.	
SUPPORT WHEELS OF HOISTING MECHANISMS	1. Flats on the wheels rolling faces.	1. Tear-and-wear of the bead thickness exceeds 50%.
	2. Thread holes damage.	2. Rim tear-and-wear exceeds 40% on thickness.
	3. Irregular wear of the rim rolling faces (more than 15 % of the initial thickness).	3. Through cracks
	4. Non-through cracks.	
	5. More than 0,005 D difference between the driving wheels diameters.	
LOADING AND WELDED CHAINS	1. Cracks in the joints of links.	1. 30 % wearing of the rod initial diameter.
	2. Notches and craters in the joints of links.	
PLATE LINK CHAINS	1. Partial damage of plates and rollers.	1. Cracks in plates.

../.4

1	2	3
		2. Tear-and-wear of roller necks and holes in plate cheeks; total wear exceeding 20% of the normal diameter.
CHAIN GEARS	1. Teeth wear on thickness does nor exceed 15%. 2. Cracks in the disc or spokes (spokes quantity being not more than 25%).	1. Broken teeth. 2. Slip tear-and wear. Expansion of the fit holes. 3. Cracks in the rim or spider.
GEAR-BOX CAST IRON CASINGS	1. Thread holes damage. 2. Through cracks of casing, which cracks can be welded. 3. Deformation of joint faces.	1. Cracks in the fit places of bearings.
ROTARY KILN FORGING RINGS	1. Separate cracks of any length. 2. Separate bulges.	1. Metal tear-and-wear exceeds 40%. 2. Structural changes of metal being resulted in cracks appearance and metal inweldability. 3. 20-25% deformation of the surface.
ROTARY KILN BANDAGES	1. Tear-and-wear of the under-bandage linings and plates. 2. Cracks. 3. Working face expansion or taper wear.	1. Box bandage rolling face wear is 50% of the rim thickness. 2. Cracks which can not be eliminated by means of welding. 3. Progressing expansion of working face.
REST ROLLERS	1. Roller taper wearing exceeds 10 mm on the diameter.	1. Roller rim wear exceeds 50 % on thickness.

1	2	3
	2. Scratches on the roller axis necks. 3. Loosening of the roller fit on the axis.	2. Cracks along the rim, spider or roller axis.
MILL CASING	1; Local damages such as cracks, deformation and wearing.	1. Walls wear exceeds 30% on thickness.
MILL ENDS	1. Cracks, taper wear and scratches on journals.	1. Wall wearing exceeds 30% on thickness.
MILL LINERS	1. 30% wear on thickness is restored by means of overmelting.	1. Wearing on thickness exceeds 70%.
PARTITIONS AND PLATE GRATES OF THE MILLS	1. Holes expansion.	1. Wearing on thickness exceeds 50%.
BLADE WHEELS OF THE FANS AND GAS EXHAUST BLOWERS	1. Vibration	1. Wear of blades exceeds 70% on thickness.

Appendix No 2

INTER OFFICE MEMORANDUM

Addis Ababa, March 7th, 19 72

From: Chief of Laboratory

To: A.A. Plant Manager

Subject: Sampling

Sampling of materials is as important as the test itself. The results of the test will have no significance if the sampling is not done properly. Every possible precautions should be taken to make sure that the sample contains both the chemical and physical characterstics of the material it represents.

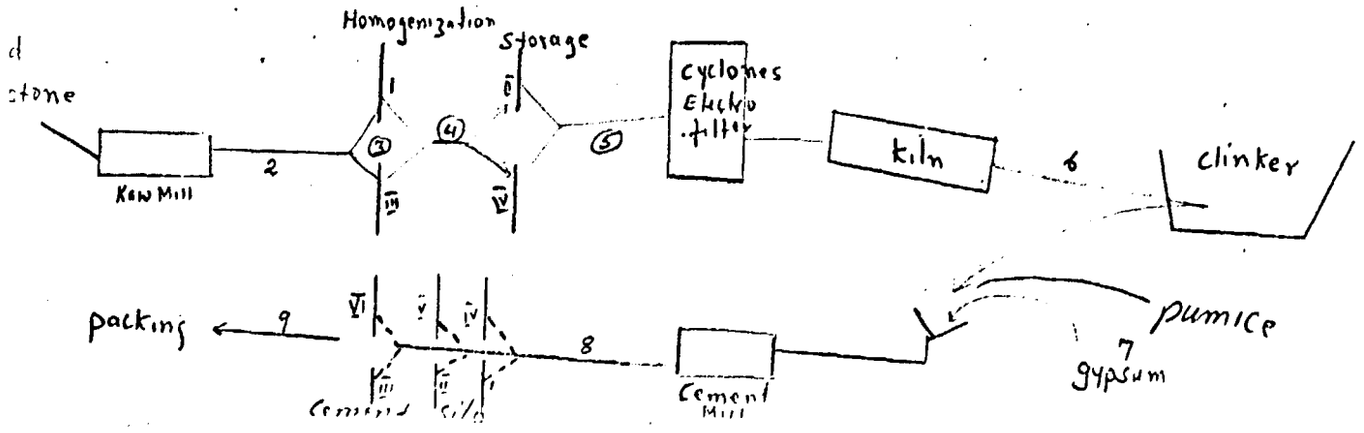
Sampling of raw materials to determine their suitablity for use in the cement plant is done at the site of the quarry. Several samples are taken at several locations and all possible depths for the whole area of the deposit. Sampling of raw materials for the purpose of quality control in the process of production is done at the feeder, truck or heap. A bit of the material is taken from several points on the heap, feeder or truck.

Sampling of raw mixture and cement are done according to chart below. See sampling locations indicated (1-9) in the flow diagram of the cement production process.

Sampling of clinker for liter weight - the clinker retained on any appropriate sieve could be used for this purpose i.e. particles of clinker with certain sizes are used for liter weight determination.

Sampling of clinker for physical and chemical tests is done in such a way that it includes all sizes of clinker produced.

Sample	Frequency of sampling	Site of sampling	Purpose of sampling
Clay	Once a day	feeder or heap	% moisture
	" " "	each truck	" "
	once a day for a month	from heap and for truck	complete chemical analysis
Limestone	once a day	feeder	% moisture, % $CaCo_3$
	" " "	heap and/or truck	" " , % $CaCo_3$
	" " "	" " " "	complete chemical analysis
	for a month		
Gypsum	Three times a day	feeder	% So_3
	for a week	"	chemical analysis
	Monthly		
	every hour daily	"	kilogram gypsum consumed per minute
Pumice	once a day	each truck	% moisture
	daily for a week	" "	% $CaCo_3$ and complete chemical analysis
Raw mixture	every half hour	on the way to homogenization Silo	% $CaCo_3$
	every hour	on the way to homogenization silo	% moisture and fineness
	" "	Top and bottom of homogenization silo	% $CaCo_3$
	" "	discharge from storage silo	% $CaCo_3$
	every half hour daily	discharge from storage silo	% $CaCo_3$ and complete chemical analysis
	once in 24 hours	balance and electro filter	% $CaCo_3$
	once in 24 hours as required	balance and electro filter	% $CaCo_3$ and complete chemical analysis



Sample	Frequency of sampling	Site of sampling	Purpose of sampling
Clinker	every half hour	end of fuller cooler	liter weight
	every half hour daily	" " " "	complete chemical analysis
	every half hour monthly	" " " "	physical tests
Cement	every hour	on the way to storage silo	fineness
	every hour for each shift (three times a day)	on the way to storage silo	% So_3
	every hour daily for a week	on the way to storage silo	complete chemical analysis
	every hour daily for a week	on the way to storage silo	physical tests
	every hour daily for a week	packed cement	physical tests
Fuel oil	on arriving at the plant site	from each truck or railway wagon	% sulfur %, water gross caloric value and specific gravity
	as required	going to kiln	% sulfur %, water gross caloric value and specific gravity
	as required	depot	% sulfur %, water gross caloric value and specific gravity
Gas	four times a day at an interval of 2 - 3 hours	feed end of kiln	CO_2, CO, O_2
	as required	cyclones	CO_2, CO, O_2
	as required	exit electrofilter	CO_2, CO, O_2

This new schedule is subjected to new chemical analysis procedures and adequate laboratory equipments.

cc. Gentosh Unido Expert

Appendix No. 7

Technological Chart No. 1.

RAW MATERIAL QUARRY

No.	Description and type of the quarry aggregate	Material to be quarried	Max. Sizes of the material particles, mm		Energy Consumption for quarrying K.W.H./T	Transport means to the treating aggregate
			In the quarry face	After the quarry aggregate		
1	2	3	4	5	6	7
1	Excavator Duro Dakovic type, Vbucket = 1.75 m^3	Limestone	400	400	0.33	Dump trucks, Duro Dakovic typo, V = 4 m^3
2	Dredger, Duro Dakovic type, Vbucket = 1.3 m^3	Gypsum	400	400	-	
		Sandstone	Massif	Smalls	-	
3	Excavatpr.Chaseside type, SL-900 Vbucket = 1.0 m^3	Clay	Massif	Smalls	-	

Technological chart No. 2

Raw material crushing.

