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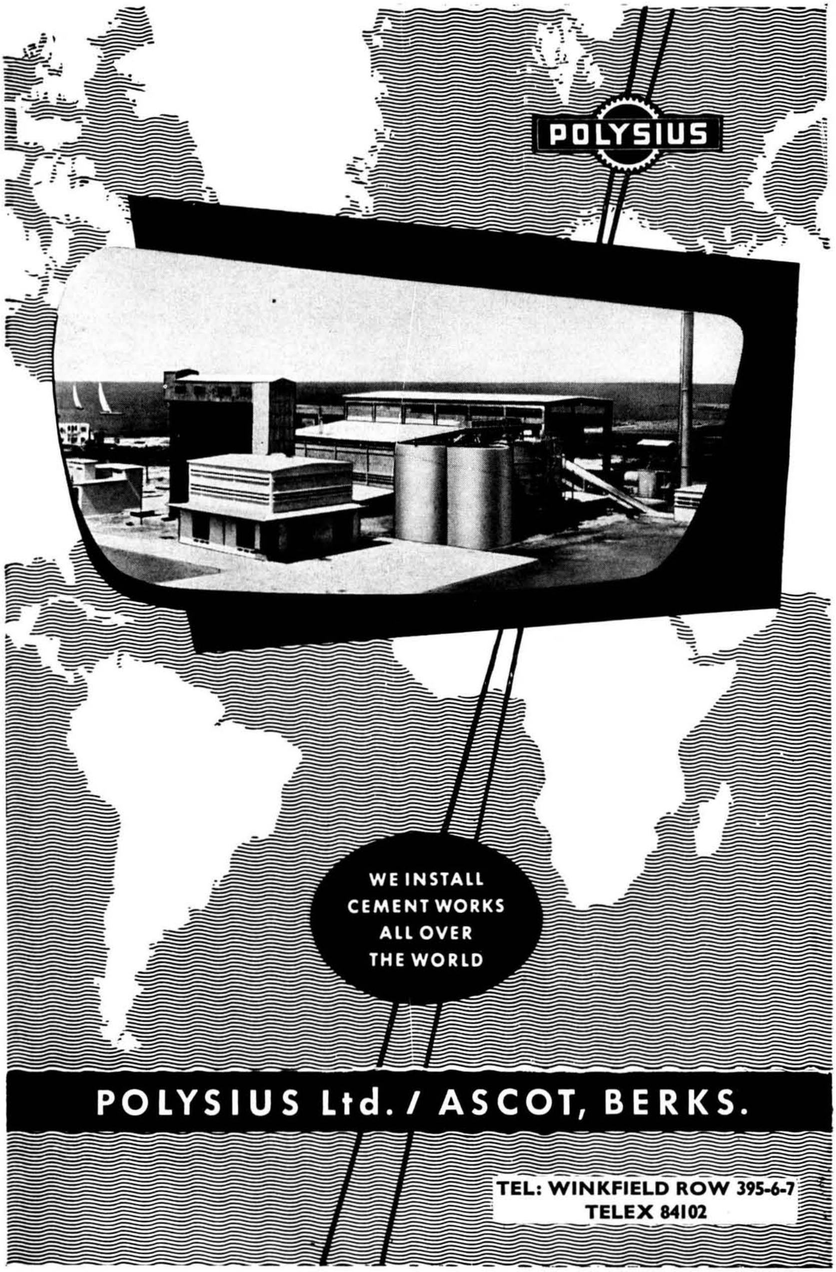
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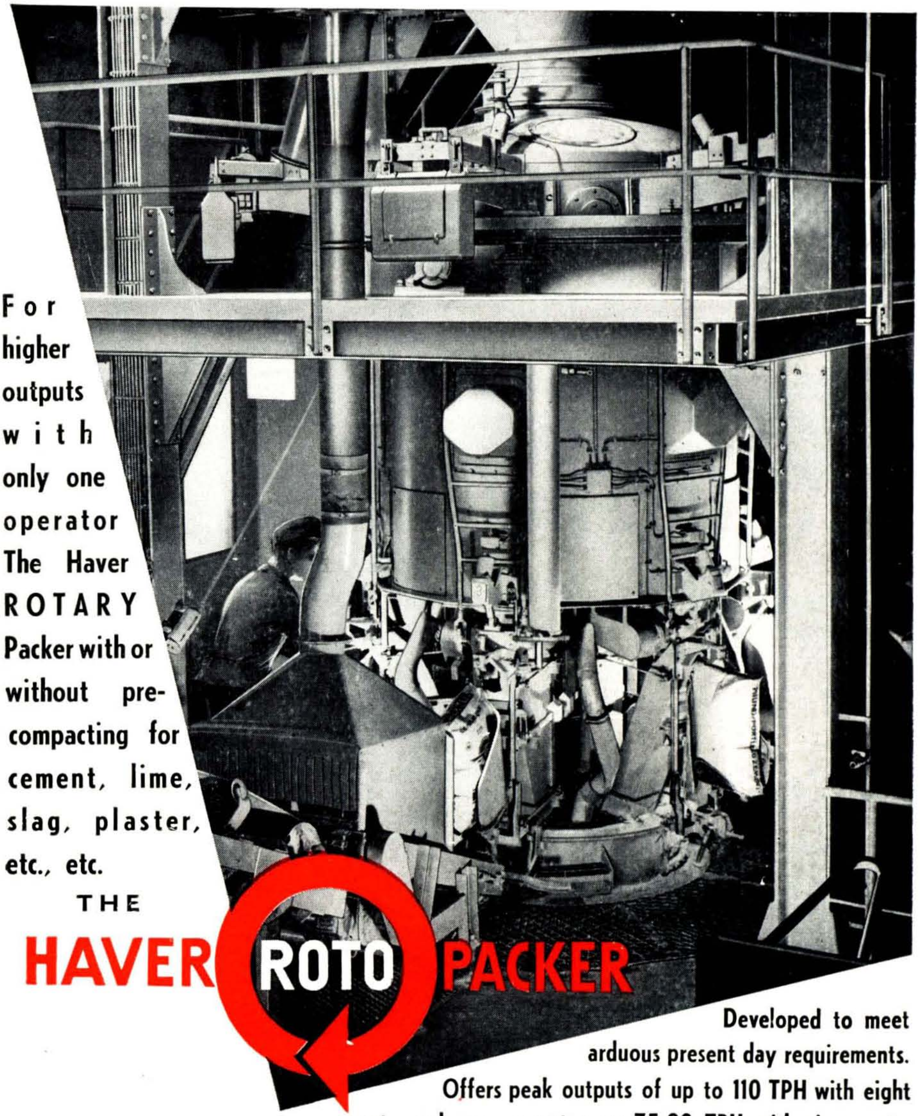

