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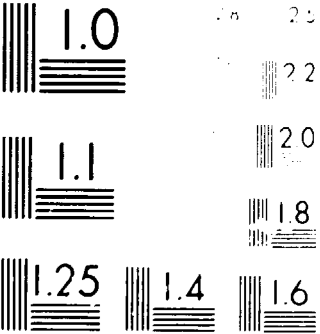
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WORK ON SOLUTIONS TO AVOID CEMENT AGGREGATION IN LCC STORAGE SILOS*

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INTRODUCTION AND PRELIMINARY REMARKS:-

Serious troubles started during operation of Hawari Packing Plant, caused by the formation of cement lumps and clogging of the cement silos, making it very diffi cult for loading of cement in the bagging section. KHD Industrieanlagen AG was asked to carry out some tests to find the reasons for this drawback and to advise LCC by practical suggestions to eliminate the troubles cau- sed by clogging of cement in silos which are considered in acceptable.

A - KHD studied the problem and explained the causes of lumps formation as well as their recommendations in four reports submitted to LCC in years 1978 & 1979.

As a general statement on the chemical composition of the cement samples the results commented on by KHD in the four reports show the following:

1 - The high loss on ignition of the lumpy cement is striking specially in some samples. This reveals no doubt that lumps are formed as a result of ex- cess moisture.

2 - There are noticeable differences with regard to the lime standard which reflect varying in the alite reduction and belite content accompanied with sli ght lowering of the alumina modulus.

3 - The calculated C_3A content of the cement samples ranges between 10 - 11. 8% by weight.

4 - This cement is rich in alkali, which suggests high C_3A sensitivity.

5 - The sulphate content could be lowered (to some 1-8-2.5% by weight SO_3) for some samples by re- ducing the quantity of gypsum added to clinker grinding when considering the C_3A contents speci-

fied

The results of chemical analysis alone do not allow decisive conclusions as to the reasons of lump formation. Therefore, KHD determined the phase composition of some samples radiographically:

1 - Through these tests aluminate, alkali aluminate and aluminate ferrite have been ascertained as 12.2% & 14.6% by weight in cement and cement lumps respectively.

Syngenite has not been definetely proved to exist in the samples. The DTA showed that there is no doubt about the existence of ettringite for one sample from silo 3. For sample from silo 4 the presence of ettrinite and syngenite could not be definitely proven.

2 - The maximum gypsum content for the freshly ground cement was compared with that of cement stored in silos and it was noticed that the silo cement samples contained less gypsum.

For the sample from silo 2 it was found that gypsum was not detected at all. The X-ray tests revealed that all samples contain small amounts of hemihydrate ($CaSO_4 \cdot \frac{1}{2} H_2O$) in addition to gypsum ($CaSO_4 \cdot 2H_2O$)

3 - Fineness tests of 2 samples gave the following results:

Sample:	D1	D2
Spec surface (Cm^2/g)	3200	2960
residue on 0.09 mm screen(% by weight)	3,7	8.6

KDH INTERPRETATION ON THE TEST RESULTS:

THE KHD four reports came to the following assumptions and interpretations:-

1 - Gypsum ore is to be added with clinker during grinding. Apart from gypsum, hemihydrate has been found in all the investigated cement samples. This can be attributed to the fact that excess cement temperature upon operation of cement mill has caused partial dehydration of gypsum to hemihydrate. Accordingly the moisture liberated reacts with clinker phases, above all the aluminate and specially the alkali aluminate which is sensitive to moisture to form needle-shaped ettringite and syngenite, which-in-turn-lead to the formation of lumps and accretions. Since in addition to hemihydrate, a high loss on ignition was found in some samples and to some extent in other samples so it is not clear to us to what extent gypsum dehydration has to continue in silo ?

2 - The cement produced by LCC has very poor flow properties. It has not been clarified to what extent the lump forming tendency and the poor flow properties are subject to mutual influence or whether the chemical composition of the cement adversely affects the cement flow properties.

KHD RECOMMENDATIONS:-

The reports stated that, basically, there are three possibilities to eliminate the lumps formation in LCC cement silos.

1 - Avoiding chemical reactions that may result in the formation of lumps.

Measures:

a) Lowering the alkali content.

b) lowering the aluminate content by adding iron ore to the raw mixture.

c) reducing the loss on ingnition of the cement by adding less gypsum, by raising the mill temperature by replacing the gypsum by anhydrite, proper adjustment of the water-injection system.

d) bonding the alkalies by sulphate up to 70% in the raw mix to decrease the alkali included in the aluminate and the latter therefore becomes less sensitive.

2 - Improving the flow properties:

Measures:

a) Grinding the cement by adding grinding aids,

b) use of additives (e.g. limestone) during cement grinding,

c) substituting the gypsum rock either partly or completely by anyhydrite (Ca SO_4) to avoid dehydration of gypsum.

A letter dated 2nd April, 1980 was received from KHD stating that addition of limestone can be implemented at their presence and they suggested a period of 2 months for these measures. They will delegate an expert for that test period who will give instructions for realization of the tests and co-ordinate the test procedure with LCC expert personnel.

They asked LCC to make the necessary arrangements for carrying out the test.

LCC INTERPRETATION

A.- We believe scientifically that there are some factors influencing the setting time of cements. These factors can be stated as follows:

1 - The greater the proportion of alumina and ferric oxide in cement the more rapid is the initial set.

2 - Fineness of cement has a great influence on the setting time i.e. fine cement sets more early than the same type of cement grinded more coarsely.

3 - Sulpher contaminated with fuel " coal or heavy Oil " has a remarkable effect in retarding the setting time.

4 - In addition of calcium sulphate there are some salts that have retardation while other group of salts have acceleration effects on the setting when a large amounts are added to cement.

The effect produced on adding these salts varies due to the composition of the Portland Cement " cement already retarded with gypsum ".

5 - The use of some agents to control the setting of cement became necessary and the addition of gypsum during grinding of the clinker became general.

The amount of gypsum added to the clinker corresponds to about 1- 3 % SO_3 and is limited by specification requirements, which in all countries permit only the presence of certain proportion in the finished cement.

The presence of free lime in clinker assists in the retardation of setting time. Although Plaster of Paris, $CaSO_4 \cdot \frac{1}{2} H_2O$ retards the setting of cement more vigoursly than gypsum but the addition of larger quantities more than 4% renderds the cement quick-setting again (less than 30 minutes).

Mixures of gypsum and anhydrite in roughly equal proportion are sometimes used as means of overcoming problems of false set.

False set is attributed to the dehydration of gypsum caused by the high temperature attained in grinding the cement clinker and its recrystallisation. These on occassion may exceed 150 °C.

<u>There are also some factors influencing the susceptibility of clinker to develop false set:-</u>

- the presence of free lime, assists the dehydration of the gypsum ore.
- carbonation of alkalies in the cement during storage has also been suggested as a cause, but this is more likely to produce a flash set than a false set.

B - <u>AERATION OF CEMENT</u>:

Cement stored in sealed containers at ordinary temperatures is usually little changed after long periods, but a high temperatures some effect is produced, for although the cement appears normal it may rapidly develop a flash set if subsequently exposed to air. Trouble with rapid setting is occassionally experienced with cements shipped from temperate to tropical climates. Development of a flash set also occassionally occurs in cement stored in bulk. The high temperatures attained during grinding probably persist for a considerable period of time in cement stored in silos, but the particular conditions which can lead to rapid setting and the corresponding changes occuring in the cement are far from clear.