Crusher type and characteristics	Material to be crushed	Max. sizes of the material particles m.m.		Crusher capacity t/h	Energy consumption for material crushing K.W.H./t
		coming into the crusher	coming from the crusher		
1	2	3	4	5	6
Hammer crusher Duro Dakovic 2 DD - 80 type	Limestone	400	30	80	.0.71
	Gypsum	400	30		

Technological chart No. 3

Raw material transportation

No.	Description and type of transport means and equipment	Material to be transported	Moisture of the material %	Number of loadings	equipment or system through put t/h	Energy consumption K.W.H./t
1	2	3	4	5	6	7
1.	Ropeway L=10 km:	Limestone	2.0 (5.0- rainy season)	1	25.0	3.73
		Gypsum	-	1		
		Sandstone	5.0	1		
2.	Dump trucks, FIAT 682/3 with a capacity of 22 tons each	Clay	22.0 (30.0- rainy season)	-		

Technological Chart No. 4.

RAW MIXTURE GRINDING

Mill type and Characteristics	Cement type and mark	Raw Material being Charged into the mill			Admixture for correction	
		Material description	Max. size of particles mm	Material max. moisture content %	Admixture description	Consumption kg/t of raw mixture
1	2	3	4	5	6	7
Separator raw mill ⌀ 2.6x5.7 m, two chambered with the simultaneous drying of the material	Ordinary Portland Cement	Limestone	30	2.0 (5.0-rainy season)	Sandstone	10
		Clay	Smalls	22.0 (30.0-rainy season)		

Technological Chart No. 4.

RAW MIXTURE GRINDING

Mill type and Characteristics	Cement type and mark	Raw Material being Charged into the Mill			Admixture for correction	
		Material description	Max. size of particles mm	Material max. moisture content %	Admixture description	Consumption kg/t of raw mixture
1	2	3	4	5	6	7
Separator-type mill ϕ 2.6×3.7 m, two chambered with the simultaneous drying of the material	Ordinary Portland Cement	Limestone	30	2.0 (5.0-rainy season)	Sandstone	10
		Clay	Smalls	22.0 (30.0-rainy season)		

Technological chart No. 4 (Continuation)

Raw mixture grinding.

Characteristics of ready production						
Fineness %				Moisture %		$CaCo_3$ Content %
residue on 900 sieve		residue on 4900 sieve		norm	tolerance	
norm	tolerance	norm	tolerance			
8	9	10	11	12	13	14
0	+0.2	10.0	± 1.0	2.5	± 0.5	in depends of L.S.F.

Technological Chart No. 4 (Continuation)

RAW MIXTURE GRINDING

Pressure Before Mill	Agip (gas) temperature °C				Corrected raw flour Min. margin for the Kiln operation hours	Mill Chambers length m	
	Before Mill		After Mill				
	Norm	Tolerance	Norm	Tolerance		I	II
15	16	17	18	19	20	21	22
80 - 100	475	± 25	60	+ 15	24	2.2	3.5

Raw mixture grinding.

Partition useful section %		filling of the mill with grinding media t			specific consumption of grinding media kg/t dry material	r.p.m. mill
		description and size of grinding media	Chamber			
I	II		I	II		
23	24	25	26	27	28	29
15.8	15.5	balls Ø 90	2.2		0.128	19.0
		" Ø 80	6.6			
		" Ø 60	3.9			
			total 12.7			
		balls Ø 50		12.0		
		" Ø 40		11.5		
				total 23.5		

Technological Chart No. 4 (continuation)

RAW MIXTURE GRINDING

Mill main motor ammeter indices a		Specific energy consumption for dry material K.W.H./t	Mill Capacity on dry material t/h	Heat Consumption Kcal/kg. dried material
Norm	Tolerance			
30	31	32	33	34
130	+ 10	30.0	18.0	38.0

Technological chart No. 4

Dust precipitator

Dust precipitator type and characteristics	gas temperature after precipitator °C		pressure after precipitator mm W.C.		degree of gases dusty gr/nm³	
	norm	tolerance	norm	tolerance	before precipitator	after precipitator
35	36	37	38	39	40	41
Bag Filter 6 KF - 150-90° L, active filter area F=150 m², capacity 28000 m³/h of dusty gases	70	±10	240	±10		

Technological Chart No. 5.

CLINKER BURNING

Kiln type and Characteristics	Cement kind and mark	RAW MIXTURE CHARACTERISTICS					
		Moisture %		Fineness %			
		norm	tolerance	residue on 900 sieve		residue on 4900 sieve	
				norm	tolerance	norm	tolerance
1	2	3	4	5	6	7	8
Rotary kiln Ø 2.6 x 34 m with one branch system of 4 - staged cyclone heat exchangers, Humboldt type	Ordinary Portland Cement	2.5	± 0.5	0	+ 0.2	10.0	± 1.0

Technological chart No. 5 (continuation).

Clinker burning.

Raw mixture characteristics					Fuel characteristics				
L.S.F.		S.M.		I.M.	moisture %	S content %	calorific value kcal/kg	of mazout heating	
norm	tolerance	norm	tolerance					norm	tolerance
9	10	11	12	13	14	15	16	17	18
0.97	+0.02 -0.01	1.9	± 0.1	no norm	up to 0.5	up to 2.6	min 10260	95	± 5

Technological chart No. 5 (continuation).

Clinker burning

Clinker characteristics							
Liter weight gr		max. content of free lime %	L.S.F.		S.M.		I.M.
norm	tolerance		norm	tolerance	norm	tolerance	
19	20	21	22	23	24	25	26
1375	± 75	0.8	0.94	+0.02 -0.01	21	± 0.1	no norm

Technological chart No. 5 (contiruation.).

Clinker burning.

Flue gas characteristics.

temperature after the kiln °C		gas composition after the kiln						pressure mm WC					
		CO_2		CO		O_2		in the kiln head		at the kiln cold end		before gas exhaust blower	
norm	tole-rance	norm	tole-rance	norm	tole-rance	norm	tole-rance	norm	tole-rance	norm	tole-rance	norm	tole-rance
27	28	29	30	31	32	33	34	35	36	37	38	39	40
850	± 25°	21	± 3	0	+ 0.2	4	± 1	3	+3	15	±5	250	±50

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Technological Chart No. 5 (continuation)

CLINKER BURNING

Primary air characteristics			r.p.m. at working speed per min.	Kiln output t/h	Heat consumption for clinker Kcal/kg	Sinter zone refractory lining		
fan capacity m^3/h	Speed at the injector out section m/sec.					Refractory type	Refractory life time days	Refractory consumption kg/t of clinker
	norm	tolerance						
41	42	43	44	45	46	47	48	49
2600	60	± 10	1.2	9.5	1080	Crome magnezite basal rubinal	300	

Technological chart No. 5 (continuation).

Clinker burning.

Cyclone heat exchangers								
Gas temperature at the cyclone inlet °C				pressure mm WC at the cyclone IV inlet	loss on ignition of material		Raw material temperature °C	
IV	III	II	I		entering into cyclone I	coming out cycloneIV	entering into cyclone I	coming out cyclone IV
50	51	52	53	54	55	56	57	58
750-850	600-700	450-560	200-300	20-30	35		60-70	600-700

CLINKER BURNING

CLINKER COOLER					
Type and characteristics	Clinker temperature coming out of the cooler °C	Air pressure under the grate plates mm WC		Temperature °C	
		Chamber No.1	Chamber No.2	Secondary air	first row of grate plates
59.	60	61	62	63	64
Grate Cooler with the grate dimensions being 1.2 x 10.25 m and slope of 20%, fuller type.		50 - 90	40 - 70	800 - 950	Max. 300

Technological Chart No. 5

CLINKER BURNING

DUST PRECIPITATOR				
Dust precipitator type and characteristics	Gas temperature before precipitator °C	Pressure before precipitator mm WC	Degree of gases dusty gr/nm³	
			before precipitator	after precipitator
65	66	67	68	69
Electro-filter EI5 - 5 type	160 - 200	140 - 200	80	0.5

Technological chart No. 6

Cement grinding.

Mill type and characteristics	Cement type and mark	Clinker characteristics		
		clinker type	max. particle sizes m m	max. temperature ^{o}C
1	2	3	4	5
Cement Mill Ø 2.4 x 6.0 m separator, two chambers	Ordinary Portland Cement	Rotary Kiln clinker	30	80-100

Technological Chart No. 6 (continuation)

CEMENT GRINDING

Gypsum and admixture characteristics				Fineness of cement %				
admixture description	% of admixture involvement	Max size of particles mm	Maximum moisture %	residue on 900 sieve		residue on 4900 sieve		Specific surface cm^2/gm
				norm	tolerance	norm	tolerance	
6	7	8	9	10	11	12	13	14
Gypsum	4	30	5	0	+ 0.1	5	+ 1	min.2700
Pumice	8	2	5				- 2	

Technological Chart No. 6 (continuation)

CEMENT GRINDING

Pressure mm WC		Max. temperature of cement coming from the mill °C	Mill chambers length m		Partition useful section %	
before the mill	after the mill		I	II	I	II
15	16	17	18	19	20	21
5 - 10	80 - 100	60 - 70	2.04	3.78	14.7	13.4

Technological chart No. 6 (continuation)

Cement grinding

filling of the mill with grinding media			specific consumption of grinding media kg/t cement	p.p.m. mill
description and size of grinding media	chamber			
	I	II		
22	23	24	25	26
balls Ø 90	2.3		0.228	20.8
Ø 80	3.7			
Ø 60	6.0			
total	12.0			
balls Ø 50		11.0		
Ø 40		7.0		
Ø 30		3.5		
total		21.5		

Technological chart No. 6 (continuation).

Cement grinding

mill main motor ammeter indices a		Energy consumption for cement grinding K.W.H/t	Mill capacity t/h	Separator		
norm	tolerance			Type and Characteristics	residue on 4900 sieve	
					in the material entering separator	in the ready production
27	28	29	30	31	32	33
120	± 5	36	14	Air separator, SV-14'-90° Sturtevant type, ø 3250, capacity - 70t/h	45	3-6

Technological Chart No. 6.

