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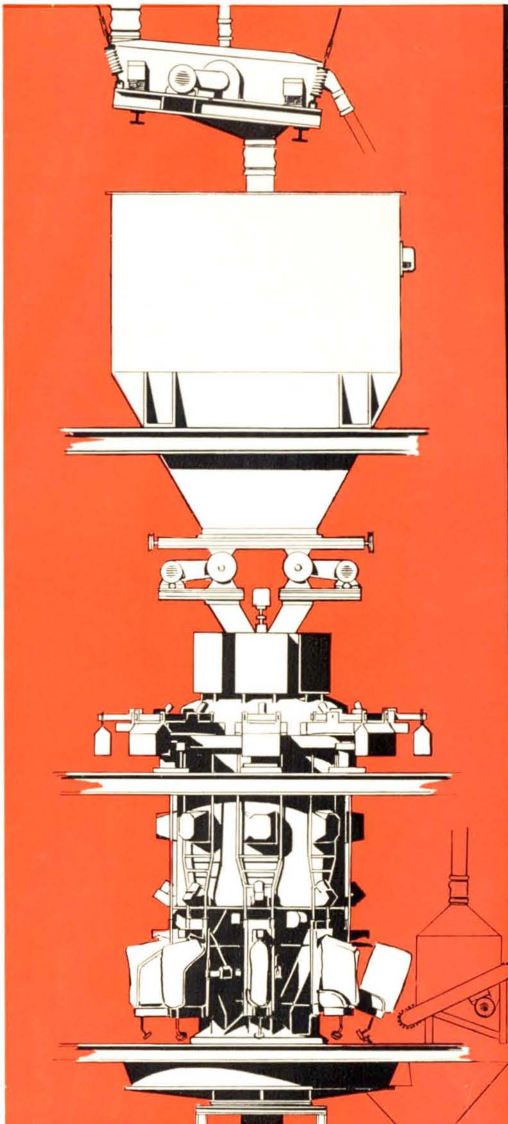

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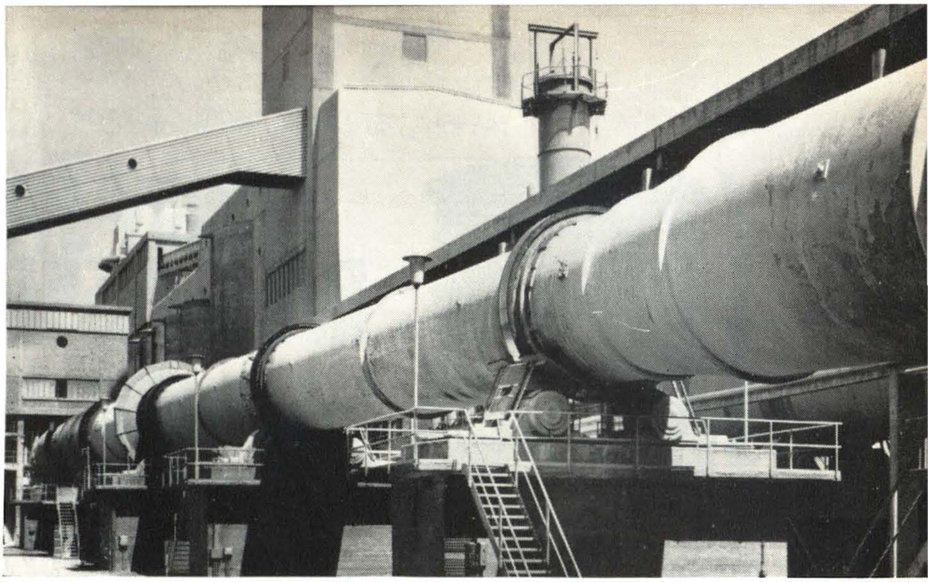

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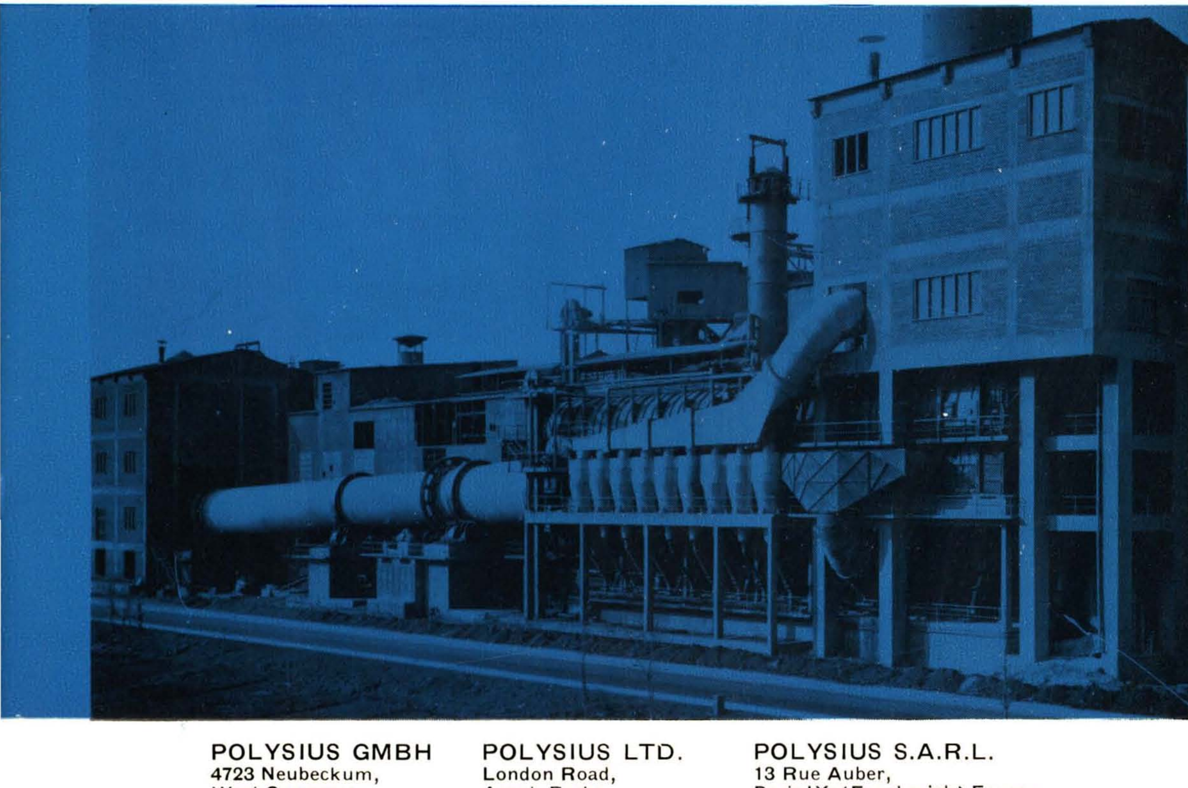

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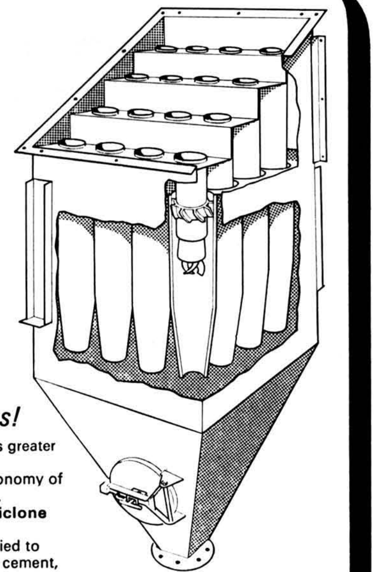

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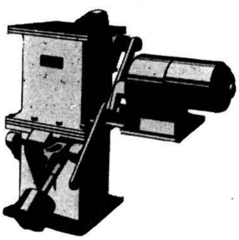

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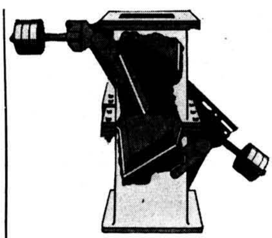

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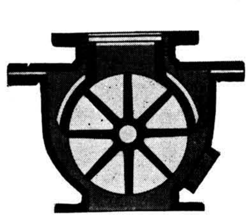

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Extension of Cordoba Cement Works, Spain.

