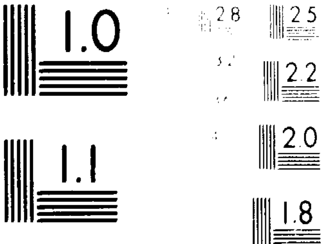
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3 December 1980
English

A STUDY OF

HARBIN BUILDING MATERIALS PROCESSING PLANT

PRODUCTION OF AUTOCLAVED AERATED CONCRETE

DP/CPR/79/019

PEOPLE'S REPUBLIC OF CHINA

Technical Report *

Prepared for the Government of the People's Republic of China
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of P. Olof Grane, Expert
in aerated concrete manufacturing equipment

United Nations Industrial Development Organization
Vienna

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TABLE OF CONTENT

JOB DESCRIPTION

Purpose of project: To improve the standard and operation of the machinery and equipment for aerated concrete production in the Harbin Building Materials Processing Plant.

Duties: The Expert will be attached to the Harbin Building Materials Processing Plant and will be specifically expected to:

1. Improve the level of operation of the machinery and equipments of the plant.

2. Supervise production and raise the product's quality up to standards and raise the qualified rate.

3. Give lectures to the technical personnel on the subject.

Acknowlegement

The Expert wishes to express his gratitude to the personnel of the UNDP office in Beijing for the assistance rendered and to the employees of the Building Materials Ministry who briefed the Expert and finally to the Plant Management in Harbin and to the Specialist Team who worked with the Expert during his mission, and especially to

Ms. Kerstin Leitner, UNDP, Beijing
Mme. Tsi Subin, Ministry of Building Materials, Beijing
Mr. Gong Fafang, Idem
Mr. Wang Menguyan, idem
Mr. Chang Chun-Fu, idem
and
Mr. Guo Yuling, Harbin Building Products Factory
Mr. Wu Zhengzi, Team leader, Local and Modern Materials Bureau of the Ministry

and
all members of the Study Group in Harbin.

ILLUSTRATIONS

Explanatory notes

Gasconcrete = autoclaved aerated concrete

A.A.C. = autoclaved aerated concrete

F.L.S. = F.L. Smidth, Copenhagen Denmark

B.I.C. = B.I.C.-Consortium, Gothenburg, Sweden

SUMMARY AND RECOMMENDATIONS

Although the Harbin gasconcrete plant runs fairly smoothly, there exist several problems, more or less serious.

1) Because of lack in the supply of cement the plant has not enough raw materials to produce more than 60% of its capacity. If the cement could be replaced totally or in part by lime, production could be increased. Tests for this purpose made by the Plant Management were not successful.

   The Expert has recommended that the cement, in whole or in part should be replaced, not by quicklime but by slaked lime and tests carried out by the Expert in laboratory as well as in full scale proved that this is feasible.

   The Expert also has given advice on different methods to produce slaked lime and considers that for proper needs, a production of lime milk (lime slurry) would be the simplest and best way out.

2) One of the main problems in the plant is lime of non-uniform quality. This depends on variations in the lime kiln and is probably also connected with the fact that the kiln is run at reduced capacity.

   Variations in a shaft kiln can never be completely avoided and the Expert therefore has recommended the installation of homogenizing silos. In such silos lime for a whole day's production can be homogenized and in the Expert's opinion 75% of all the difficulties in the casting section can thus be eliminated.

3) Poor mixing depends on the construction of the mixer and the way the powders are added. Lime is difficult to mix completely with a slurry but if it is premixed in its dry state with the cement, a considerably better dispersion is achieved. For this purpose the Expert has recommended a flow-mixer. Even a simplified one would be useful. A final and more intense

mixing can be achieved by installing a recirculating pump.

4) Crack formation can be due to unsuitable lime, unsuitable aluminium powder, careless handling, faulty machinery and/or machinery lacking precision and too long waiting time and/or a too quick uptake of the pressure in the autoclaves. Each of these reasons have their own obvious and natural remedy. Their correction should considerably reduce the amount of waste.

5) Unexact dimensions are solely due to poor precision of the cutting machine which has to be adjusted accordingly. For future plants the Expert has recommended that the B.I.C. system should be considered, which is a modern system which treats the material very cautiously and has a high precision and produces blocks and panels with exact dimensions.

6) Low strength of gasconcrete is due to low quality raw materials. In this particular case it is the sand which is of a very low quality. It is a brownish riversand containing a high degree of foreign rock minerals, it is very low in free quartz and is contaminated by a high degree of clay.

   The Expert has recommended that the sand be washed and in the ultimate case that it should be subjected to flotation. As an alternative the Expert recommends that part of the sand is replaced with flyash which contains a high degree of reactive soluble silicic acid.

7) Maintenance problems will cease to be problems when a proper maintenance scheme is prepared. Point number one on that scheme is to keep the plant and its machinery clean. Secondly oiling and greasing program should be made and followed. Weak parts or worn parts shall be substituted. Inspection and control should be made with certain fixed intervals.

LECTURES

During the Expert's stay in Harbin he gave two lectures at the Harbin Architectural and Civilengineering Institute.

24/7 1980: "Trends in the A.A.C. field with special emphasis on the development prospects in the Third World".

25/7 1980: "The A.A.C. production process and the application of the material on the building site".

INTRODUCTION

Research on autoclaved aerated concrete (A.A.C.) started in China in 1962. The first plant was built in 1957 and the equipment and the machinery was bought from Siporex in Sweden. This plant was installed in Beijing. In 1979 the plant was modified and its capacity increased.

Today there are 9 A.A.C. plants in operation with a yearly production of 1.0 mill. m^3 and 17 more are under construction or under planning. The total capacity of those plants will be 3,5 mill. m^3/yr. and they shall be ready in 1982.

Harbin Building Materials Processing Plant

This A.A.C. plant was built by the Ministry of Building Materials according to its own design. The construction was started in 1975 and completed in 1979. The plant has 4 autoclaves and its capacity is 72 moulds or 389 m^3 working 3 shifts or about 100.000 m^3 per year and 280 working days.

1.0 RAW MATERIALS

The raw materials used are cement, lime and sand.

1.1. Cement

The cement is high early strength portland cement procured from the Harbin cement factory. The chemical analysis is:

loss by ignition	0.9%
SiO_2	22.3
CaO	62.3
MgO	1.8
Fe_2O_3	5.0

Al_2O_3	5.4
Alkali	60.5 mg equivalents/lit.

Although normal portland cement can perfectly well be used in A.A.C. production, Plant Management has chosen the high early strength type supposedly because it reduces the setting time of the mix.

However it is quite possible to produce gasconcrete from almost any type of cement but its suitability is dependant on the chemical composition and its uniformity in order to avoid trouble in the production. The following requirements should be laid down for a cement:

1) The quality should be as even and uniform as possible. Chemical composition and calcining temperature shall not be allowed to vary. This is an important condition and of much greater importance in gasconcrete production than in common concrete work.

2) When cement only is used as a binder its content of soluble alkali must be sufficiently high to produce a good expansion. Especially the content of potassium is important. Experience tells that the following norms can be set forth:

	K_2O	Na_2O
Suitable cement	0,8	0,5
Suitable cement	0,9	0,2
Suitable cement	0,9	0,5
Unsuitable cement	0,3	0,2

If the alkali content is too low, alkali in some form must be added. Because of the risk for efflorescence (Na_2SO_4), sodium salts should not be used.

3) The cement should be practically free from soluble chromium salts as they inactivate the aluminium particles and thereby retard or prevent the expansion reaction. The following examples can be given:

	$\%CrO_3$	$\%K_2O$	$\%Na_2O$
Suitable cement	0,005	1,0	0,5
Unsuitable cement	0,015	0,7	0,2
Unsuitable cement	0,008	0,3	0,6

The influence of moderate quantities of chromium salts in the cement can be eliminated by an addition of iron sulfate in the mix.

4) The sulphate content respectively the gypsum addition should be constant. The sulphate content should be sufficiently high that not too large quantities of gypsum must be added. As is well known the expansion process is gypsum consuming and consequently it is necessary with a high content of $S0_3$ in the cement which should not be less than 2,5%. But in spite of this it is necessary to use gypsum addition when producing the lighter densities. A high addition of gypsum is a rule not to prefer because the reaction temperatures during the setting of the mass tend to be too high and the hydration of the cement proceeds more than what is adequate from the point of view of strength. In order to achieve a reasonable time of setting it may be necessary to add gypsum when sugar is present as modifier of the viscosity as gypsum then will accelerate the setting.

5) A low content of aluminium in the cement seems to contribute to an increased strength of the gasconcrete. Cement with a low content of C_3A show a relatively slow increase in the concrete strength which is very advantageous to the strength of the finished product, because it appears that the less part of the cement has hydrated during the setting, the better is the end product. Moreover a relatively large amount of aluminium is added for the expansion process and it is adequate that the content of Al_20_3 does not exceed 5%.

As an example can be mentioned that the added aluminium powder during the expansion process binds not only 2,5 Kg. of lime and 4,5 Kg. of water but also 1,8 Kg. of $S0_3$. This means that the aluminium powder during the first half-hour after casting transfers about 40-50% of the cements setting regulator, the gypsum, into an inactive form. If furthermore a cement rich in aluminium is used, then it is obvious that a quick setting of the mass will take place and the consistency of the mass will be such that is prevents a normal development of pores. When setting is too quick, it may be necessary to use a special setting regulator like sugar,*/ phosphates, etc. whose object it is to keep the mass so thin that the development of pores can proceed unimpeded. Furthermore such regulators might contribute effectively to as quickly as possible transfer the hydroxide of aluminium that has been formed by the addition of the aluminium powder, into the formation of the crystalline compound 3 $CaO \cdot Al_2O_3 \cdot 3\ CaSO_4 \cdot 31{,}5\ H_2O$, this because the hydroxide of aluminium is a water absorbing compound and will contribute to the setting of the mass.

1.2 Lime

The lime is produced in a vertical shaft kiln erected on the premises. Its main data are:

Total height	38 m
Effective height	17 m
Diameter, interior	3.0 m
Diameter, cooling zone	2.4 m
Feed, stone	72 t/d
Feed, coal	7.7 t/d
Charging	every 2 hours
Discharging	every hour
Charge, each time, stone	6 t
Charge, each time, coal	0.64 t
Air pressure	30-50 mm aq.
Sinking speed	0.3 m/h
Burning duration	28-30 hours
Burning height	9 m
Max. temp.	1200° C

*/ Regarding the influence of sugar see Annex N° 1.

The limestone had been procured from different sources, the present one shown 80% $CaCO_3$ and less then 3% MgO.

The burnt lime was fed to a crusher and then to a 2 chamber tube mill to be milled to a fine powder

Specification of the tube mill:

Diameter	1.5 m
Length	5.7 m
Charge, chamber I:	80/70/60/40 mm balls
Charge, chamber II:	22 mm cylpeps
Motor	130 kw
rpm	28
Capacity	3 t/h
Fineness	5% on ASTM 170
Feed size	40 mm
Input temp.	40° C
Output temp.	60° C

The mill was watercooled. As grinding aid 1 promille of trietanolamin was added to prevent clogging.

Before one really can discuss the quality of the lime one must test the lime both chemically and physically. First the total alkalinity must be determined and then the free lime and the absolute and relative activity. Although the lime may have a high alkalinity it can have a low activity and therefore the Expert recommends that activity tests are carried out. This is done according to the description in Annex N° 2.

Example of a good lime is:

- alkalinity	92,8%
- Absolute activity	77,4% (min. 65%)
- relative activity	83,0% (min. 80%)

The slaking curve is another important determination but it must be noted that this should be done with an agitator in the Dewar vessel to get an even temperature increase and a correct curve.

Another very good and easy way to test the activity of the lime and its slaking ability is to make a titration curve with hydrochloric acid as described in Annex N° 3.

1.3 Sand

The sand was river sand of the same quality as used for concrete work. It was of brownish colour.

Specification:

loss by ignition	0.39%
SiO_2 (total)	75.85%
free quartz	40. %
CaO	1.57%
MgO	0.92%
Fe_2O_3	1.64%
Al_2O_3	12.82%
Clay	2-10%
K_2O	3.60%
Na_2O	3.17%

The sand was wetmilled in a tube mill.

Mill specification:

Diameter	1.5 m
Length	5.7 m
Motor	130 kw
Charge	12.5 t clypeps, 22x22 mm
rpm	28
Capacity	3.5 t/n
Slurry density	1.62

The sand slurry was pumped to two slurry tanks above the mixing station. In order to be able to continuously control the density of the slurry, it is recommended to install a densimeter. The B.I.C. type is shown in Fig. N° 1. (Regarding the sand quality, see under paragraph 3.7.1.)

1.4 <u>Aluminium powder</u>

One producer only exists in China for Aluminium powder so there was no choice.

Specification:

Al	91.53%
Rest on 0.08 mm sieve	0.498%
Blaine surface	>3500 cm^2/g

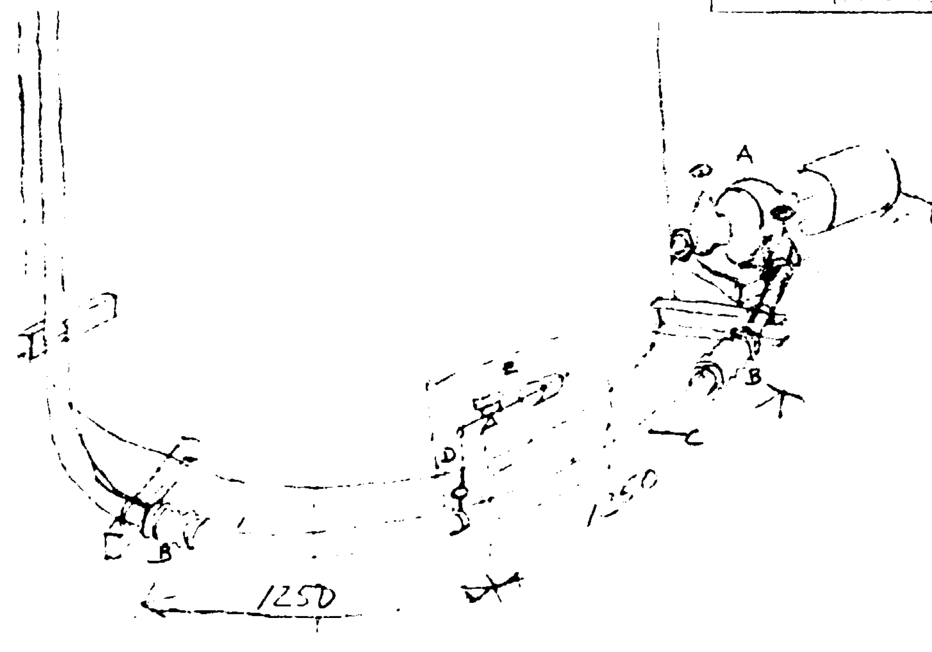
This seems to be a low quality Al-powder. Generally the Al content is 93-95% and the Blaine surface about 12.000 cm^2/g.

1.5 <u>Reinforcement</u>

Hot rolled reinforcement iron was received in rolls which were straightened and cut in desired lengths, and then spotwelded into nets. These were given an anticorrosion treatment by dipping them in a mix of lime in asphalt solution and emulsion to which a water soluble resin was added. The nets were then dried artificially in hot air.

The nets were mounted into cages which were kept together by plastic holders and loose wire strips and thereafter placed in the moulds.

P. OLOF GRANE Consulting Engineer P. O. Box 9 Torremolinos/Spain	SUBJECT: FLOW DENSIMETER CONTROL according to B.I.C.-Consortium	Fig. No. 1 SHEET NO. 1 OF 1 JOB NO. SSA-CPR/79 DATE August 1980



Description:

A: circulation pump

B: Rubber hose

C: 2" pipe

D: Suspension point

E: Balance with mercury switch

A 2,5 m length of 2" pipe is connected at the points B with thin rubber hose and is suspended at the point D onto an adjustable balance device. At the end of the balance arm is a mercury switch connected to a valve opening and closing water inlet to the tank. The density of the circulating slurry can be automatically regulated to 1,65 ± 0,02.

2.0 PRODUCTION

2.1 Mixing

The mixer was a mobile 4 m^3 mixer of the turbine type with a 22 kw motor at 550 rpm.

The following recipe was used:

Cement	15%
Lime	25%
Sand	60% (Blaine 2800-3200 cm^2/g)
Gypsum	2% (on lime)
Al-powder	1900g/mould (= 345 g/m^3)
Casting viscosity	300-350 mm (The cylinder for viscosity measuring was not the original FLS type. The original type has an inner diameter of 60 mm and height of 50 mm. Harbin used a cylinder diameter of 50 mm and a height of 100 mm and consequently the viscosity values were confusing and wrongly evaluated).
Mixing time	4 minutes + Al 15 seconds
Rising time	20 minutes
Drying time	4 hours
Max. temp.	80° C

In the mixing station all raw materials were measured and weighed and then dumped into the mixer. When the mixer was charged it moved along the line of moulds and stopped in front of the mould to be filled. The whole time the mixer was working and when the 4 minutes were up, the Al-powder was added and the mixing continued for fifteen seconds whereafter the mix was emptied into the mould. The filling grade was about 50%.

2.2 Casting

The expansion in the mould started almost immediately and the mass rose in 10 minutes to about 75% of the total expansion which was finished after some 20 minutes. The temperature rise was slow in the beginning but then increased in speed. The moulds were covered with plastic sheeting to retain moisture and heat.

2.3 Cutting

After some 4 hours the mass had solidified allowing cutting to be made. The cutting machine was similar to the Polish Ytong type and worked in the following manner: The moulds were placed on a table where the sides were taken away. The mass, resting on the mould bottom, was tilted 90° and vertical cutting was made with horizontally strung piano wires which moved downwards. The wires were fixed to springs but were quite loose.

After the vertical cut the horizontal cut was made with wires fixed into a frame which moved from one end of the mould to the other. The surplus material cut away from the side (= mould top) fell into a canal through a double grating of which the upper had a to and fro movement whereby the larger pieces were broken and crushed before falling into the canal. In the canal slurry circulated which thus was enriched with waste material and water was added as and when needed.

The cut mass was then tilted back 90° and the mould bottom with the mass was transported to a place in front of the autoclaves where three moulds were stacked upon each other and so put into the autoclave.Waiting time before taken into the autoclave could vary from 2 to 4 hours and occasionally some moulds would have to wait over night.

2.4 Autoclaving

There were 4 autoclaves, each with an inner diameter of 2.85 m and with a length of 25.6 m. Each autoclave could take 12 moulds. Working pressure was 12 atm. The steam boiler worked at 13 atm. and was fired with heavy fuel oil but will be changed to coal.

The steam curing cycle was as follows:

vacuum of 60%	30 minutes
uptake	2 1/2 hours
constant pressure	8 hours
downtake	2 1/2 hours

2.5 Demoulding

Taken out of the autoclaves the panels and blocks were taken off the mould bottoms using cranes and clamps and were then stacked in the yard.

3.0 PROBLEMS

Although the production flows relatively easy there are various problems to overcome in order to increase production and improve quality.

3.1 Production increase

Presently the plant is only working in 2 shifts and the reason is that one of the raw materials, portland cement, cannot be procured in sufficient quantity. If high early strength cement is difficult to procure, perhaps normal portland cement is easier to get? It can very well replace the high early strength cement. The desire of the Plant Management is therefore to diminish the percentage of cement in the mix, which is presently 15%. Trials have been done to replace part of the cement with lime but without success, the temperature rose too much and the mass cracked.

3.1.1 This problem, in the Expert's opinion, is the easiest to solve and can be done in a simple way. Cement can indeed be replaced by lime but not by quick-lime but by slaked lime. Thus no increase in heat evolution will take place in the moulds, the CaO content can be kept constant and the expansion of the mass will take place undisturbed and no cracking will occur.

In order to prove this proposal the Expert undertook some laboratory tests with 15,10,5 and 0% of cement replaced with slaked lime. If the lime is well slaked or not should be tested according to the "popping and pitting" test. See Annex N° 4. The result is shown in the following table:

Table 1

	1		2		3		4	
	%	g	%	g	%	g	%	g
Lime, quick	25	6250	25	6250	25	6250	25	6250
Lime, slaked	-	-	5	1250	10	2500	15	3750
Cement	15	3750	10	2500	5	1250	-	-
Sand */	60	1500	60	1500	60	1500	60	1500
Gypsum	3	750	3	750	3	750	3	750
Al-powder		17.5		17.5		17.5		17.5
Water		2600		2600		2500		2850
Water factor		0.48		0.48		0.47		0.49
Total water, lit.		11.9		11.9		11.8		11.2
Viscosity		200		240		210		170
Density, dry		0.702		0.590		0.609		0.662
Compr., strength		47		34		36		49
" " at 0.70 dens		46.5		44.2		45.0		53.9

*/ Sand slurry in liters, d=1.62; 1 lit. = 1 kg of sand + 0.62 lit. of water.