Takemot (1959), studied the dehydration of gypsum when grinded with clinker in a laboratory mill at different temperatures by applying the thermal analysis method. The results showed that hemihydrate Ca SO_4 $\frac{1}{2}$ H_2O is formed at temperature 85 °C after 40 minutes grinding and scluble anhydr te has also been formed at 130 °C after grinding the mixture up to 80 minutes. Due to the formation of hemihydrate water leaves the clinker gypsum mixture. This water in case of the presence of more than 4% of hemihydrate leads to hydration of cement.

C- EFFECT OF STORAGE ON CEMENT PROPERTIES:

During grinding and storage cement may come in contact with water vapour formed as result of:

a) - spraying water into the cement mill during grinding.

b) - dehyd ation of gypsum at elevated temperatures.

c) - water accompanying compressed air.

The cement can react chemically with the water vapour and undergo solidification which creates lumps and accretions. These solidfied lumps are due to the formation of acicular syngenite (K_2SO_4 . Ca SO_4 . H_2O) or ettringite - (3 CaO . Al_2 O_3 . 3 Ca SO_4 . 32 H_2O)., accordingly retardation of setting and decline in strength seem to be caused if the cement contains substantial amounts of hemihydrate, rapid setting my occur as a result of secondary formation of gypsum.

The dehydration of gypsum takes place at different rates at the various storage temperatures. Dehydration evidently occurs more rapidly and the demonstrable residual gypsum content is lower, according as the clinker contains more C_3A and according as the amounts of alkali combined in the C_3A are greater.

D - PARTIAL HYDRATION IN THE SILO:

The liberated water from gypsum diffuse as vapour into colder zones of silo, where it reacts with the stored cement. The water content of the cement rises from about 1% at the centre of the silo to 5-10% by weight near the silo wall.

In consequence, there occurs solidification of cement, starting at the wall and progressing towards the centre.

The cause of such solidification is the build up of a rigid structure of tabular calcium aluminate hydrate and acicular syngenite and ettringite which are formed by reaction of C_3A, alkali sulphate and calcium sulphate with water.

CONCLUDING REMARKS:-

As have been shown by KHD recommendation for elimination the lumps formation in silos by using additives like limestone and grinding aids, it is worthy to state here that the autho read the " Rock Product " magazine February, 1977 which includes a paper concerning " Limestone Substitues for gypsum as a Cement Ingredient ".

It is worthy to introduce here summary and results of the mentioned paper, as it will be very useful for us to carry out the test (limestone substitutes for gypsum) that the author recommends to start with in LCC to eliminate to some extent the formation of lumps in cement silos.

A - SUMMARY OF PAPER

USING ADDITIVES LIKE LIMESTONE

Limestone substitutes for Gypsum as a Cement - ingredient (Rock Product, February, 1977)

During December, 1975 ASTM committee week meetings, some members discussed the possibility of using a substitute for gypsum which might react in much the same way. What was of key interest was the fact that gypsum substitute was not some highly complex organic additive, but it was the familiar limestone.

Several major advantages were possible as it is known that the limestone cost or price is low and it is about 30% of the gypsum price and cost.

The other advantage is tha false set problem that meets the customer in many cases specially with the cements highly ground in mills with increasing temperature of the cement content above the temperature required to transform the gypsum to hemihydrate or anhydrite and the use of partial substitution of limestone for gypsum to prevent this problem.

Samples of clinker were taken from 8 plants with their typical limestone and gypsum. These materials were than ground separately to different fineness; clinker 3,300 m^2/g. Limestone - 4,000 cm^2/g and gypsum.

Care was taken to avoid exposure of the pastes to atmospheric CO_2. The pastes were allowed to hydrate for 1,3,7, 14,28 and 60 days in sealed vials.

Results of laboratory grinds with partial substitution of limestone for gypsum have shown that a definite reaction between limestone and clinker does take place.

The reaction product is a calcium carbo aluminate (CCA) which may form in a mechanism similar to that of calcium sulpho aluminate CSA

Physical properties of the cement such as autoclave expanstion and setting times can be maintained as acceptable values with the correct ratio of limestones/gypsum for a given clinker.

Mortar strengths at constant water content are generally reduced, but concrete strengths although lower at early ages, generally compared, favourable with the straight gypsum product.

Materials obtained by actual plant experimental grinds generally show acceptable performance in all area except very early strengths.

So operational problems were encountered during this plant evaluation. Partial substitution for gypsum reduces false set properties dramatically in a severe false setting system.

The paper came to the conclusion that although more work needs to be conducted before definite conclusions can be reached, the results of work thus far indicate that partial substitution of limestone for gypsum can be positive factor not only in cement performance but in cement plant profitability as well.

B - USING GRINDING AIDS.

It is always observed that the grinding balls and cylpebs discharged from cement mills (Benghazi) and (El Hawari Cement Plants) were compeltely coasted with thick layer of finely ground cement particles.

The thickness of the finely ground cement coating covering the surface of the grinding media reaches 2 mm.
It was also observed that lumps of accumulated cemented grinding balls or cylpebs were scattered through the discharged grinding media in some cases.

We beleive that the causes of ball or grinding media coating may be attributed to one or more of the following:-

1 - Static electricity.

2 - Adsorption theory.

3 - Mechanical packing theory.

The factors contributing to ball coating are:-

1 - Ball coating increases with elevated temperatures.

2 - When gypsum is ground with clinker, gypsum dehydrates which causes ball coating.

3- Stored clinker have the tendency to cause ball coating more than the fresh burned clinker.

4 - (Roughness of ball surface accumulate coating while smooth surface balls do not cause accumulation of finely ground cement.

5 - Presence of non burned clinker.

6 - Absence of hard material.

7 - Using open circuit mills.

The presence of thick coating makes it necessary to use grinding aids. These grinding aids are materials able to enter the micro cracks of the solid, possibly by way of the micro-cracks; and because of the highly reation surfaces produced in breaking, these materials move with velocities akin to the velocities of the crack propagations and provide a barrier to the dissipation of energy.

Rehbinder, Sehreiner and Zhigach suggested that the effect was that of the additive filling the cracks during stress relief and preventing them sealing up during the comminution process.

The grinding aids also prevent ball coating and desperse the ground material. The majority of the grinding aids can be strongly adsorbed by the ground particles, so that surface energy requirements are satisfied and no bonds remain to attract other particles and cause agglomeration.

These materials increase mill efficiencies beside reducing power costs thus, paying their way. They increase the efficiency of air serpators by dispersing the particles so that the smaller ones are not carried along by the larger.

There is a decrease in volume of the circulating load as a result of more fines being released as finished product. The grinding aids improve the cement flowability after grinding.

C - ADDITION OF IRON OXIDES TO THE RAW MIX.

The substitution of ferric oxide for alumina, or an increase in ferric oxide content reduces the proportion of C_3A and increases that of C_4AF in the cement. The latter has less rapid setting properties and hence if the iron oxide content is raised along with the alumina, and increase alumina and ferric oxide content can be carried without setting troubles arising.

To study the trend in the tricalcium aluminate content of the clinker produced by using the raw materials already prospected and available to the Libyan cement Company we returned back to Holderbank report concerning (the raw material basis, plant site, section C, report No. E D 67/6075/E)

It has been stated that based on the results obtained from the complete analyses of the limestone and red clays as shown in the tables from the area south of Wadi Al Gattarah and the calculated two components raw mixes, that an ordinary Portland Cement of the ASTM Type I, " for the use in general concrete construction ". may be obtained.