IN the number of this journal for January 1966, it was reported that the Asland Asociada S.A., in which the Blue Circle Group of cement companies had purchased a 40 per cent. interest in 1964, was extending its works at Cordoba to increase the then annual productive capacity of 150,000 tons by over 400,000 tons to a total of about 550,000 tons per annum. The new works, which comprises the extension, was designed by, and construction was supervised by, the Works Department of The Associated Portland Cement Manufacturers Ltd.

Construction commenced in September 1964 and the kiln plant was commissioned by March 1966. The new installation, a plan of which is given in *Fig.* 1, is described in the following.

Of particular interest is the method of proportioning and preliminary blending of the raw materials fed to the raw mill for grinding. This replaces the conventional method of storing each material separately and then controlling the proportioning by means of feeder-weighers for each component fed to the mill.

The Quarry and the Crushing and Sampling Plant.

The raw materials are a soft and fairly porous limestone, which is brought down by blasting, and a marl which over-lies the stone. The overburden above the marl is dug by a $1\frac{3}{4}$-cu. yd. 38RB diesel excavator which loads dumpers by which it is transferred away from the working area to be discarded. The useful raw materials are loaded by another 38RB and a $2\frac{1}{2}$-cu. yd. 54RB electric excavator into a fleet of 15-ton Aveling Barford dumpers for transportation to a crushing plant in the quarry area (*Fig.* 2).

The dumpers discharge the materials into an intake hopper above a variable-speed Ross drop-bar feeder, which controls the rate of feed. This is followed by a Ross two-roll grizzley and between them these two machines screen out much of the fine wet material before the bulk of the material is passed to the crusher. The large material containing pieces of limestone weighing up to 2 tons is

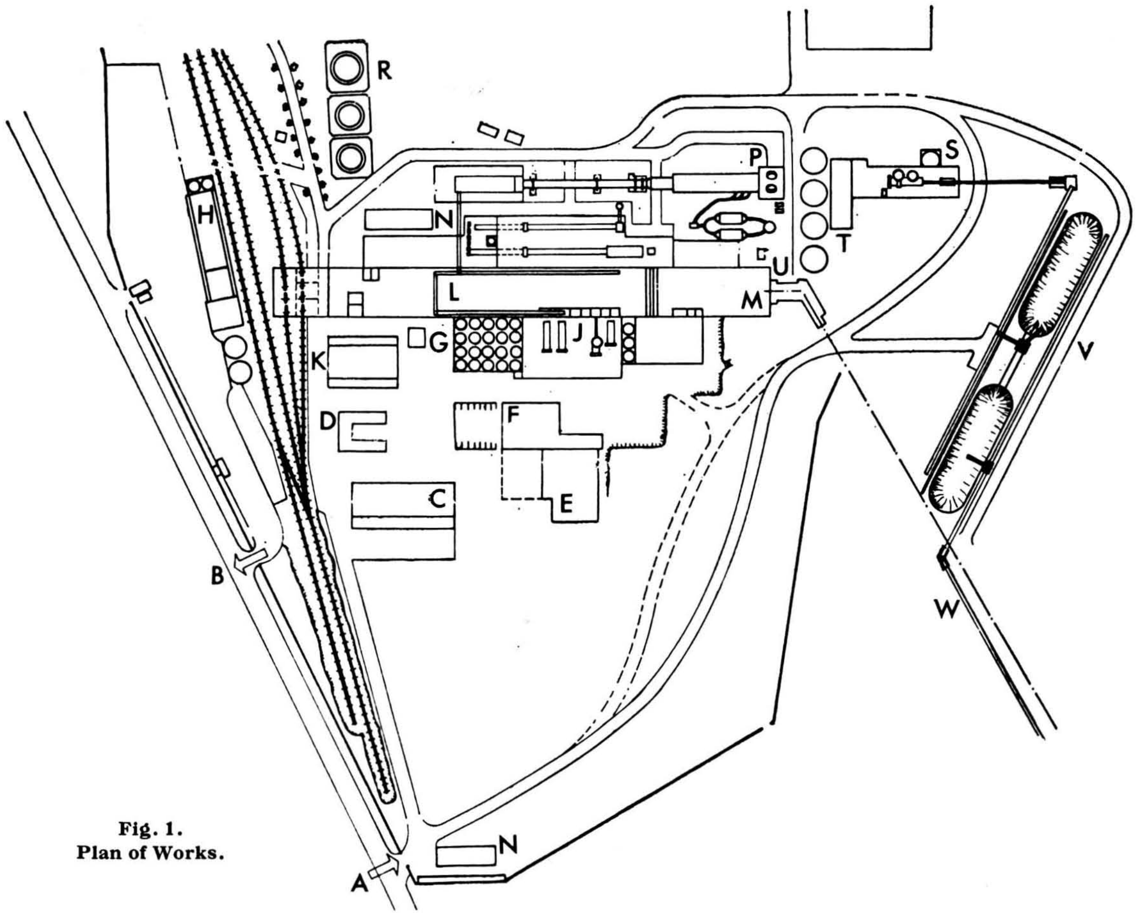

Fig. 1.
Plan of Works.

A Entrance
B Exit
C Workshop
D Office
E Sub-station
F Electrical centre
G Cement silos
H Parking
J Cement Mill
K Stores
L Clinker store
M Raw meal store
N Control
P Grate
R Fuel-oil store
S Blending
T Raw mill
U Electrostatic filters
V Pre-blending
W Cable-belt conveyor

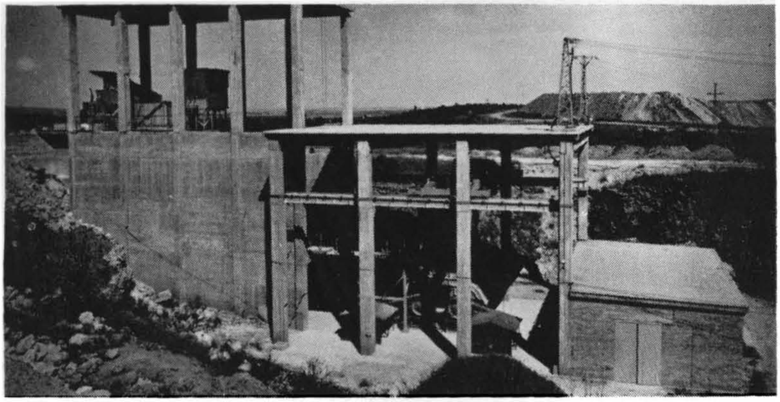

Fig. 2.—Crushing Plant.

discharged on to a flat belt, its fall from the grizzley being checked by a Ross chain controller. The belt is provided with an electronic metal detector, whereby the presence of any piece of tramp metal of significant size sounds an alarm and stops the system, thus preventing damage to the crusher which it feeds. The crusher is a G.E.C. type 8880 Dyad double-rotor fully-caged hammer crusher.