The above laboratory test has unequivocally proved that cement as far as the compressive strength concerns, can be replaced by slaked lime. The tests should be repeated and the other properties of the product, such as shrinkage and water absorbtion, should be tested.

The Plant Management wanted full scale tests to be carried out and such were made although the preparations were hasty and perhaps not quite adequate so that for various reasons successful castings were difficult to carry out. However results from tests 27/7-1-3, showed good values. In these tests the quicklime content was reduced from 25 to 20% because the lime that day was softburnt and reacted very quickly. The cement was reduced from 15% to 10% and 10% slaked lime was added.

	27/7-1	27/7-2	27/7-3
Density, dry kg/cm^3	0.741	0.682	0.682
Compr. strength kg/cm^2	61	53	49
Compr. strength at 0.70 density	54.0	55.7	51.5

Although in this test only a smaller part of the cement had been replaced with slaked lime it has been demonstrated that the compressive strength has not been negatively influenced and after more tests to confirm this fact, Plant Management shall be able to plan the adopting of this thesis, namely replace the cement in whole or part with slaked lime.

3.1.2. Slaked lime production

To produce 400 m^3/d of gasconcrete some 30 t/d of slaked lime will be needed. This is an appreciable quantity and therefore an adequate installation for slaking will be needed. If this new installation shall produce slaked lime for own use only, the simplest will be to produce a lime slurry, but if part shall be sold as building lime, a dry powder must be produced.

There exist many different types of slakers of which a few will be briefly described.

a) Wet slakers:

Wallace-Tiernan

This slaker, as shown in fig. N° 2 consists mainly of a screw-conveyor into which the crushed quicklime and hot water are fed in one end whilst taking out the lime suspension in the other end. An arrangement for the separation of sand and unburnt particles is provided for. This type of slaker works with 0.14 to 0.28 kg of lime per kg of suspension, i.e. 2.5 to 6 lit. of water per one kg of lime. The suspension is pumped to storage tanks which should be provided with agitators to avoid sedimentation.

Dorr Oliver

This type of slaker produces a putty of lime and works with 0.3 kg of lime per kg of putty, i.e. about 2 lit. of water per kg of lime. It consists mainly of a cylindrical tank provided with an agitator as shown in Fig. N° 2. Sand and unburnt particles are separated and washed and the washing water is recycled and used in the slaking process.

b) Dry slakers:

Tiaveh

The design of dry slakers varies from simple ones to very sophisticated ones. The Tiaveh (see Fig. N° 3) is of simple design and consists mainly of one or more reactor silos in which the final hydration of the lime takes place after the hydration has been initiated in a screw conveyor with hot water. After a suitable number of hours varying for softburnt and hardburnt lime, slaked lime is taken out from the silo and put through a

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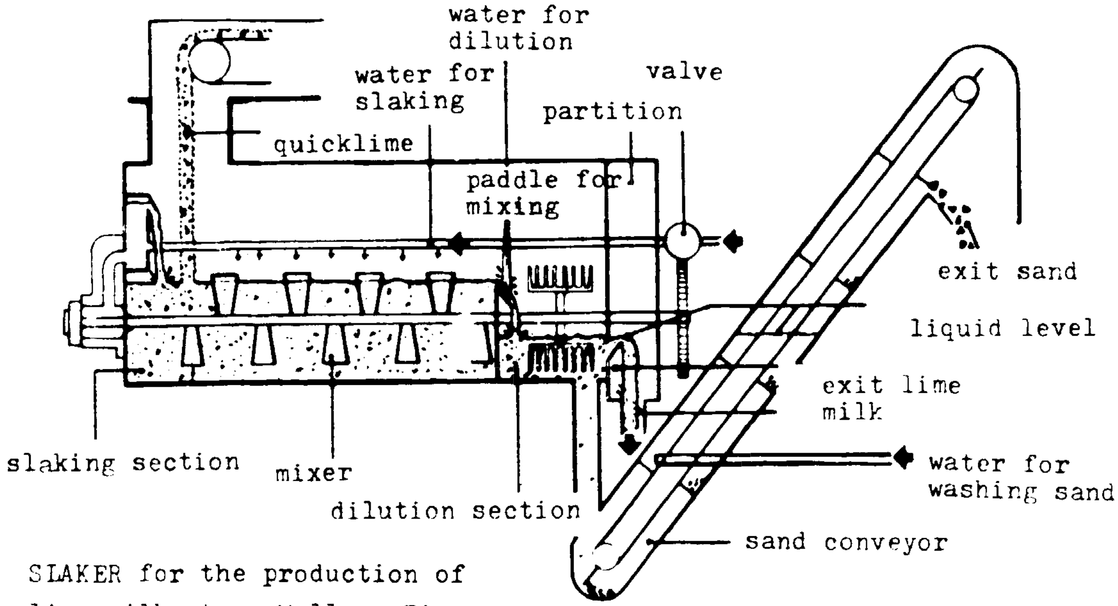
SUBJECT: LIME SLAKERS for the production of lime milk and lime putty.

Fig. No. 2

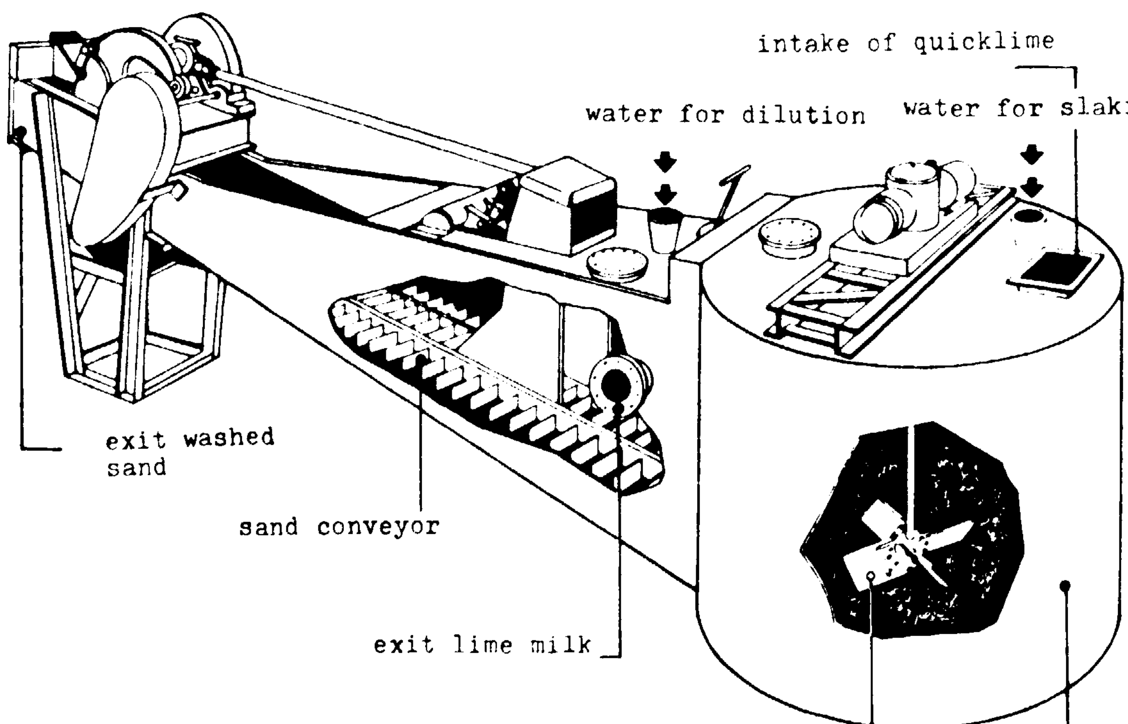
SHEET NO. OF

JOB NO. UNIDO SM/BDI/73/011/11-01/03

DATE Mars 1976

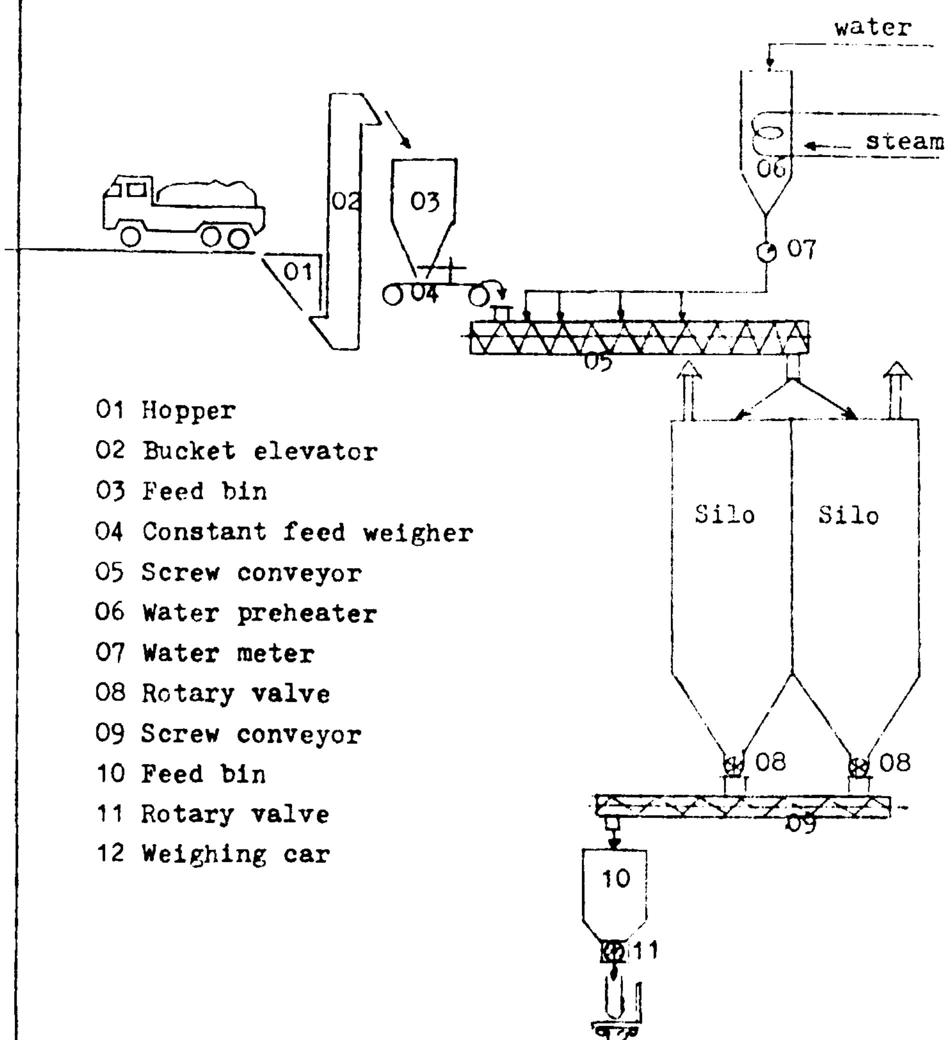


SLAKER for the production of lime milk, type Wallace-Tiernan



SLAKER for the production of lime putty, type Dorr-Oliver

P. OLOF GRANE Consulting Engineer P. O. Box 9 Torremolinos/Spain	SUBJECT: -16- LIME HYDRATOR type TIAVEH	Figure no. 3 SHEET NO. 1 OF 1 JOB NO. UNIDO 79/005 DATE Jan. 1980



01 Hopper
02 Bucket elevator
03 Feed bin
04 Constant feed weigher
05 Screw conveyor
06 Water preheater
07 Water meter
08 Rotary valve
09 Screw conveyor
10 Feed bin
11 Rotary valve
12 Weighing car

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SUBJECT: LIME HYDRATOR

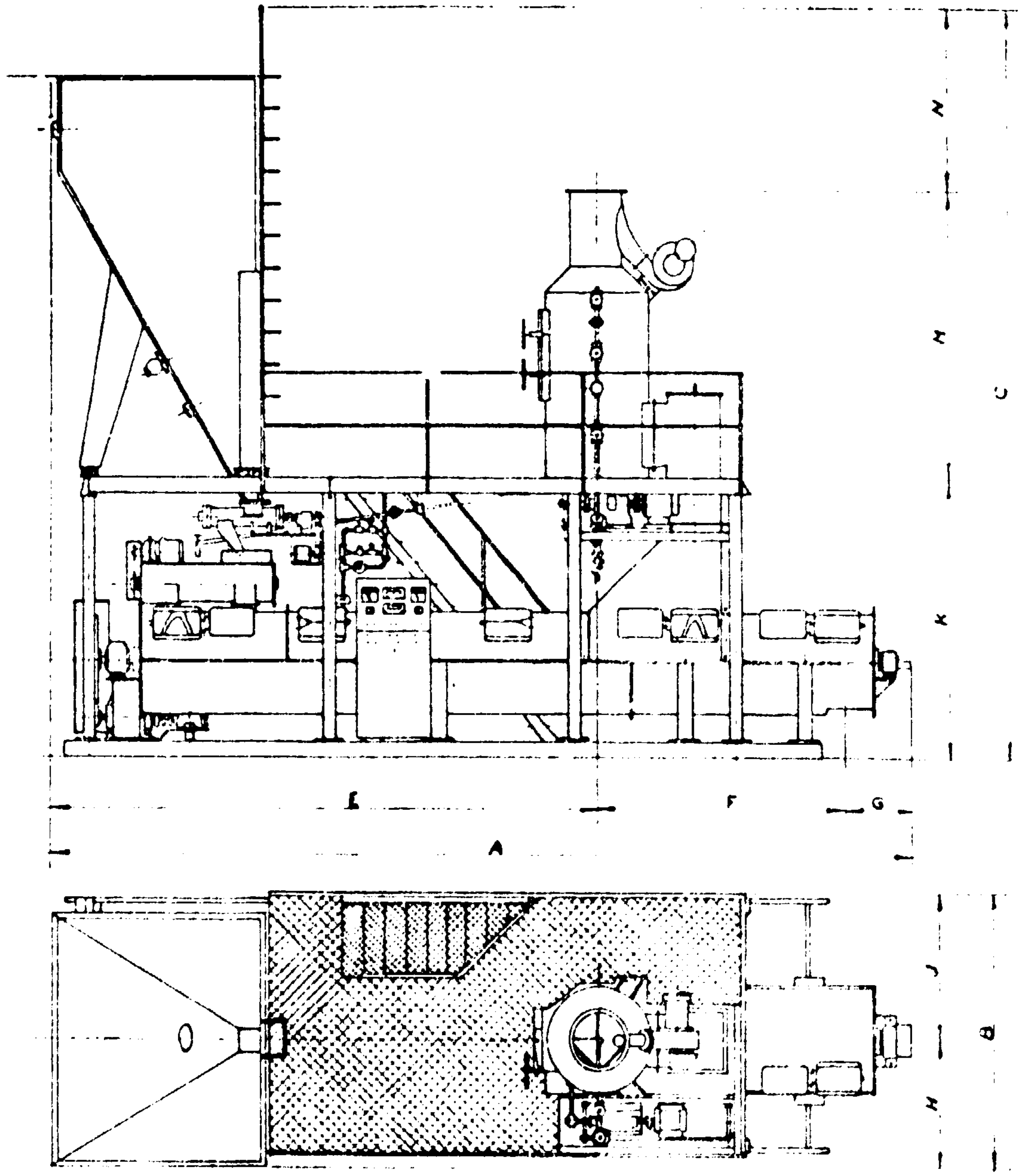
type Peach-Rover

Figure no. 4

SHEET NO. 1 OF 1

JOB NO. UNIDO 79/005

DATE Jan. 1980



Capacity: 3 - 3,5 t/h. General dimensions

A	B	C	D	E	F	G	H	J	K	L	M
5300	2400	7000	6000	3000	1800	500	1200	1200	2600	2700	1700

Weight: 6380 kg

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SUBJECT:

LIME HYDRATOR

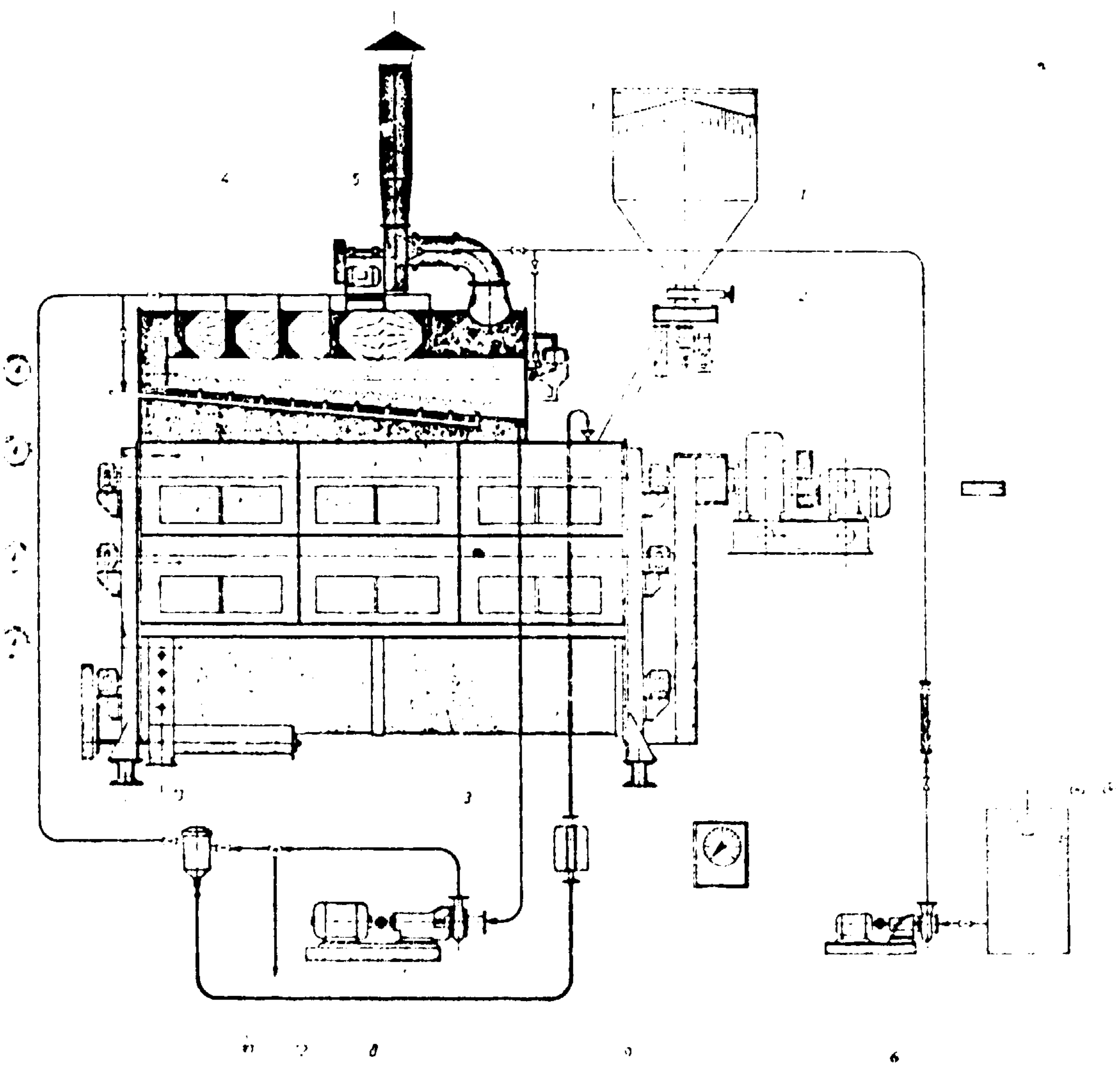
3-stage type KLD

Figure no. 5

SHEET NO. 1 OF 1

JOB NO. UNIDO 79/005

DATE Jan. 1980



1. Feed hopper for quicklime
2. Feeder
3. 3-chamber hydrator
4. Dust remover
5. Ventilator
6. Freshwater pump
7. Measuring device
8. Circulation pump
9. Measuring device
10. Refuse separator
11. Temperature indicator
12. Emergency outlet
13. Outlet for hydrated lime

classifier to separate unsolubles from the lime. Sometimes the insolubles are milled in a ball mill and brought together with the lime.

Peach-Rover

This type of slaker, see Fig. N° 4, consists of a horizontal cylinder through which goes an axis provided with paddles. The crushed quicklime is fed into one end and is sprayed with hot water which is received from the condensator-deduster placed on top of the slaker and in which fresh water is sprayed against the rising steam and dust.