Table : 1

CHEMICAL AND MINERALOGICAL COMPOSITION OF CALCULATED

2 - COMPONENT RAW- MIXES FROM

BENGHAZI AREA.

(Calculated to 50% C_3S)

Raw mix. No.		1	2	3	4	5	6	7	8	9	10	11	12	13
LIMESTONE DESIGNATION		Z-A	Z-4	Z-5	Z-5	Z-5	Z-31	Z-31	Z-11	Z-28	Z-28	Z-31	Z-28	Z-11
Mixing ration%		66,08	70,66	71,95	67,84	61,54	54,82	58,69	57,20	62,61	64,32	60,47	74,73	56,06
RED CLAY designation		Z-4	Z-5	Z-5	Z-4	Z-11	Z-4	Z-11	Z-11	Z-11	Z-16	Z-16	Z-28	Z-11
mixing ratio %		33,92	29,34	28,05	32,54	38,46	35.18	41,31	42,80	37,39	35,68	39,53	25,63	43,94
Calculated chemical compositon of the clinker	SiO_2	23.01	22,13	21,88	22,69	22,21	22,72	22,19	21,89	22,18	22,53	22,56	22,19	22,53
	Al_2O_3	5,50	6,29	6,27	5,54	6,09	5,64	6,26	6,56	6,34	5,95	5,82	6,36	5,81
	Fe_2O_3	2,30	2,48	2,53	2,35	2,42	2,23	2,34	2,37	2,37	2,34	2,33	2,33	2,21
	CaO	65,09	64,81	64,35	64,61	64,66	64,82	64,84	64,83	65,04	64,99	64,08	65,05	64,74
	MgO	2,08	2.50	2,56	2,56	2,50	3,25	3,14	3,19	2,90	3,06	3,31	2,93	3,38
	K_2O	1,02	1,12	1,08	1,00	1,03	1,05	1,08	1,04	0,98	1,01	1.08	1.01	1,01
	Na_2O	0,25	0,43	0,34	0,36	0,37	0,42	0,44	0,44	0,36	0,33	0,36	0,36	0,41
	SO_3	0.15	0,15	0,86	0,84	0.78	0,19	0,17	0,17	0,16	0,16	0,19	0,14	0,14
TOTAL		99,40	99,91	99,89	99,95	100,06	100,32	100,46	100,49	100,33	100,37	100,44	100,37	100,23
Moduli	$\frac{Al_2O_3}{Fe_2O_3}$	2,39	2,53	2,45	2,36	2,51	2,53	2,67	2,77	2,68	2,54	2,50	2,73	2,63
	$\frac{SiO_2}{R_2O_3}$	2,95	2,52	2,49	2,88	2,61	2,89	2,58	2,45	2,54	2,71	2,77	2,56	2,81
Lime sat. Lea &Parker		89,88	91,29	91,54	90,24	91,13	90,37	91,27	91,87	91,45	90,74	90,58	91,44	90,70
potential mineralogical composition of the clinker	C_3S	49,63	49,64	49,73	49,77	49,84	49,90	49,96	49,88	50,00	49,80	49,76	49,89	49,90
	C_2S	28,60	26,08	25,29	27,57	26,15	27,56	26,20	25,19	25,93	27,09	27,21	26,06	27,01
	C_3A	10,67	12,46	12,33	10,69	12,04	11,17	12,62	13,36	12,78	11,80	11,45	12,90	11,65
	C_4AF	6,99	7,54	7,69	7,14	7,36	6,78	7,11	7,20	7,20	7,11	7.08	7.08	6,72

Table: 2

CHEMICAL AND MINERALOGICAL COMPOSITION OF CALCULATED 3 - COMPONENT RAW MIXES FROM THE BENGHAZI AREA.

(Calculated to 50% C_3S and 8% of C_3A) Pyrite ash : CA Mat. No. 5244 " Attisholz ".

Raw mix No.		1A	2A	3A	4A	5A	6A	7A	8A	9A	10A	11A	12A	13A
LIMESTONE														
designation		Z-4	Z-4	Z-5	Z-5	Z-5	Z-31	Z-31	Z-II	Z-28	Z-28	Z-31	Z-28	z-II
Mix. ratio %		64,25	70,16	71,41	65,64	61,48	62,94	58,67	57,18	62,59	64,24	60,39	73,66	56,14
RED CLAY														
designation		Z-4	Z-5	Z-5	Z-4	Z-11	Z-4	Z-11	Z-11	Z-11	Z-16	Z-16	Z-28	Z-11
Mix. ratio %		34,34	27,85	26,63	32,96	36,70	35,44	39,28	40,42	35,27	34,07	38,07	24,18	42,23
PYRITE ASH														
Mix. ratio %		1,41	1,99	1,96	1,40	1,81	1,62	2,05	2,40	2,14	1,69	1,54	2,16	1,63
Calculated chemical composition of the clinker	SiO_2	21,48	21,15	20,91	21,25	21,27	21,06	21,10	20,62	21,06	21,60	21,71	21,06	21,65
	Al_2O_3	5,63	6,14	6,13	5,64	5,96	5,76	6,10	6,38	6,19	5,84	5,70	6,19	5,72
	Fe_2O_3	4,10	4,90	4,88	4,11	4,62	4,30	4,83	5,27	4,97	4,42	4,21	4,97	4,23
	CaO	63,15	63,66	63,19	62,74	63,49	62,64	63,46	63,19	63,59	63,83	63,71	63,59	63,65
	MgO	2,46	2,44	2,49	2,51	2,45	3,17	3,06	3,11	2,83	2,99	3,24	2,86	3,32
	K_2O	1.04	1.08	1,04	1,01	0,98	1,06	1,02	1.00	0,97	1,00	1,05	0,97	1,00
	Na_2O	0,37	0,36	0,33	0,35	0,39	0,39	0,42	0,42	0,37	0,32	0,36	0,35	0,40
	SO_3	< 0,15	< 0,15	0,87	< 0,76	< 0,78	< 0,12	< 0,17	< 0,17	< 0,16	0,14	< 0,19	< 0,14	< 0,14
Total		98,38	99,88	99,84	98,37	99,94	98,50	100,17	100,16	100,14	100,14	100,17	100,13	100,11
Moduli	$\frac{SiO_2}{R_2O_3}$	2,21	1,91	1,90	2,17	2,01	2,09	1,93	1,77	1,89	2,10	2,19	1,88	2,18
	$\frac{Al_2O_3}{Fe_2O_3}$	1,37	1,25	1,26	1,37	1,29	1,34	1,26	1,21	1,24	1,32	1,35	1,25	1,35
Lime sat. Lea & Parker		90,92	91,38	91,62	91,15	91,22	91,37	91,43	91,99	91,50	90,87	90,70	91,49	90,78
potential mineralogical composition of the clinker.	C_3S	50,05	50,05	50,05	50,05	50,05	50,05	50,05	50,05	50,05	50,05	50,00	50,05	50,05
	C_2S	23,86	22,92	22,24	23,19	23,26	22,64	22,75	21,39	22,64	24,19	24,53	22,65	24,34
	C_3A	8,00	8,00	8,00	8,00	8,00	8,00	8,00	8,00	8,00	8,00	8,00	8,00	8,00
	C_4AF	12,46	14,90	14,82	12,50	14,04	13,06	14,68	16,03	15,12	13,45	12,80	15,11	12,87

It is clear from the calculated raw mixes results shown in table 1 that C_3A content of the clinker ranges between 10.67 % - 13.36 %. These percents runs parallel to the quantities of C_3A content in the clinker produced already by LCC production lines and they can be considered as fairly high taking in consideration the presence of high percent of alkalies which makes it very sensitive to any moisture content. The clinker alkali content ranges between 1.34 - 1.55.