CEMENT GRINDING

Dust precipitator type and characteristics	Dust precipitator: pressure mm WC after precipitator		Dust precipitator: Temperature after precipitator °C		Degree of gases dusty gr/ nm³	
	norm	tolerance	norm	tolerance	before precipitator	after precipitator
34	35	36	37	38	39	40
Bag filter, 6 KF-150-90°L, dimensions being ∅ 2642 x 3500, active filter area F = 150 m², capacity-28000 m³/h of dusty gases.	210	± 10	25	± 5		

FINAL REPORT

by K.A.VEJLIVTSEV, UNIDO expert, covering phase I and II of the Contract between the United Nations Industrial Developement Organisation and Technopromexport of January 14, 1971.

INTRODUCTION

The present report is stipulated by Contract No.70/75 concluded between the United Nations Industrial Development Organization and Technopromexport for the provision of services relating to the assistance to the Ethiopian Cement Corporation for its cement factory located in Addis-Ababa.

In accordance with the programme previously agreed with the administration of the Ethiopian Cement Corporation I acquainted myself with the equipment of the factory its exploitation and its structure.

While studing the running and the structure of the equipment in question I proposed some recommendations aimed at the improving of the organiztion of repairs and increasing the time of operating service life of some parts and assemblies of the main technological equipment.

Special attention was paid to the improving of system of organization of repairs. The proposed system is also acceptable for implementation at the cement factory in Dire Dawa.

OPERATION AND REPAIR OF THE EQUIPMENT

Operation of the equipment comprises a complex of organisation and technical events consisting of the following:

- systematic training of the operating personnel with a view to improve qualification as well as provide regular instruction and checking of knowledge;
- availability of the equipment to be maintained by way of proper lubrication and timely maintenance;
- elaboration and periodical revision (according to change of the local conditions) of the operating manuals. Duties, rights and responsibilities of workers should be stipulated therein. Routine of maintenance during operation; efficient measures to be taken under the accidents or disturbances in the technilogical process, procedure of inspection of the equipment are to be set forth in the operating manuals;
- opportune and qualicative repair, replenishment of the obligatory stock of spares and materials.

Organisation of training

During erection of the factory specialists from Yugoslavia, indigenous shift foremen as well as Chief of production realized training of the local operating personnel. Later on systematic training was forgotten in spite of the fact that there existed the urgency of it. It should be noted that the burners of the rotary kiln are in great need of such a training. The workers do not take exams aimed at checking of their knowledge.

Maintenance of the Equipment

The technical condition of the equipment depends upon meeting of the requirements stipulated in the operating

manuals as well as requirement concerning maintenance, lubrication and inspection of the equipment when taking over and acceptance of the shift.

The standard instructions on all kinds of the main technological equipment are available at the factory. The instructions in question include the data on the arrangement, commissioning, maintenance and lubrication of the equipment. (These instructions were worked out by the Design Bureau on the Civil Engineering, Zagreb, Yugoslavia). But they do not comprise a number of necessary provisions concerning duties, rights and responsibility of the operating personnel, monthly maintenance as well as the procedure of inspection of the equipment.

On the basis of the above instructions and with the account of the local conditions a group of engineers of the factory elaborated the operating manuals for the main technological equipment but they have not yet been approved by the Board of the Cement Corporation.

Lubrication of the equipment is effected in compliance with the recommendations proposed by the technical staff of "Shell" upon agreement with the engineers of the factory on the basis of the above mentioned standard instructions.

The aim assigned to the said recommendations was to cut the assortment of the lubricant materials. As a result the number of these materials was reduced to 15 from 31 previously provided for the purpose.

All materials supplied by "Shell" are of high quality; but it should be noted that the periodicity of oil refilling of the main technological equipment is not set forth on the recommendations.

Observation of the Equipment Condition

Limestone and gypsum quarries

Excavator, EB-45 type

The excavator working equipment is in order, all joint and solid

connections are characterised by good repair. The beam racks are well fixed. The tear and wear of the rack teeth as well as rack gears is midget, practically no wear of saddle bearings, no cracks in the weld joints of the boom. Rope wheels and drums are sound, the turning mechanism details are in order; normal gearing (along length and height of the tooth) can be observed between the gear and turning mechanism rim. The contact in the running mechanism between the longitudinal shaft bevel driven gear and transverse shaft bevel gear is not sufficient - about 20-25 per cent both along the length and height of the tooth; good gearing in the gear drives; good condition of the supporting roll drag and driving chain gears. All the units of the excavator are lubricated properly.

Crushing Department

The acceptance bin is in order.

Plate feeder

All the details of the feeder in question are in order, good tension of the canvas should be marked. The chain plates as well as rollers are exposed to wearing but still can be exploite for a long time; one can observe good tightning of the details. Centering of the high-speed coupling is far from satisfactory - the distortion between the semi-coupling is about 1.5 mm. The coupling on the motor shaft is fixed by way of the electrical welding (this is quite an infringement).

Toothing between the gears of the plate feeder drive open gear has a big radial play - ab. 6-7 mm and it leads to the irregular wearing of the teeth along the height.

Tear and wear of the pinion teeth on thickness is about 20-25 per cent and that of the driven gear teeth - ab. 15 per cent.

The plate feeder is open from above, hence when discharging the material from the dump trucks the dust drops into the mobile interconnection and causes its premature wearing.

Crusher, 2DD-80 type

The crusher shell is in good repair. Smooth operation of the crusher testifies to the good balancing of the rotors. The hammers and grate bars are in need of restoration or replacement due to their great wearing.

Since wear of the hammer holders is insignificant they still can be operated. The liner plates of the shell are worn out and further exploitation may cause the shell wearing and appearance of cracks.

The play control device between the hammers and the grate plate is sound. One could state the normal operation of the shaft bearings.

There are no obvious defects on the flywheels - no cracks both on the rims and spokes. Good condition of bracing. Much dust coming from the crusher precipitates in the interconnections of the mobile details and accelerates their wearing.

Belt Conveyor

During operation the belt run-out is not observed. Sufficient control of the belt drag is provided by way of a drag device. The connection of ends is well executed. The support rollers, driving and pulley drums are in good repair, there are no faults in the belt drive.

All the overflow pipes are sound. The drives of the technological equipment are interlocked; pre-starting signalling and emergency switches are available. The auxiliary equipment as well as the material transport means (from the quarry face to the crushing department)are in order

Ropeway

The ropeway is in good repair. There are no visible faults (cracks) in the rims and spokes of the vertical and horizontal pulleys of the driving and drag stations.

The pull and carrying ropes are well lubricated and have no brakes of the surface wire. The couplings and shoes of the line are in a good state.

One of the counterbalances of the carrying ropes (at the first intermediate pull station) has a very midget action radius, but the rest - a sufficient one. The supports are sound. The rest rollers are changed and lubricated in good time.

The waggon locks and switches actuate well, there were no cases of their failure. The waggon hangers are systematically checked and lubricated; there were no cases of the waggon spontaneous tipping. The drive is kept clean. All the drive details are well lubricated and have no wearing. In order to provide proper control of the operation and condition of the details and units the ropeway is equipped with all the necessary devices and facilities - sound and light signalling, direct telephone communication between the terminus and control stations, special equipment to clean and lubricate the ropes etc. 4 controllers effect daily checking of the ropeway.

Grinding Department and Raw Material Storage

Metal Structures

The metal structures are covered with a layer of the set dust. The layer is thicker along the row A between axles 3-8. The dust prevents from thorough inspection of the metal structures.

The brake truss bolt bracing got loosening along both rows - A and B, especially along A row. The crane rails are well fixed but rather worn-out. Side wearing (of 6 mm) is observed along A row, between axles 3-4, 6-7 due to the great oscillation of spans (in respect to the rest) between axles 4-6 caused by the centrifugal separator vibration.

The bins being provided for the mill charging are in good condition and equipped with the grates.

Grab Crane

There is no deformation of the crane main metal structures. The crane operates with the distortion due to the following reasons: driving wheels irregular wearing (greater wear of wheels from the bin side), bridge bolts loosening of the travel mechanism transmission couplings and their ill-timed tighting.

This testifies to the insufficient daily mantenance.

The expansion of the lifting mechanism drum toothed clutch is 2.5-3 mm. The details and units of the rest mechanisms are in a satisfactory condition.

The brakes of the lifting and closing mechanisms are properly relulated. The trolly railway line is rather worn-out, especially from the side of the control booth nearby A row.

The trolley bucket condition if far from being satisfactory. Tear and wear of the bearings and rod bracing axle to the bucket is up to 35-40 mm, and that of the ears and jaw bracing axle to the bucket head is up to 20-25 mm. As a resut the bucket head jaws went away by 40-45 mm.

Great wear of the ears and rod bracing axles to the traverse should also be noted.

The jaw edge has the great and non-equal wear, hence the bucket is not closed properly and some material is released during transportation. In some places of the jaw end play there are holes. The ropes are well maintained and lubricated.

The crane is equipped with all the necessary facilities to provide safety operation and maintenance of the crane.

Raw Mill with accessories

The mill shell and end plays are in good condition. The charging device is sound.The inlet grate liners are strained to the chamber side (went away from the end play by 80-100 mm). It results in the bracing bolts braking.

The partition sagged to the side of the second chamber and requires repair. Thickness of the discharge grate is consumed by appr. 20 per cent, besides there are big slits (12-15 mm) in the grate.
The shell plate liners are in good repair, equal wear thereof should be marked. The discharge device and discharge screen are sound.; they can operate for a long time since their consumption is insignificant.