KLD

The KLD slaker, see Fig. N° 5, is of a more sophisticated type and consists of 3 superimposed horizontal cylinders, through which the lime slowly moves downwards while being sprayed with hot water from the deduster. Preslaking is done in the first cylinder whilst the main reaction takes place in the second and finally total slaking is secured in the third and largest cylinder.

Corson

The best slaking and the finest lime is produced according to the Corson pressure hydration process, where the slaking takes place in a vessel under pressure. This process is specially suitable in case of dolomitic lime which is difficult to slake completely, but is also used for common lime, which, because of its ultrafine particles gives a lime of very high plasticity, especially suitable as building lime. As the Plant Management has expressed a special interest in this process and has a pressure vessel available, the Expert will give a more detailed description of this process.

The process is illustrated in Fig. N° 6, from which is seen that the quicklime is fed from a silo into a continuous weigh feeder. From here it is mixed with water yielding a thick slurry,

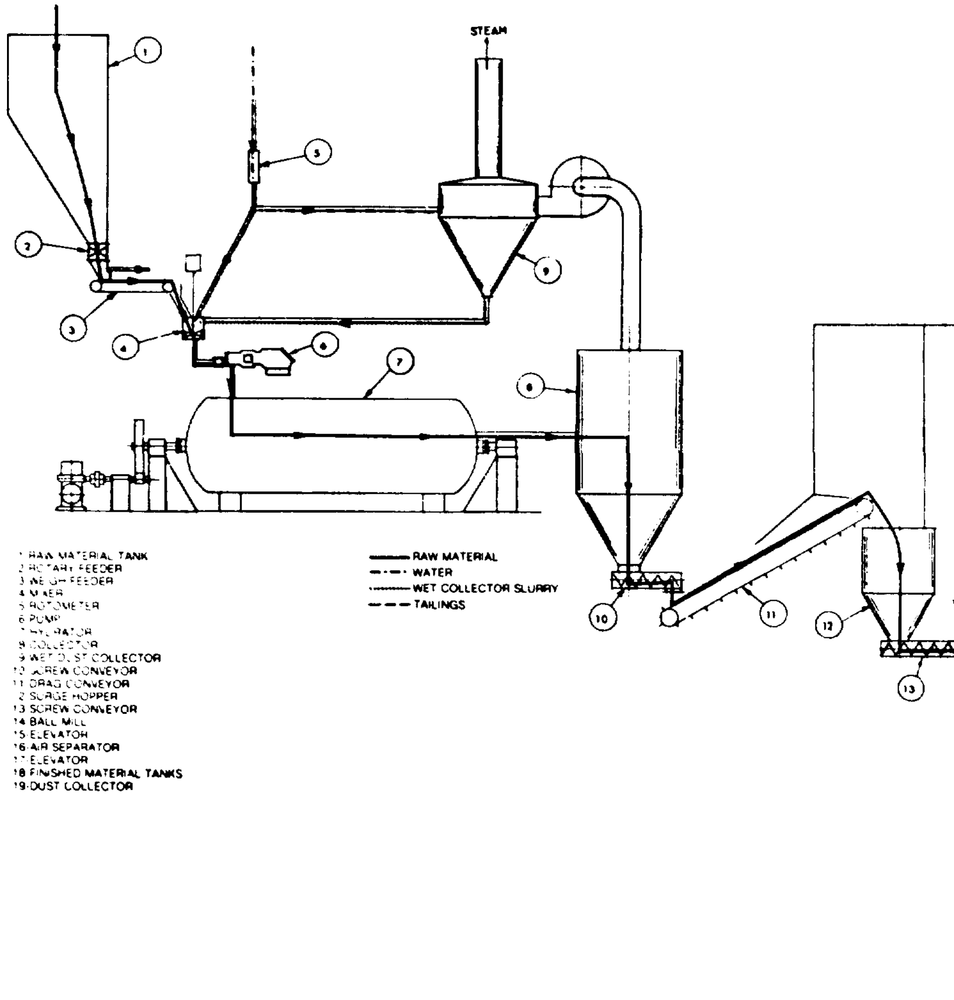
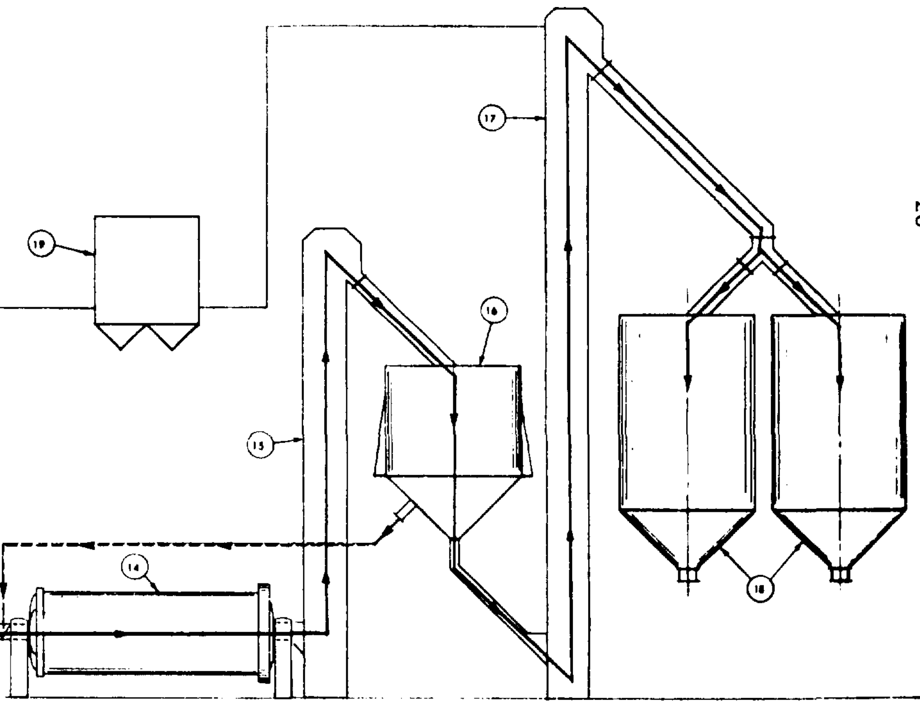

STEAM
1 RAW MATERIAL TANK
2 ROTARY FEEDER
3 WEIGH FEEDER
4 MIXER
5 ROTOMETER
6 PUMP
7 HYDRATOR
8 COLLECTOR
9 WET DUST COLLECTOR
10 SCREW CONVEYOR
11 DRAG CONVEYOR
12 SURGE HOPPER
13 SCREW CONVEYOR
14 BALL MILL
15 ELEVATOR
16 AIR SEPARATOR
17 ELEVATOR
18 FINISHED MATERIAL TANKS
19 DUST COLLECTOR
RAW MATERIAL
WATER
WET COLLECTOR SLURRY
TAILINGS

Fig. No. 6



FLOW DIAGRAM
OF
CORSON PRESSURE HYDRATION PROCESS

then fed into a specially designed pump and forced into the pressure hydration vessel. In the pressure hydrator, the quicklime is exposed to water in the liquid phase for a period of 10 to 30 minutes. The steam pressure generated within the hydration vessel is caused by the exothermic reaction of the quicklime with the water.

The discharge orifice of the pressure hydration vessel releases the damp, hydrated lime mass into the collector. Steam pressure may reach about 7 kg/cm^2 corresponding to a saturated steam temperature of 170° C. When this energy is released at the orifice, instantaneous flash-drying and explosion of the particles occur. At this point the average resultant particle size is approximately 0.4 microns. In the collector the lime particles fall out while steam is drawn upward to a wet scrubber which removes any residual fine lime particles and this water is recycled and used in the initial hydration process. The hydrated lime is fed to the air separator and the tailings to a ball mill to be incorporated with the hydrated lime.

Whilst the Plant Management has expressed interest in this process the Expert wants to point out that the installation is not as simple as it may look. One special point, subject to a patent, is the very special and complicated pump, and although a pressure vessel may be available, it only forms a part of a complete installation.

As the gasconcrete production process can advantageously work with lime milk and its production is the simplest and cheapest, the Expert recommends that this alternative is first taken into consideration.

3.2 Mixing:

The mixer causes problems as the mass produced in it is not uniform. The mixer is a turbine mixer which is suitable for very fluid mixes but not for more heavy ones. One can observe white spots in the finished blocks demonstrating agglomerated fine lime particles not having been dispersed. To solve this problem there are several ways out. One would be to replace the mixer with one of the HEBE type (see Fig. N° 7) in which fixed paddles are interspersed between mechanical agitators. This mixer is well suited for both viscous and lighter mixes.

If one does not want to change the mixer there are other solutions to improve the mixing. The first one would be to install a powder flow-mixer at the entrance of where the lime and cement enter and premix those two dry powders. The lime particles always have a tendency to clog but intimately mixed with the cement a homogenous powder will be obtained which more easily is dispersed in the wet mix. This type of flow-mixer is shown in Fig. N° 8. A simplified version would probably suffice.

A second way to increase the mixing capacity of the mixer is to install a slurry pump and recirculate the mix. This is a very effective means of improving the mixing and has proven to be a good aid.

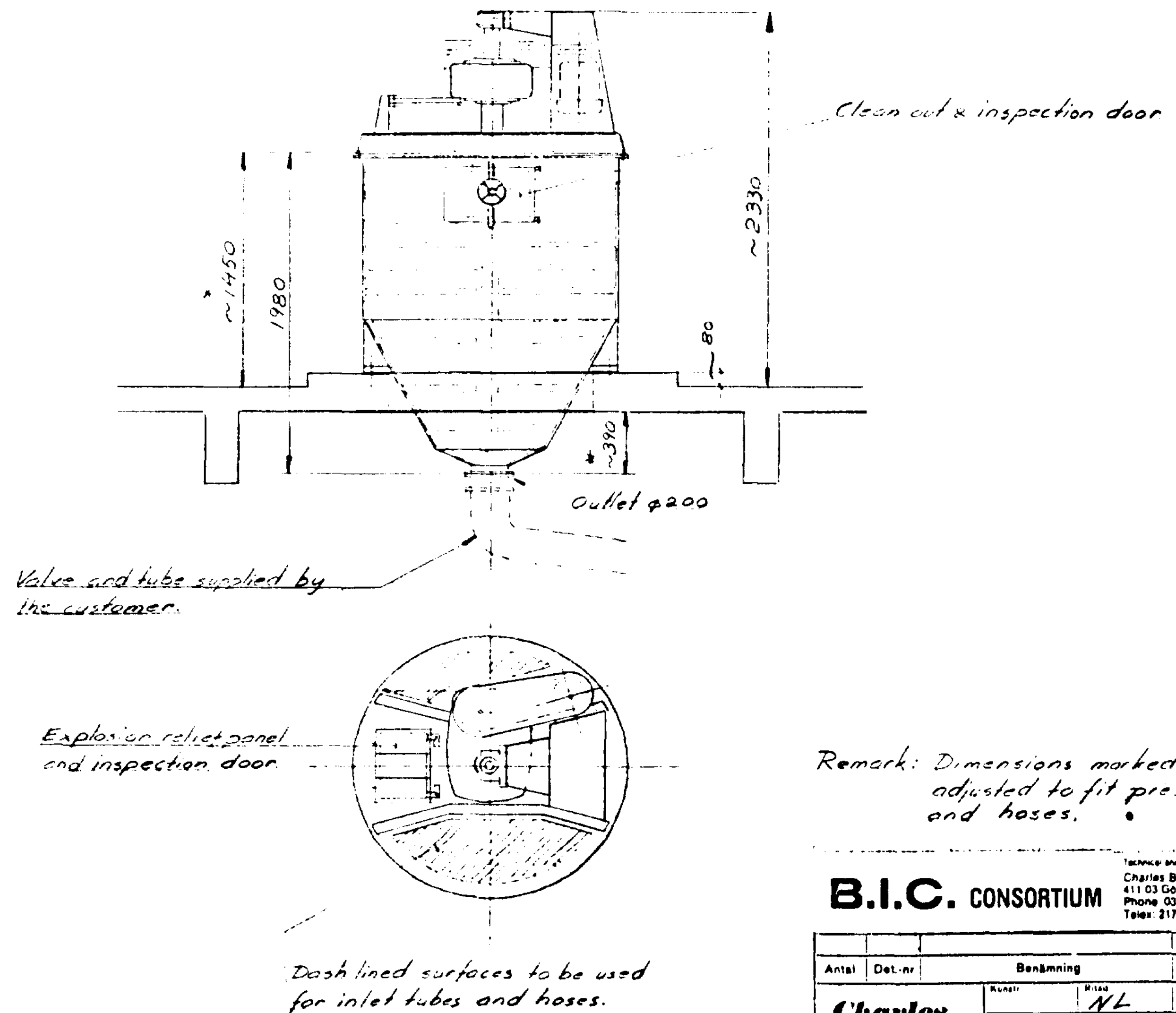
An improved mixing will give an improved finished product and it is therefore worth while to install one or both of the above mentioned mixing aids.

3.3 Casting

The main problem in the casting station is the variation of the expansion in the moulds. Sometimes the moulds overflow and sometimes they do not rise enough. In this latter case the content of the whole mould is waste. The variation in expansion is said to be 7 to 8 cm. */

The reason for the variation can be manifold but the main

*/ If the mould is only one centimeter too low the whole content is waste. It is therefore better to cast all moulds a little bit too high, this will produce less waste.



Remark: Dimensions marked * can be adjusted to fit present connecting tubes and hoses.

B.I.C. CONSORTIUM

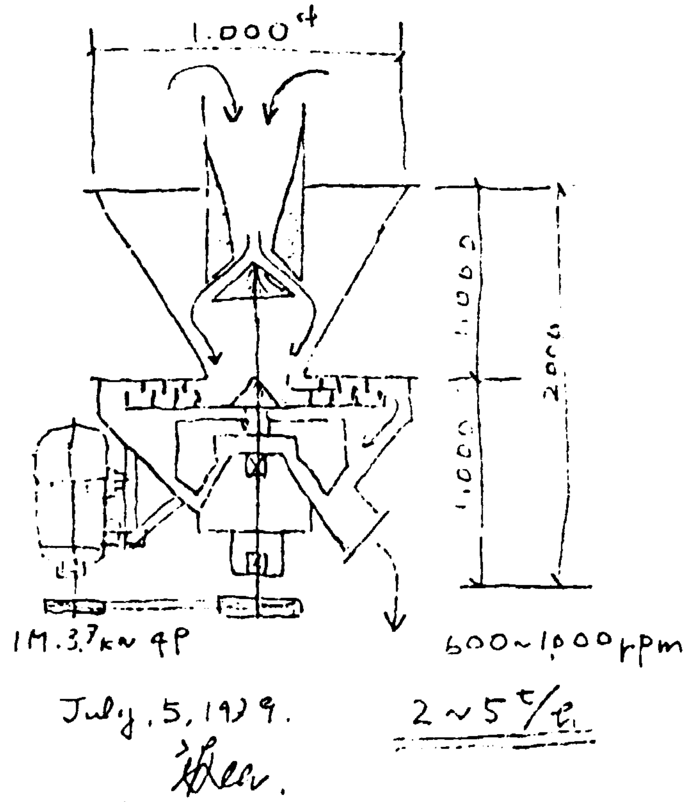
Technical and Administrative office
Charles Bergling & Co AB
411 03 Göteborg, Sweden
Phone 031-80 33 46
Telex: 21764

Antal	Det.-nr	Benämning	Dimension	Material	Anm.

Charles Bergling & Co. Ab GÖTEBORG · SWEDEN	Konstr	Ritad NL	Kontr.	Gods	Skala 1:25
	Batch Mixer, type 2,5/30 type HEBE (Different sizes available				Skala där ej annat angives; Dat 1979-12-10; Ritn nr GO-791023-1

Nr	Antal	Ändring	Inf.	Godk	Datum

Fig. no. 8



Sketch showing the principle of a Flow-Mixer.
July 5, 1979.
Drawn by: Y. Fujino

reason is the variation in the quality of the lime.

Apparently the slaking curve of the lime and the maximum slaking temperature varies from hour to hour and this makes a uniform casting difficult not to say impossible. The variation in the slaking curve depends of course on the performance of the lime kiln. If there is too big a variation in the feed size of lime stone, the smaller stone easily gets overburned especially as the sinking speed of the kiln is as low as 0.3 m/h and the stay in the calcining zone is as long as 28-30 hours.

Bigger stone on the contrary may be underburnt and have an inner nucleus of unburnt material. To produce a uniform product, great importance must be laid upon a uniform feed size. This problem however is not specific for this particular lime kiln, all shafts kilns have the same problem and only careful attention to the running of the kiln can minimize this problem. The high maximum temperature of 1200° C plus the low sinking speed tend to produce a hardburnt lime. A somewhat hardburnt lime is required in gasconcrete manufacture (see slaking curve, p.1, Annex 2) but as different limestones, depending on their geological origin, tend to behave differently, only trials and experience can decide how to best burn the lime. It is possible that a change in the feeding of the kiln from every 2 hours to every hour and a discharge from every hour to every halfhour, can contribute to a more uniform calcining.

Also it seems that the kiln is rather big for the present production and an increased production rate probably will help to equalize the variations in quality. If Plant Management decides to use slaked lime instead of cement, a higher production of lime will be required,so this should benefit the running of the lime kiln.

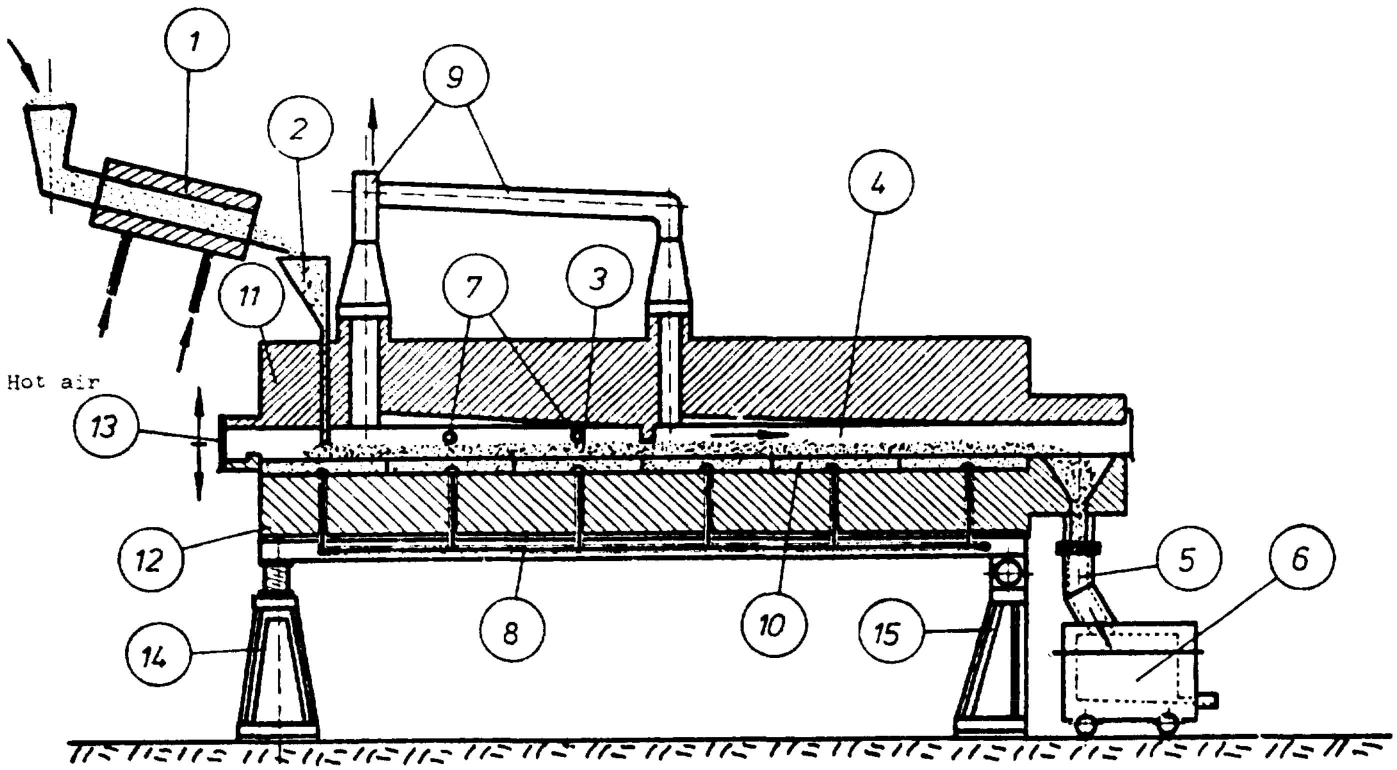
A special method to even out variation in the calcining zone in oil-fired shaftkilns is to recycle part of the exhaust gases, but it is doubtful if this could be successfully done in a mixed feed kiln.