The output of the crushing plant is 300 to 400 tons per hour, depending on the moisture content, with a product 80 per cent. of which is below 20 mm. The crushed product and the fine screenings are transported on a single belt to the sampling plant.

The Koulakoff sampling plant, which takes continuous samples, progressively divides, crushes and dries the material in order to produce a dry powdered representative sample for chemical analysis. Samples taken hourly are analysed. The weight of material passing through the sampling plant in the hour represented by the sample is determined by an Adequate summating weigher on the conveyor. By this means an accurate control is kept of the composition of the material leaving the quarry. The drier (*Fig.* 3) uses propane gas to heat the infra-red panels.

Raw Material Conveying, Storage and Preliminary Blending.

The raw materials are conveyed from the crushing plant to the works by a cable-belt conveyor which is 1,850 metres long. The terrain crossed is rugged with a deep ravine into which the conveyor goes down at an angle of 17 deg. After crossing a river on a light gantry, a special unit in the conveyor enables it to change gradient abruptly to climb up the other side of the ravine, also at an angle of 17 deg. (*Figs.* 4 *and* 5). A conventional conveyor would have entailed an expensive high-level bridge.

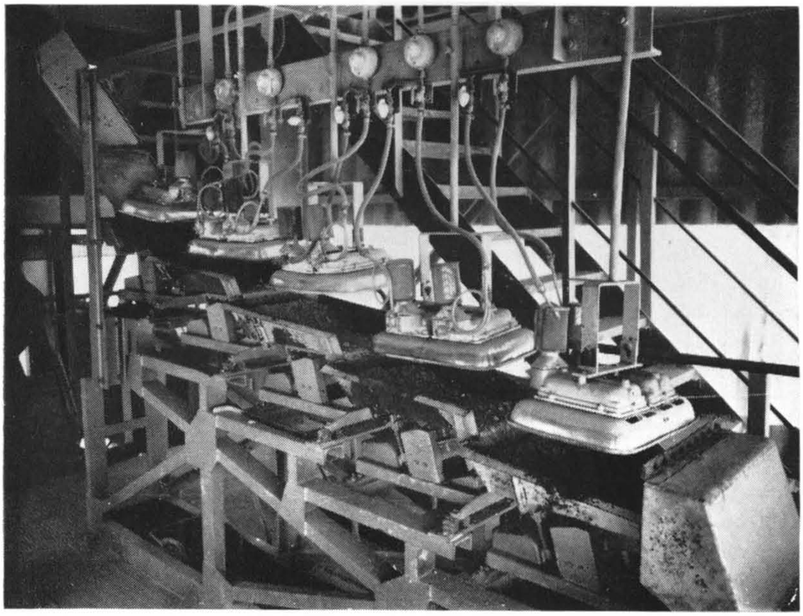

Fig. 3.—Sample Drier.

The material is discharged at the works into an Applevage stockpile system. In this, the material, the average hourly composition of which has been controlled, is blended, to a uniform composition throughout.

Two separate stock piles of 8,000 tons each are built up, each being produced in a series of layers in the shape of inverted chevrons, by progressive longitudinal passes of a stacking conveyor mounted on a boom transporter travelling on a rail-track parallel to the centre line of the two piles (*Fig.* 6). Between the two piles, there is a bucket-wheel excavator which can reclaim from either pile in a series of transverse sweeps, thus cutting across the chevron layers produced by the stacking machine, with the effect that a high degree of blending of the raw material is obtained (*Fig.* 7). The arrangement for stacking and reclaiming is indicated in *Fig.* 1.

The reclaimed material is conveyed to a surge hopper at the raw mill. A level-indicator in the hopper regulates the bucket wheel. The extractor, which feeds the material from the hopper to the mill, is controlled by signals from an acoustic device on the mill.

Raw Material Grinding and Raw Meal Blending.

The raw material is ground and dried in a 2,300-h.p. Polysius Double Rotator mill, 3·80 m. in diameter and 12 m. long, working on closed circuit with two classifiers. The hot gases for drying are obtained from an oil-fired furnace. The gases leaving the mill are cleaned in cyclones from which the recovered meal is added to the mill product. The gases are finally cleaned before discharge to atmosphere in wet-scrubbing towers, the effluent from which is subsequently used in the nodulisers at the kiln. The raw meal is blended in two Fuller quadrant continuous-blending silos, each having a capacity of 1,200 tons, and is stored in two ready-meal silos each of 1,500 ton capacity. The whole of this section of the plant is seen in *Fig.* 8.

Kiln Plant.

The raw meal is nodulised in two nodulisers using the scrubber effluent and such additional water as is necessary to give a moisture content in the nodules of about 12 per cent.

Fig. 4.

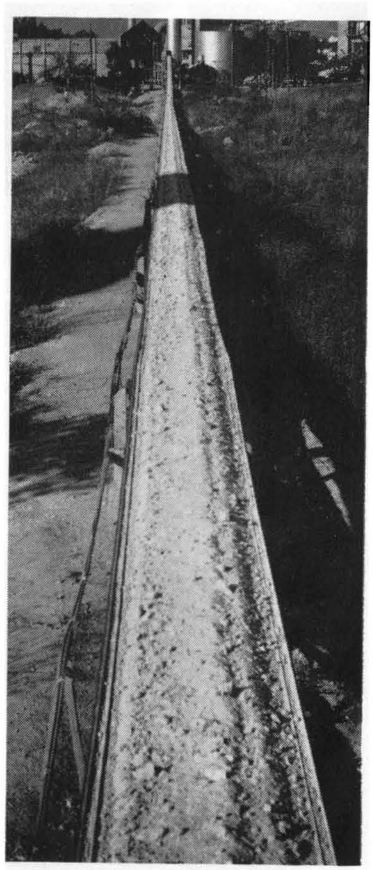

Fig. 5,

Cable-belt Conveyor.

Fig. 6. (Right) Boom Transporter for stacking Raw Meal.

Fig. 7. (Below) Bucket-wheel Excavator for reclaiming Raw Meal.

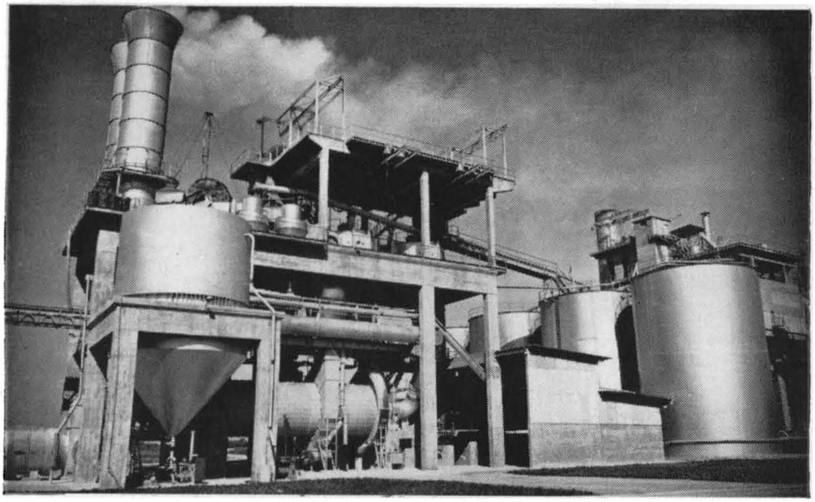

Fig. 8.—Raw Meal Grinding and Blending Plant

The preheater is a double-pass Lepol grate which discharges into an oil fired Polysius rotary kiln, 4 m. in diameter and 65 m. long. The clinker is cooled in a Recupol cooler with a surface of 120 sq. m. The surplus air from the cooler is partially cleaned in cyclones and is then taken through a long pipe to join the flue gas leaving the first pass of the Lepol preheater. The flue-gases from the kiln, together with this air, are cleaned in Sturtevant plate-type electrostatic precipitators. The preheater and rotary kiln are illustrated in *Fig.* 9 and the cooler is shown in *Figs.* 10 and 11.