The end play bolts as well as those of the pinion are well tightened. The operation of the journal bearings is good.

Lubrication of the above bearings is effected by virtue of the oil buckets which provide even oil clad all the length long.

The mill main gear-box runs smcothly. The intermediate shaft bearings operate without vibration. The filter, cooler, all facilities and devices being necessary for the operating control are available in the main gear-box lubricating system. The cooling system of the journal bearings, intermediate shaft bearings, gear-box lubricating system is O.K.

The mill plate feeders are sound. The mechanisms being assigned to regulate the quantity of the charging raw material are well lubricated and operate easily.

The firing device for the raw material drying provides the required temperature of the gas.

The bucket elevator works smoothly.The elevator drive is kept clean. The drive couplings are centered properly.

The centrifugal separator running is satisfactory. The distribution plate, the blades of the separating and circulating ventilators as well as the armours are partially consumed.

The separator mobile part rotates easily; but the separator vibrates during the operation.

The condition of the screw conveyor is good, it operates smoothly. The srew blades wear is insignificant, good running of the conveyor drive and bearings can be observed.

The air-slide together with the fan is in good repair.

The condition of the bag filter is satisfactory.

The bevel driving gear of the bag filter machanism drive is consumed up to 30-35% as far as the tooth thickness is concerned. The rest details are sound.

The bag filter fan operates well. The bag filter cell feeder is O.K. All the details and units of the mill and its accessories are properly lubricated and kept clean. The working places are maintained in order.

Cement Mill

The mill casing, inlet and outlet ends are in good repair. The inlet liners properly adhere the end play, the consumption thereof being insignificant.

The partition is devoid of the central ring and the balls roll from one chamber into the other.

The discharge grating wear is up to 45 %.

The centrifugal separator operation is not satisfactory due to the great vibration. The vibration is caused by the bad balancing of the separator rotary part. During checking it was found out that the separating fan blades were asymmetrical. The blade wear of the circulating and separating fans is not equal. Here and there the separating fan disk is eaten through.

The distribution plate is consumed by 35 %; the liner cylindrical part wear is up to 5 mm (in some places). Constant vibration of the separators (eepecially of the cement separator) leads to vibration of the metal structures of the grinding department and raw materials deposit hall. It affects operation of the crane, condition of the building structures and may lead to the fatigue cracks in the metal structures.

Along A row, on axles 4,5 and 6 up to the top level of the bins the columns are embedded in concrete, but in the places of the column abutting to the bins down to the column foundation there are some cracks in concrete, caused by vibration of the separators.

The condition of the rest units and accessories of the mill is the same as of the raw mill.

Homogenisation; Ready Meal and Cement Silos

The equipment of the above silos is well lubricated and in good repair. There is no doubt of its availability for a long time provided that timely preventive maintenance is undertaken.

Rotary Kiln Unit

Rotary Kiln

The kiln housing is good, no cracks and cenvexities. Support

rollers operate without distortion. Contact between the rollers and bandages is spread along the whole width of the working face. The rest roller and bandage surfaces are smooth. The rest roller bearings operate at the normal working temperature.

The thrust rollers rotate easily and have no visible faults. The kiln drive runs without chocks and outward noise. The gear pair can operate for a long time, its consumption being insignificant and equal along the tooth length and height.

Smooth operation of the drive (it can be inferred also from the ammeter indices) and good operation of the rest roller bearings testify to the linearity of the kiln axis.

The kiln discharge end is constantly heatedup to 1100-1200°C due to the close-to-exit sinter zone.

It should be noted that the kiln is exposed to the additional thermal loads since it protrudes from the cooler pit by 220-230 mm. It affects the discharge end segments. The orange or dark yellow colour of the segments testifies to their being heated up to 1050-1150°C and higher. The quantity of air forced by the ventilator for their cooling is apparently not sufficient.

The primary air fan and all the facilities of the injector are in good repair. The kiln hot end packing is not efficient since between the packing sectors and the cooling branch pipe there is a slot of 100 mm.

The kiln cold end packing operates well. The condition of the cyclone heat exchangers is satisfactory.

The roofs of the IY and III stage cyclones are strained and it affects the lining. The gas exhaust blowers after IY, III and II stage cyclone have cracks (in places of the chute abutting).

The cyclone chute valves move with difficulty along the axles. The gas exhaust blowers operate smoothly, the bearings thereof being cool.
All mechanisms of the kiln feeding system are O.K.
The balance metal structures have no visible defects.

The condition of the electrical filter and all its mechanisms is satisfactory. The barbed electrodes require centering, since the interval in between exceeds 5 mm. The flue gas pipes are in good repair. All mechanisms are lubricated properly and kept clean.

Fuller Cooler. Clinker Transportation

The first chamber grate bars of the cooler very often operate under high temperature - 500-600°C. The air being supplied into the first chamber is not directed under the bars. On entering the chamber it stalls the speed and the cooling therefore is not effective.

The wear plates of the cooler walls are in good repair. The cooler drive operates smoothly. The chain drive chain gears have insignificant consumption.

The connecting rod insertions on the driving shaft are worn out by 2.5-3 mm.

Wear of the rest roller bushings is up to 14 mm. The rest rollers and their guides are consumed by 2 mm. Wear of the rest roller bushings leads to the clearance expansion between the solid and mobile bars, which expansion causes additional load on the drive and accelerates wear of the bar interconnected parts.

Wear of the front face sealing frames (in contact places with the rest rollers) is up to 4-5 mm.

The front face sealing of the driving shaft is not hermetic and air from the first chamber is blown out.

The small drag chain is satisfactory. The scraper connecting pins are worn out by 25 per cent. The chain is slack.

The concrete chute with the guide plates is very worn out.

The drive details are in order. The chutes after the cooler are eaten through in many places.

The condition of the drag chain to supply clinker to the deposit hall is also satisfactory. Here and there the concrete chute is consumed up to 250-300 mm. Some guide plates are missing. The chain drive driven chain gear of the conveyor drive is worn out by 20-25 per cent as far as the tooth thickness is concerned.

Packing Plant

All the facilities for cement supply to the packing machine are in good repair.

The packing machine aspiration is not satisfactory. There is plenty of dust in the air. The presence of dust in the weighing mechanism interconnections affects the accuracy of weighing.

The belt conveyors are O.K. All the drives as well as the bearing mechanisms are properly lubricated and operate normally.

Note: The above comments concerning the condition and operation of the closed gears as well as the bearing units are based on the observation of thir running (checking by ear and to the touch) There was no possibility to examine them being opened.

Maintenance & Repair

De-centrilized system of repair is being applied at the Addis Ababa cement factory.

Every section has its own repair personnel headed by a foreman or a mechanic, which personnel executes all kinds of the repair jobs.

The required devices and stock are available at the disposal of the sections.

Manufacture of the new details, simple mechanisms and devices, restoration of the worn out details is effected at the mechanical workshop.

Sometimes the repair personnel pf the workshop takes part in repair being effected in the production sections.

The mechanical workshop is equipped with the machines for metal cutting, welding; with the hoisting mechanisms, tools and instruments for repair.

Mechanical workshop

1. Universal lathe, model TES-3-250-3000 Prvomayska

Height of centres	: 250 mm
Distance between centres	: 3000 mm
Turning dia over saddle	: 350 mm
Turning dia in the gap	: 750 mm

Width of gap in front of face plate : 220 mm

The lathe is equipped with the rest.

2. Universal lathe, model S-4 Galleb

Height of centres : 210 mm
Distance between centres : 1500 mm

A part of the lathe is removable. The lathe is equipped with the rest.

3. Universal Milling Machine, model UHG-290x1350 Prvomayska

Size of table : 290x1350 mm
Max distance of spindel centre from table surface : 480 mm

The machine is equipped with the interchangeable facilities and dividing heads.

Milling, gear cutting and slotting jobs can be executed by means of the machine in question.

4. Shaping Machine, KP-400 Seping

Size of table : 400x400
Slide travel : 400

5. Radial Drill, model RB-35 LZTK

Bore of drilling	: 32 mm
Spindle travel	: 200 mm
Maximal radius of swing	: 950 mm
Bracket travel along the column	: 600 mm

6. Drilling Machine, BU-32 FAM

Max bore drilling	: 32 mm
Size of table	: 400x400 mm
Spindle travel	: 180 mm
Max distance between spindle and table	: 680 mm

7. Electrogrinder, model EBR 35/14 Prvomayska

Size of grinding wheels	: ø 350x127x40 mm
Grinding wheel speed	: 1600 rpm

8. Electrogrinder, model EBR 20/28 Prvomayska

2 grinding wheels with the size of ø 200/32x25 mm
Grinding wheel speed : 2800 rpm

9. Sheet cutting machine MM ITM

Sheet max thickness	: 4 mm
Sheet max length	: 2000 mm

10. Hand operated lever shearing and cropping machine with notching attachment, model KS-1 Jelsingrad

The SHEAR cuts:

sheets up to : 10 mm

The Cropper Attachment, cuts:

Rounds in steel up to diam	:	30 mm
Squares in steel up to	:	26 mm
Angles at right angle up to	:	60x60x8
Angles diagonaly up to	:	45x6

11. Sheet Rolling Machine, SSL-5 Jelsingrad

Sheet thickness up to	:	5 mm
Roller diameter	:	150 mm
Roller length	:	2050 mm

12. Hydraulic press, Matra M-78

Press force : 15 and 100 tons

13. Air Hammer VC-150 ILR

Weight of ram, kgs	:	150
Max stroke of ram, mm	:	487
Size of anvil pallet, mm	:	290x360
Distance centre of ram to body of hammer, mm	:	320

14. Two mechanical saws are available for billet cutting

15. Welding Machine IICC-300

Nominal current 300 a
Nominal voltage 30 V
Current control range(for welding) 75-320 a

16. Complete OXY-Acetylen welding and cutting set with reducing valves, TE-BA (3 tons)

17. Manually operating girder is provided at the workshop for transportation of the details and units.

It can be inferred from the above characteristics that at the mechanical workshop it is quite possible to handle various details provided that relevant materials, casting & forging ballets as well as relevant facilities being applied.