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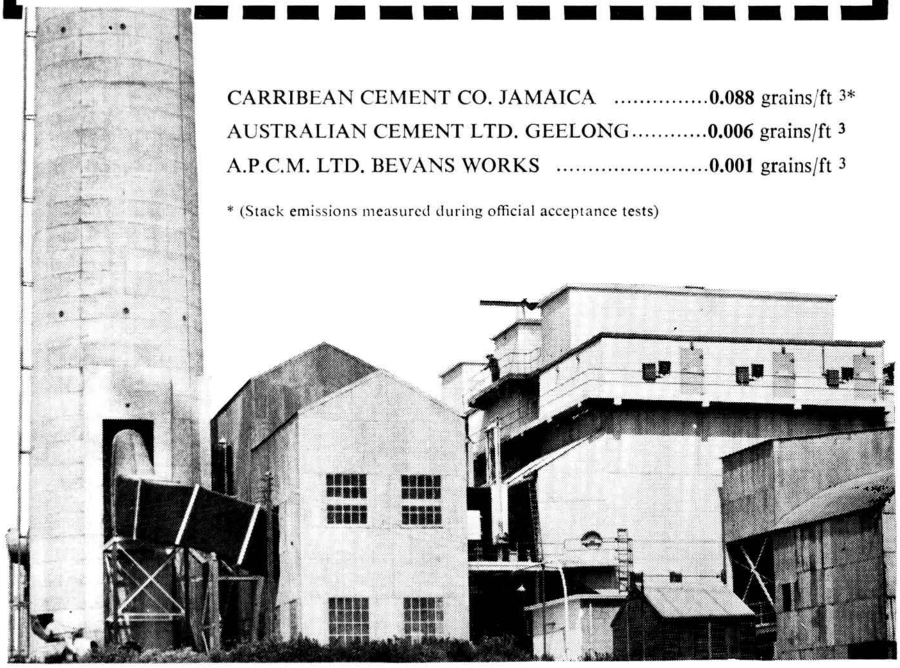