The cooled clinker is conveyed to a central store which has a capacity of 10,000 tons and in which gypsum is also stored.

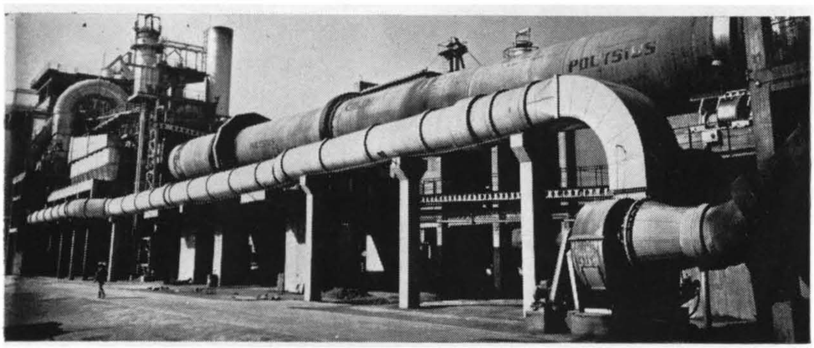

Fig. 9.—Preheater and Rotary Kiln.

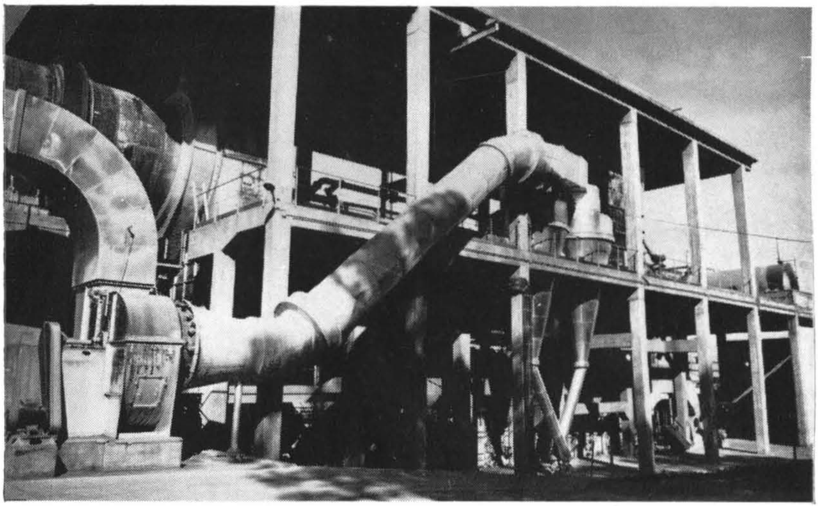

Fig. 10.—Recupol Cooler.

Cement Grinding, Storage and Packing.

The clinker and gypsum are reclaimed from the store and discharged into the mill-feed hoppers by an electric overhead travelling crane fitted with a grab.

In addition to the existing mills, a new 2,300-h.p. Polysius mill of 3·40-m.

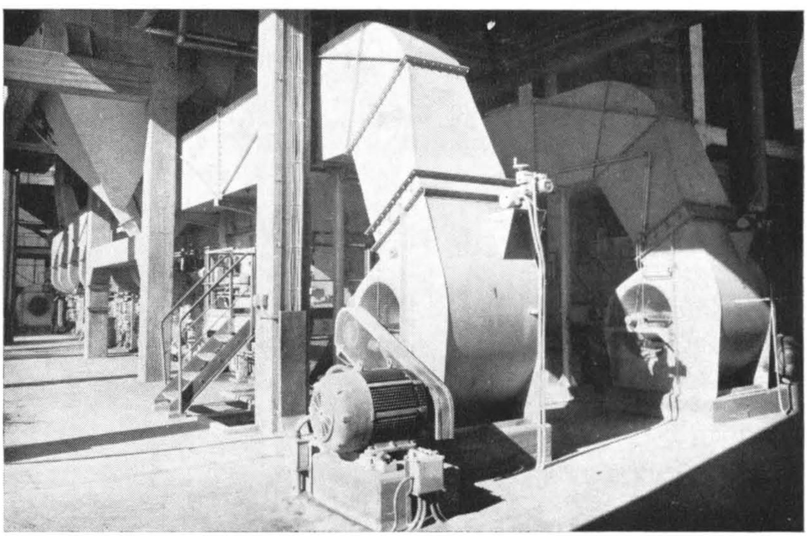

Fig. 11.—Recupol Cooler.

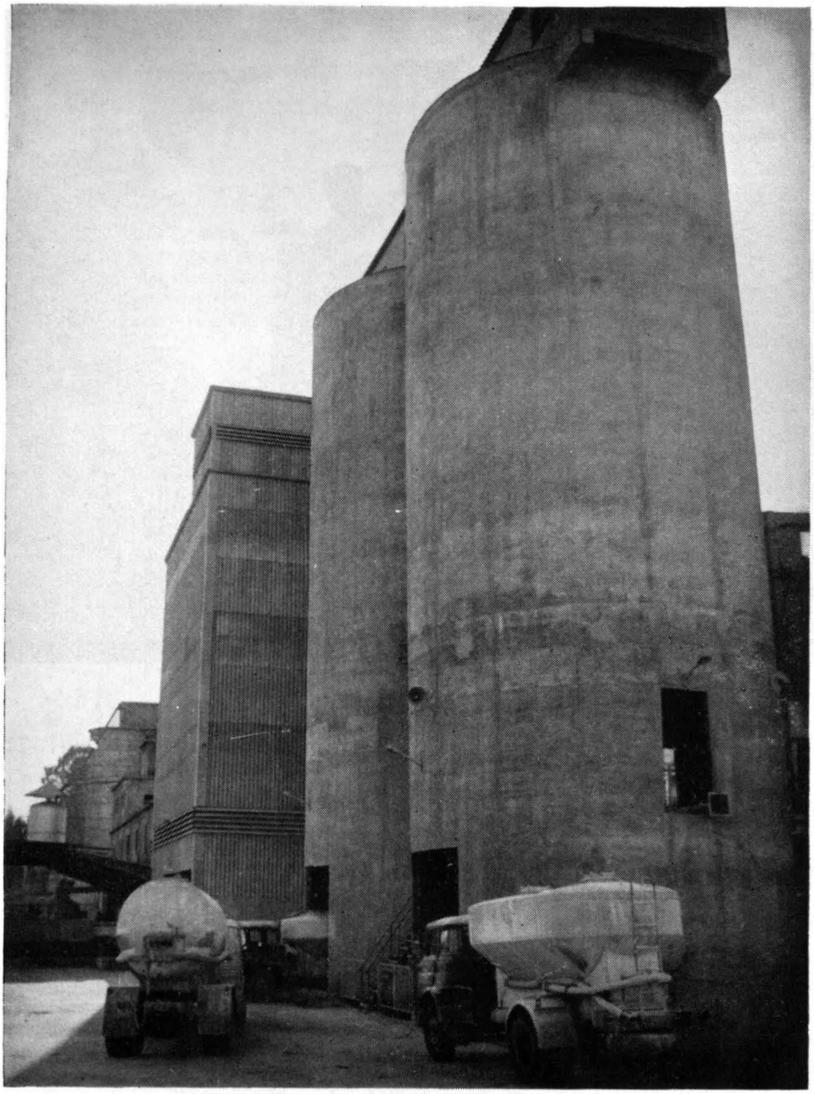

Fig. 12.—Cement Silos and Despatching Plant.

diameter and 11·50 m. long, has been installed. This mill is arranged for closed-circuit grinding using a Heyd separator to classify the product and return oversize particles to the mill for further grinding.