The following details can be handled:

1. shafts with the diameter up to 350 mm and length up to 3000 mm by means of the rests or intermediate supports;

2. wheels and disks of different shapes with the diameter up to 750 mm and width up to 220 mm;

3. pinions of ø up to 400 mm up to module 16, forged pieces, rings etc.

The electrical welding is widely applied at the factory to restore the initial dimensions of the details.

Organisation and Registration of Repair

The technical condition of the equipment is not recorded at the factory. Repair of the equipment is made as required. The period between the two repairs varies from 15-20 days to one or a few months with the duration of repair being 5-6 days.

Only one repair is carried out regularly - during rainy season in June or July with the duration of 10-20 days. The executed jobs are registered in the logbook which was started in July 1967.

According to the records in the said logbook it is rather difficult to analise the condition of the equipment, assess lifetime of the consumable details and make any conclusions about the repair system since the records are not complete and sometimes not exact.

The network schedules elaborated at the factory serve for the repair operative control as well as the repair dates compliance. 3 or 4 links (Three persons each) are involved in the repair for about 12-14 hours per day. Such practice extends the time being necessary for repair.

Provision of Materials and Spares.

There exists a certain assortment of materials and spares necessary for the factory needs since 1964.

The orders for the materials and spares delivery are placed with a number of countries in Europe, as a rule in Italy, Western Germany and England.

The period from placing the order up to getting the materials is about 6-9 months.

Lack of the permanent suppliers and two-party agreements sometimes delays the deliveries.

There are no technical passports of equipment and almost no detail drawings at the factory, a moment being an obstacle for the timely drawing up of the requests.

Placing of orders as well as correspondence concerning deliveries are under responsibility of a specially assigned person.

The materials and spare parts are kept in the closed store.

CONCLUSIONS AND RECOMMENDATIONS

The main tasks of the up-to-date cement factory are as follows:

- to fulfil the plan as far as the quality and quantity of production are concerned;
- to raise labour productivity;
- to get a high co-efficient of equipment at the rated hour's output by way of proper maintenance and timely qualicative repair;

The equipment at the Addis Ababa cement factory is in order, kept clean and lubricated properly.

The weak points of the factory are:

- grab crane
- cement mill
- cement mill centrifugal separator
- Fuller cooler

The condition of these units requires more serious approach as regards maintenance, systematic inspection and repair.

The organisation of repair and the logbook of the work done testify to the imperfect system of the equipment shut down for repairs.

The shut down taking place as required does not permit to be prepared for the repair in advance, besides, it extends the duration of the repair. The jobs are not executed in full scope and sometimes they are not qualicative.

Prolongation of the interrepair periods at the expence of the abnormal (progressing) wear of the details increases expenditu-

res for repair and sometimes reduces the output due to the decreased capacity of the equipment. Such cases take place at the cement mill when the plate liners are being operated up to their complete wear; at the hammer crusher when hammers, grate bars and liners are abnormally consumed and etc.

Timely restoration and strengthening of the details can prolong their lifetime.

At the same time the forced standstill of the equipment (lack of the electrical energy, raw materials, clinker etc.) are not used in full for checking and meintenance of the equipment.

The faults records as well as schedules of preparatory jobs (which are not prepared at the factory) would provide more thorough execution of the work and facilitate to shorten the time for repair.

There are no norms of the details and units wearing, no list of the consumable parts and list of the specific jobs to be executed when repair of the technological equipment; when being on hand they would permit to plan somehow the jobs of technical maintenance and repair of the equipment.

The simple methods of raising the detail wear-resistance were not spread at the factory:

- strengthening of the inner and outer surfaces by way of the surface running in;
- strengthening of the working faces by way of the surface hardening;
- hardening of faces being exposed to cruching and abrasion by means of filling with the hard alloys, cast iron etc.

As it came to my knowledge there are about 20 details to be replaced ow repaired which cause the most frequent stanstill of the equipment:

- cooler first chamber grate bars and support grates;
- rest rollers;
- cooler rest roller bushings;
- kiln discharge end segments;
- drag chain (SK-30) lower supports;

- inlet plate liners;
- first and second chamber armours;
- cement mill partition sectors;
- cement mill centrifugal separator fan blades and armour plate;
- grab crane trolley and bridge driving & driven wheels;
- pins of rods bracing to grab bucket jaws and head; etc.

The lifetime of the above-mentioned details can be extended by way of improving their working conditions and raising wear-resistance with the aid of the known methods.

It can be inferred from the foregoing that the existing repair system is in need of improvement.

Repairs can be organised as per one of the following methods.

Standard repair method

The machine is stopped for repair after a certain number of working hours or after a certain amount of production and all the details and units (to be replaced in compliance with the technology of this repair) irrespective of their condition are changed. The positive side of the method in question is high quality of repair and high reliability of the machine operation and its drawback is high cost of repair since the details with a slight probability of being out of order till the next repair are replaced.

Periodical repair

The equipment is shut down within the time provided for by the repair schedule. During this repair should be replaced only those details and units which can become out of order before the next planned repair.

Method of after-inspection repair

Inspection of equipment is planned beforehand but time and scope of repair are defined after or during the inspection.

The method is simple: the machine is repaired as required but the method is not devoid of a number of shortcomings.

The date of repair is fixed some time before the work should be done that is why there is no time to be prepared for the repair properly; the outcome is the prolonged time of standstill.

According to the experience of the USSR the best results can be obtained when applying the periodical method of repair which is quite acceptable for the Addis Ababa cement factory.

On the basis of this method the system of preventive maintenance was worked out. The said repair is aimed at preventing from wearing and sudden failure of the equipment.

The preventive maintenance provides a complex of events in respect to maintenance and repair of the equipment to be executed in a certain order and within the period being fixed in the plan.

The events should secure uninterrupted operation of the equipment under the set working conditions at a high efficiency and min expenditures for maintenance and repair.

As far as the jobs to be executed during the preventive maintenance are concerned see Appendix 1 to the present report.

Note: All the Appendices attached hereto are made with the account of the equipment operation at the Addis Ababa cement factory.

Such system of the repair service at the cement factories of the USSR has been prooved in operation, provided the best utilization of the equipment, permitted to raise the usage factor of the main aggregate - rotary kiln - up to 0.94, sometimes even higher.

With a view to improving the repair service and achieving the high factors of the equipment usage at its working capacity being kept I would recommend to introduce the system of the preventive maintenance at the Addis Ababa cement factory.

For the better planning system, rational use of facilities and manpower the preventive maintenance provides for the elaboration of a list of specific repair jobs and setting of the following norms: periodicity, duration, repair cycles, complication.

On the first stages of the PM introduction I suggest definition of periodicity, duration and repair cycles and further on resorting to the complication.

Periodicity of the equipment shut downs for this or that kind of repair as well as periodic technical maintenance is defined according to the lifetime of various details, peculiarities and conditions of operation.

Duration of repair (periodical technical maintenance) is defined according to the equipment complexity, possibilities of the repair service and organisation of repair. The duration in question is calculated from the moment of the equipment shut-down up to its starting up into operation.

The structure of the repair cycle comprises the totality of the periodical technical maintenance, mean repair being carried out after the set periods of time between the two general overhauls.

One and the same structure of the repair cycle is applied to the main technological and complete equipment (coolers, gas exhaust blowers, fans, centrifugal separators, elevators, feeders etc.).

The calendar time of the work execution is fixed in accordance with the structure of the repair cycle, periodicity and duration of the periodical technical maintenance and repair of the equipment.

The electrical and mechanical parts of the equipment should be repaired simultaneously.

In order to obtain the initial data being necessary when planning of the repair jobs at the Addis Ababa cement factory I have :

1. Made the approximate list of the specific jobs on repair of the main technological equipment (Appendix No.2);

2. Compiled the nomenclature of spares to the technological equipment with the aid of which together with Mr. Negash, The Senior Mechanical Engineer of the Cement Corporation, it became possible to assess the lifetime of the consumable parts (Appendix No.3);

3. Elaborated the approximate list of the obligatory stock of the consumable and most importatnt details of the main technological equipment (Appendix No.4)

On the basis of the initial data obtained, with the account of the repair service possibilities I have prepared a Table of periodicity, duration and number of repairs as well as the periodical technical maintenance within the repair cycle.

The said Table contains also the data on the number of repairs and technical maintenance, total standstill of the equipment in hours and percentages to the calendar time of the year.

For example, it was possible to assess the periodicity of maintenance for the rotary kiln and cooler (three months) according to the lifetime of the grate bars as well as plate supports of the cooler first chamber; periodicity of the mean repair (12 months) according to the lifetime of the kiln discharge end segments and ring, also some other details with the lifetime from one to ten years.

The general overhaul should take place once per 10 years since the lifetime of the relevant details (underbandage rings, sinter zone rings, bandages, toothed rim etc) is over 10 years.