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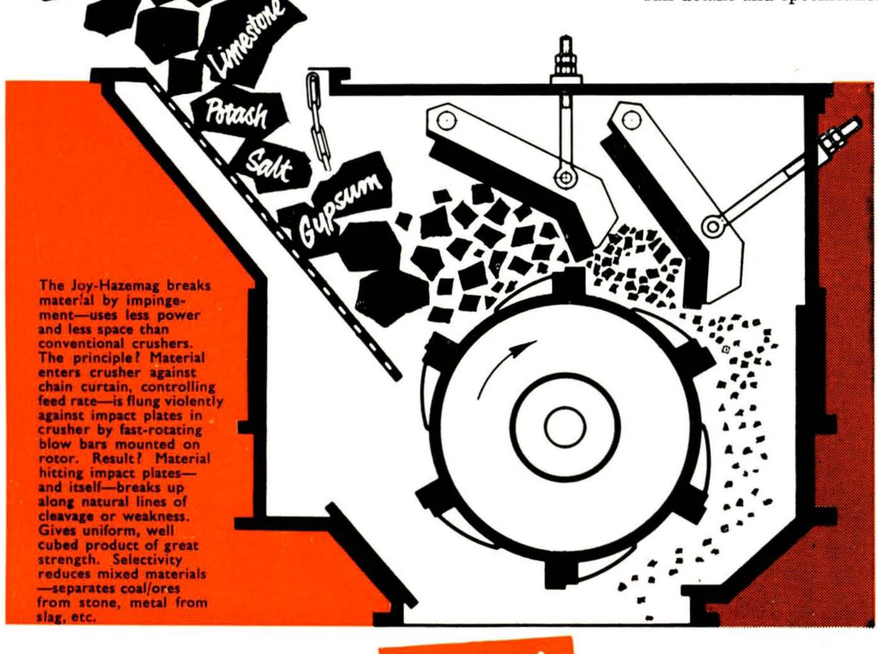

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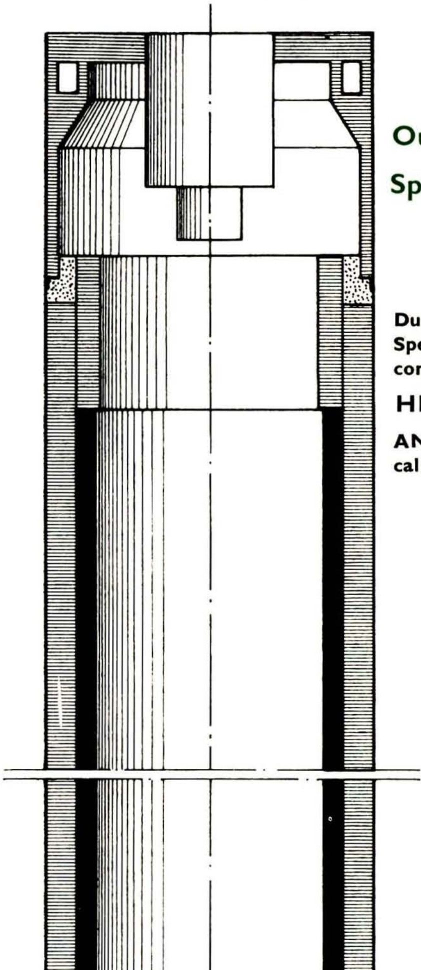