The cement from the old and new mills is conveyed and elevated into an

Fig. 13.—Eight-spout Rotary Packer.

existing group of twenty silos, which have a total capacity of 10,000 tons. The cement is extracted as required from these silos and pumped to either the new or old packing plants.

The new packing plant has two silos each holding 1,500 tons, the packing machine being a Haver & Boecker eight-spout rotary packer (*Fig.* 13) with a capacity of 110 tons per hour when filling 50-kg. paper bags. Facilities are also provided for bulk-loading of road and rail vehicles as seen in *Fig.* 12.

The old plant will in future be used only for special grades of cement.

Electricity Supply.

The high-tension supply at 70 kv. is transformed in the works substation to the working pressures of 6,000 v., 3,000 v., 380 v. and for lighting. There are two emergency generating sets each of 450-kw. capacity.

X-ray Diffractometry as a Method for determining the Portland Cement content of Mixtures of Portland Cement and milled granulated blast-furnace Slag.

By K. H. L. SEHLKE.

SYNOPSIS

AN X-RAY diffraction method which can be used for determining the Portland cement content of mixtures of Portland cement and milled granulated blast-furnace slag is described. A linear relationship between the ratio of X-ray intensity and the concentration of Portland cement in a mixture has been found. The concentration of Portland cement in such mixtures can be determined with a fair degree of accuracy.

Two independent methods have recently been developed at the National Building Research Institute, Pretoria, for determining the slag content of mixtures of Portland cement and blast-furnace slag[1, 2], and a third method based on quantitative X-ray analysis has now been examined. This method is limited to the determination of the crystalline phases as glassy phases are not sufficiently characterized in the X-ray powder diffractogram. The method is based on the fact that the integrated intensities of an X-ray diffractogram are directly proportional to the concentration of a crystalline constituent.

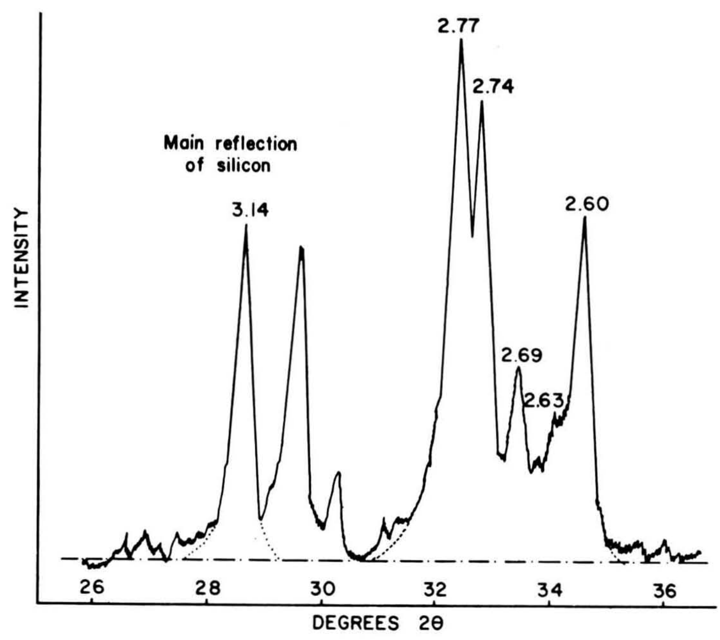

Fig. 1. X-ray Diffractogram of Portland Cement *b* plus Silicon.

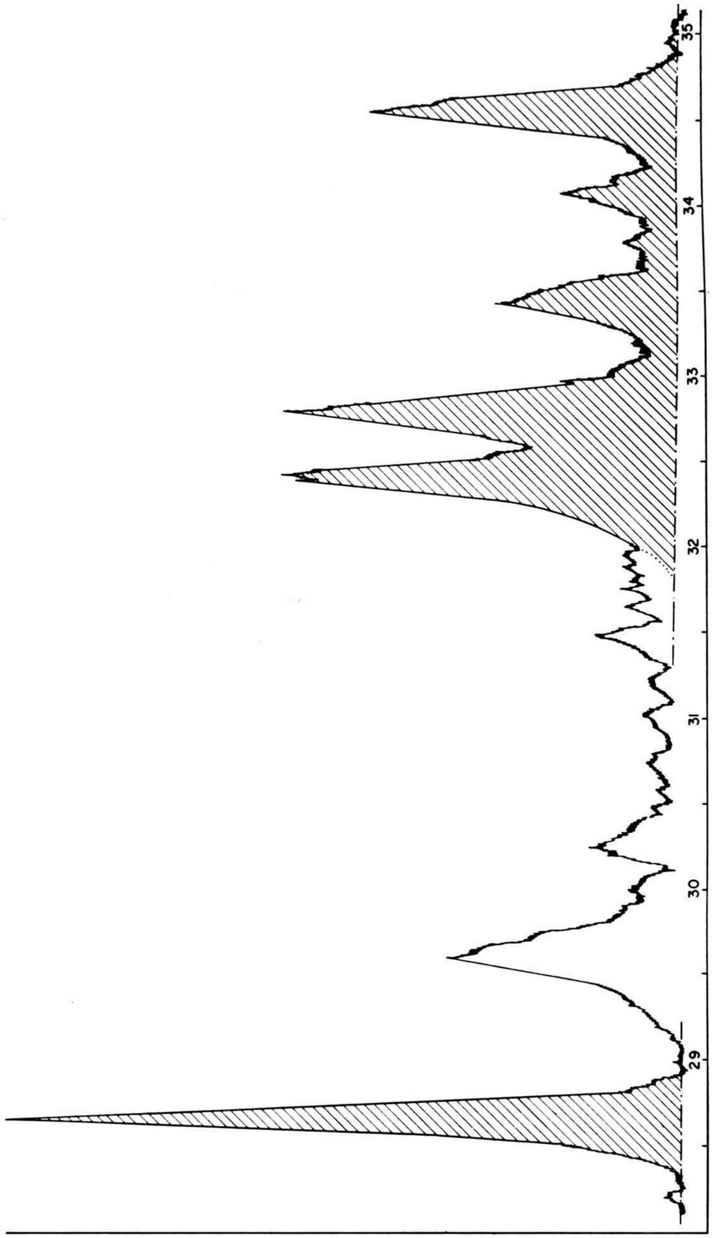

Fig. 2.—X-ray Diffractogram of Mixture No. 5 of Series 1.

The mathematical treatment of the quantitative X-ray analysis has been discussed in great detail in the relevant literature[3, 4, 5].

A Philips X-ray diffractometer, of U.S.A. design and equipped with a proportional counter, was used. Cu Kα (Ni filtered) radiation from a tube operating at 30 kv. and 20 ma. was employed. The optical system consisted of a 1-deg. divergence slit, a 0·003-in. receiving slit and a 1-deg. scatter slit. The specimen was 10 mm. by 20 mm. and 1·5 mm. thick. The Norelco wide-range goniometer was aligned with a silicon standard.

Eight ordinary Portland cements and one sulphate-resisting Portland cement were examined. A microscopic examination of the cements suggested that they contained between 5 and 10 per cent. of glassy material. Their gypsum contents varied between 2 and 3 per cent.

Three South African blast-furnace slags were used. Their magnesium-oxide content varied between 15 and 20 per cent. As estimated under the petrographic microscope, the slags contained about 3 per cent. of birefringent material.