For checking of the kiln technical condition, revealing and elimination of minor defetts (to prevent from the accident), assessing the degree of the details wear I would recommend once/month to stop the kiln for the periodical technical attendance.

DURATION, PERIODICITY AND NUMBER OF REPAIR & PERIODICAL TECHNICAL ATTENDANCE OF THE EQUIPMENT

	Duration of repair and per. techn. attendance				Periodicity of repair and PTA months				Number of repair and PTA within one repair cycle				Number of repair and TA per year / Number of hours			Total standstill for repair and TA per year	
	days			hrs													
	GO	KR	K	PTA	GO	KR	K	PTA	GO	KR	K	PTA	KRorGO	K	PTA	hours	% of calen.time
1. ROTARY KILN with ϕ 2.6 x 34 with the Cooler	20	15	3	12	120	12	3	1	1	9	30	80	1/360	3/216	8/96	672	7.67
													1/480	3/216	8/96	792	9.04
2. RAW MILL with the outfit	6	4	2	4	180	12	6	1	1	14	14	150	1/96	1/48	10/40	184	2.1
													1/144	1/48	10/40	232	2.65
3. CEMENT MILL with the outfit	6	5	3	8	144	9	3	0.5	1	15	43	269	1/120	3/216	20/160	496	5.66
													2/264	2/144	20/160	568	6.48
4. HAMMER CRUSHER with the outfit	7	6	2	8	48	12	3	0.5	1	3	12	80	1/144	3/144	20/160	448	5.1
													1/168	3/144	20/160	472	5.4
5. ROPEWAY	20	8	2	8	48	12	3	0.5	1	3	12	80	1/194	3/144	20/160	498	5.68
													1/480	3/144	20/160	784	8.95
6. GRAB OVERHEAD CRANE	5	3	0.5	4	120	12	3	0.33	1	9	30	320	1/72	3/36	32/128	236	2.7
													1/120	3/36	32/128	284	3.24
7. PACKING MACHINE with the outfit	5	2	1	8	60	12	3	0.25	1	4	15	220	1/48	3/72	44/352	472	5.4
													1/120	3/72	44/352	544	6.2

GO - general overhaul
KR - mean repair
K - maintenance
PTA - periodical technical attendance

On the basis of the above principle it was possible to define the periodicity of repair and technical handling for the rest technological equipment.

Systematisation of the equipment shut-downs for repair helps to keep the equipment working capacity and, as it can be seen from the Table, to get a high usage factor.

Thus, the total standstill of the kiln for repair will amount for 672 hours per year, i.e. 7.67% of the calendar time whereas in 1971 it was 965 hours - 11%; the total number of the standstill hours being 1261 (14.5%) in 1971.

The annual and monthly schedules for repair should be made on the basis of the said Table.

When working out of the annual schedules it's necessary to coordinate the shut-down for repair with the planned stops (relining of the kiln refractory, reloading of the grinding media of the mills etc.).

Besides, for planning of all the events of the P.M. it's necessary to record the technical condition of the equipment, for which purpose there should be the technical passport per each machine containing the main technical data, structural modifications, if any, the dates and description of the major jobs executed during the general overhaul or reconstruction.

The data on the repair jobs executed (as well as results of inspection) should be recorded in the logbook of the equipment periodical attendance and repair.

In order to control the condition of the equipment details I have elaborated a list of defects and allowable wear (see Appendix 5).

The events which help to decrease the equipment standstill and prolong the interrepair periods are of great importance as far as the usage factor and expenditures for the equipment maintenance are concerned.

It's possible to decrease the repair duration by way of:

- the high degree preparation of the repair - availability of the faults record, detailed plans of the preparatory and repair jobs, done-in-good-time manufacture and fitting of all the necessary new details and units. The technological charts should be maid for the most complicated jobs.);

- the good organisation of the repair according to the plans and schedules elaborated in advance. These schedules provide for the parallel-subsequent repair and assembling of units, the two-shift work of the repair crews etc.;

- utilisation of the max possible number of workers during some part of the repair period depending upon the scope of work;

- application of the per-unit-method of repair.

Prolongation of the interrepair period can be achieved by way of:

- raising the wear-resistance of the consumable details;

- improving quality of the repair and current prophylactic events (lubrication, cleaning, clearance regulation, bracing tightening etc.), timely revealing of faults;

- partial repair and replacement of a number of units and details during the forced standstill of the equipment .

Besides the above-mentioned events the system of preventive maintenance stipulates the provision of the repair with the spare parts being manufactured or repaired at the workshop or received from outside.

In Addis Ababa there a possibility to get the steel and cast-iron castings (no guarantee on the material), bronze and aluminium castings. So, the factory needs in spares can

partially be satisfied on the spot. These are the details which do not require specially stipulated materials and those made of the rolled stock: couplings, various bearing casings, labyrinth rings, shafts & axles, guide and support rollers, chain gears, gear wheels, pins, bolts, armour bolts, bronze bushings and inserts excluding the rest roller inserts and some other details.

The details with the special properties such as: grate bars, grate supports, cooler side plates; drag chain links; discharge end segments and kiln rings; plate liners, grates and partitions of mills; hammers, grate bars, liners and shafts of hammer crusher; gear pairs of gear-boxes and some others, the most important details are to be ordered outside.

For manufacture and timely preparation of requests on the spare parts delivery I would recommend to acquire the drawings of all the details.

The factory ran into difficulties when there was a necessity to handle the elevator wheels and cooler eccentric shaft (no machine). For the above purpose I suggest using of the milling machine.With the changeable turn head and various holders it can serve as the boring one and then under certain conditions of cutting it would be possible to handle details with the diameter up to 1000 mm (max possible distance between the spindle head centre and the table surface is 600 mm).

The cooler eccentric shaft can be handled on the screw-cutting lathe, model TES-3-350-3000, with the following modification: to replace the shaft butt-end washers by the similar ones having two centre holes with the distance being equal to the shaft eccentricity.

As it has already been mentioned above the periodicity of the equipment shut-downs for repair (or the interrepair period) in many respects depends upon the details lifetime, i.e. their wear up to the allowable limit. The following factors exercise over the detail wearing: materials they are made of; quality

of the friction faces machining; hardening of the working faces; load and its distribution, speed of the details running; temperature and working conditions of the details; impurity and dustiness of the working faces; characteristics and kind of lubrication; soundness of sealings etc.

Hence, in order to prolong the interrepair period it"s necessary to reduce influence of the factors leading to the wear of details.

With this in view I would recommend to take the following measures at the Addis Ababa cement factory:

1. In order to reduce the influence of the secondary air and heat of clinker over the discharge end segments it's necessary to improve their working conditions by way of changing the refractory lining of the cooler pit front wall - sketch No. 1 -(or by mooving away the head as far as the coupling permits) and intensity of the discharge end blowing.

2. To improve the working conditions of the grate bars and grate supports by virtue of concentrating and directing the air current under the grate bars, reducing in this way their temperature (sketch No. 2).

3. To strengthen the cyclone flue gas pipes (in places of the chute abutting) with collars or to connect the chutes and the flue gas pipes by means of flanges in order to prevent spreading of cracks (sketch No. 3).

4. To raise the working face hardening of the mill plate liners, hammers, grate bars and liners of the hammer crusher by refilling them with the hard alloys and cast iron increasing thereby the lifetime of the details.

Special survey of operation of the cement mill liners being refilled with stalinite or cast iron proved their high wear-resistance: after 1.5 year running the mill liners refilled with stalinite turned out to be worn-out; whereas consumption

of the liners refilled with cast iron was insignificant and they went on operation.

Upon my request the workshop in Addis Ababa casted the cast-iron rods of ø 10-12 mm. By means of these rods I demonstrated the way to refill details made of the alloy and simple steels (using the worn out liners of the cement mill) with the hard layer.

I taught the welder of the shop of the said method and showed the best conditions for it.

The worn out piston rings can be substituted for the above-mentioned cast-iron rods.

By the same way it's possible to raise the wear-resistance of the edges of buldozers, dredger buckets, grab jaws and other details being exposed to crushing and abrasion (support rollers, drag drums, drag chain driving chain gears, screw conveyor spirai edges; elevator bucket front edges etc.).

5. To slow down the centrifugal separator rot.speed by 25% replacing the pulleys of ø 600/ø 355 by ø 800/ø 355 or ø 710/ø 315 or by putting the electromotor with 720 rpm instead of 980 rpm.

   The electromotor with a phase rotor would be the best one since it gives a possibility to change the rot.speed.

   Decreasing of the separator rot.speed will reduce vibration and in this way improve the operation of the separators as well as beneficially tell upon the metal structures of the grinding department and the General Store.

Decrease of the rot.speed is possible sinde there is a 3-4 time margin of the separator capacity and the flow speed required for the material separation can be raised by way of increasing the number of the separating blades of the ventilator up to 48 pcs. as well as throwing the control gates into operation.

At present the raw separator fan has 8 blades and that of the cement separator - 14. The control gates are pulled out and do not operate.

6. The lifetime of the elevator driving wheels can be increased by substituting the distance boss between the halves for a ring. At that the load from chains acting at present on the wheels arms only will be distributed between the arms and the ring (sketch No. 4).

7. In order to prevent wearing of the drag chain (SK-30) reinforced chute it would be beneficial to embed along the drag chain length the railway rails (the worn out ones) instead of the lower supports according to sketch No. 5 .