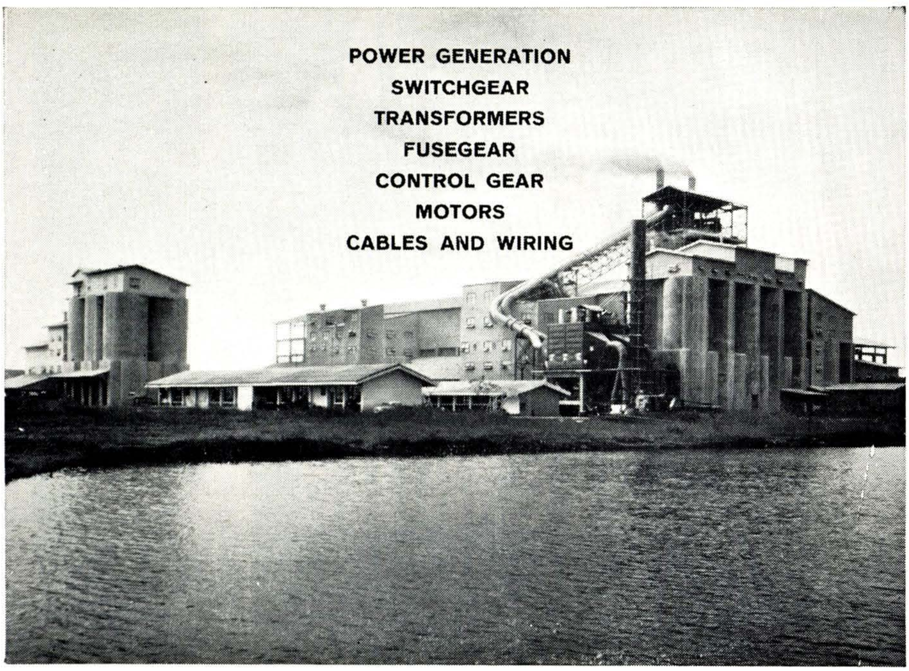
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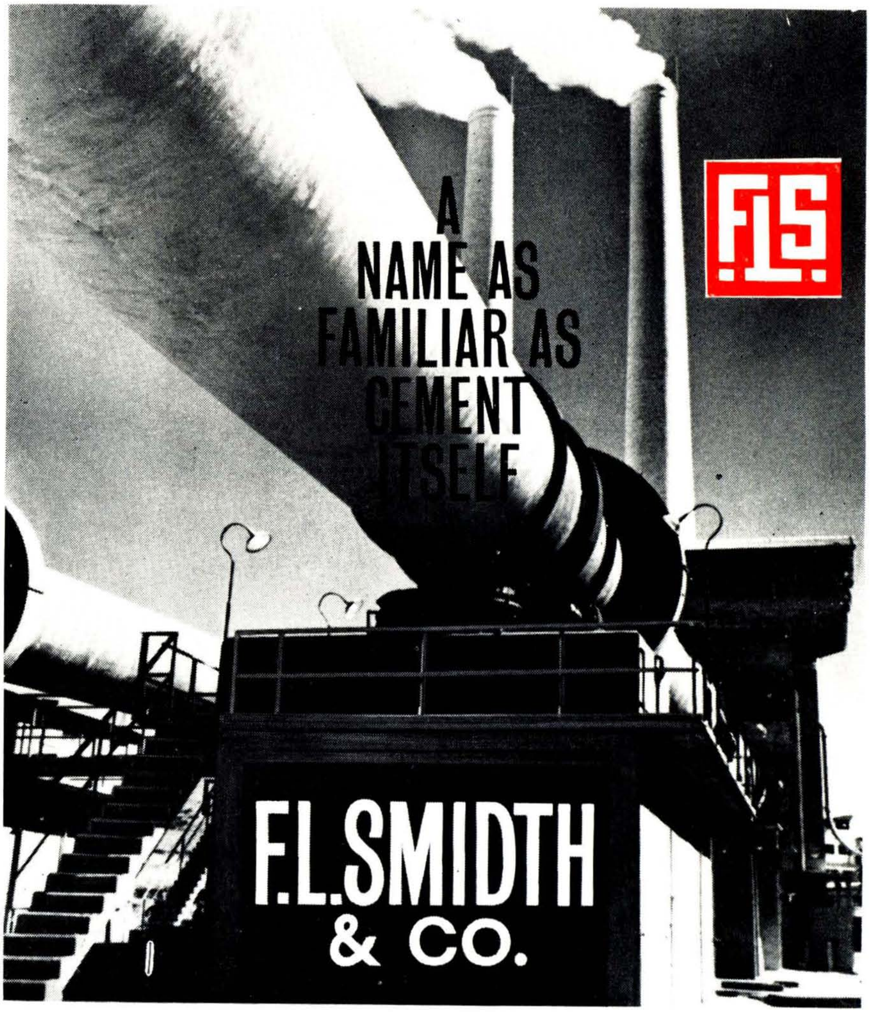
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VOLUME XXXV. NUMBER 5. SEPTEMBER, 1962