For these reasons it was suggested to add pyrite ash of the following composition to the raw mixes as a third compound to decrease the C_3A and increase the C_4AF content of the clinker.

Table 2 shows the calculated three component raw mixes. By using pyrite as a third component in the raw mixes in the range between 1.4 % - 2. 4 %. it will be possible to increase the value of the C_4AF and decrease the value of C_3A to maximum 10 % which helps in eliminating the formation of cement lumps in the cement silos to a great extent.

Accordingly the quantity of pyrite ash required to produce two million tons of cement is:-

20.00,000 X 1.18 % = 23,600 Tons/Year.

D - MILLING CONDITIONS:-

Overcoming generation of heat during grinding by cooling.

The majority of the energy input is usually converted into heat during grinding any material in ball mills. The mill temperature rises to more than 100 °C and when the temperature increases more than that temperature limit the gypsum which is sensitive to temperature dehydrates with partial separation of its water of cystallization and accordingly it loses its property as a cement setting retarder.

To reach the required results from cooling the ball mill, this can be done in the closed circuit mills specially in the air separators. Cooling of ball mill can be approached through mill ventilation, a controlled amount of water is injected inside the hottest part of the finish mill where most of it is evaporated at once. About 15% of the non evoporated water is carried out to the storage silos.

The problems that may accompany water injection is dropping of such non- atomized water inside the mill. Such water droplets are adsorbed on cement grains leading to setting, hydration and accumulation of cement accretions.

This process might have a negative influence on the produced cement. Injection of non atomized water inside the ball mill can be attributed to the clogging of the water nozzle or to the insufficient compressed air pushing the water through the nozzle or to the diameter of nozzle opening etc.

In some cases cement can be cooled in the air separators or by introducing the discharged ground cement into special tanks equipped with internal water pipe cell system and a sloping bottom made of a porous medium through which compressed air is applied and passes to the introduced cement to fluidize, mix and cool.

The discharged cement temparature coming out of these tanks is reduced depending on the cooling water temperature and thus minimizing the possibility of gypsum dehydration. The only defect of using such system is the formation of cement lumps around the water cooling pipe cell.

Some cement plants spray water on the produced clinker while transported by drag chain. This process which we do not recommend usually creates severe problems in forming big clinker lumps in its storage period time.

E: - CEMENT SILOS DESIGN:-

As a matter of fact any cement silos design has to be based on some factors to make the cement flow easily inside the silos to be discharged without any serious problems. These factors are:-

1 - The chemical composition of the produced cement and the effect of such composition on the formation of lumps and accretions.

All the calculated raw mixes studied through [illegible]ibility studies by Holderbank and the contract [illegible]een LCC and KHD showed that the expected produced cement is of moderate to high content of C_3A and alkalies which makes the first more sensitive to produce syngenite or ettringite leading to the fomration of lumps and accretion. This problem has to be taken in consideration before designing the cement silos.

2 - The distance between the air slides at the bottom of the cement silo has a pronounced effect on fluidizing and mixing the stored cement easily inside the cement silo. The minimum the distance the maximum the fluidizing action.

- The designed distance between the air slides at the bottom of the tank is obviously apart and tne air slides can possibly be increased to minimize the distance in between in order to reduce the static stability of the covering stored cement by contineous fluidizing it.

3 - The dead space between the discharging cement outlet and the silo wall creates the presence of dead quantities which within the required period of time undergo chemical reactions leading to the dehydration of gypsum and the formation of lumps and accretions specially in this space. The formation of lumps at this space makes it possible for heaping more cements on.

- To minimize the dead space around the discharging openings some silo designers prefer to install a cone like shape structure inside the silo covering these discharging openings.

  Accordingly the space between the conical bases structure and the silo wall will reach the minimum distance avoiding any dead cement heap accumulations to prevent the cement from undergoing any chemical reactions.

  To increase the discharging cement outlets from all parts of the silo to avoid the cement long residence. (the silo contain two discharge outlets).

  To increase the inclination of the cement silo bottom along and vertical to the air slides.

4 - Painting the inner-silo walls by special enamel coating will help to reduce the adherence of stored cement to the cement silo inner walls to the minimum but it will not avoid the lump formation caused by the action of chemical reaction.

  A proposal from Holderbank to paint the inner walls of the LCC cement silos was received during (June, 1980).

5 - Efficiency of the compressed air and its injectioning fluidizing device system in the cement silo is helpful for continuous fluidizing and mixing cement inside the silo. It is worthy to state also that the injected compressed air must be free of water resulting from condensation of water vapour. This can be done through water traps installed before the cement silo, or by introducing the compressed air inside big tanks and water have to be expelled continuously through a tap installed at the bottom of these air tanks.

After discussing the reasons and factors affecting the formation of cement lumps and accretions whether chemically or physically or due to the design of cement silos or a combination of both.

Accordingly and in order to locate specifically which factor has the major effect to create the formation of such lumps and the poor flow of cement, it was recommended to proceed in various ways to attck the problem of avoiding to a great extent the formation of lumps in LCC cement silos as follows:-

1 - Accepting the KHD proposal by partial substitution of the common used limestone for gypsum during clinker grinding.

2 - As LCC is producing cement sensitive to water vapour which reflects adverse effects on the properties of cement, accordingly the amount of moisture available to the cement should be kept as low as possible and the water injection into cement mills should be avoided during the test period.

By eleminating the compressed air from condensated water by installing water traps before the cement silos, or by introducing the compressed air inside big tanks equipped with taps at their bottom to expell continuously the condensed water.

3 - It is advantageous to decrease the temperature of the produced cement and to keep its temperature as low as possible below 110 °C. This can be reached by:

Using stored cooled clinker i.e. the newly produced clinker must be stored before grinding for about one week.

4 - To discuss with Holderbank their proposal to paint the cement silo "inside walls" from its advantage, costing, duration etc., to come to a conclusion.

5 - To contact IBAU HAMBURG INGENIEURGESELLSCHAFT INDUSTRIEBAU MBH, to send one of their specialists according to thier proposal to LCC to discuss with him on spot much more details concerning their offer to install a cone like shape structure inside the cement silos to minimize the dead space between the discharging openings and the silo wall.

6 - To try to use controlled explosive force (Cardox) Pressure gas method as a mechanical method to avoid the formation of lumps and layering (coat) of cement on the silo walls on some elevated distances.

7 - Using the grinding aids by contacting the producers to carry on special tests on the LCC cement production to choose the most effective grinding aid applied. (Laboratory tests must be carried out by LCC specialists before applying it on large scale production).

8 - As a final step it is recommended if negative results is obtained to add iron oxide ore or pyrite ash to the raw mix as a third component to decrease the C_3A and increase the C_4AF content of the clinker.