8. Grab Crane

a) To avoid the crane distortion it's necessary to impose as a duty and demand from the operator daily tightning of the bridge travel mechanism transmission shaft couplings (which tightning does not exclude the daily maintenance of the crane) and measure the bridge driving wheels diameter 2 times per month. Should the difference between the diameters be over 0.005 the wheels have to be replaced.

b) It is necessary to ream and exchange the crane rails. It will give a possibility to continue operation of the crane untill replacement of the rails without frequent stops for refilling the worn out parts of the rail being overloaded as well as improve the crane operation and operating conditions for the operator.

At present one can observe the intensive vibration of the crane due to the great wear of the rail part. The most worn out sections of the rails (along A row, between axles 3-4, 6-7) should be exchanged with the end sections of the rail.

c) In the near future the cran should be stopped because of the grab repair.

In order to spare time required for the above repair (i.e. cut standstill of the crane) it's necessary to manufacture in advance the new jaw ears and when repair to replace the old ones.

Later on to avoid the crane standstill due to the grab repair I consider it worth while to buy a stand-by grab. It would provide more thorough repair of the grab.

9. The rolling face of the bridge and trolley wheels can be strengthened by way of the surface hardening with the acetylene-oxide flame.

10. Dropping of dust between the shaft (or journal) necks and cooler rest roller bushings should be prevented in order to extend their lifetime.

11. To cut spreading of dust when limestone charging into the bin above the hammer crusher feeder at the quarry, for which purpose to protect the feeder with a housing and supply the crusher shafts with the back blades.

The list of jobs to be executed at the factory could be continued. For instance, in order to prevent warping of the raw mill inlet liners it's necessary to expand the clearance between them; to avoid braking of the raw and cement mills discharge devices - to hang from inside the false walls and knock them as required to eliminate accumulation of cement or raw meal etc.

Proceeding from the foregoing it is clear that the problem of the interrepair period extension as well as decrease of the equipment standstill is always vital.

All the jobs suggested excluding buying of a new grab do not require great labour and material expenditures.

Upon request of Mr. Negash, The Senior Mechanical Engineer, I have picked out the conditions for metal heating(prior to refilling)depending upon the chemical composition and the conditions of the thermal treatment after refilling. Besides I have made a list of metal articles being used in the cement engineering in the Soviet Unich.

The proposed system of the preventive maintenance is applicable to any cement factory in Ethiopia with the account of the local conditions.

For rendering of the technical assistance when introduction of the system in question as well as all events being in connection with it I consider it worth while to depute the expert - Engineer in Cement Machinery - to Addis Ababa, the duration of stay being 12 months.

The above findings and recommendations have been discussed with the engineering and technical staff of the factory and with Mr. Civis; The UNIDO Senior Industrial Adviser.

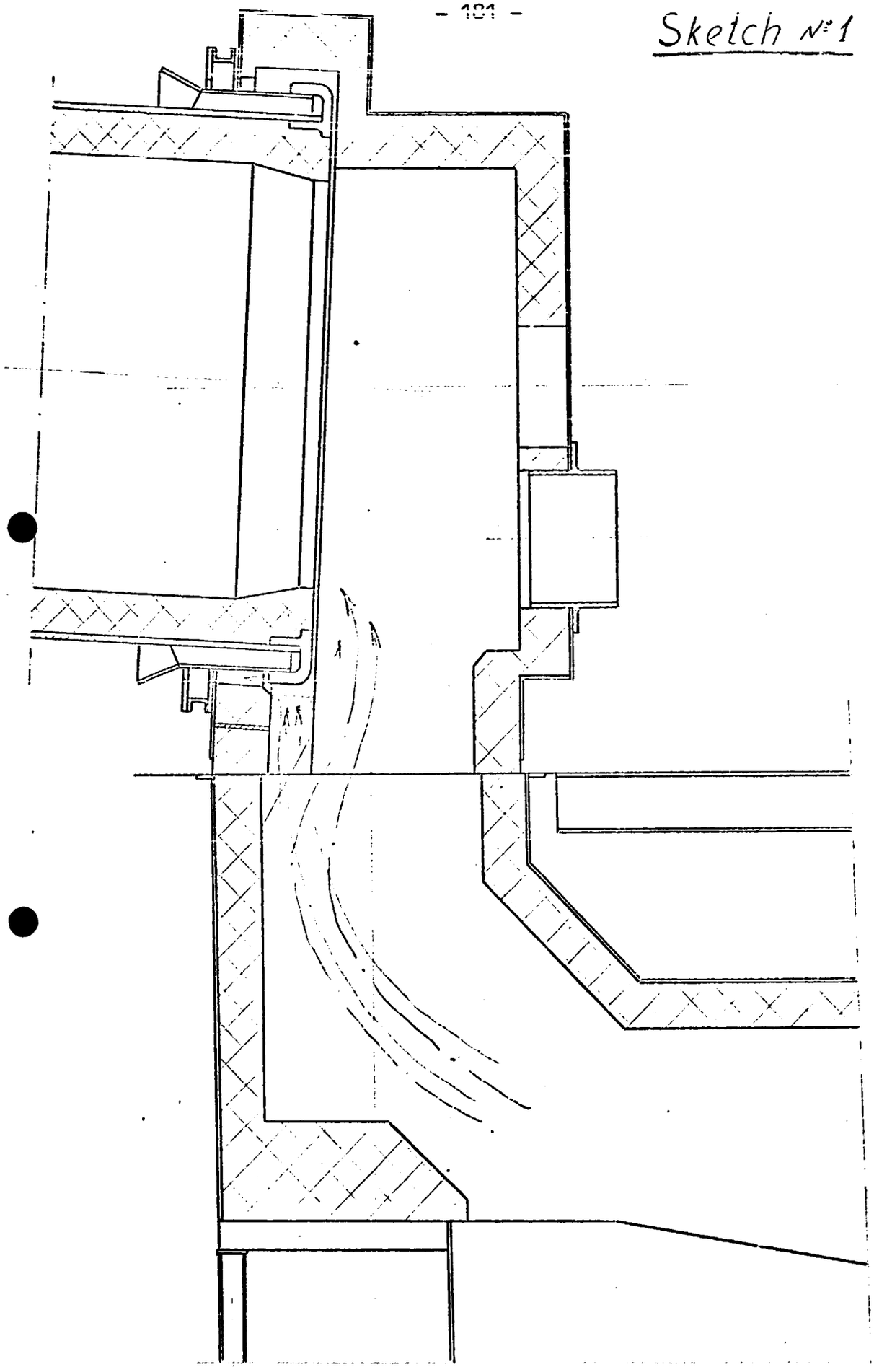
In conclusion I would like to express my deep appreciation of Mr. Vonchina's, The plant Manager, efforts and those of Mr. Negash's, to facilitate my work at the factory and present the required documentation.

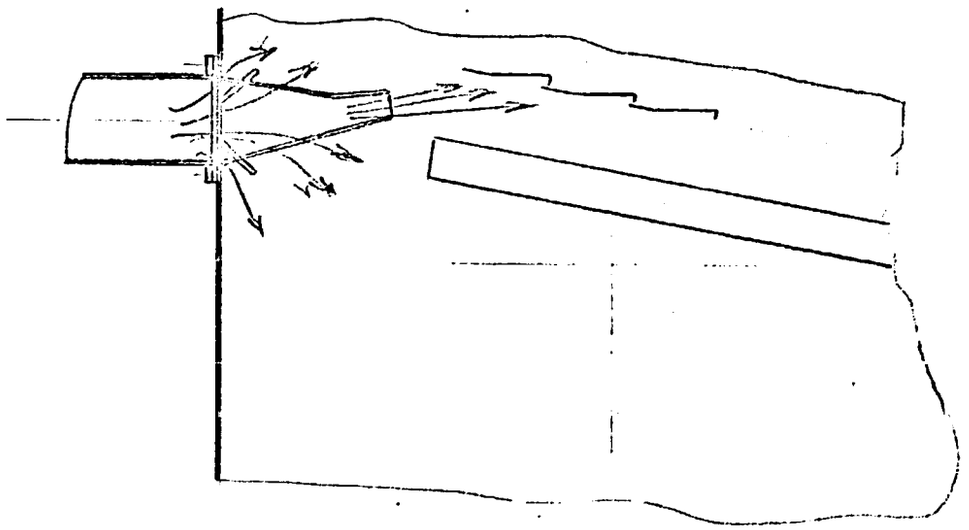
K.VEJLIVTSEV
Mechanical Engineer,
UNIDO Expert on Phase II