A New Cement Works in Saudi Arabia.

THE new cement works for the Saudi Cement Co., in the Province of El Hasa, Saudi Arabia, commenced operating early this year (as reported in this journal for May last). The works, general views of which are shown in *Figs.* 1 and 2, has a capacity of 300 tons per day. A plan of the works is shown in *Fig.* 3. There is one dry-process rotary kiln, fired by natural gas, and provision is made for installing another. The works, which is situated on a level site 430 ft. above sea level is about 80 miles west of the port of Dammam on the Persian Gulf. It is connected to Dammam by the 4-ft. 8½-in. gauge Saudi Government Railway and a main road.

The locality is such that day temperatures in the summer range from 100 to

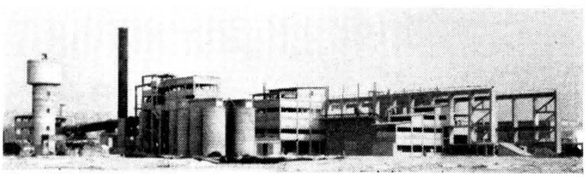

Fig. 1.—General View of Works (Looking West).

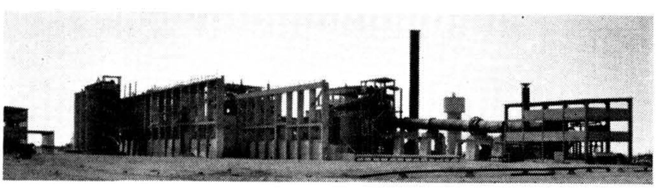

Fig. 2.—General View of Works (Looking East).