TABLE I. RATIOS OF INTENSITIES FOR MIXTURES OF PORTLAND CEMENT AND MILLED GRANULATED BLAST-FURNACE SLAG PLUS SILICON (INTERNAL STANDARD).

Mixture No.	Known Portland cement content of mixture (percentage)	Ratio I_P/I_{Si}*				
		Series 1	Series 2	Series 3	Series 4	
		Portland cement (b) and blast-furnace slag (C)	Portland cement (c) and blast-furnace slag (B)	Portland cement (i) and blast-furnace slag (A)	Various Portland cements and blast-furnace slags	
1	10	1·01	0·92	1·34	a/A	0·90
2	20	1·64	1·46	1·77	b/B	1·63
3	30	2·12	2·16	2·25	c/C	1·97
4	40	2·75	2·54	2·92	d/C	2·59
5	50	3·14	3·26	3·27	e/B	3·63
6	60	4·06	4·10	4·25	f/A	3·83
7	70	4·78	4·44	4·79	g/C	4·36
8	80	5·33	5·38	4·91	h/C	5·14
9	90	5·83	5·92	5·70	i/A	5·70
10	100	6·40	6·29	6·18	b/–	6·40

*I_P = Intensity of crystalline Portland cement in terms of peak area (arbitrary units).
I_{Si} = Intensity of crystalline silicon in terms of peak area (arbitrary units).

Experimental Procedure.

The components of the artificial mixtures, that is, Portland cement, blast-furnace slag and silicon, were separately ground to pass a 325-mesh Tyler screen, and thereafter reduced to a finer powder by grinding under isopropyl alcohol in a motor-driven pestle and mortar for two hours. The fractions smaller than 5 microns were recovered by suspension in isopropyl alcohol and the three components were then thoroughly mixed in the required proportions. Silicon as the internal standard was added to each mixture in a proportion of 1 to 10.

Previous studies[3] on Portland cement showed that a grain size smaller than 5 microns reduces micro-absorption and orientation effects. It was also found that, with fine grinding, intensities became relatively insensitive to variation in particle size.

Thirty-eight artificial mixtures were prepared containing varying known quantities of Portland cement and high-magnesia blast-furnace slag. The sum of the integrated intensities of the main diffraction peaks of Portland cement at 2·78Å, 2·74Å, 2·69Å, 2·63Å, and 2·60Å was considered to be representative of the actual concentrations of Portland cement present in the mixture. This range

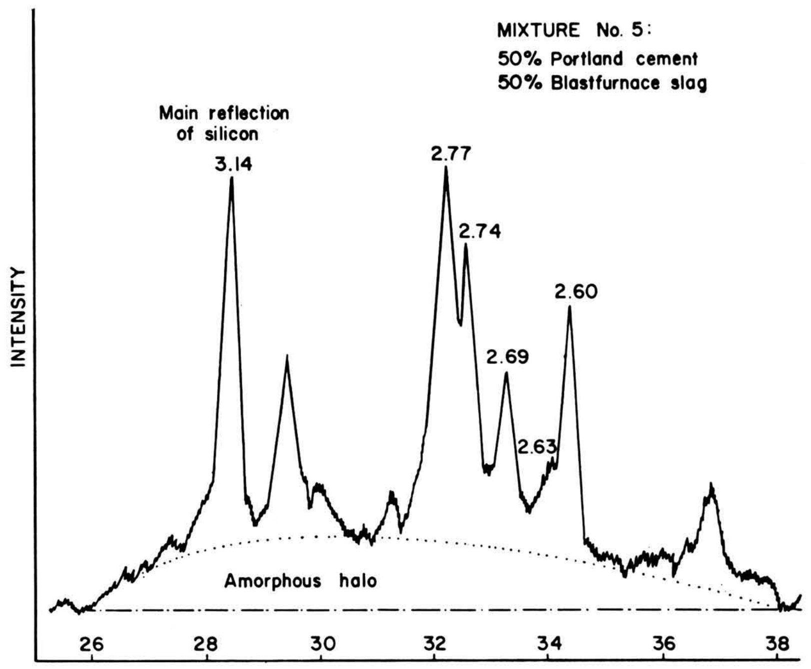

Fig. 3. X-ray Diffractogram of Mixture No. 5 Series 1. (Silicon was used as internal standard.)


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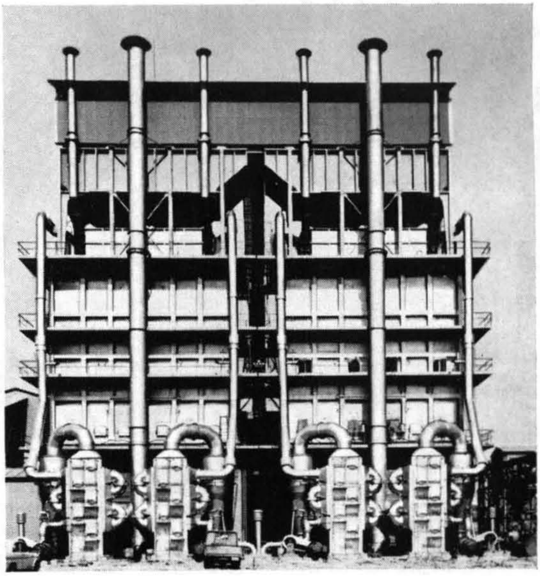

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also covers gypsum which exhibits some minor reflections at 2·79Å, 2·68Å and 2·59Å. Magnesium oxide, with its main reflection at d = 2·11Å, was not detected in the X-ray diffractograms.

The silicon used as the internal standard was of a suitable crystallite size to give sharp diffraction lines. It also provides a strong basal diffraction peak (reflecting plane III at d=3·14Å) in the desired vicinity of the relevant reflections of Portland cement. In addition, for the angular region investigated, the diffraction lines of Portland cement and of gypsum are not superimposed on those of silicon. As silicon belongs to the cubic system, it has the further advantage of giving diffractograms with few but intense lines. Because it gives distinct diffraction peaks even at low concentrations, relatively small quantities are required as internal standards.

The main diffraction peaks of Portland cement and the basal reflection of silicon were used to obtain the ratios of intensities for the different test series listed in *Table* 1. The reflections used are marked with their d-values in *Fig.* 1, while *Fig.* 3 shows the development of an amorphous halo with the corresponding decrease in intensity of the relevant diffraction lines of Portland cement for the 50-per cent. level of Portland cement.

The integrated intensities were obtained by drawing the base line to correspond to the background level, and then measuring with a planimeter the cross-hatched areas under the peaks as shown in *Fig.* 2. A time constant of eight and a

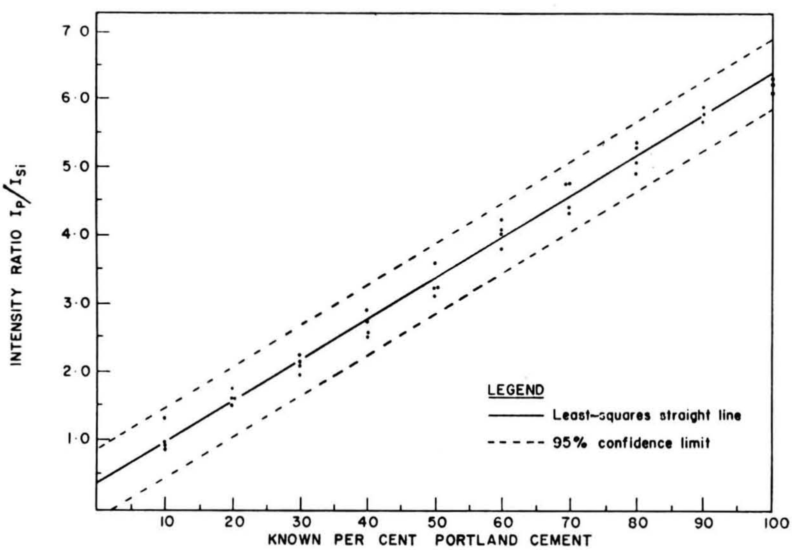

Fig. 4. Relation between intensity-ratio I_p/I_{si} and Concentration Portland Cement in Mixtures of Portland Cement and milled granulated blastfurnace Slag.

scanning speed of $v = \frac{1}{4}^{\circ} \cdot 2$ per minute were found most satisfactory for this work. The average value of the areas for each determination was based on three X-ray recordings.