Possible improvements in the running of the lime kilm will not be able to completely overcome variations in quality. To obtain a disturbance free casting in the gasconcrete production more rigorous measures must be taken. A completely uniform lime quality can only be obtained in one way but a fairly simple one, and that is to install homogenizing silos.

A homogenizing silo is filled with one days need of lime and that quantity is agitated so as to be mixed and homogenized into a uniform product. The homogenizing mechanism can vary but mostly this is done with compressed air in a fluidized state. An effective system is that used by Claudius Peters and which mainly consists of a wide innertube placed in a silo. Under the tube compressed air is fed through porous stone with the result that the powder flows up and out of the tube and returns downwards on the outside of the tube. A continuous revolving of the powder in the silo brings about an intimate homogenizing and with two such silos it will be possible to cast every day with the same quality of lime from morning till night.

It must be noted that to do homogenizing of lime with compressed air has certain disadvantages. The air contains carbon dioxide and moisture and this will affect the lime, preslaking it to a certain degree and carbonizing it as well. It is therefore important that the compressed air installation is provided with after-coolers to take away most of the moisture. In special cases another type of homogenizer can be used, the FLS type, which uses only a small amount of air and where the mayor part of mixing is done by mechanical agitators. This may be the method to prefer in this case.

For one or more of the new gasconcrete plants under building or planning the Expert would recommend that a fluo-solid kiln should be considered. One such kiln, type BUDIN (B.I.C. Consortium) (see Fig. N° 9), with a length of only 5 meters has a capacity of 50 tons of lime per day. The calcining temperature can be very narrowly controlled and the lime will be of very uniform quality. The feed is 80% - 1 mm which explains the short calcining time and the high capacity of the kiln which is completely automatic and



1 ... Dryer
2 ... Feeder
3 ... Heating zone
4 ... Calcining zone
5 ... Feeder pipe
6 ... Cooling zone
7 ... Top burners (if necessary)
8 ... Feeder air/gas pipe
9 ... Exhaust
10 ... Linings
11 ... Upper linings kiln
12 ... Lower linings kiln
13 ... Safety doors
14 ... Kiln adjustment

B.I.C. CONSORTIUM

Air/gas slide calciner,
type BUDIN.

Technical and Administrative office
Charles Bergling & Co AB

Fig. No. 9

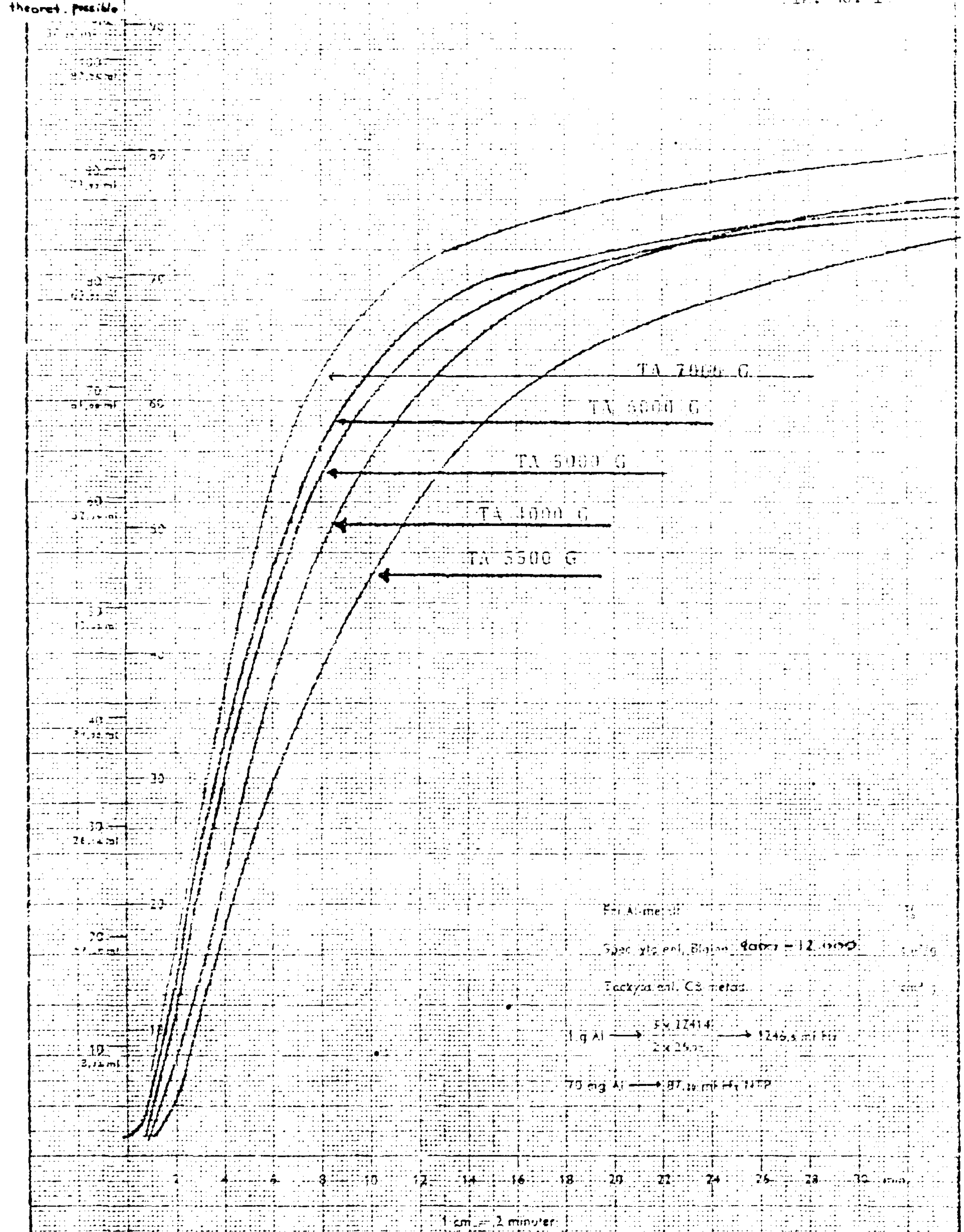
needs a minimum of labour. The kiln is built according to a module system and it is possible for example to start with only 2 modules which then have a capacity of 15 tons/d. By adding later one more module the kiln is lengthened 1,5 m, it is given a more steep inclination which increases the velocity through the kiln and consequently its capacity. Such a kiln produces an absolute uniform product, it is more economic in investment than a shaft kiln and the running cost is lower.

Besides the problem with non-uniform lime quality there are other factors which influence the casting. One minor but important factor is the accuracy of the measuring and weighing devices. Balance and measuring vessels tend to get dirty and may accumulate waste which will influence the accuracy and bring about minor or mayor changes in the mix, thus influencing the casting operation. It is therefore important to keep such devices clean and to check their performance periodically. This is specially important with the aluminium powder balance where only small variations have great influence.

The aluminium powder as such and its properties are of great importance. Apparently the plant only has one type of powder and it is far from certain that just this type is the most adequate one. Also no control of its quality is done.

The gas evolution curve should be checked periodically and if possible various types of powder should be procured so as to test the one that gives the best performance under the circumstances. In Fig. N° 10, are shown five different powders from the same manufacturer. As can be seen they vary in the velocity in which they produce gas and one powder will be more suitable than another one for a certain gas concrete mix. Mixes vary from factory to factory depending on the raw material composition, on the alkalinity, on heat evolution and on the time of solidification. It is most important that the gas evolution has ended when the solification sets in but again it must not be too quick as otherwise the not solidified mass may sink back.

Fig. No. 10



Hydrogen evolution curve

No	ST	RITN.	NAMN	ANMÄRKN.
RITAD:	KOPIERAD:		GASUTVECKLINGSKURVA	RITN. No:
SKALA:			CARLFORS BRUK, HUSKVARNA	DET. No:

The method of making a gas evolution test consists in letting a sample of the aluminium powder react in an alkaline solution at a constant temperature, with the reacting vessel in a water bath, and measuring the amount and rate of gas produced, reduced to normal temperature and pressure. While some use a mixture of sodiumhydroxide and cement as the alkaline medium, the Expert prefers to use $Ca(OH)_2$, proanalysis, as cement vary in their alkalinity. A gas evolution curve made according to this latter method is shown in Fig. N° 11. A further description of the testing methods for aluminium powder is given in Annex N° 5.

It should be pointed out that sedimentation occurs of the heavier Al-particles in a drum leading to varying quality. It is therefore necessary to roll every drum some 10-15 minutes before it is opened and used.

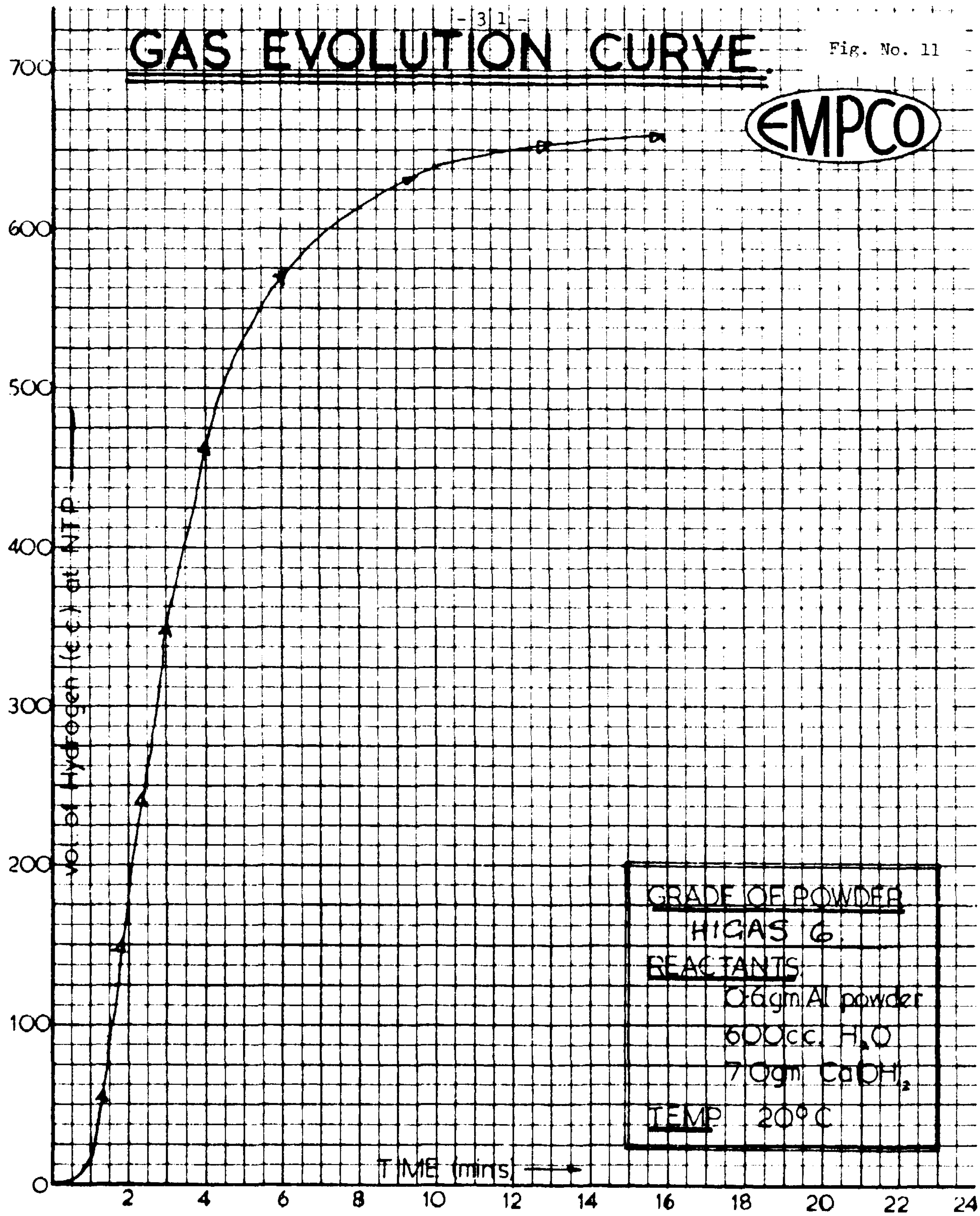
Another factor that influences the casting is the viscosity.

A sinking back in the moulds can be eliminated by casting with less water, i.e. with a higher viscosity, but then more aluminium powder is required to obtain the same expansion. The viscosity is generally measured in a rotation viscosimeter and given in centipoise. A simpler instrument is the FLS viscosimeter consisting of a bottomless brass cylinder with an inner diameter of 60 mm and a height of 50 mm. The cylinder is filled with the mass and by lifting it, the diameter of the outspread mass in mm is given as the viscosity of the mass.

Unfortunately the Expert did not notice that the cylinder in the Plant did not have standard measures, (it had a diameter of 50 mm and a height of 100 mm.) Thus the interpretation of the viscosities were confusing.

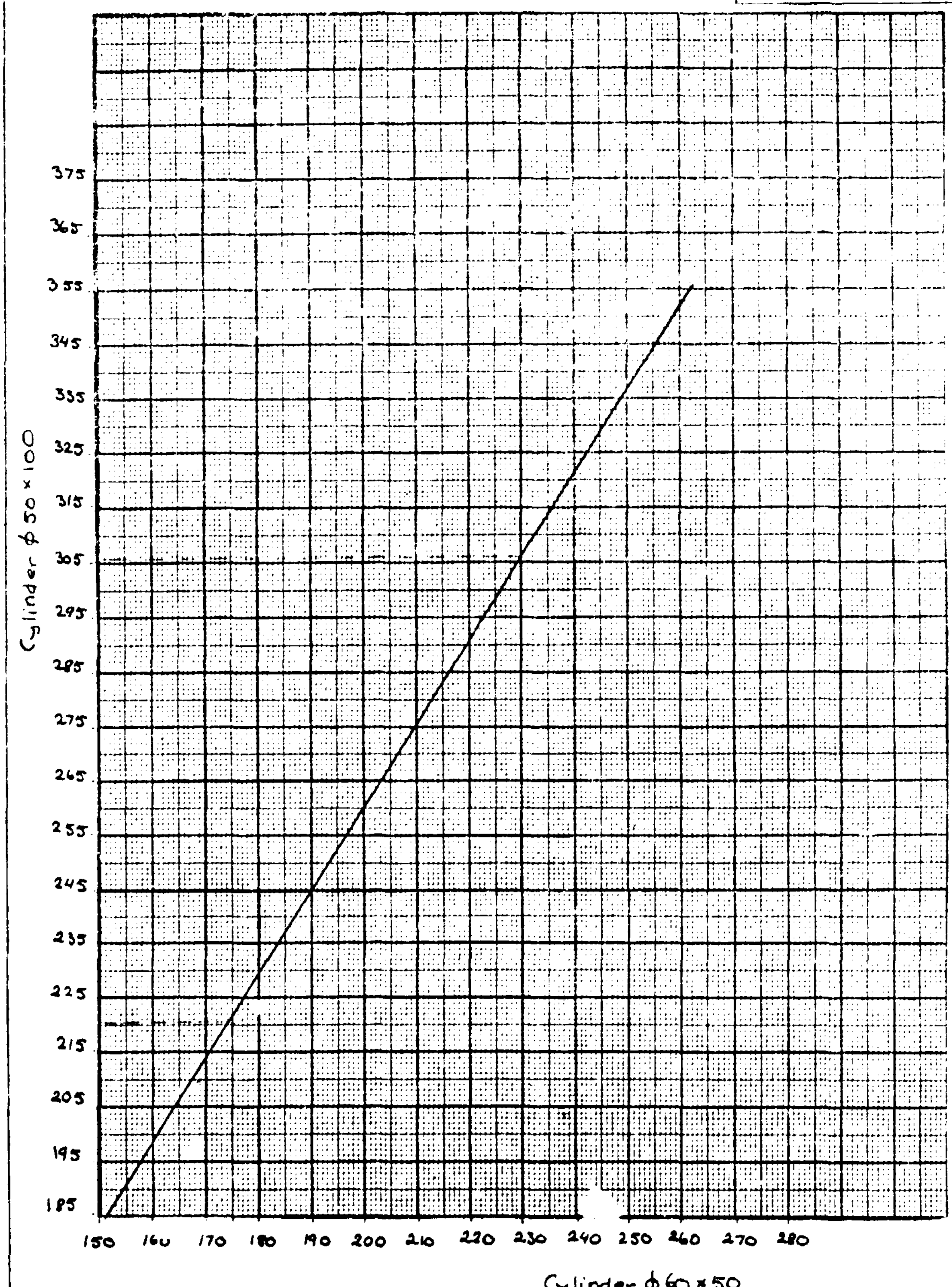
Afterwards the Expert has in his own laboratory made a comparative test between the values from the two cylinders and the relation is shown in Fig. N° 12. In Fig. N° 13, a comparison is shown between the FLS values and the viscosity in centipoise.

Fig. No. 11



ENGLISH METAL POWDER Co. LTD. P.O. BOX 4. WIDNES, WA 8 OPG. CHESHIRE. ENGLAND.	CUSTOMER :– DATE :– 20.5.77

P. OLOF GRANE Consulting Engineer P.O. Box 9 Torremolinos/Spain	SUBJECT: FLS viscosity Comparison between cylinder ø 60 x 50 and ø 50 x 100	Fig. No. 12 SHEET NO. 1 OF 1 JOB NC SSA-CPR/79 DATE Sept. 1980



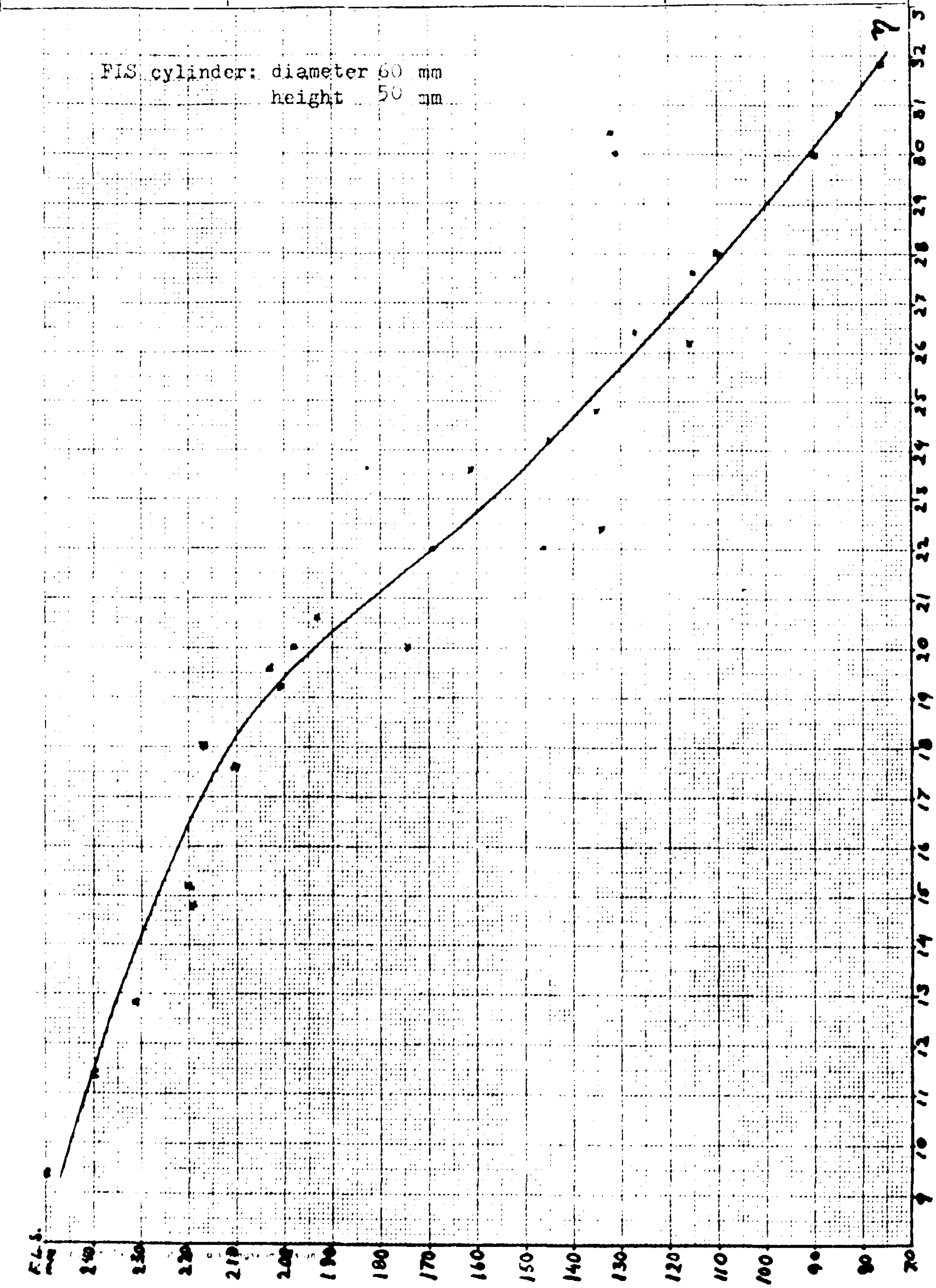
P. OLOF GRANE
Consulting Engineer
P. O. Box 9
Torremolinos/Spain

SUBJECT: The relation between the viscosity measured according to FIS and the viscosity in Poise.