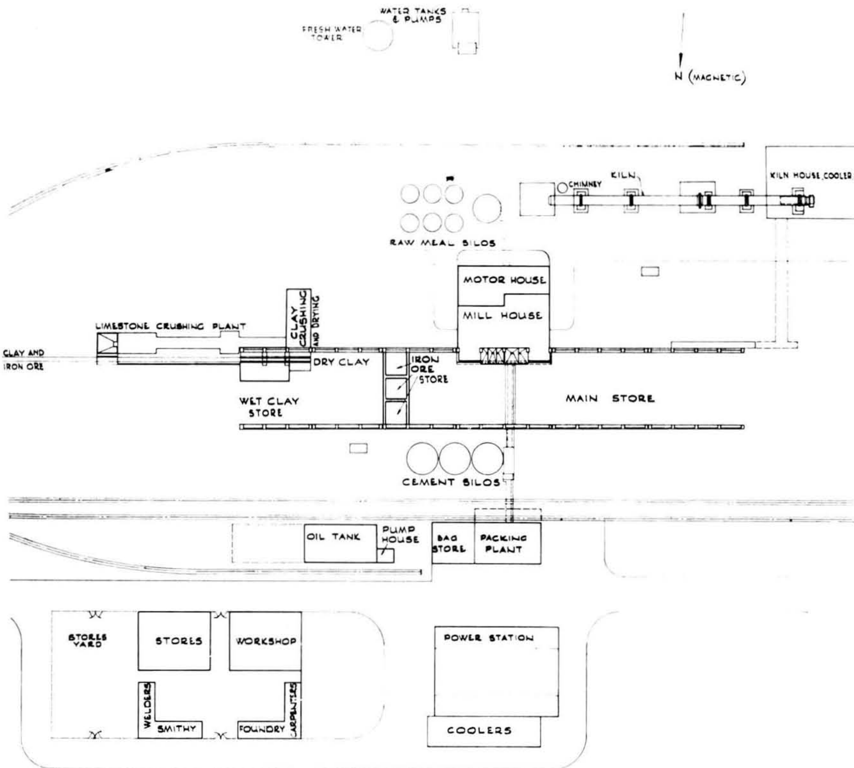

Fig. 3.

125 deg. F., falling by about 40 deg. F. at night. The highest humidity is in July and August. Winds are moderate, but sand-storms occur generally in April and May. Rainfall, which averages 3 in. a year, occurs in the winter. Water is obtained from a bore-hole 110 m. (360 ft.) deep and is supplied to a water tower of 33,000 gallons capacity by a submerged pump. The tank of the tower comprises two compartments, one for drinking water for the works and houses of the staff, and the other for the circulating system in the works.

Electricity is generated at the works in a power station having a capacity of 600 k.v.a. at 0·8 power-factor and contains four pressure-charged 9-cylinder four-stroke 1750-b.h.p. sets running at 300 r.p.m. and using white diesel oil. Current is generated at 6000 volts 3-phase 50 cycles. The mill motors operate on 6000 volts, other motors on 380 volts, and lighting and other single-phase circuits on 220 volts. Two small generating sets, which were used during construction are retained as auxiliaries. The cooling water and lubricating oil are cooled in air-blast coolers.

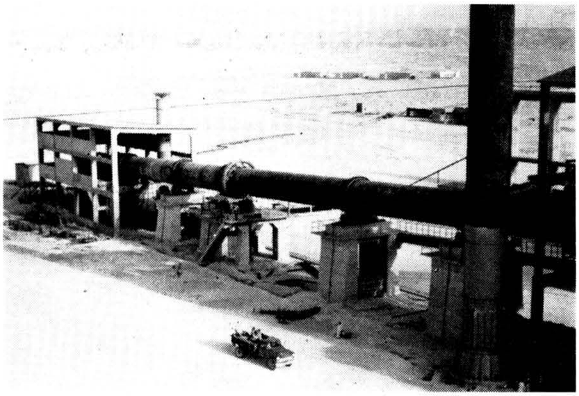

Fig. 4.—The Kiln.

Raw Materials.

Limestone.—The part of the quarry being worked at present is 600 metres (660 yards) from the works, which is built on a limestone deposit. The limestone is of medium hardness and of constant quality having about 88 per cent. of $CaCO_3$. It is drilled by wagon drills, blasted, and loaded by a 2½-cu. yd. 54-R.B. diesel-operated shovel into 9-cu. yd. Mercedes dumpers in which it is transported to the crushing plant at the works. It is discharged into a hopper and is fed by a 1·2 m. (42-in.) apron-feeder to a primary jaw-crusher which reduces the pieces of stone to 150 mm. (6 in.). To obtain optimum loading, the speed of operation of the feeder, which is variable, is linked to the power taken by the crusher. The crushed stone is carried by a belt-conveyor and fed to a secondary Symons No. 4 cone crusher which reduces it to a size at which 95 per cent. passes through a 32-mm. (1¼-in.) screen. It is then conveyed either to the store or direct to the mill bunkers.