The graph shown in *Fig.* 4 shows the values of the intensity ratios I_P/I_{Si}, listed in *Table* 1, plotted against the known concentration of Portland cement. The experimental values fit a curve in accordance with the calculated least-squares straight line $y=0{\cdot}060x+0{\cdot}39$. From this it appears that the concentration of Portland cement in the mixtures examined is a linear function of the intensity ratio I_P/I_{Si}. For a mixture containing 50 per cent. of Portland cement, the accuracy of the determination was 6·5 per cent. at the 95-per cent. confidence limit.

The variations shown in *Table* 1 are normal with regard to quantitative X-ray diffraction analysis. The work showed that the values were fairly reproducible.

The experimental data appear to indicate that the mineralogical composition of the cements investigated had little influence on the intensity ratios—compare, for example, mixture No. 1 in series 2 and 4; in series 2, an ordinary Portland cement was used for this mixture, while in series 4 a sulphate-resisting Portland cement was employed.

Conclusions.

The experimental work indicates that X-ray diffractometry could be considered for determining the Portland cement content in mixtures of Portland cement and milled granulated blast-furnace slag; a linear relationship appears to exist between the intensity ratios and the concentration of Portland cement in a mixture. If parameters such as the effects of grain, particle and crystallite size, uncertainty about uniformity of mixing, and problems concerned with the construction of the background, can be reduced to a minimum, greater accuracy may be obtained.

Acknowledgement.

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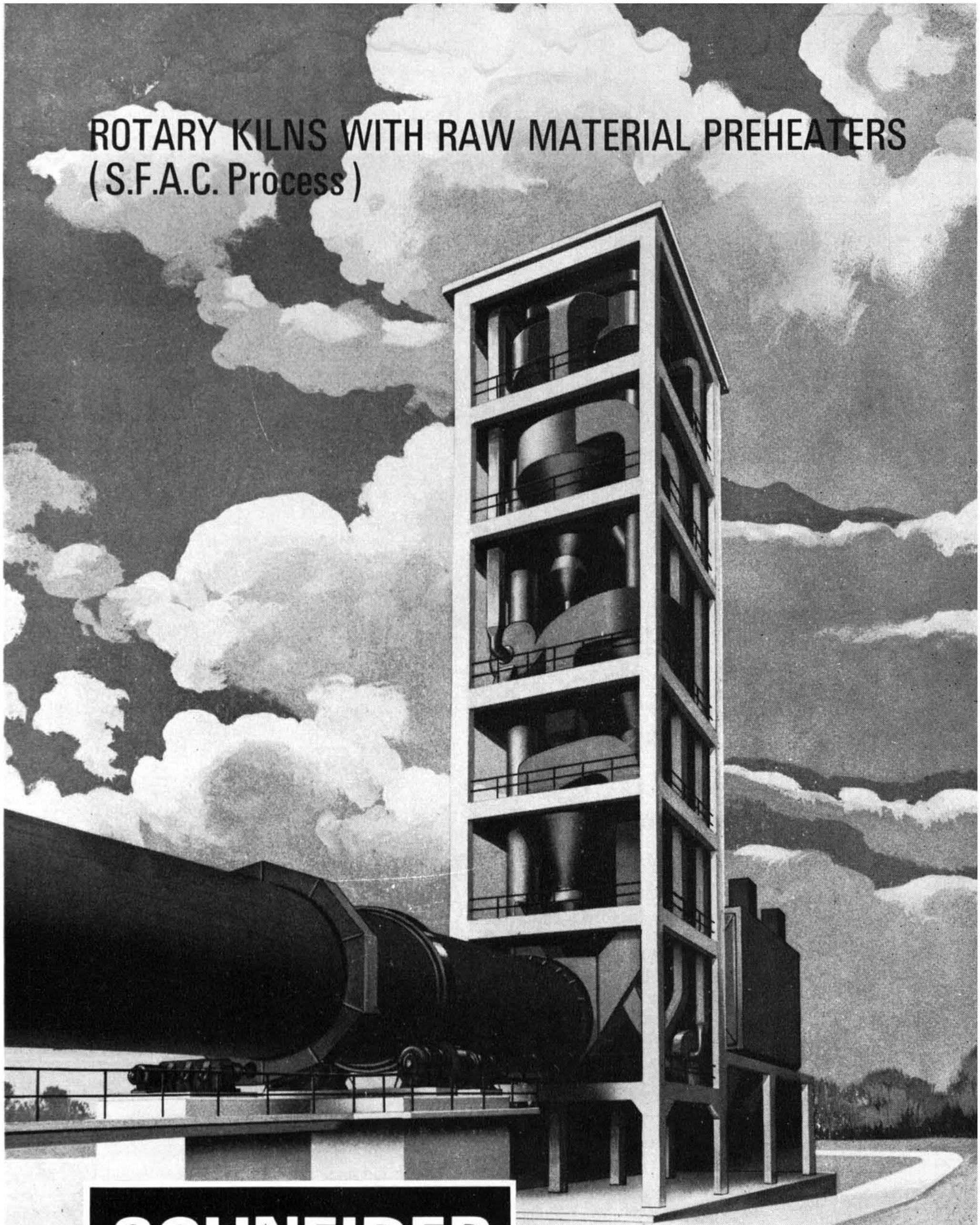
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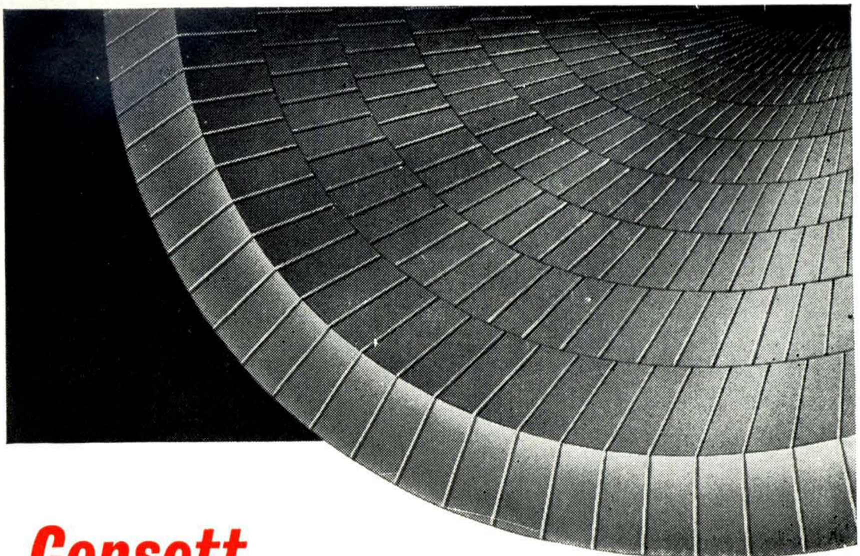