OPERATIONAL TESTS BY USING LIMESTONE

ADDITIVES TO IMPROVE CEMENT FLOWABILITY

As discussed before and according to the author's advice LCC accepted KHD recommendation to carry out operational tests on it's cement production by using limestone additives to improve LCC cement flowability.
A technician from ZEMLABOR according to KHD order to this Institute carried out the job in co-operation with the LCC technical authorities and UNIDO ADVISER according to a special program agreed upon as follows:

1 - Fixing to some extent the SO_3 content of the cement produced.
2 - Adding limestone to gypsum in low percentage as indicated in table..3.........
3 - The cements produced were to meet the standard specifications BS 12/1958.
4 - Individual samples has to be tested every one hour which were collectively combined later and subjected to testing by ZEMLABOR.

Table:.3.........................Grinding Operations.

Grinding Operation	Date	Limestone addition	SO_3
		% by Weight	% by Weight
1	28th August, 1980	2	3.0
2.1	4/5 September, '80	2	2.2
2.1	7th September, '80	2	2.0 - 2.2
3	21/22nd ,, '80	3	2.0 2.2
4	2/3rd October, '80	4	2.0 2.2

TABLE 4

Chemical composition of the Portland Cements

cement sample	0	1	2.1	2.2	3	4
	portions in % by weight					
loss on ignition	(1.95)	(3.62)	(2.37)	(2.62)	(2.96)	(3.32)
(insoluble matter)	(0.57)	(0.65)	(0.44)	(0.32)	(0.36)	(0.30)
SiO_2	21.82	20.91	20.90	20.76	21.26	21.36
Al_2O_3	5.42	5.17	5.40	5.30	5.50	5.53
Fe_2O_3	2.29	2.20	2.27	2.23	2.25	2.28
MnO	0.05	0.05	0.05	0.05	0.05	0.05
CaO	63.97	64.90	64.23	64.33	64.05	64.13
MgO	3.54	3.09	3.32	3.18	3.38	3.70
SO_3	1.50	2.07	2.18	2.32	2.15	1.69
Na_2O	0.17	0.16	0.14	0.15	0.23	0.25
K_2O	0.75	0.73	0.74	0.73	0.74	0.73
balance	0.49	0.72	0.77	0.95	0.39	0.28
CO_2	1.34	2.67	1.74	1.91	2.22	2.81
lime saturation	91.2	96.0	94.5	95.3	92.7	92.8
silica ratio	2.83	2.84	2.73	2.76	2.74	2.74
alumina modulus	2.37	2.35	2.39	2.37	2.45	2.43
C_3S	50.7	61.5	56.8	58.7	52.9	53.5
C_2S	24.3	13.6	17.1	15.2	21.1	20.9
C_3A	10.5	10.0	10.5	10.3	10.8	10.8
C_4AF	7.0	6.7	6.9	6.8	6.8	6.8

Determination of the grinding fineness

Specific surface according to Blaine

Table 5

Blaine values

cement sample (tested cement)	specific surface acc. to Blaine cm^2/g
- o -	2,730
1	3,050
2.1	2,780
2.2	2,890
3	3,060
4	2,820

Cement testing as per BS 12/58

Table 6

Results as per BS 12/58

cement sample	0	1	2.1	2.2	3	4
volume stability (Le Chatelier test) (in mm)	1.5	1.5	1.0	1.0	2.0	1.0
setting beginning (h)	2.30	2.20	2.20	2.20	2.20	2.40
end (h)	3.30	3.40	3.40	3.30	3.30	3.50
compressive strength (lbf/in^2)						
3 days	3356	3877	3745	4465	3678	3394
7 days	4370	5480	5280	5555	5385	4787

Increase in compressive strength can be represented in comparison to 0 - grinding as shown in table 7.

Table 7:

Relative compressive strengths
referred to 0 - Cement (= 100 %)

Cement Sample	0	1	2.1	2.2		4
Compressive Strength (%)						
3 days	100	115.5	111.6	133.0	109.6	101.1
7 days	100	125.4	120.8	127.1	123.2	109.5

Flow Properties Determinations:-

The flowability test of cement samples were carried out by ZEMLABOR according to Imse method, published in journal ZKG 25 (1972) 147.

ZEMLABOR used steel plate instead of a glass place in contrast to the equipment described in article mentioned above Sieves of mesh widths 0.20 - 0.50 - 0.63 and 1.00 mm have been used.

Each experiment was carried out twice and the results are shown in table - 8.

Table - 8.

Testing of flow properties of samples (average values)

Cement Sample	0	1	2.1	2.2	3	4
	Screen through in % by weight					
Sieve/Mesh Width (mm)						
1.0	100.0	100.0	100.0	100.	100.0	100.0
0.63	94.5	76.0	80.0	85.5	86.7	83.5
0.50	71.5	62.5	67.5	69.0	74.8	72.0
0.20	14.0	13.0	15.0	14.5	14.2	14.2

FINDINGS AND CONLUSIONS OF USING LIMESTONE AS ADDITIVE

From the tests carried as shwon in the previous tables the following can be stated:-

1 - Addition of limestone (specially 2%) to clinker druing grinding to produce cement l ds to increase in compressive strength. This accor to the authors idea was due to the action of limestone to fill the voids of the cement paste , mortar) causing more compaction of the cement mortar.

2 - Impure gypsum is used as an additive in LCC, during clinker grinding. This relatively high percentage of gypsum impurity (mainly limestone and marl) influences the percentage of impurity of limestone contained with gypsum ore which influence the grindability and flowability of the cement to such an extent and accordingly the effect is not so obvious and distinct. For this reason the author is carrying some laboratory tests to deal with adding limestone to the impure and pure gypsum respectively.

3 - It was clear from the shown results that the effect of adding limestone to gypsum during grinding with clinker has not any significant effect, and this effect is very difficult to assess i.e. the effects the ad dition of limestone to improve flowability cement does not reveal significant charges as achieved by some other plants mentioned in the previously represented paper.

PAINTING THE INNER-SILO WALLS:

As stated before painting the inner-silo walls by special enamel coating will help in reducing the adherence of stored cement to the cement silo inner walls to the minimum.

Mr. Hans Schatzmann from SCHATZMANN AG, on his way to Derna Cement Project with Mr. Schatzmann (Holderbank) passed by LCC (Benghazi) at July 1981. A meeting was held.

The first started to explain the following:

1 - Painting the inner-silo walls by special paintings produced by his company. " 5620 Bremgarten, Inten - hardstrasse 42, Switzerland " will prevent lumps formation in cement silos as the painting (plastic) will act as a very smooth surface which will prevent adherence of cement particles on these inner silo walls.

2 - It is advisable that the painting can be used after the erection of the new cement silos. The painting can be applied to the bottom surface and upto about 2 meters level.

3 - For LCC Cement silos (Old Silos) he proposed to paint all the inner - silo walls.

4 - Painting of one square meter costs, if applied in Switzerland 65 S.F.

The author started to discuss the previously mentioned facts and concentrated on the following:-

1 - Painting can be applied only immediately after erecting the cement silos in any cement projects to avoid any! humidity whether penetrating from out-side through the outer walls or resulting from the new concrete.

2 - The main factor for creating lumps in LCC cement silos is a chemical factor and according to the author's idea this painted surface will not prevent the formation of lumps as these lumps will be formed whether -

the inner walls were painted or not (the chemical factors effecting the lumps formation were previously discussed).

3 - It is better to try an acceptable solution i.e. to avoid the lumps formation whether chemically or physically as painting will cost much and its application will not lead to full success.