The store structure, which is seen in *Figs.* 1 and 2 and is shown on the plan in *Fig.* 3, contains an overhead crane of 25-m. (82 ft. 6 in.) span and provided with a 2½-cu. yd. grab, which serves the stocks of raw material, clinker and gypsum and the respective mill bunkers which are within the store structure.

Clay.—The clay deposit is located 14 km. (about 9 miles) from the works and is on the railway. There is an overburden of lime-marl 6 m. (20 ft.) thick which is drilled, blasted, and loaded by a 22-R.B. diesel-operated shovel into 9-cu. yd. dumpers for removal to a tip. The clay bed is 10 m. (33 ft.) thick. The clay is hard and compact and contains 28 to 30 per cent. of moisture. It is dug by another 22-R.B. diesel-operated shovel and also loaded into 9-cu. yd. dumpers. The pieces are up to 250 mm. (10 in.) in size but occasional pieces are as large as 500 mm. (20 in.) cube.

The dumpers run on to a loading ramp at the railway and discharge into

50-ton tipping railway wagons, which have compressed-air mechanism for tipping to either side; they were originally used on harbour construction. On arrival at the works, the clay is tipped into a grab-hopper which is situated at the east end of the main store structure. The hopper is served by the grab-crane in the store, by which the clay is transferred to the store or direct to the hopper of the clay crusher. A roll crusher reduces the clay to 25 mm. (1 in.) and it then passes through a "Rapid" drier; this equipment consists of a chamber with rapidly rotating impellors at the bottom, which repeatedly throw the material into a stream of hot gas in the chamber until the moisture is reduced to 6 to 8 per cent. Heat is provided by natural gas. The dried clay is then transferred by a belt-conveyor and elevators to the store. The system is provided with multi-cyclone dust collectors.

IRON OXIDE.—Iron ore of 90 per cent. purity is brought by road from a local source. It is crushed in the limestone crushing plant and delivered to the store or mill bunker.

Grinding and Blending of Raw Material.

The raw materials, which have a moisture content up to 8 per cent., are ground in a Polysius double-rotator mill and classifier to a fineness giving a residue of not more than 8 per cent. on a 170-mesh screen. The mill is 2·8 m. (9 ft. 2 in.) in diameter and is 8·5 m. (28 ft.) long, and is driven through girth gears and a reduction gearbox by a 630-kw. 6000-volt motor. The output is 28 tons per hour. Heat for drying in the mill and classifier is obtained either from a gas-fired furnace or the flue gas from the kiln. The purge from the system is cleaned in a fabric bag filter.

The raw meal is conveyed by screw-conveyors and elevators to the blending

Fig. 5.—Feed-end House and Chimney.

silos, which are six 440-ton concrete silos 6·1 m. (20 ft.) in diameter and 14 m. (46 ft.) high. The silos, which are seen to the left-centre in *Fig.* 1, are equipped with the Polysius pneumatic system for mixing, and with screw-conveyors and elevators for re-circulation. The blended meal is stored in another silo (*Fig.* 5) which is 9·5 m. (31 ft.) in diameter and 14 m. (46 ft.) high, and from this it is extracted by a drag-link conveyor and elevated to the kiln-feed hopper. The feed is extracted from the hopper by a variable speed Redler conveyor and delivered into a double paddle mixer, where water is added as necessary to dampen the meal before discharge into the kiln.

Burning.

The Polysius rotary kiln (*Fig.* 4) is 3·2 m. (10 ft. 6 in.) in diameter and 90 m. (295 ft.) long, and is supported on five bearings with thrust rollers at the central bed and the adjacent bed. It is operated by a 90-kw. slip-ring motor, with rotor-assistance speed control, through a reduction box equipped with barring gear driven by a petrol engine for emergency use. The flue gas is cleaned in a multiple-cyclone dust collector and discharged by an induced draught fan to a steel chimney (*Fig.* 5).