Fig. No. 13

SHEET NO. OF

JOB NO. SGAB 3-53



Reverting to the problem of sinking back, crack formation, no solidification, etc., these problems are dealt with in detail in Annex N° 6.

3.4 Cutting

The cutting operation plays an important roll in the gas concrete production and its execution should therefore be done with great care and above all, the machinery should be k pt scrupulously clean and in good working order. Daily maintenance of the machinery is a must. Plant Management complains that during the cutting operation:

a) transversal cutting does not go up and down in the same line
b) after turning 90° cracks happen in big part of the mass, especially between blocks/reinforced.
c) slope of standing mass, 82-89°, does not cut correctly.
d) cutting surface and grooving not satisfactory.

Re a) the cutting wire is much too loose and consequently goes down in one line and up in another. It must be stretched much harder. Convenient would be to give the wires a to and fro movement.

Re b) the hydraulic system is not coinciding in both ends of the machine. Moving, turning and setting down are made with "bumps", must be soft. Make a solitary pre-cut between blocks" reinforced before cutting. The steelplate on which the mass is standing must be absolutely even.

Re c) if this is due to shrinkage in the mould some 15 mm ought to be cut away from the sides before the actual cutting is made.

Re d) the wires were not stretched sufficiently and the grooving cutters must be made and be fastened with more precision.

As a general rule success or failure during the cutting operation is to a large degree depending on the state of hardness of the mass and the rest depends on the handling of the moulds and the mass and the precision of the cutting machine.

The state of hardness of the mass which as said is most important, should be tested with a penetrometer, it is not sufficient to stick a finger in the mass. A penetrometer of the type used to test concrete mortar is shown in Fig. N° 14.
For gas concrete however it must be completed with a teflon cone as shown in Fig. N° 16. When experience tells which penetration value is ideal for cutting, that value should then be adopted as a standard and always be kept. This will reduce failures in cutting.

After cutting, 3 of the mould bottoms with the cut mass are placed on each other on a bogie and transported into the autoclave. Again must be pointed out that all movements, especially when setting down a mould with its mass, this must be done with utmost care and 2-speed hoists should always be used in order to avoid "bumps" producing cracks. It is of course important that the mould bottoms have sufficient mechanical rigidity.

3.5 Autoclaving

The autoclaving curve with 1/2 hour vacuum and 2 1/2 hours uptake is quite normal for blocks. For reinforced products a 3 hour uptake is to recommend with a very slow uptake in the beginning. The time for constant pressure keeping is less for blocks and longer for reinforced products. This is so because the blocks have many vertical cuts which allow the steam to penetrate quicker and heat the blocks quicker.

The autoclaving as such does not seem to cause any special problem although it was said that sometimes cracks ocurred during the autoclaving. This can, of course, happen but it is more likely that cracks have been caused before the autoclaving and had only been visible afterwards. However the Expert noticed that the reinforcing nets were placed at approximately 1 cm distance from the mould side and several times they touched the mould side. This is unacceptable and can cause not only cracks

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CT-421

CT-421 CONCRETE PENETROMETER

ASTM C-403

The new Concrete Penetrometer for field and laboratory evaluation of the INITIAL SET of concrete mortar has been developed by Soiltest.

The penetrometer can be used in conjunction with the ASTM C-403 test. *The test involves forcing the penetrometer's steel shaft* into the mortar to a depth of one inch (scribed on the shaft) at time intervals at a constant rate. The resistance in pounds per square inch is shown on the penetrometer's direct reading scale by the indicator sleeve which automatically holds its position until released.

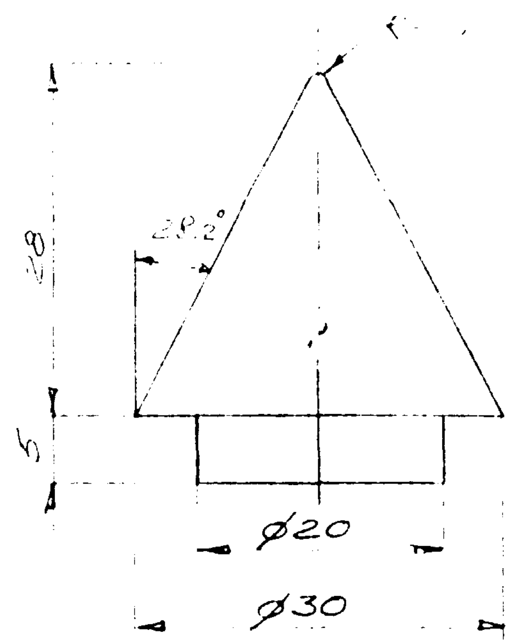
It has been established that the point of INITIAL SET as been reached when the penetrometer penetration is 500 psi. "Initial Set" is the semi-hardened, partially hydrated condition of the concrete beyond which it can no longer be worked or consolidated by vibration. By using retarders, the time of initial set of concrete can be controlled.

The calibrated range of the penetrometer is 0 to 700 pounds per sq. inch. The shaft needle has a 1/20 sq. inch surface area. The penetrometer weighs only 9 ounces. The diameter is ¾ inch and the length is 7 inches.

Shipping weight: 1 pound. *Net weight: ½ pound.*

Nr	Antal	Ändring	Inf		Datum

Fig. No. 15



Antal	Det.-nr	Benämning	Material	Dimension	Anm.
			teflon		

	Konstr.	Ritad MG	Kontr.	Godk.	Skala 2:1
P. OLOF GRANE Consulting Engineer P. O. Box 9 Torremolinos/Spain	Penetrometer cone				Svets när ej annat angives Dat. 1/977 Ritn.-nr A 102

during autoclaving but is markedly inappropriate as a construction piece. The distance between the reinforcement and the outside of the panel should never be less than 25 mm. A minor problem which however can cause cracks, is that sometimes the expansion in the moulds is so strong that the pinholder and even the reinforcement is lifted. This can be easily remedied by affixing a fastening screw to the pinholder whereby neither the holder nor the reinforcement can be lifted and produce cracks.

Cracks during autoclaving can occur when a set of moulds have had too long waiting time, i.e. the time after cutting but before they are put into the autoclave. If a set of moulds for example are left waiting a whole night, the cement hardens and the mass will have a considerably higher strength than normal. When these moulds are put into the autoclave, the reinforcing iron will dilate quicker than the gasconcrete mass. Usually this mass is fairly soft so then nothing happens, but when the mass is relatively hard it breaks and cracks occur. Depending on the hardness of the mass micro fissures or large cracks can form. It is a good rule that ready cut moulds should be autoclaved as soon as possible.

3.6 Demoulding

Demoulding seems to be a weak point in the production line as a rather large quantity of waste falls there. It may be true that the cause for broken blocks and cracked panels have their origin earlier in the process but nevertheless the handling and the equipment seem to need a drastic overhaul. Not only the demoulding but the further transport and stocking needs revision. As one example only can be mentioned that the blocks are stocked directly on the ground which is uneven. This means that the whole pile of blocks will be uneven with the result that some fell to the ground and broke. Furthermore moisture from the ground is soaked up in the lower layer of blocks making them unsuitable to be built into a house.

A storage yard should have an even and stable surface which is best accomplished with a concrete foundation. On top of the concrete slab wooden staves should be placed allowing the first layer of blocks to be lifted up from the ground thus not coming in direct contact with water. The stapling of the rest of the blocks in the pile should be made orderly and with care to avoid breakage and waste.

A good way of stapling, storaging and transporting blocks and panels is to put them on standardized pallets of which a few types are shown in Fig. N° 16 . A further improvement is obtained by bandaging the block staple with steel bands. Another way to keep the blocks together is to put them in shrink foil packets. In this case it must be observed that the fresh blocks coming out from the autoclave have a moisture content of about 25% of which the mayor portion should be allowed to escape before the blocks are packed in the plastic. Besides natural drying this can advantageously be done in the autoclave at the end of the autoclavization cycle by applying vacuum for a short time. The 100° C warm blocks will quickly loose the mayor part of their moisture and this is of advantage at the building site, not only because no moisture is built into the house but very much less shrinkage will happen with the corresponding less risk for cracks, which of course is very beneficial to the construction. The humidity of the blocks should also be controlled when testing the compressive strength as its influence is considerable (see Fig. N° 21). In Sweden the tests are carried out at about 10% moisture.

3.7 Quality

According to the Chinese standard the gasconcrete shall have a density of 0,5 kg/dm^3 and its compressive strength shall be $\geq$ 27 kg/cm^2. The Plant Management informs that they have difficulty to keep the compressive strength and cannot comply with the required standard. The reason for the low strength depends on the raw materials and especially on the low quality of the sand.

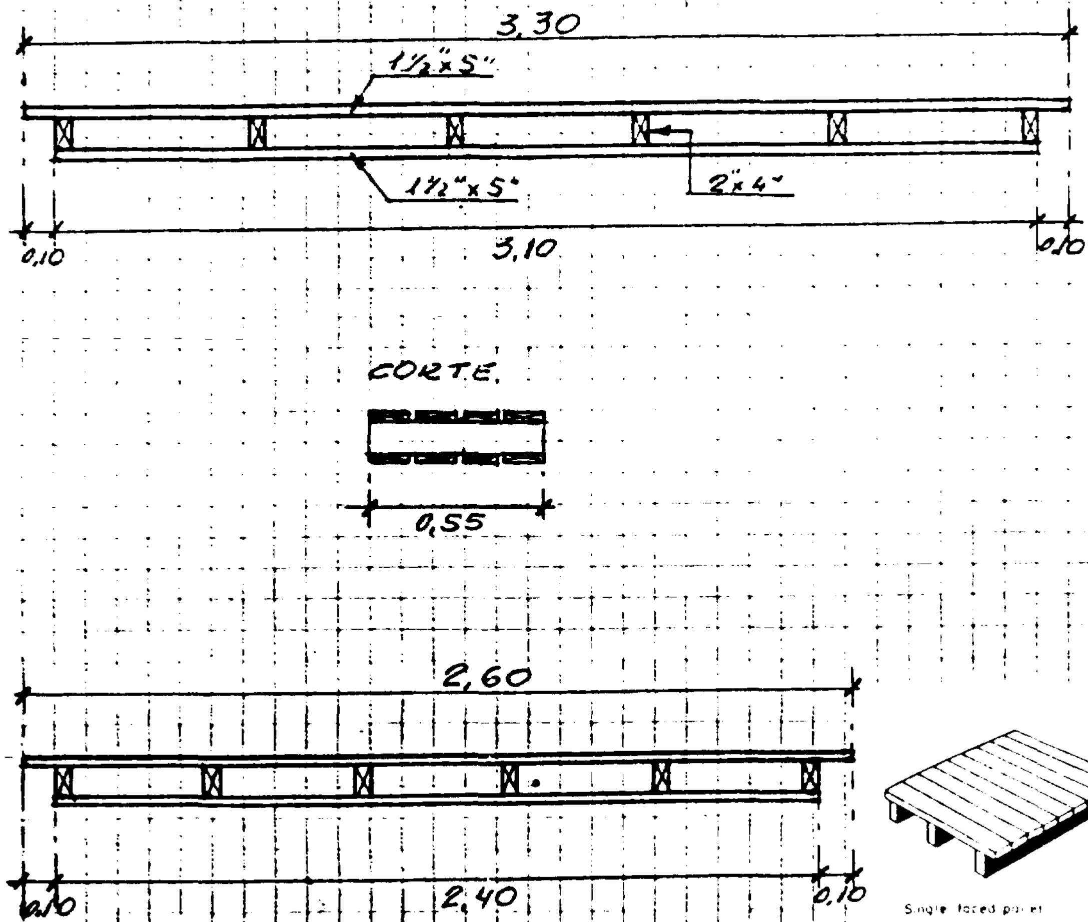
3.7.1. The sand is a brownish riversand with a low content of silica (76% Si.02) and very low content of free quartz ($\angle$ 40%).

PLANTA VICTORIA.

PALLETS PARA TRANSPORTE DE PANELES.

MADERA: ALGARROBO

PALLETS FOR THE STORAGE AND TRANSPORT OF PANELS.



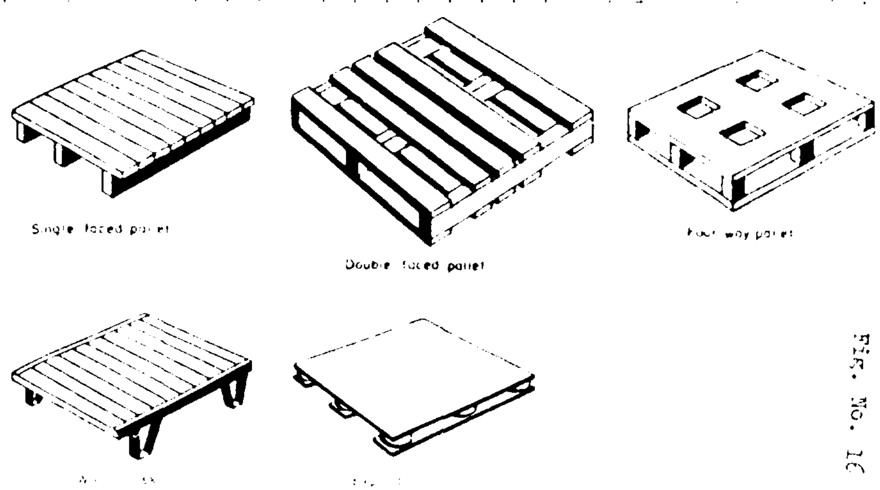


Fig. No. 16

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SUBJECT: CONTROL de la calidad del hormigon gaseoso.

Resistencia a la compresión.

Fig. No. 21

SHEET NO. 1 OF 1

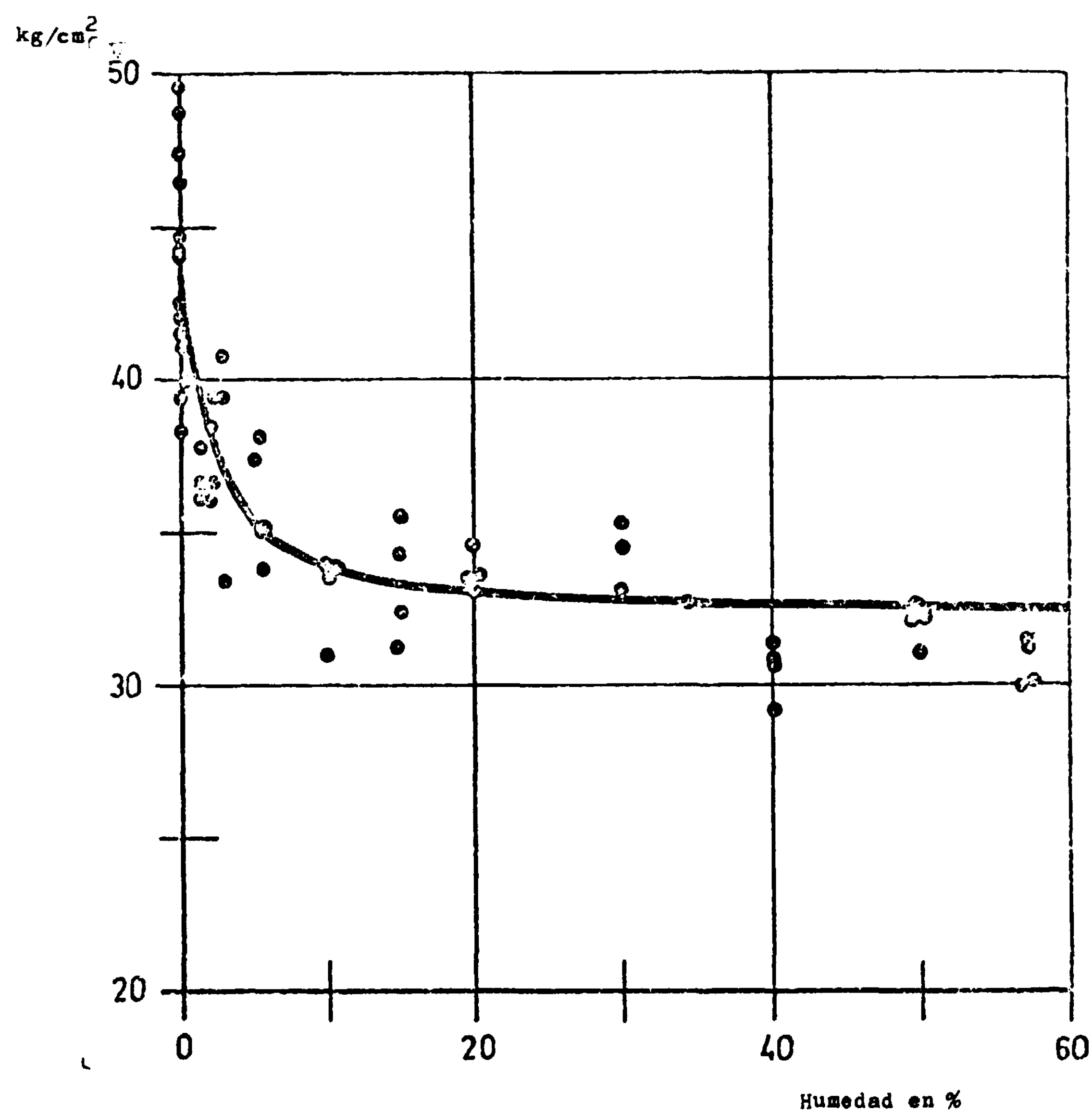
JOB NO. ARG -101

Memo 4 - 003

DATE Julio 1977.

Diagrama mostrando la influencia de la humedad sobre la resistencia a la compresión.
(Segun "Normas de elementos de gasbeton, Comentarios, Suecia 1972)

Diagram showing the influence of the humidity on the compressive strength.



With such sand it is impossible to make a better gasconcrete. If a purer sand or a quartzitic rock cannot be found the Expert's opinion is that under all circumstances the sand should be washed to get rid of the high content of clay which is highly detrimental to the strength of the gasconcrete. Such washing is a simple process and is carried out in a drumwasher followed by a spiral classifier. This classifier is an open screw conveyor sloping upwards in which the sand is transported upwards while being sprayed with water. Hence a clean, washed sand is taken from the upper end of the classifier while the dirty, clayey water runs out at the lower end. The process is shown in Fig. N° ...

To prove that washed sand gives better strength, the Expert made some laboratory tests with washed sand. The values obtained during two days of casting did however not give a clear interpretation. The reason was variations in the raw materials.

Thus the fineness of the milled sand differed and the lime one day was softburnt and quick slaking and reached a maximum temperature of 93° C, while the next day the lime was very slow and only reached 80° C. Under such circumstances tests have little value. When test series are planned, enough raw materials must be at hand so that the same raw material is used in all tests, thus eliminating a factor of possible error. Also must the series be repeated several times until an unequivocal conclusion can be drawn from the results.