At the end of discussions it was agreed that as the lumps are formed chemically or physically accordingly, it is preferable to try to solve the problem chemically or physically and to postpone application of painting the inner silo walls.

CEMENT SILO DESIGN

As stated before any cement silo design has to be based on some factors to make the flowability of cement in-side the silo and on discharging it very easily. One of these factors is to install a cone like shape structure inside the silo with many discharging openings situated around its periphery.

Installing such cone like structure base will lead to minimum distance between the cone and the inside silo walls and accordingly will avoid any dead cement heap accumulations.

It was also recommended to contact the designers of this cone shape cement silo base (IBAU HAMBURG INGENIEUR - GESELLSCHAFT INDUSTRIEBAU MBH), to send one of their specialists to discuss in more details on spot LCC cement silos circumstances, advantages and the availability of installing this cone structure inside LCC cement silos.

Two representatives of IBAU HAMBURG CO., arrived Benghazi according to the request of LCC. They are :-

1. Mr. W.E. LUMMEL
2. Mr. P.K. KLEIN - ALIBENHAUSEN

They met Mr. Ali Fathi and the UNIDO Adviser and they began to discuss the whole matter concerning the installment of a steel cone with 8 discharging openings at the bottom of LCC cement silos. A meeting was held in the training centre between the above mentioned representative and LCC engineers and they lectured about the up-to-date technology of designing the cement silo concentrating on their own design (steel cone structure cement silo base) as it is the latest up-to-date design in this field and it is performing in a successful way in many cement companies distributed in many countries all over the world.

The adviser submitted the following questions in the tripartite meetings and at the end of the lecture.

i - Is this design (Steel cone structure) will be helpful to LCC to overcome completely the problem of Cement lumps and accretion formation in its existing cement silos ?

ii - As this structure and the upper parts of the cement walls are the coldest parts accordingly the possibility of lumps formation will increase specially on the sides and the upper most part of the cone structure, leading to adhesion of cement particles not only against the upper parts of the cement inner walls but also against! the steel cone structure as the main factor of creating such lumps is a chemical factor.

iii - What is the main action of this designed steel cone structure against lumps formation?

iv - What is the possibility of clogging all the discharging 8 openings ?

v - The possibility of getting rid of these lumps.

As a matter of fact the following statements and facts were reached through the tripartite and lecture meeting:-

1. This cone will not influence the formation of the cement lumps inside the silo as these lumps are formed chemically.
2. The design of the steel cone structure is to decrease the dead space between the discharging points and cement particles accumulated in this dead space, no giving opportunity to react chemically to form such lumps as there is no much time left to continue cement chemical reaction in this place.

3. The chance of forming these lumps will be concentrated on the upper parts of the cement silo inner walls due to chemical reaction between the liberated water (formed) through the dehydration of raw gypsum due to high temperature) and cement in contact to the upper parts of the inner wall of cement silo to form the next texture of ettrringite.

4. The main action of th's design is a physical factor.

CONTROLLED EXPLOSIVE FORCE (CARDOX)

Pressure Gas Method

KHD proposed to use the pressure gas method to act upon the solidified cements in L.C.C. cement silos. This system is practically employed in those cases where a predictable pressure effect in such a special direction and extent is required. This system can be applied with pressure gas apparatuses which can work with highly compressed carbon dioxide (CO_2), also known as carbonic acid. Pressure gas tubes are filled with CO_2 under pressure and inserted in boreholes into the silo's concrete at special levels due to the accumulation of lumps. These tubes have to be triggered off by electricity, the charge quickly expands and presses the surrounding material apart. This method is always used and employed to break up deposits in rotary and shaft furnaces to drop the clinker rings and disintegrate the contents of silos which have become jammed (as in our case) to loosen rocks and overhangs in vicinity of installations requiring protection and to break up bulk goods in halls and narrow spaces.

The Company agreed on the KHD proposal and the whole equipment consisting of pressure gas tubes, pressure gas filling machines for filling the pressure gas tubes with CO_2, drilling apparatus for making the boreholes, priming machine and cable for release were bought. Fortunately, all the equipment arrived just a few days ago and we hope that this method will help us in getting rid of cement lumps in our cement silos.

A MECHANISM TO CLEAN THE CEMENT SILOS.

CONTENTS:-

1 - TECHNICAL DISCRIPTION OF THE MECHANISM

2 - INSTALLING THE MECHANISM

3 - FUTURE MODIFICATIONS

4 - TECHNICAL DRAWINGS OF THE CLEANING MECHANISM.

MECHANISM TO CLEAN THE CEMENT SILOS

Due to the general complaints of cement deposits on the silos walls in these days, the Libyan cement company's Mechanical Department, after authentic research and planning, was succeeded to create a special mechanism to clean out the cement silos without taking any risk of human lives and finally this mechanism after trail, proved the worthness and hardship of the LCC and got through of cleaning one cement silo of height..........., width.......... in only .... working hours.

Now about the details of the said mechanism, shown in the drawings:-

The whole mechanism is based upon a cast steel plate, having a centre hole, for the bolt D, and have four structural arms.

The centre hole on the base plate B is created specially for bolt D, with which the wire rope is attached for to and from vertical motion.

The bolt D is supported by two auxiallary lower plates at the base and one auxiallary top plate, which as well works as a tension centre for the lever arms, with the help of section C and E.

Moreover, the base plate B has four horizontal structural arm channels, one in each direction to hold the cutting devices holder.

The cutting blades and scraping tools are mounted on the curved rectangular bars, and the cutting blades on each curved rectangular bars are to be increased or decreased according to the requirements, while the distance between each blade is adjustable.

Each active side of the blade is 120 wide. Each rectangular curved bar is attached with a hollow channel beam of 1000 Lg. which while assembling is attached with the lever arms of the base plate B by over lapping method and as well can be adjusted any time according to the sticking! layers of cement on silo walls and according to the different diameters of silos.