Addis Ababa, May 8, 1972

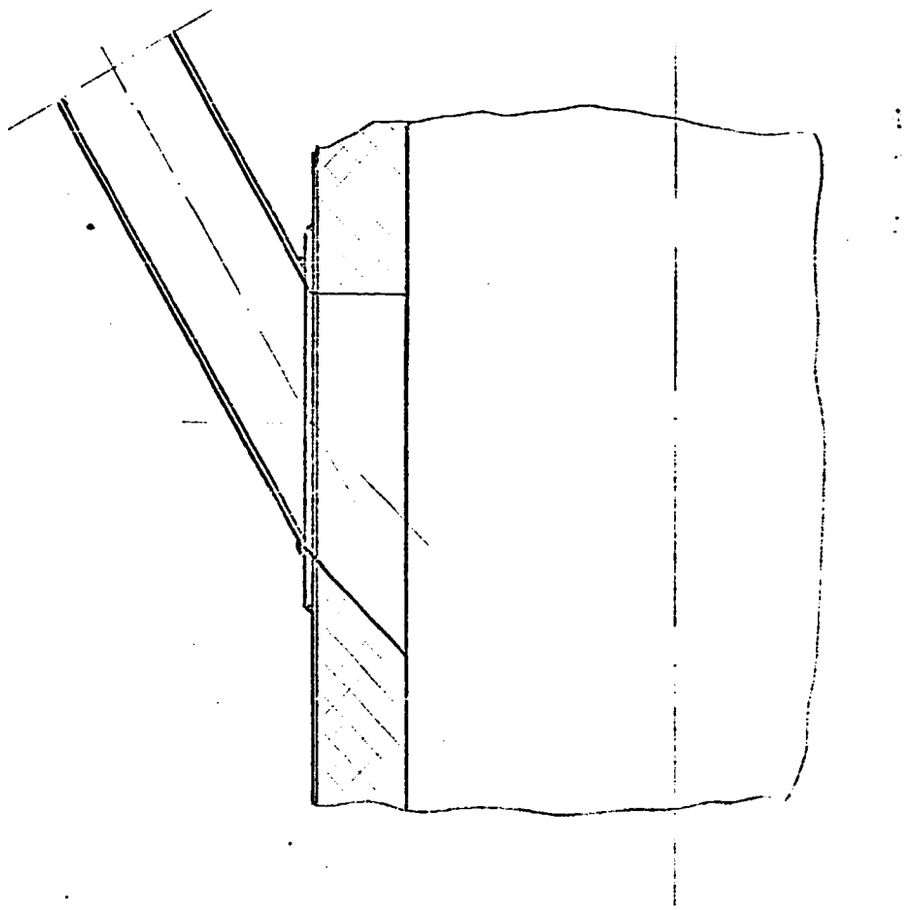
Translated from the Russian by Svetlana Efimova

Sketch N° 1





Sketch N° 2

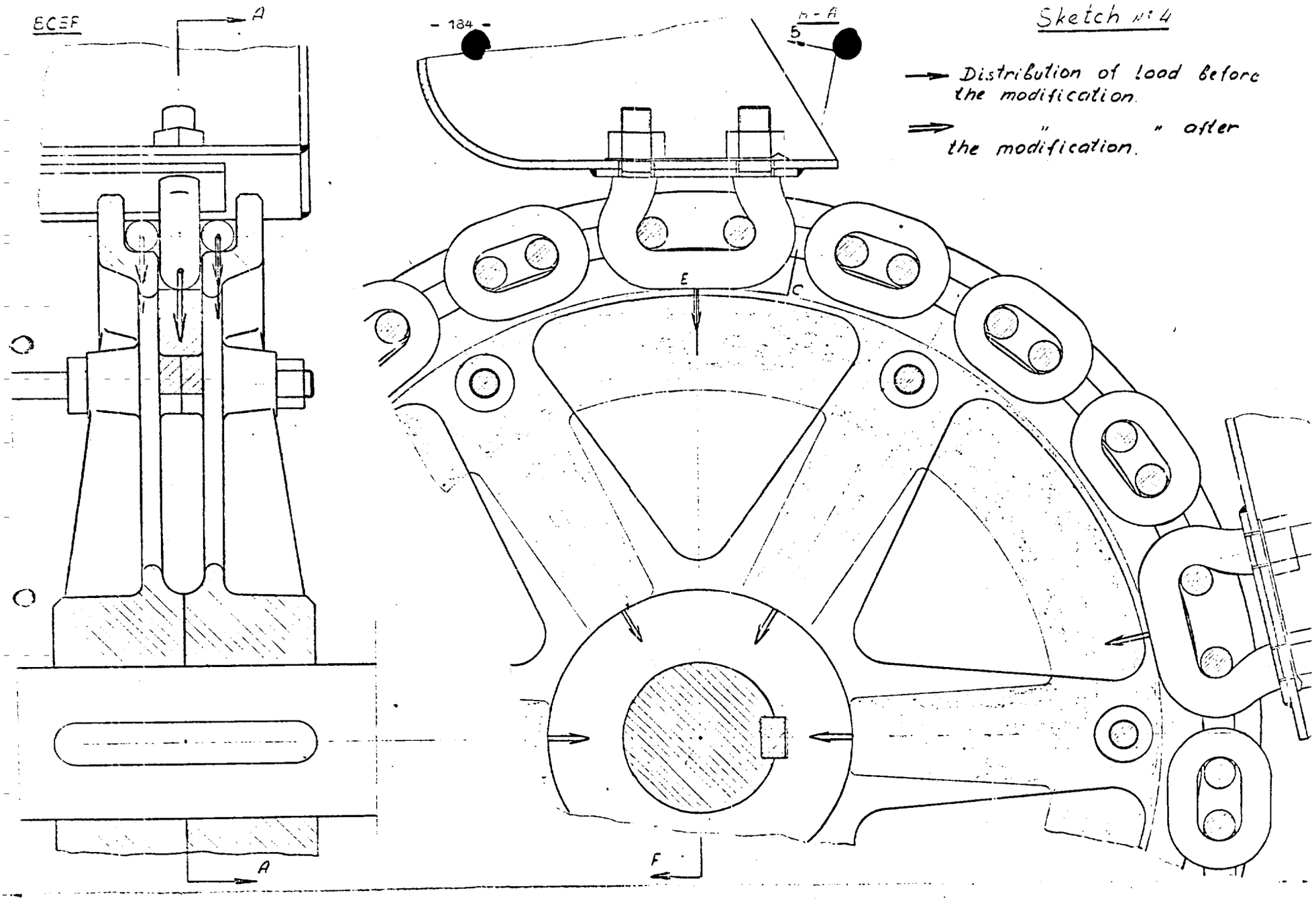


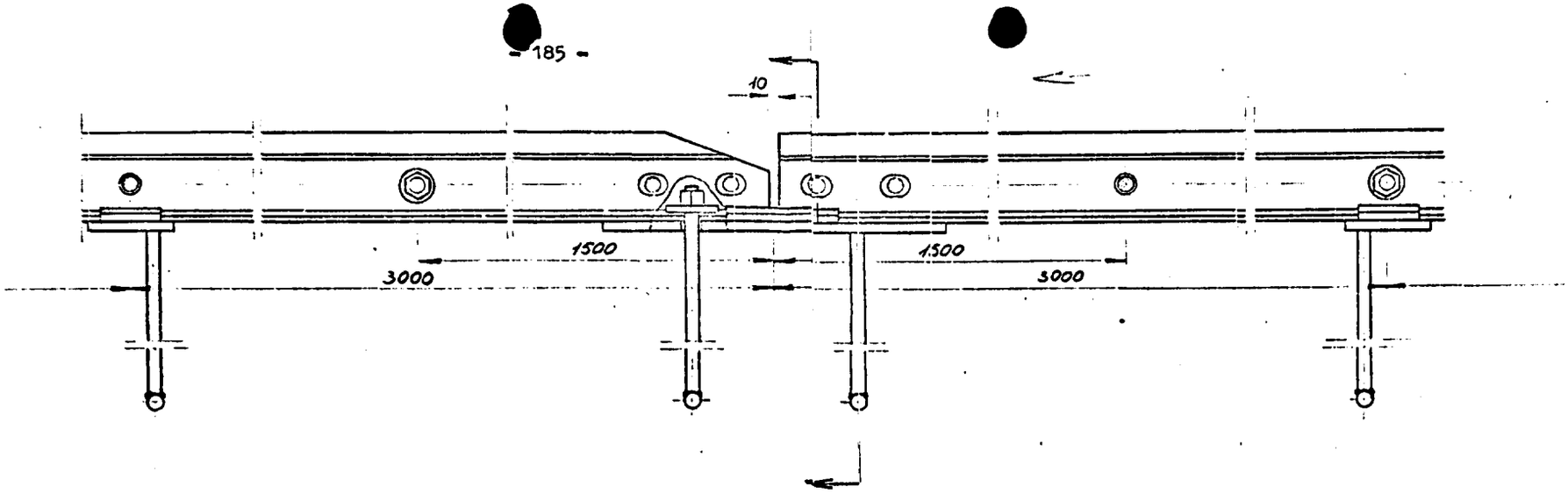
Sketch N 3

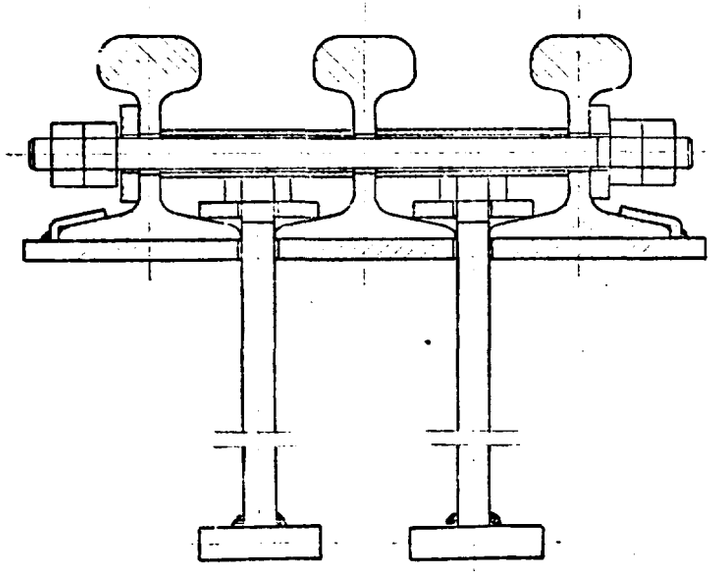
Sketch n° 4

→ Distribution of load before the modification.

⇒ " " after the modification.







Sketch №5

Alternative to brace the roies should they are used as the guides for the screw conveyors.