A second method to improve the quality of the sand is through flotation whereby the content of free quartz can be raised. This is a method which is used in the production of glass sand whereby the iron-bearing minerals are floated off in the froth while high grade silica is collected in the under flow. To the Expert's knowledge this is also done in cement plants (Paraná, Argentina) in order to increase the SiO_2 content of the siliceous raw material. It is recommended that flotation tests are carried out to improve the riversand which is badly needed. With a sand rich in quartz

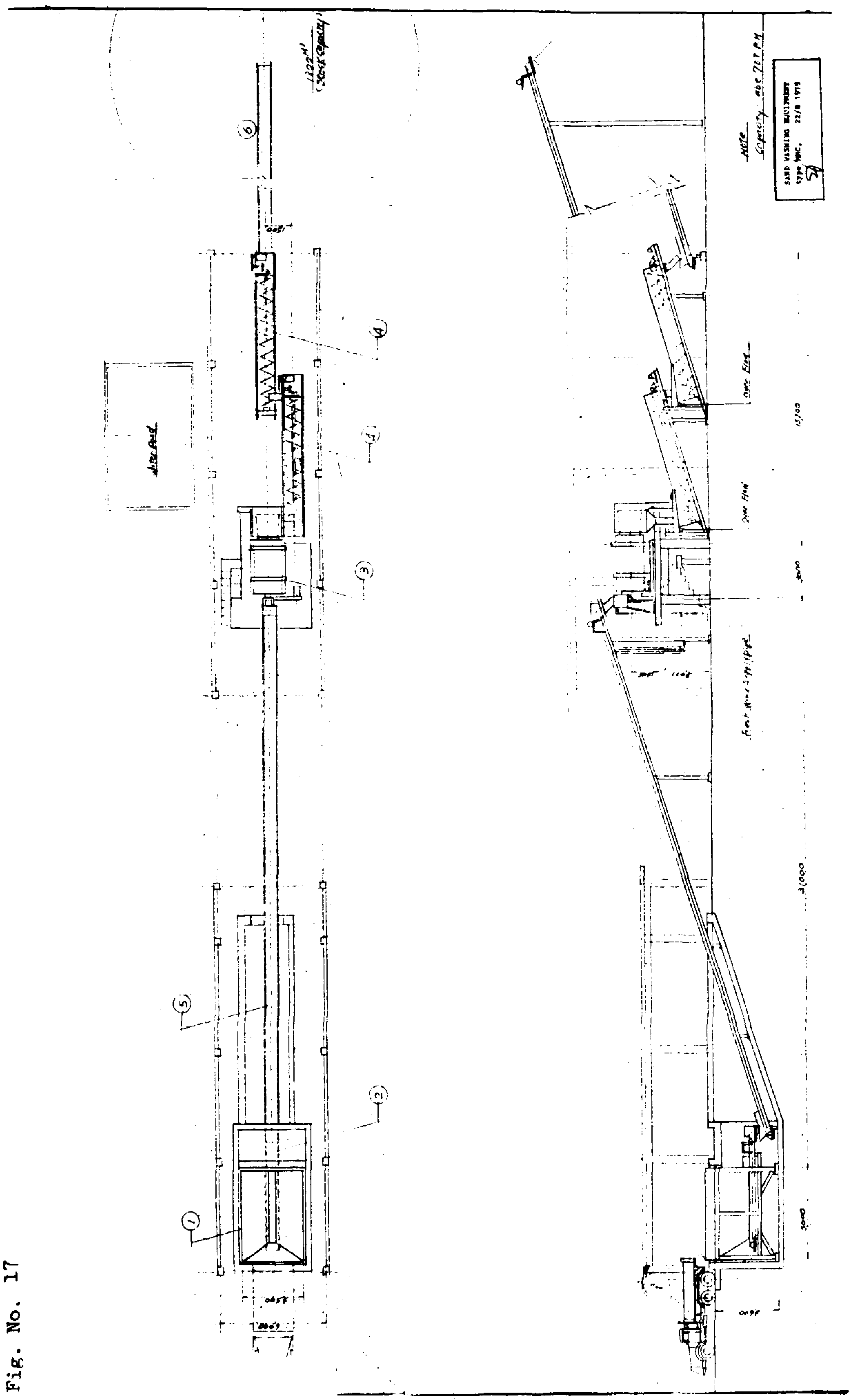


Fig. No. 17

the Plant Management shall have no difficulty in reaching the required strength. In the meantime this can be reached by increasing the density, and/or prolonging the autoclaving time, or milling the sand finer.

It is namely a fact that a low quality sand needs to be milled to a higher fineness than a quartz rich sand in order to obtain the necessary SiO_2 reaction surface and therefore tests with higher Blaine fineness will lead to a higher compressive strength. A too high fineness however will also lead to an increase of the shrinkage and therefore this must be kept under control. Finally a different way to cope with a bad sand is to partly replace it with flyash. Flyash is an artificial pozzolana with a high content of soluble silica and reacts quite willingly with lime. Also it is in a very fine state and as a rule does not need any grinding. Even using high quality sand, an addition of 10% flyash has proved to be beneficial, especially on the shrinkage. */

Certain norms must be put on the quality of the flyash, amongst others the content of carbon should be as low as possible, not over 10%.

3.7.2. Cracks

In all gasconcrete factories cracks occur from time to time in more or less degree. The origin of the cracks generally are twofold,

- unsuitable raw materials
- careless handling.

The unsuitable raw materials mostly are inappropriate lime and unsuitable aluminium powder. If the lime content is too high or if the lime slakes too quickly, cracking may occur. The same will happen if the lime is too hardburnt and the slaking with the ensuing heat evolution and volume expansion comes too late, i.e.

*/ Determination of shrinkage, see Annex N° 7.

after the solidification has set in, then again cracking will occur.

Regarding the lime it is the Expert's opinion that as soon as homogenizing silos have been installed 75% of the problems will disappear. Regarding the aluminium powder it cannot be right to cast density 0,5 and 0,7 with the same powder and absolutely not to cast viscosity 175 and 325 with the same powder. If gas evolution continues after solidification has set in, horizontal cracks may occur. Efforts must be made to obtain different qualities and try out the quality most suitable under the circumstances.

Careless handling is something that can be reduced but can never be completely avoided. A weak point in the production process are the many movements of the moulds. After solidification the moulds are lifted by a crane and transported to the cutting machine, then they are put down, more or less carefully, then the sides are removed, the mass is tilted 90° , then moved forward, cut, moved back, tilted back, lifted, transported to the autoclaves, set down and finally moved on the rails into the autoclaves. So many movements of such heavy moulds with such fragile mass undoubtedly can easily cause power ful impacts with cracking as result. This is the weakness of the two present systems used in China, the Siporex and the Ytong system.

3.7.3. There exists in Europe a third system, the B.I.C. system where the moulds never are lifter under the whole cutting operation and that system is very much more considerate to the fragile mass. As 17 more gasconcrete plants are under construction or planning in China, the Expert suggests that at least one of those plants are built according to the B.I.C. system.

The B.I.C. system is well illustrated in the flow sheet, Fig. N° [illegible] . A layout of a plant with a capacity of 36.000-40.000 m^3 on a 2-shift basis is shown in Fig. N° [illegible] . To increase the capacity, the plant can work 3 shifts and by adding more autoclaves and more mould bottoms the capacity can be further increased.

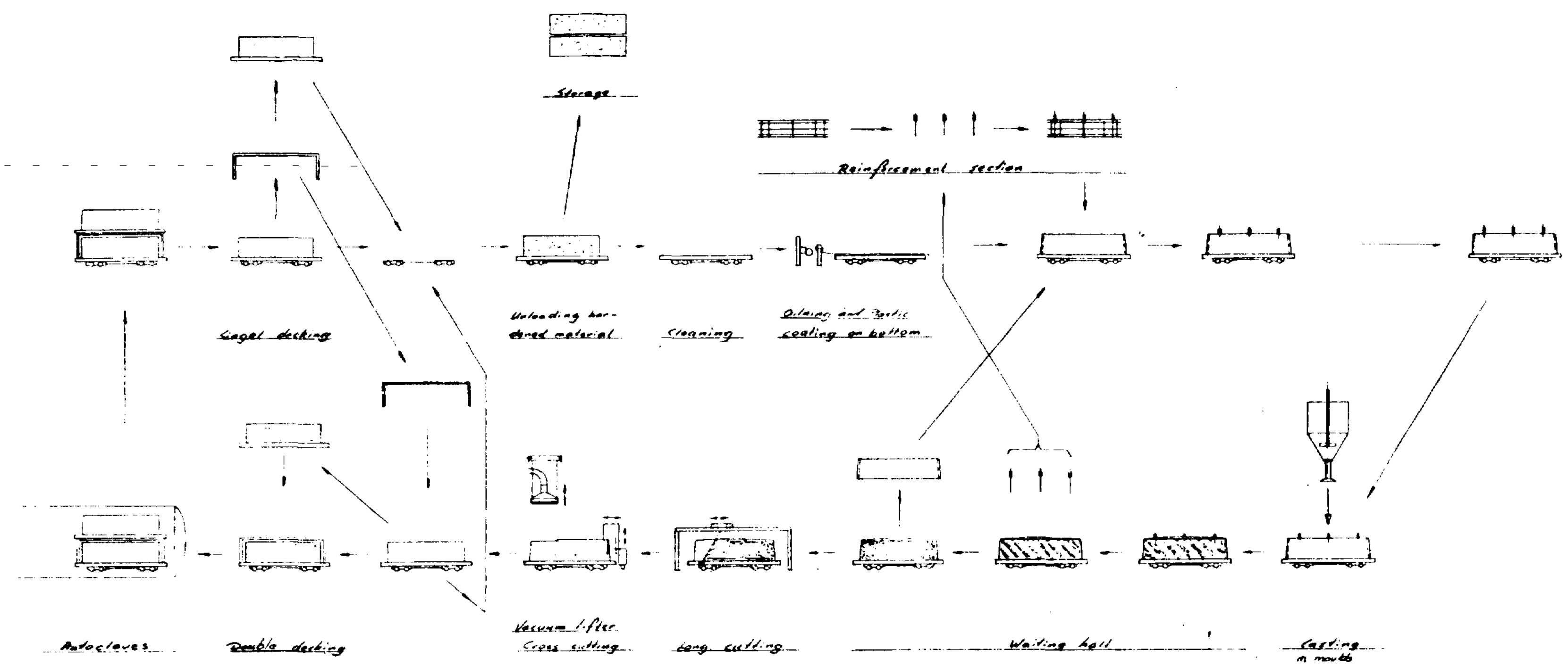


Fig. No. 18

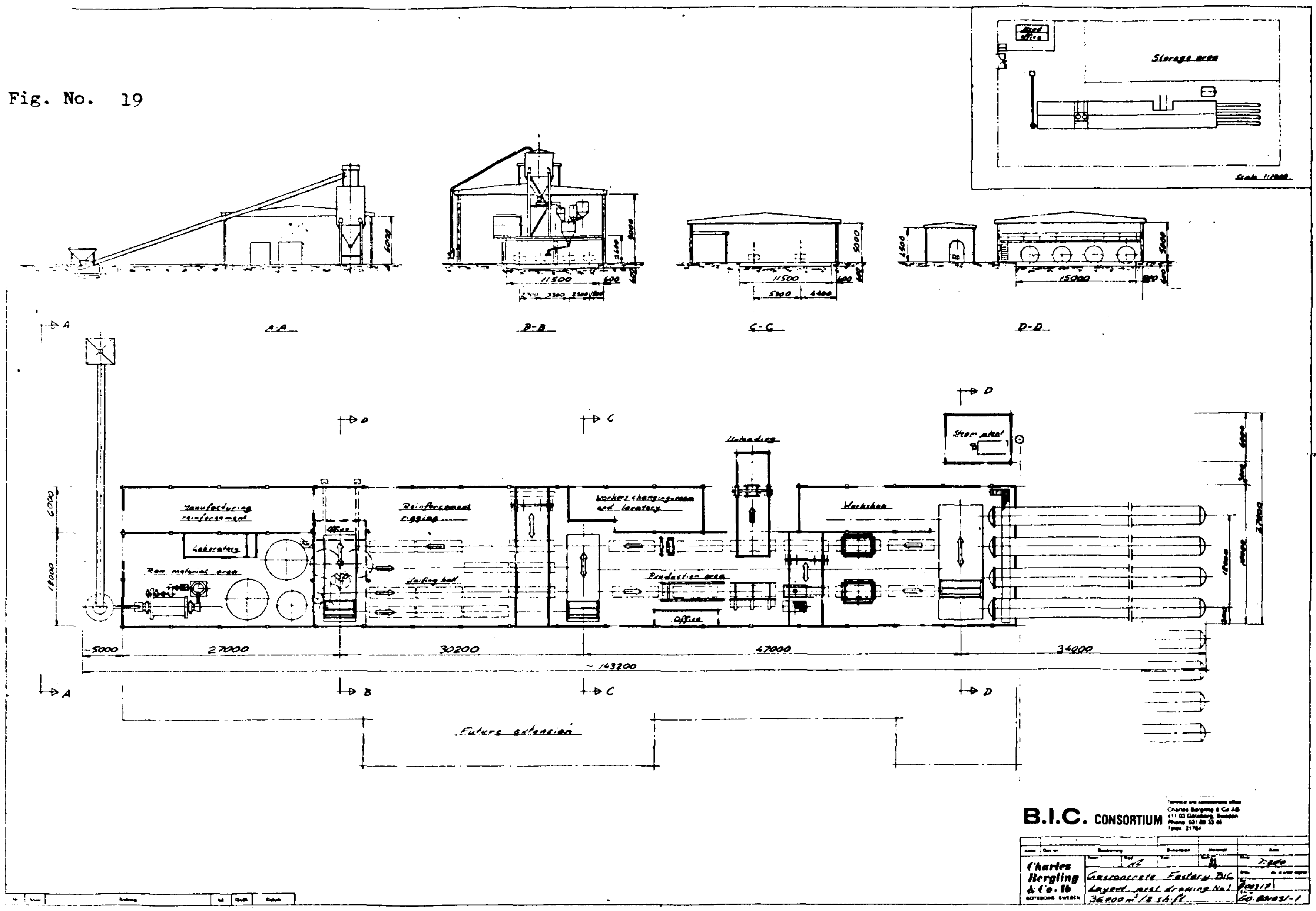
B.I.C. CONSORTIUM

Charles Bergling & Co. Ab

Flow sheet, E-system
Victoria ... concrete
factory, Argentina

791007-30

Fig. No. 19



Storage area
Scale 1:1000
A-A
B-B
C-C
D-D
Manufacturing reinforcement
Laboratory
Raw material area
Office
Reinforcement rigging
Workers changing room and lavatory
Unloading
Steam plant
Workshop
Production area
Office
Future extension
5000
27000
30200
47000
34000
~ 143200
11500
15000
B.I.C. CONSORTIUM
Charles Bergling & Co. Ab
Gasconcrete Factory BIC
Layout, prel. drawing No 1
36 400 m³/8 shift
GO. 80051-1

The B.I.C. system gives very precisely cut blocks and panels with exact dimensions and the Expert recommends that this system is used in one or more new plants to be erected.

The B.I.C. Consortium also build grooving machines which the Expert noticed were needed in the production of the prefab wall elements. Such a machine is shown in Fig. N° 20.

3.7.4. Maintenance

The primary and most important condition for obtaining a first class product is to see to it that all machinery is in perfect working order. This again can only be achieved by a well organized maintenance scheme.

Maintenance starts and finishes with cleanliness. It is quite natural that machinery gets dirty but it should be equally natural that they should be cleaned. If one keeps the pots and pans and the floor in ones private kitchen clean it should be equally natural to keep the machines and the factory premises clean. Only under such circumstances can the machinery function well. There is also a psychological factor involved. If the labourer sees that he is permitted to keep his working place dirty he will not lay stress upon his handling of the machines or the product, he will become careless and negligent and the percentage of waste will increase. Thus, cleanliness is a must. Before a worker leaves his working place for the day he shall leave it clean, including the machinery and equipment he handles, and the foreman of the area section shall be responsible for this.

Secondly most machines need oiling and greasing in order to function well. In every factory therefore it is customary to have a maintenance scheme including a program and a specification of which type of oil and grease should be used on every machine and its different parts including a timetable how often this shall be done. It is a good rule to detail one particular worker to do all the oiling and greasing of the plant machinery.

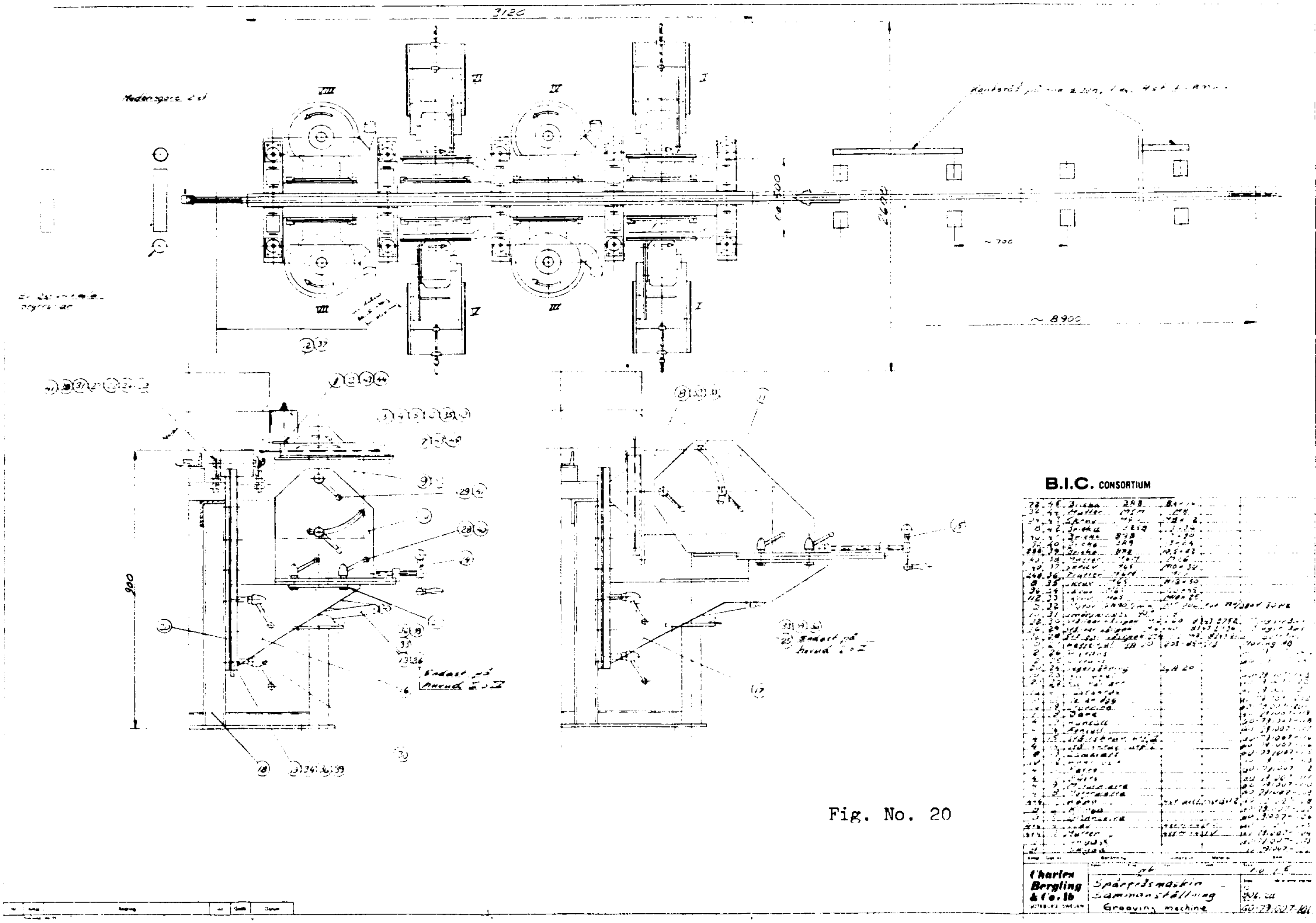

3126
~ 8900
900
B.I.C. CONSORTIUM
Charles Bergling & Co. Ab
Spårfräsmaskin
Sammanställning
Grooving machine

Fig. No. 20

Certain parts of a machine wear out quicker than others. They should be replaced before they are totally worn out and can cause serious damage to the machine. It is therefore important to maintain a stock of spare parts.

If one is unhappy about the performance of a machine its design should be studied and checked and a proposal be made for its improvement. If such ideas for improvement, coming from the man who runs the machine, are rewarded with a cash payment - and this is made known to the employees - it has been proved that many valuable changes and improvements in the running of a plant have come forward. Such reward should be proportional to the saving that can be done or to the value of the improvement and Plant Management should not be hesitant to pay out even a large sum if the saving is considerable.

Not only machinery but such things as moulds tend to become damaged and the sides and the bottom at times are more or less bent. Each mould should have an affixed number and then they should with a regular interval, needed or not, be sent to the workshop for a check-up and eventual repair.