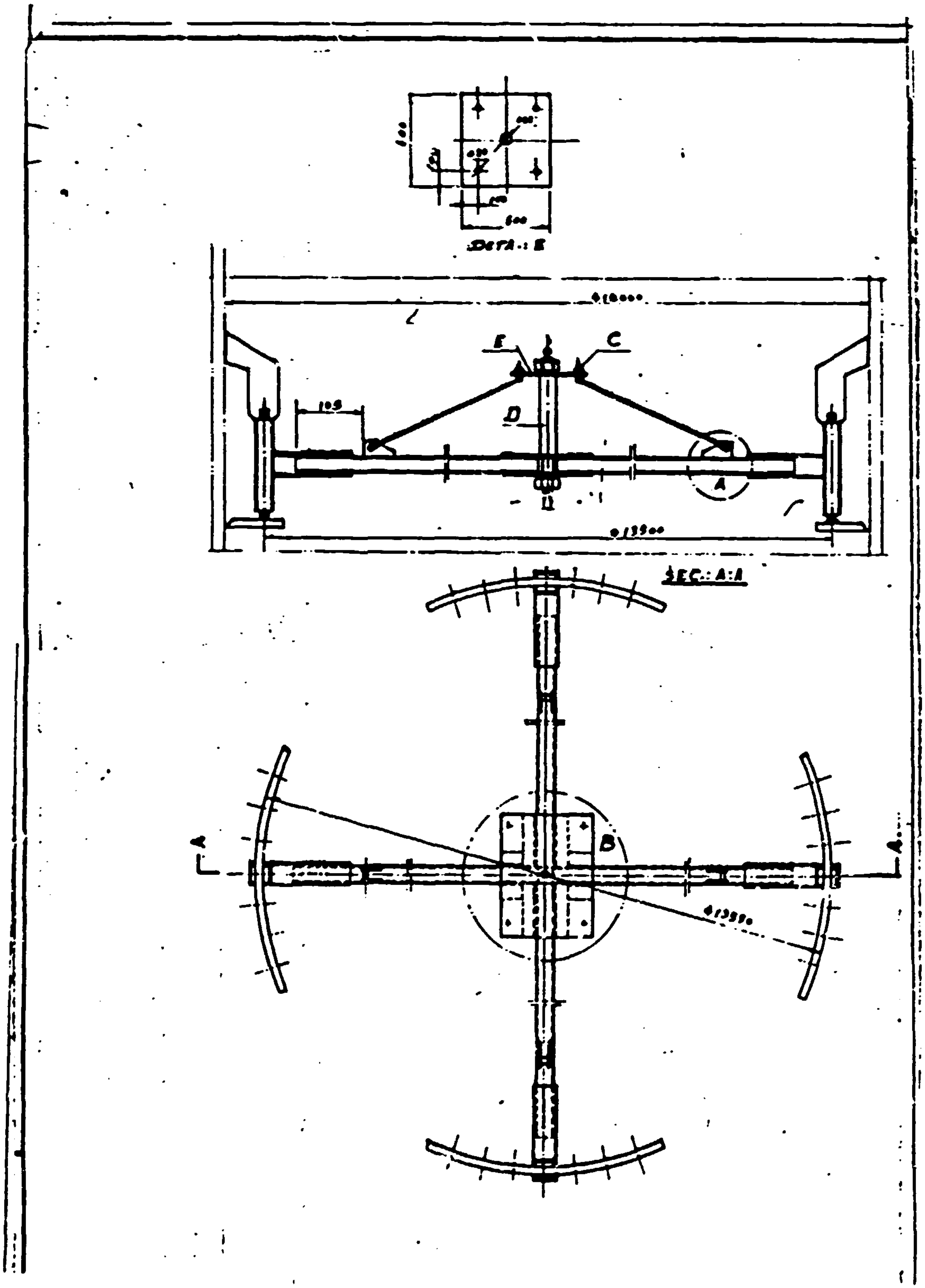
Now the way of installing the said mechanism.

The two wire ropes are entered into silo through the top roof of the silo and are brought out from the down window of silo.

Part of this mechanism i.e. two arms are assembled out side the silo in 180 ^{o} position, one wire rope is attached with D and this partly assembled mechanism is taken inside the silo through the lower windo, while a special protection cover is taken inside the silo by the help of other wire rope and when this partly assembled mechanism is covered by the said special protection, then the workers go inside turn the mechanism and fix the other two arms.

The vertical to and fro motion is given with the help of first wire rope with wench, while the horizontal rotational movements are given with the help of ordinary rope which works in the grooves of two pulleis attached under the lower side of the base plate B

In future LCC plans to run this mechanism mechanically i.e. the horizontal rotational motion will be transmitted by a motor, which will be attached with the help of couplings with main bolt D, and then this mechanism will do the neat cleaning of the silo in the horizontal rotational way.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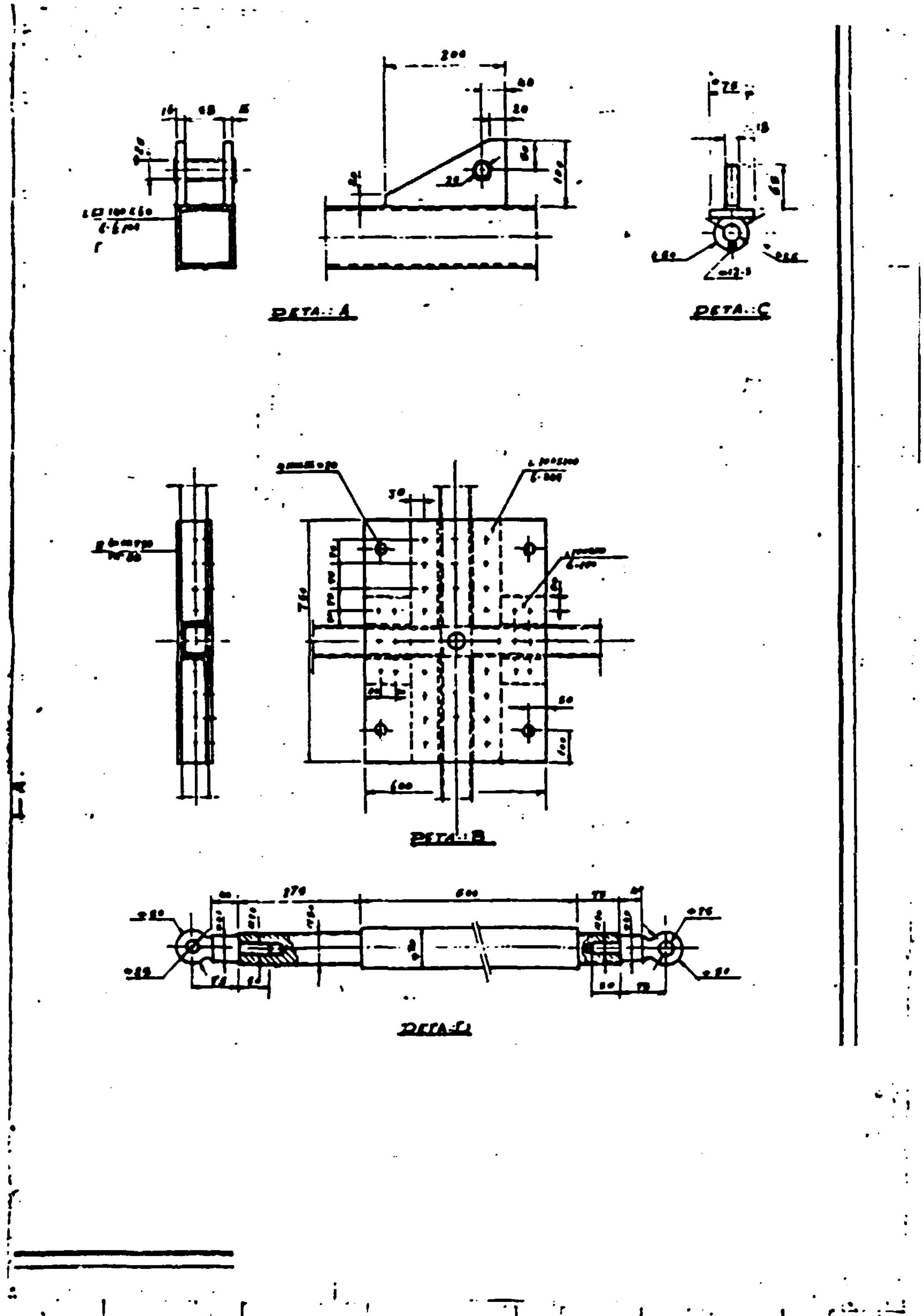
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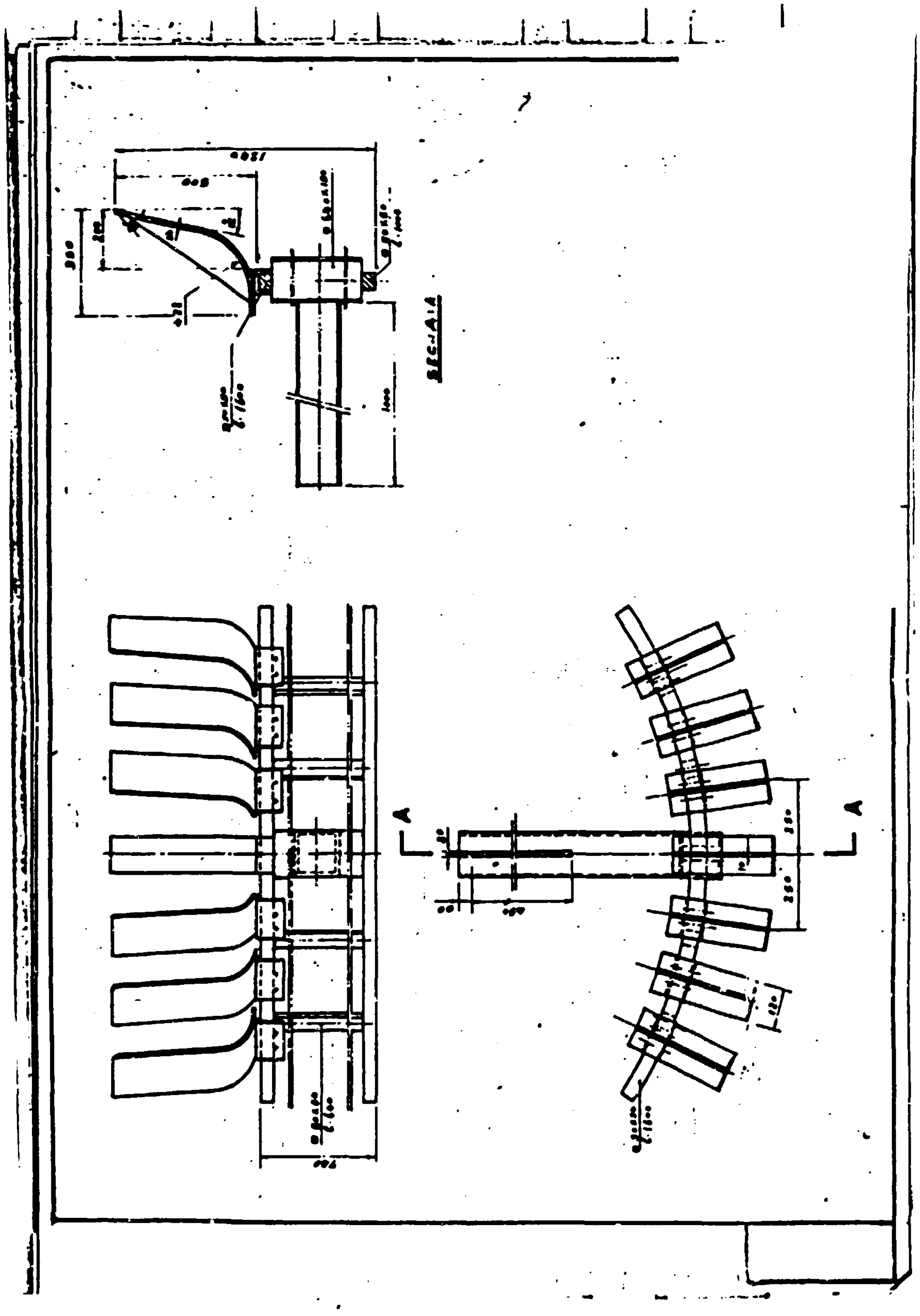