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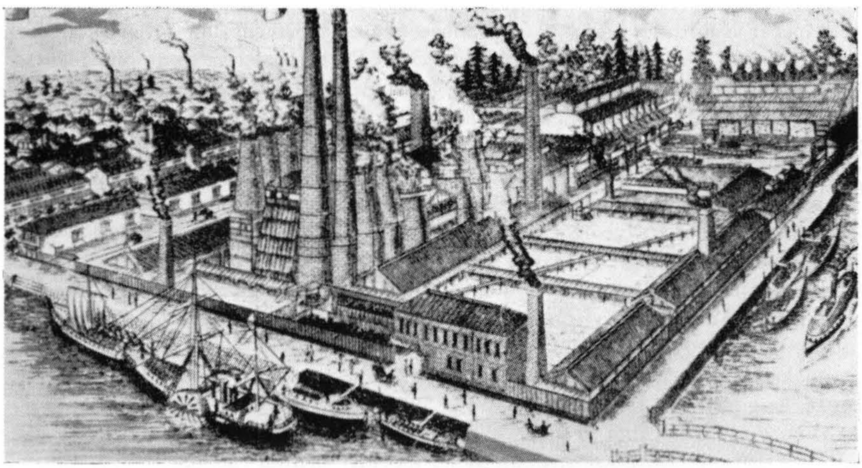
The Cement Industry in Japan.

The Cement Association of Japan recently published a brochure, entitled " The Cement Industry in Japan 1967 ", in which it is shown that, in 1966, Japan was the third largest producer of cement in the world, being preceded only by the U.S.S.R. and the U.S.A.

The strength of the Japanese cement industry lies in the fact that the country abounds in rich deposits of limestone. Many of the cement works have their own quarries and are situated in localities selected for their proximity to rich limestone deposits and easy transportation. Other works, however, are near cities or on the coast where they are established to supply cement to large consuming areas. The clay and requirements such as labour are generally distributed evenly throughout the country and have not exercised much influence on the selection of sites



for works. The industry has relied on coal of suitable calorific value, and of sufficiently high quality for the manufacture of cement, such coal being mined in Japan in sufficient quantities to supply the cement industry. In recent years, however, an increasing number of works are changing over to fuel oil which is more economical; 86 per cent. of the total amount of the fuel consumed by the cement works in 1966 was oil.

The first cement clinker was produced in 1875 in the works illustrated which was managed at first by the Government but was soon given over to private enterprise. About the beginning of the present century, the first rotary kiln was imported into Japan from the U.S.A., since which time the Japanese cement industry has adopted large-scale production with modern equipment. However, during this period, the recurring rise and fall of the cement companies were much more pronounced than was the case with other industries in Japan, this being due no doubt to numerous firms venturing into this field because of easy access to the raw material and fuel. The following figures of annual production show the speed with which tne industry has grown.

1910 ..	.. 453,920 tonnes	1940 ..	.. 6,074,543 tonnes
1920 ..	.. 1,350,598 ,,	1960 ..	.. 22,424,890 ,,
1930 ..	.. 3,277,383 ,,	1966 ..	.. 37,273,390 ,,

(1950 omitted since productive capacity was affected by World War II)

During the past ten years the increase in cement production has been exceedingly rapid to meet the heavy domestic consumption due to large government and private construction programmes and by the steady progress made in the export of cement. To keep pace with this increase in cement demand, productivity is being advanced by establishing new works and increasing the productive facilities of existing works.

There are now twenty-two cement companies operating sixty-one works of which sixteen companies with fifty-two works are exclusively producers of cement. The other companies and works produce not only cement but other products such as soda, fertilizers, coal and chemicals. Of the existing sixty-one plants, fifty-six are complete cement works and seven are clinker-grinding plants. Among the cement companies, there are two old and prominent companies having histories going back to the time when cement production was first undertaken by private management. The number of employees in the works is few. Despite the increase in productive capacity in recent years, the rise in employment is insignificant. Compared with 1961, cement production for 1965 showed an increase of 32 per cent. while employment increased by only 1 per cent.

Recent trends in cement manufacture include the installation of larger kilns. One of the kilns in a wet-process works installed in recent years is 5·25 m. in diameter and 205 m. long. For the Lepol system, a kiln of 5 m. diameter and 70 m. long has been installed; in a dry-process works a kiln of 5·4 m. diameter and 85 m. long has been installed.

Economy in burning to increase the heat efficiency of the kilns is also being given attention. The air quenching cooler was installed for the first time in Japan about twenty years ago; today 191 of the existing 220 rotary kilns are equipped therewith. The prevalence of the long kiln for the wet process and the Lepol kiln for the dry process contribute to fuel economy as does the suspension preheater system which was introduced recently. It is expected that both Lepol and suspension preheater systems will be the leading systems in future installations of kilns. Improved instrumentation and the introduction of computers are also features ot the modern Japanese cement industry.

The Cement Association of Japan is sponsored by cement manufacturers and its members comprise twenty-one out of the twenty-two companies operating in January 1967. In April 1966, the Association merged with the former Japan Cement Engineering Association.

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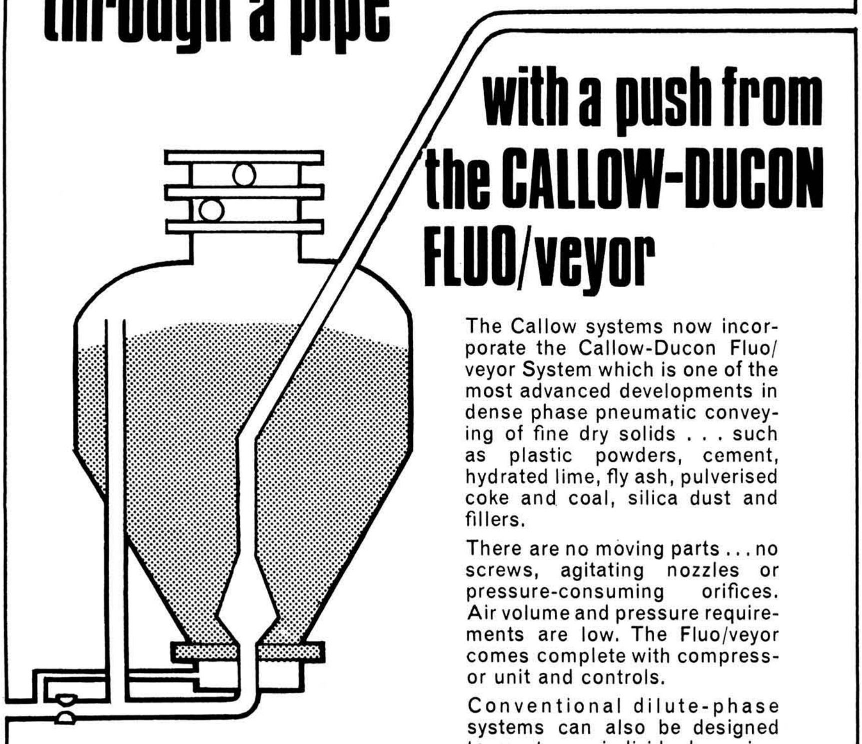

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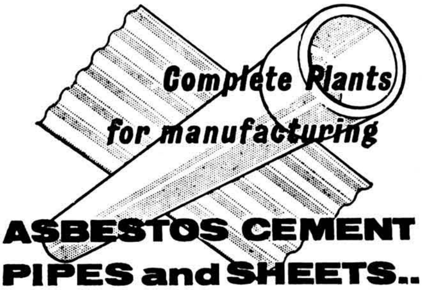

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