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SUBJECT: The influence of addition of sugar to Al-powder Empco SB

ANNEX No. 1

SHEET NO. 1 OF 2

JOB NO. SGAB

Memo No. 43-01

DATE Feb. 1979

The test was carried out in the Al - test apparatus. 0,6 g Al-powder was mixed with 0,02 g sodiumlaurylsul-phate in water. 250 ml of a suspension of slaked lime was mixed with the sugar. The values of the sugar are counted on the quantity of Al-powder and the results are shown in the diagram.

As can be seen the sugar retards considerably the evolution of hydrogen gas and a certain loss of gas is noticed. Using 50 -100 % of sugar a gas loss of 15 - 19% results and the evolution of gas is not terminated until after about 1,5 hours. At lower sugar values the curve takes on a peculiar appearance, namely in the beginning the gas evolution is very rapid, then it is braked and then again it is rapid.

Conclusion:

Smaller amounts of sugar can advantageously be used if the mass shows a tendency to solidify slowly (hardburnt lime). Higher amounts of sugar should be used only in case of extreme need, partly because of the higher losses of gas, partly because the strong delay can cause risk for cracks and fissures as the mass has solidified long before the evolution of gas has terminated.

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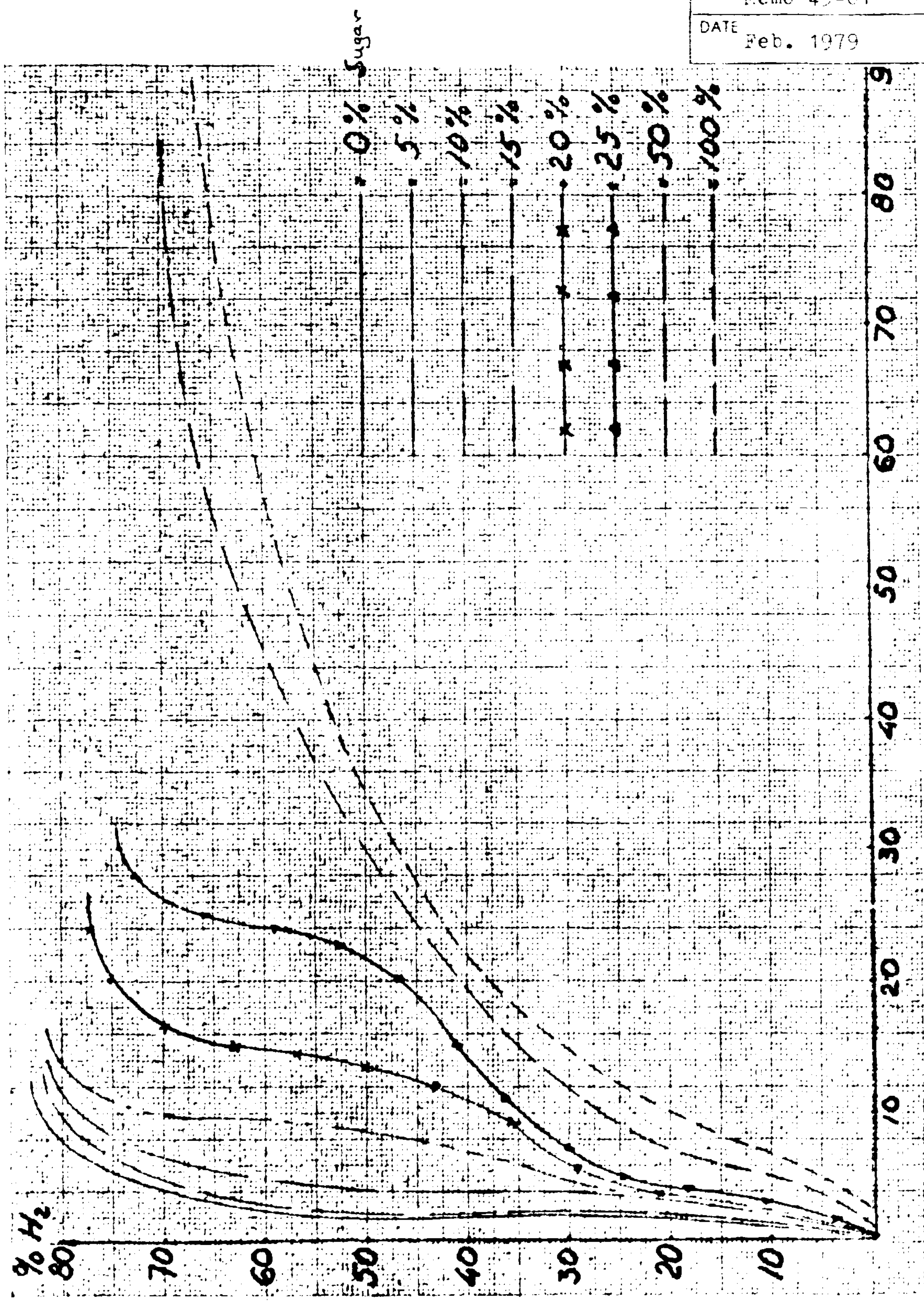
SUBJECT: The influence of addition of sugar to Al-powder Emrco SB.

SHEET NO. 2 OF 2

JOB NO. SGAB

Memo 43-01

DATE Feb. 1979



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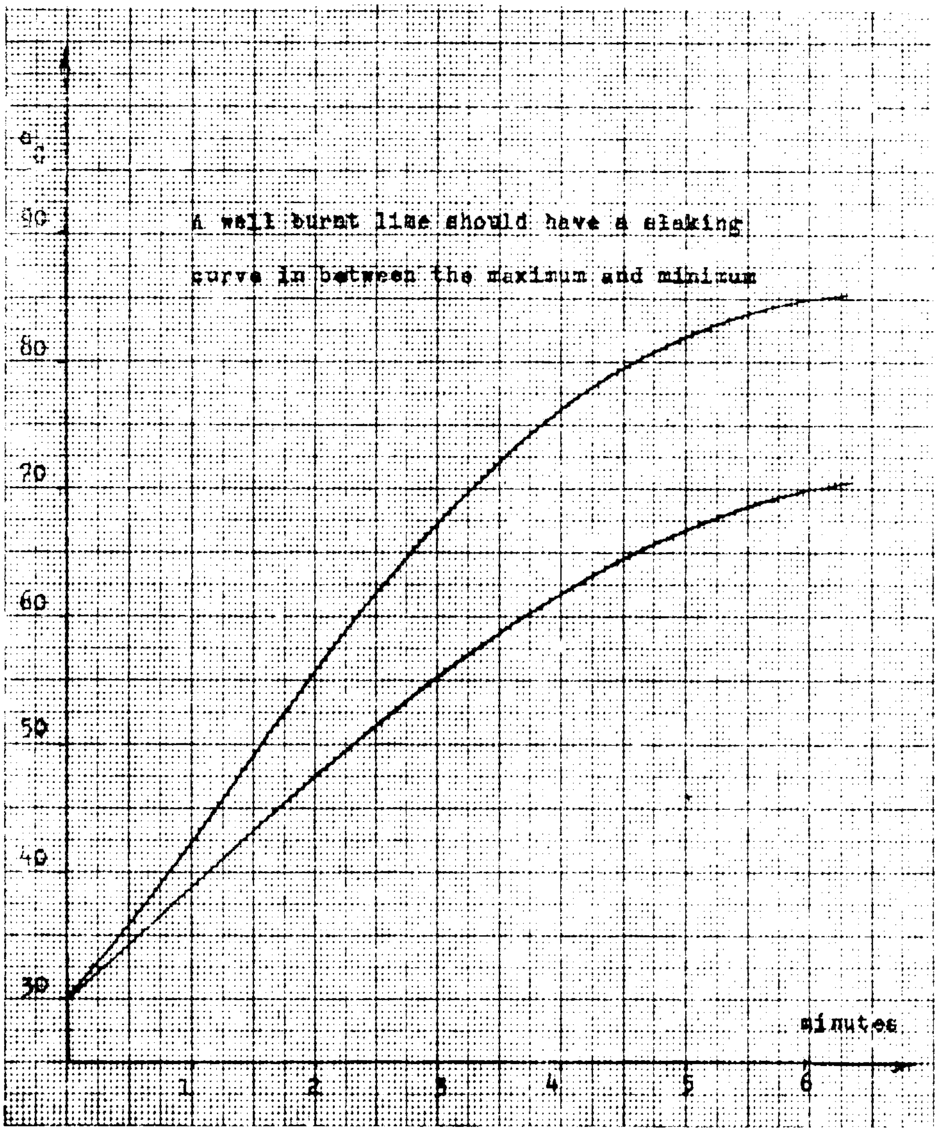
SUBJECT	Annex 2
QUICKLIME, slaking curve	SHEET NO. 1 OF 6
	JOB NO. UNIDO DP/INS/74/034/11-07
	DATE July 1978

Determination of slaking curve:

Put 300 ml water of 30°C in a Dewar flask provided with a me chanical stirrer, add 100 g of quicklime passed through sieve ASTM 170. Measure the temperature every minute with a thermometer which is passed through the cork.



This curve is valid only for the raw materials and the casting viscosity it was established for.

P. OLOF GRANE Consulting Engineer P. O. Box 9 Torremolinos/Spain	SUBJECT: QUICKLIME Determination of free lime	Annex 2
		SHEET NO. 2 OF 6
		JOB NO. UNIDO DP/INS/74/034/11-07
		DATE July 1978

PRINCIPLE

The substance is boiled in a mixture of two parts by volume of ethyl alcohol and one part by volume of glycerol, free CaO (and $Ca(OH)_2$) being extracted. As accelerator strontium nitrate is used. The filtrate is tatrated with hydrochloric acid using methyl red as indicator.

The method is suitable for analysis of quick lime, cement, protecting coating for steel (cement latex), pulverized lime-shale and gas-concrete.

EQUIPMENT

1. Analysis balance, accuracy at least ± 0,1 mg.
2. Erlenmeyer flask, 250 or 300 ml, with glass stopper.
3. Reflux condenser with standard joint, fitting the EM-flask.
4. Heat source, e.g. LPG-burner.
5. Büchner funnel, Ø 100 mm
6. Filtering flask with rubber rings.
7. Vacuum pump, e.g. water jet pump.
8. Burette, grading at least 0,1 ml.
9. Support and clamp for reflux condenser and burette.
10. Measuring cylinder, 50 ml.

CHEMICALS

Absolute alcohol, 99,5 % by volume.

Anhydrous glycerol, p.a.; 0,25 N HCl.

$Sr(NO_3)_2$ (strontiumnitrate), p.a.

Phenol phtalein, 1 g/100 ml absolute alcohol

Methyl red, 0,2 % in alcohol

Na OH, p.a. 1% in absolute alcohol

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SUBJECT: QUICKLIME

Determination of free lime

Annex 2
SHEET NO. 3 OF 6

JOB NO. UNIDO DP/INS/74/034/11-07

July 1978

1. Extraction solution

Mix 2 parts by volume of absolute alcohol to 1 part by volume of glycerol. Add 2 ml solution of phenol phtalein per litre mixture. If, after this the sulotion is colourless, then add an alcoholic NaOH solution in drops, until it obtains a weak tint of red.

2. Accelerator

Heat $Sr(NO_3)_2$, p.a. for 30 minutes at 500°C.

Grind the salt after heating and keep it in a desiccator in a closed container.

PROCEDURE

1. Rinse the Erlenmeyer flask and the reflux condenser with absolute alcohol. Measure out 40 ml extraction solution in the measuring cylinder, pour the solution into the flask and insert the stopper.

2. Weigh a suitable quantity (about 200 mg quicklime, about 1 g pulverized lime-shale or about 2 g cement, rust protection or gas-concrete) of the ground sample along with 2 g of the accelerator. Put the weighed substance into the extraction solution in the flask.

3. Add 10 - 15 glass beads. Measure out 10 ml extraction solution in the graduated glass and wash down substance, if any, adhering to the inside of the flask.

4. Boil the mixture for 15 minutes with a reflux condenser. The boiling should be intense enough to keep the glass beads in motion during the entire period of boiling.

5. Rinse the reflux condenser with 10 ml absolute alcohol and disengage the flask by lifting the condenser 1 - 2 cm. Wash the bottom part of the condenser and the neck of the flask with 10 ml absolute alcohol. Cork the flask and cool the sample to indoor temperature, under running cold water.

6. Filtrate through Büchner funnel by a hard filter paper, e.g. Munktell OOH or Schlecher and Schüll 589/3 (The filtration may sometimes be facilitated by placing a soft paper, e.g. Munktell OOR or Schleicher and Schüll 589/1, on the top of the hard filter paper). Rinse out the flask 4 times and wash the funnel and the filter carefully 3 times with 10 ml portions of absolute alcohol.

7. Titrate the filtrate with 0,25 N HCl to colourlessness. Add 3 drops of methyl red solution and continue the filtration until tho indicator changes from yellow to orange.

CALCULATION

$$\frac{\text{ml HCl} \times \text{the normality of the acid} \times \frac{CaO}{2} \times 100}{\text{Weight of sample in mg}} = \%\ \text{free lime}$$

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SUBJECT: QUICKLIME

Determination of total alcalinity

JOB NO. UNIDO
DP/INS/74/074/11-07

DATE July 1978

1. 40 ml of 1-N HCl is transfered into a 300 ml Erlenmeyer flask.

2. 1 g of lime is weighed and put into the Erlenmeyer flask. 50 ml of distilled water (warm) is added and the content is heated to boiling or close to.

3. Cool the content of the flask to ambient temperature. Add 2 or 3 drops of fenolftalein and titrate with 1-N NaOH until colour change.

$$\% \, CaO = (40 \text{ ml} \times Fc.HCl) - (\text{ml } NaOH \times Fc.NaOH) \times \frac{2{,}804}{\text{weight of sample}}$$

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SUBJECT: QUICKLIME

Determination of the absolute and relative activity.

Annex 2

SHEET NO. 5 OF 6

JOB NO. UNIDO DP/INS/74/034/11-07

DATE July 1978

1. Grind a representative sample of 100 - 150 g of the lime in a porcelain mortar and sieve it through sieve ASTM 120.

2. Transfer the sieved material into a flask with stopper and shake it so that the content is well mixed. Put then 50 g of the sample in a porcelain bowl which should be as well insulated as possible to prevent temperature exchange with the surroundings. Add 100 ml of distilled water of 20^{o}C and stir with a thermometer until maximum temperature is reached.

3. Transfer in totality all the slaked lime, when cooled off, from the porcelain bowl into a 500 ml glas flask and fill it up to the mark with distilled water. The flask is shaken vigorously and quickly 100 ml are pipetted off and transfered into another 500 ml flask. This one is again filled up to the mark with distilled water, it is vigorously shaken and 100 ml are transfered into a 200 ml flask, 95 ml 2-N NH_4. Cl are added and the flask is filled up to the mark with distilled water whereafter it is well shaken.

4. The mixture is allowed to repose for 7 minutes and is then filtered through a dry filter of medium velocity into an Erlenmeyer flask. 100 ml of the filtrate is pipetted off into a 300 ml Erlenmeyer flask and 3 drops of methyl red is added and titration is made with 1-N HCl.

% absolute activity = ml HCl x Fc HCl x 2,804

% relative act ity $= \frac{\text{\% activity abs.}}{\text{\% total alcalinity}} \times 100$

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SUBJECT: QUICKLIME
Determination of pre-slaked lime, unburnt lime and insolubles.

JOB N.: UNIDO DP/INS/74/034/11-07

DATE July 1978

1. The proper method to determine the amount of pre-slaked lime is to heat the sample to 550°C and determine the liberated, bound, water by adsorbtion,

2. A quicker, but not accurate method is to simply weigh the pre-dried sample before and after heating it.

3. Likewise the content of unburnt $CaCO_3$ should also be determined by heating the sample to further 1100°C and determine the amount of liberated CO_2 by adsorbtion. By simply weighing the sample before and after an approximate estimate is arrived at.

4. While the exact amount of insolubles is determined when the complete chemical analisis is made, a practical method is to wet-slake a sample of 50 or 100 g and then wash away the hydrate through a ASTM 200 sieve. The residue on the sieve is ovendried on the sieve and then weighed. It constitutes insolubles + unburnt lime.

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SUBJECT: Reactivity test of quick-lime

ANNEX No. 3
SHEET NO. OF
JOB NO. UNIDO SM/BDI/73/011/11-01/03
DATE February 18, 1976

This test purposes to show the rate of slaking of quick lime which varies depending upon if the lime is soft-burnt, medium-burnt or hard-burnt.

The test is based on the following reaction:

$$Ca(OH)_2 + 2\ HCl = CaCl_2 + H_2O$$

Procedure:

50 g calcined lime with a particle size between 2 - 5 mm is added in one portion to 1.000 ml of water at 40°C and stirred. Phenolphtalein is added simultaneously as indicator. A red colour appears as slaking takes place.

4-n hydrochloric acid is then added from a 500 ml burette until the red colour disappears. Additional hydrochloric acid is added at any new sign of red colouring in such a way that the solution always remains colourless. This continues for ten minutes and the consumption of hydrochloric acid is recorded every minute. The values are entered in a diagram.

50 g CaO correspond to approximately 430 ml 4-n HCl. Extremely hard-burnt lime may within the lo minutes consume only 20 ml HCl.

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SUBJECT: SLAKED LIME
Popping and pitting test

ANNEX No. 4
SHEET NO. 1 OF 1
JOB NO. SSA-CIR/79
DATE August 1980

Slaked lime test called "popping and pitting"

1. Calcined gypsum of standard type that ones uses for this test should not have a hardening time over one hour when it is tested according to A.S.T.M. C-472. The gypsum should be tested first without lime in the manner described in paragraph 2, this in order to make sure that it is free of "pops and pits".

2. 100 g of slaked lime is mixed with a sufficient quantity of water to give it a consistency which gives a penetration of 20 ± 5 mm when it is tested according to Section 6 of ASTM C-472. 25 g of the standard gypsum is mixed with this paste adding water as required to maintain a workable consistency. Sufficient quantity of this putty is extended on a glass plate to make a specimen of approximately 15 x 20 cm and of 3 mm thickness. The specimen should be smoothed to give it an even finish.

3. Put the glass plate with the specimen on a shelf over a water bath, so that the water is not in direct contact with the test specimen. An inclined cover should be put above the specimen in order to prevent condensation drops to fall on the specimen. The temperature of the water bath is raised to boiling and it should be kept boiling for 5 hours. Thereafter the specimen is removed and examined for "pops and pits".

P. OLOF GRANE Consulting Engineer CANGALLO 925 (1038) BUENOS AIRES - ARGENTINA	SUBJECT: Alumirium powder for aerated concrete.	ANNEX No 5 SHEET NO. 1 OF 6 JOB NO. SSA-CPR/79/019
		Memo No. 32-001 DATE August 1980

ALUMINIUM POWDER FOR LIGHTWEIGHT CONCRETE

PRINCIPLE

Cellular concrete, the strongest and most important type of light-weight concrete, is produced by the chemical reaction between aluminium powder and lime or a lime-generating material, particularly Portland cement. Hydrogen is liberated in this reaction, which takes place in aqueous medium, so that the mass rises to about twice its initial volume. It is allowed to set in this condition and, if the final product is intended for the construction of load-bearing walls, it is steam-hardened.

RAW MATERIALS

The solid raw materials, other than aluminium powder, are ground and intimately mixed and the mixture, also knows as "flour", is stored in silos. The active ingredient usually is Portland cement or lime or a mixture of cement and lime. Fine sand or some other silicious material like burnt shale is added and, frequently, a filler like pulverised fuel ash, originating from coal-burning power stations, is incorporated. The aluminium powder is of the lamellar type, commonly known as "Aluminium Flake Powder".

PROCEDURE

The flour is mixed with water, the temperature being adjusted to about 40°C, and the aluminium powder is added either as such or in the form of an aqueous suspension. After thorough mixing, the composition is cast into moulds, which are filled to about half their depth. The reaction starts soon after casting and, as a rule, takes 15 to 20 min. to complete, but shorter and longer reaction times are both encountered in practice. It is desirable for the reaction to take place in a draught-free atmosphere, in order to avoid structural unevenness and cracks in the product. When the reaction is complete and the concrete has set, the latter is cut into blocks or slabs, which are subsequently steam-cured in autoclaves.