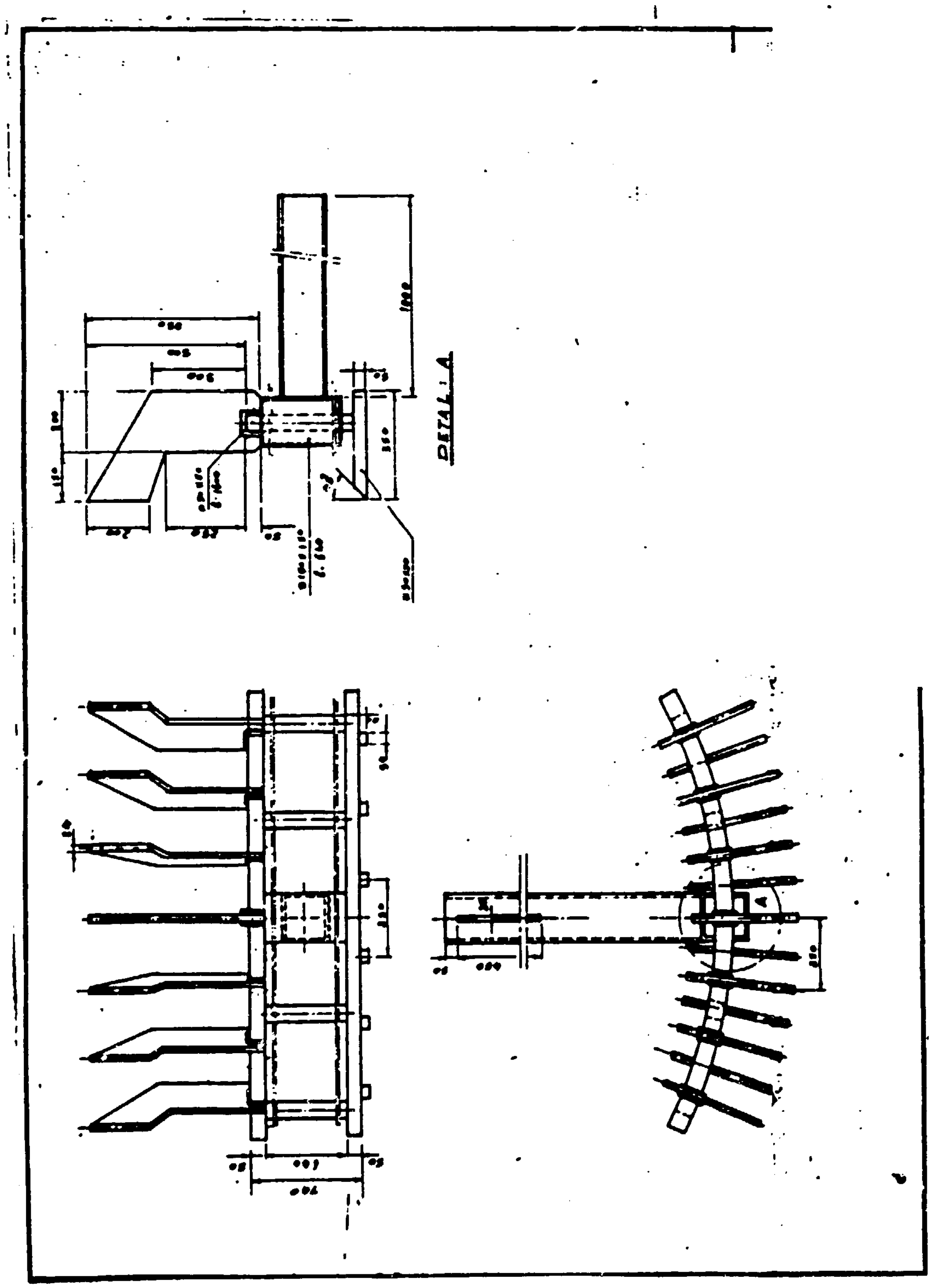
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