ALUMINIUM POWDER

Aluminium flake powder is preferred to other types of Al-powder, owing to its large specific surface and resulting high reactivity. The early types of aluminium flake powder were produced by dry-milling with a fatty acid lubricant and, as a result of their fatty coating, were not miscible with water. Wetting agents were therefore employed in light-weight concrete production. Alternatively, the metal powder was submitted to heat-treatment before use, so as to destroy the fatty surface film. This procedure was laborious and accompanied by occasional fires and is not practised any longer in the lightweight concrete industry. Water-dispersible aluminium powder has been available for many years. Apart from the surface configuration of the aluminium powder, i.e. presence or absence of a coating on the particles and the nature of any such coating, its physical parameters determine its suitability for the lightweight concrete process in question. The relevant physical properties are particle size distribution, apparent density and specific surface. Chemical reactivity closely depends on these characteristics. It is desirable that the aluminium powder starts reacting very soon after the mixture has been cast into moulds and that the reaction proceeds evenly, reaching completion just when the mix is about to set. It should be pointed out that different lightweight concrete processes require different aluminium powder grades. This is partly due to differences in raw materials, leading to wide variations in chemical reactivity, partly to differences in operating methods and conditions. The aluminium powder should be adapted to the reactivity and rheological properties of the lightweight concrete composition. This has been achieved, as a result of many years' development work, with the range of

CARLFORS BRUK ALUMINIUM POWDERS

the properties of which are tabulated on page 5.

TESTING METHODS FOR ALUMINIUM POWDER

A- APPARENT DENSITY

PRINCIPLE

The apparent density of the powder is first measured in the loose (untapped) state and the powder is then tapped to reach its minimum volume, from which the apparent density in the compact state is calculated.

APPARATUS

One graduated cylinder, 25 ml., sub-divided in 0,2 ml., fitted with a plastic stopper. One powder funnel.

PROCEDURE

The metal powder is slowly and evenly introduced through the funn into the tared cylinder, which is protected from vibrations. When the 25-ml. mark is reached, the cylinder is closed and weighed. Finally, the cylinder is tapped on a leather or rubber pad or on an asbestos millboard mat, until there is no further reduction in the volume of the powder.

$$\text{Apparent Density (loose)} = \frac{\text{mass of aluminium powder}}{25} \text{ g/ml}$$

$$\text{Apparent Density (compact)} = \frac{\text{mass of aluminium powder}}{\text{final volume of powder}} \text{ g/ml}$$

B - SPECIFIC SURFACE

For this purpose, either the Blaine test or the Rigden test is used. Both are air-permeability methods and yield closely similar results. The cell used in these methods, which were invented about the same time (1942), consists of a metal tube, usually made of stainless steel, fitted with a perforated metal disc, which rests on a sleeve near one end of the cell. In view of the fineness of the aluminium powder, it is essential to insert a circular disc of filter paper, cut to the size of the internal cross-section of the cell, so as to cover the disc before the powder is introduced. In the Blaine method, the depth of the powder bed is kept constant and the mass of powder taken varied with its bulk volume. It is generally 1,00g ± 0,10g. The powder bed is covered with a second filter paper disc and the powder is compacted by means of a metal piston. In the Rigden method, in which a rather larger permeability cell is employed, the mass of powder is kept constant, generally 4,00 g, the powder being gradually introduced into the cell and finally covered with a disc of filter paper as before. A metal piston is then inserted and the cell tapped on a leather or rubber pad. It is important to standardize the tapping technique, as the porosity of the powder bed and therefore also the final test result depend on it. The depth of the powder bed is measured by means of a vernier calliper and the piston is removed. In both methods, the cell is next inserted in the circuit. The glass U-tubes of the instruments are provided with marks indicating start and finish of the run, respectively. A low-volatile barrier liquid, e.g. dibutyl phthalate, is drawn up and the liquid is allowed to return to the reservoir under atmospheric pressure. The time taken from start to finish marks is measured by means of a stop-watch. The specific surface of the powder is calculated from this interval, the mass of aluminium powder and the depth of the bed. The test is repeated and the mean of two concordant results taken. The repeatability tolerance is 2-3%, in the case of the Blaine test, slightly larger for the Rigden test.

C - REACTIVITY

PRINCIPLE

The aluminium powder is reacted with a suspension of Portland cement in water and the hydrogen liberated is periodically measured for 34 minutes.

APPARATUS

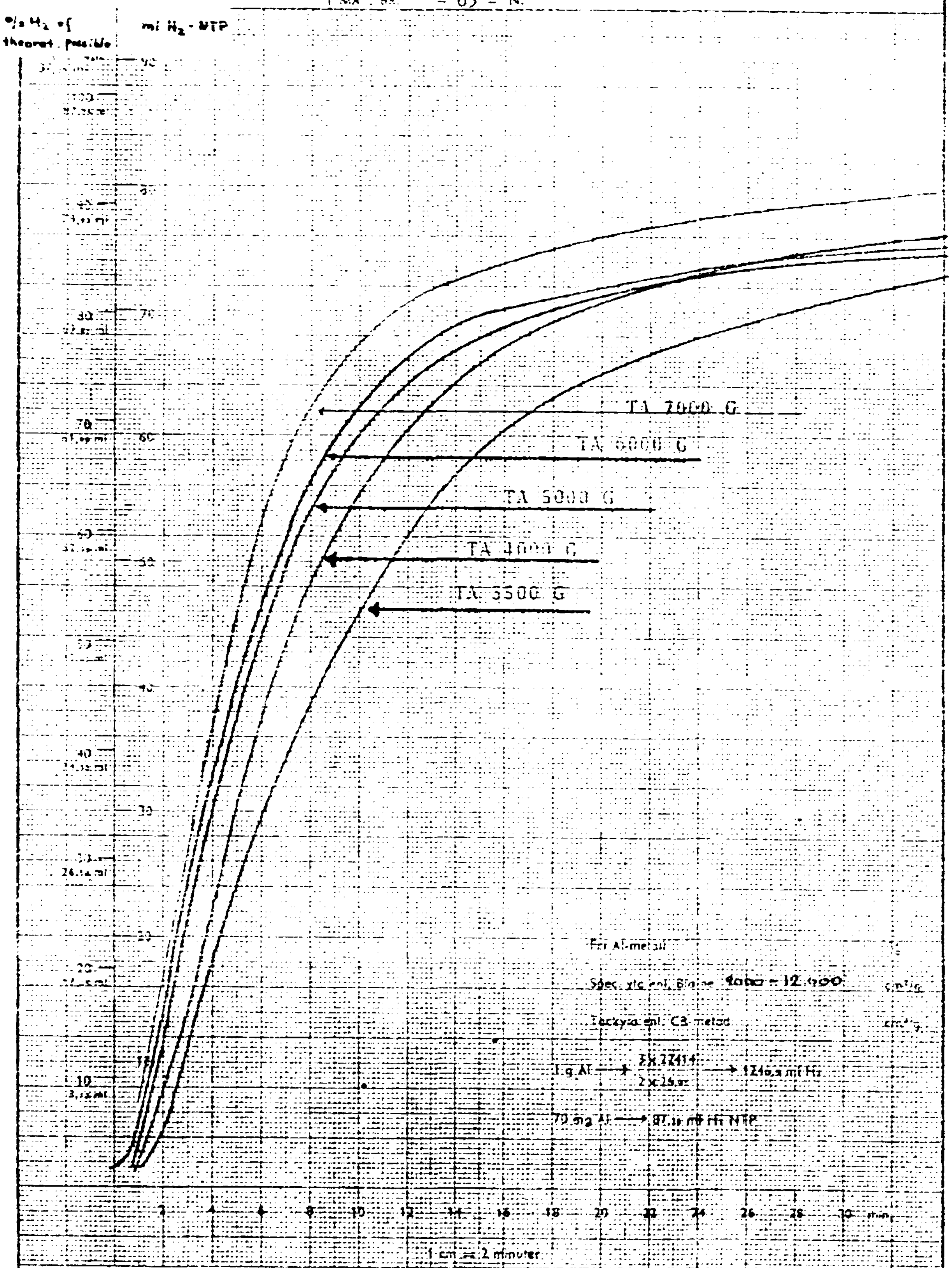
A 250-ml wide-necked round-bottom flask, connected, through a trap, to a 250-ml burette, graduated downwards and fitted with a thermometer. The apparatus is thermostatically controlled at 45°C.

REAGENTS

Sodium hydroxide solution, containing 0,4 g NaOH in 100 ml of water. Portland cement.

PROCEDURE

A mixture of 20 ml of the sodium hydroxide solution and 30 ml of water is heated to about 46-50°C and transferred to the flask. 50 g of cement are added. The mixture is swirled in the flask for 5 minutes and is kept immersed in the bath. 70 mg of aluminium powder are transferred to the flask and the whole mixture is swirled for 30 seconds. Connections are made and the hydrogen developed is measured under atmospheric pressure, at 2-minute intervals for 34 minutes. All readings are reduced to NTP.



Hydrogen evolution curve

NO	ST	RITN.	NAMN	ANMÄRKN.
RITAD:	KOPIERAD:		GASUTVECKLINGSKURVA	RITN. No:
SKALA:			CARLFORS BRUK, HUSKVARNA	DET. No:

Grade	App. density (loose) kg/l	App. density (compact) kg/l	REACTIVITY — CEMENT TESTING METHOD — HYDROGEN EVOLUTION					Free metallic Al. %	Specific surface (Blaine-value) m^2/g
			1 min.	2 min.	6 min.	20 min.	34 min.		
TA 3500 G	0,18	0,35	0,0	4,0- 5,5	25,0-30,0	62,0-65,0	69,5-72,0	93,0-95,0	0,80-0,9
TA 4000 G	0,17	0,29	0,0	6,0- 7,5	35,0-39,0	66,0-69,0	71,0-74,5	93,0-94,0	0,95-1,2
TA 5000 G	0,16	0,24	0,0-1,0	8,0-11,0	40,0-45,0	67,5-71,0	72,0-75,0	92,0-93,5	1,20-1,5
TA 6000 G	0,15	0,23	1,0-2,5	11,0-13,0	48,0-50,0	69,0-72,0	73,0-75,0	92,0-93,0	1,50-1,6

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SUBJECT: CASTING PROBLEMS AND THEIR REMEDY

ANNEX Nº 6

JOB NO. DUROX

DATE 1960

Because of unavoidable variations in the properties of the various raw materials problems do arise in the casting of gasconcrete. At one time perhaps the mass will rise and overflow whilst later it may not rise completely to fill the mould. Experience only will tell the reasons for such anomalies and how to overcome and remedy those problems. However, some general rules exist which may serve as a guidance.

The difficulties that normally appear are as follows:

1) The mass does not rise completely.
2) The mass rises but sinks down again
3) The mass rises but then cracks
4) The mass does not solidify

The reason for each of these troubles varies. Each trouble has its remedy and in the following an attempt is made to explain each problem in order.

1) <u>The mass does not rise completely</u>

One reason might be that the lime is too soft burnt and reacts too quickly with the water. In other words, the lime slakes too quickly. Another reason might be that there is not enough $Ca(OH)_2$ present.

The main reasons for an unsatisfactorily mixed batch with this type of powder are:

a) not enough water
b) not enough aluminium powder

This situation is the easiest one to correct. The simplest and cheapest way to do so is to add water.

2) <u>The mass rises but sinks back</u>

The reason why a mass sinks after rising completely are manifold. The main reason is that the solidification or drying occurs too late or not at all. It is necessary to take various steps to insure that the rising of the mass ends at the same time that solidification sets in. The various reasons for the mass sinking can be:

a) <u>too much aluminium powder</u>

Result: gas escapes from the mass

Correction: Less aluminium powder.

b) too much water

Result: no solidification. Mass rises too far, flows over side of mould, boils, and sinks back down to bottom of mould.

Correction: less water and less aluminium powder.

c) lime burnt too hard

Result: the heat comes too late, therefore the mass rises but does not solidify in time so it shrinks back again. Drying cracks appear when heating begins.

Correction: more water and less aluminium powder.

d) lime burnt too lightly

Result: the heat comes instantly, the mass thickens and starts to rise directly, usually in the mixer. Does not solidify, because there is not enough CaO to take up the excess water.

Correction: it is not recommended to attempt to correct this condition with less water in the mixer as this results in the mass sticking in the mixer. The only way out is to throw away all the too lightly burnt lime on hand and start with better raw material.

e) too much preslaked lime, $Ca(OH)_2$

Result: no heat and no solidification

Correction: use less waste slurry and more cement and lime.

f) high content of unburnt lime

Result: everything goes to hell

Correction: hopeless, nothing to do but go home.

g) too low CaO content

Result: no solidification

Correction: less water slurry, more cement and lime.

Generally speaking, when the mass rises and sinks back, it can be corrected by adding less aluminium powder and more water. This results in slower rising and gas escape. However, care must be taken when adding more water as it can result in poor drying or no drying at all.

3) <u>The mass rises, then cracks</u>

Paradoxically enough the mass might crack either from drying too hard or from not drying at all.

The main reasons for cracking are:

a) <u>too high content of burnt lime</u>

Result: the mass dries rapidly under high temperature. The cracking occurs soon after solidification sets in.

Correction: more water, more waste slurry, less cement and lime, less aluminium powder.

b) <u>too little water</u>

Result and correction: same as under a) above.

c) <u>mixing of hard burnt and soft burnt lime</u>

Result: when the lime does not contain enough medium burnt lime, it takes less water then normally, and by reducing the water the mixing man attempts to adjust to normal viscosity. The mass rises normally but after between a half and one hour, the temperature in the mass begins to increase again and this results in large or small cracks depending on how dry the mass is and on how rapidly the temperature is increasing.

Correction: if the conditions existing in the lime are detected in time, do not change the water quantity, even if the slurry gets thinner, and add less aluminium powder.

d) <u>cold moulds</u>

Result: the cold mould steals too much heat from the mass. After the rising the mass near the sides and bottom does not contain enough heat to solidify. Thus the interior parts of the mass solidify while the outer parts remain wet. This results in the entire mass rising but the outer perimeter sinking back again and causing a crack all the way to the bottom of the mould.

Correction: heat the moulds to casting temperature.

4) <u>Bad drying (The mass does not solidify)</u>

The reasons can be many:

a) <u>too softly burnt lime</u>

Result: the mass appears to dry rapidly. The mixing man then adds more water, and reduces the amount of aluminium powder, but that results in the mass not drying at all, or in sinking back.

Correction: there is no real correction except to dispose of the poor lime although an attempt can be made to cast as thickly as possible and hope for the best.

b) <u>too much preslaked lime</u>

Result: the mass rises fast, thickens too fast, does not dry, does not solidify.

Correction: less waste slurry, less aluminium powder, more cement and lime. If trouble persists an attempt must be made to cast as thick as possible using more aluminium powder in order to make the mass rise

c) <u>unburnt lime</u>

Result and correction: same as noted in 2 f).

d) <u>too low CaO content</u>

Result and correction: same noted in 2 g)

e) <u>too much water</u>

Result and correction: same as noted in 2 b)

DUROX INTERNATIONAL S. A. SKÖVDE, SWEDEN	# INVESTIGATION REPORT
Division: Lab. *Report no:* 570624/3 *Date:* 24.6.1957	*Subject:* Description of the determination of the volume variation (shrinkage and swelling) of gas concrete on account of humidity in the material, according to the DUROX special rapid method. *Written by:* LJ/AJ

Besides the normal DUROX method for determining the volume stability of gas concrete at various humidities, a more rapid method has been developed, by which the desired constant length of the test prisms at 45 % relative air humidity is quicker received. This method is described below. Things not considered refer to report no. 570524/2.

The apparatus used appears from the enclosed sketch.

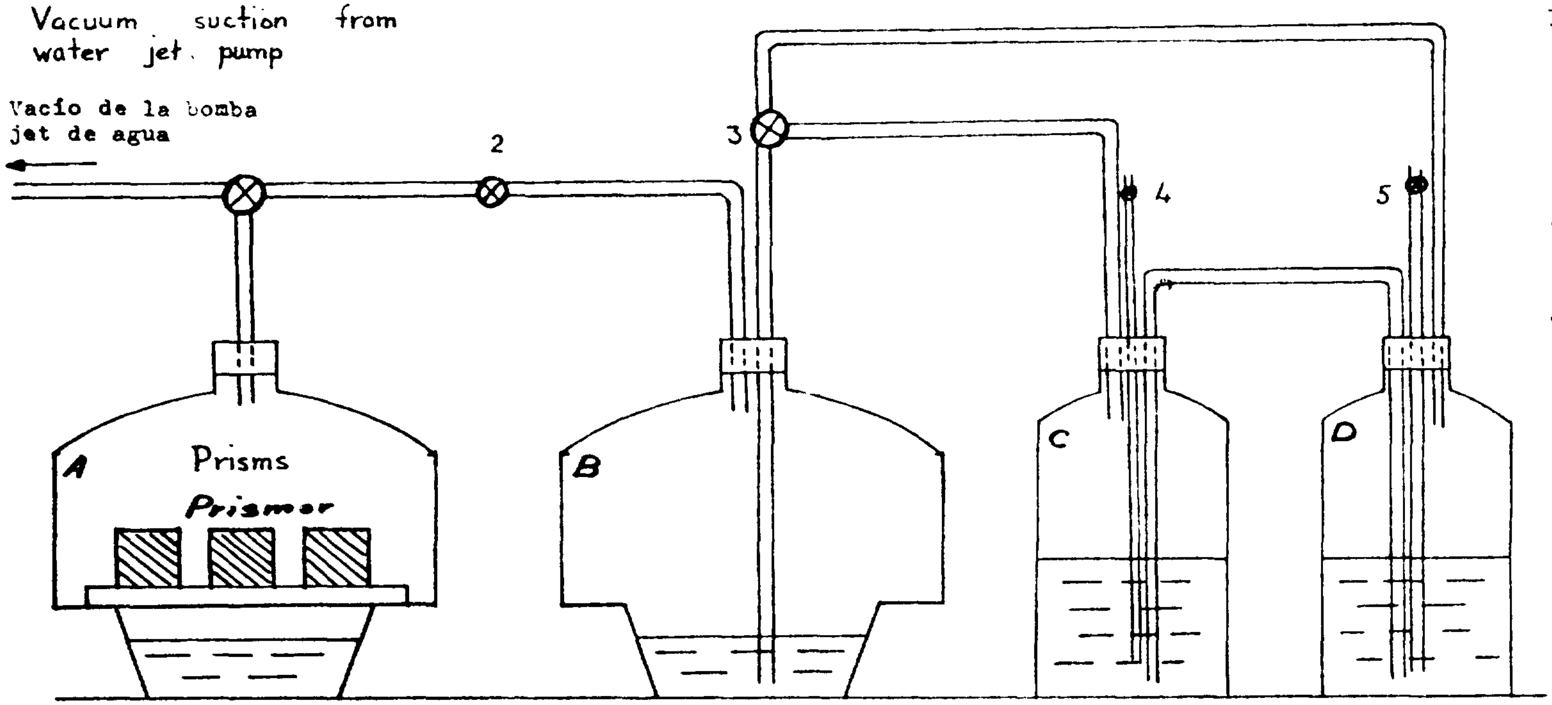
A = vacuum exsiccator	1 = two-way cock
B = " "	2 = cock
C = 5 l glass bottle	3 = three-way cock
D = " " "	4 = cock
	5 = cock

In the lower part of A and B there are solutions of K_2CO_3 + solid K_2CO_3. C and D are half-filled with the corresponding liquid and solids. On a lattice inset in A the test prisms are placed. The connections (rubber and glass tubes) between the containers and the valves appear from the sketch. The air humidity in A is controlled by an hygrometer in the same. The temperature in the room, where the apparatus is standing shall be around 24,5 °C.

The principle functions of the bottles are. In Exsiccator A, containing the prisms, vacuum is made to easier allow the prisms to absorb the desired humidity. Air having desired humidity is made in the bottles C and D alternatingly, by letting air pass through the liquid when part of the liquid is transferred from one to the other by vacuum. Also by vacuum this air is transferred into the container for the prisms. The exsiccator B serves as a balancing vessel.

A is evacuated, the cock no. 2 closed, by the water jet pump during 1/2 h, whereupon cock 1 is closed. Cock 2 is opened, cock 3 closed. When pressure equilibrium is received in A and B cock 3 is opened between B and D and also cock 4 (=C's connection with the air) On account of the vacuum in D the liquid in C is transferred to D. This transferration is stopped when about 5 cm liquid remains in C by closing cocks 3 and 4. C is shaked. Then cocks 5 and 3 (between B and C) are opened and the air in C is transferred to A and B (cock 1 open between A and B, cock 2 open) This operation is continued, using alternatingly C and D to make the humid air, until air pressure in the apparatus, whereupon the whole procedure is repeated until the lengths of the prisms are constant.

The test prisms are measured every day. After two measurements in succession not differing more than ± 0,002 mm the prism is filled with water under vacuum as described in report 570524/2.



Apparatus for giving gas concrete prisms certain humidities

Durox Laboratoriet

Apparat för snabbestämning av krympning och svällning.

Skövde 13/6-57

Memo No. 12-002