The kiln is fired with natural gas having a calorific value of 1550 B.t.u. per cu. ft. gross (1425 B.t.u. per cu. ft. net). The gas, which is preheated, is discharged through a dual-purpose burner which can also operate with white diesel oil in an emergency. The gas for the kiln and for drying the raw material is supplied, through the 200 mm. (8-in.) pipeline seen in the foreground of *Fig.* 2, from the Arabian Oil Co.'s (ARAMCO) gas-oil separation plant at Shedgum 11 km. (7 miles) from the works. The gas enters the pipeline through regulating and metering equipment at a pressure of about 50 lb. per sq. in., and emerges at the works through an oil and water separator at about 20 lb. per sq. in.

The clinker is cooled in a Fuller-629 inclined cooler, the breaker of which discharges into vibrating conveyors which carry the clinker horizontally to an inclined belt-conveyor, with an automatic-weigher, to the store.

All instruments and motor controls for the kiln are located on a control board with mimic panels which gives central manual control of the plant.

Grinding, Storing and Packing.

The gypsum, which is delivered by road from a source 125 km. (78 miles) from the works, is a hard crystalline material and is reduced in a hammer crusher to a size such that 90 per cent. passes through a 25-mm. (1 in.) screen. From the crusher, it is conveyed to a bin in the main store. The clinker and gypsum are ground in an open-circuit three-chamber Polysius compound mill, 2·2 m. (7ft. 3 in.) in diameter and 13 m. (42 ft. 7 in.) long, fitted with a girth gear and pinion driven by a 630-kw. 6000-volt motor through a reduction box with barring gear. The mill is ventilated through an automatic bag-filter. The output is 18 tons per hour with a residue of not more than 5 per cent. on a 170-mesh.

The cement is taken by screw-conveyors under the main store and then by elevators to the three concrete silos (seen at the left of *Fig.* 2), which are 9·5 m.

(31 ft.) in diameter and 19·7 m. (95 ft.) high. It is taken from the bottom of the silos by Polysius extraction equipment and by means of screw-conveyors it is taken to the packing plant. Here it is elevated to a screen and the hopper of the four-spout packer, which is provided with a dust collector, and where it is packed into paper bags for despatch by rail or road. The packing plant is seen on the extreme left of *Fig.* 2.

Buildings.

The buildings housing the plant are of reinforced concrete. The climate requires open buildings as exemplified by the firing and feed-end buildings. Since the ground is capable of bearing over 4 tons per sq. ft., the work of constructing the foundations was simple. A workshop fully equipped with machine tools and a 3-ton overhead crane, and an air-conditioned laboratory and offices are also provided.

The senior staff are European and for them there is a housing estate with suitable amenities; the houses can just be discerned in the background of *Fig.* 4.

The works were designed and constructed under the supervision of Henry Pooley (Consulting Engineers). The plant for the preparation of the raw material, the kiln, and the grinding mills were supplied by Polysius G.m.B.H. The main electrical equipment was supplied by Siemens-Schuckertwerke A.G., and the complete power plant by M.A.N.A.G. The civil engineering work was carried out by Mist Concrete Development Co., S.A.E., of Cairo.

False Set.

IN a paper entitled " Quick and False Set in Portland Cement " by W. C. Hansen [reprinted from " A.S.T.M. Materials Research & Standards," October 1961, and issued by the National Ready Mixed Concrete Association (U.S.A.)], the information in the papers presented at the Fourth International Symposium on the Chemistry of Cement is reviewed. False set is defined as the stiffening produced by the crystallization of gypsum in the cement paste and quick set as the stiffening produced by the reactions of C_3A and C_4AF with water. Some cements containing dehydrated gypsum may not show false set until aeration reduces the rate at which C_3A reacts with $CaSO_4$. It is shown that some cements may develop quick set by aeration, reducing the ability of C_3S to release $Ca(OH)_2$ to the solution to control the reactions of C_3A and C_4AF with water.

Cement Industry in South Africa.

Transvaal.—The works at Slurry of the Pretoria Cement Co., Ltd , has been converted from a wet-process plant to a highly instrumented efficient dry-process plant having a daily capacity of about 1,400 tons. The new plant incorporates two new raw-mills each 19 ft. 6 in. long and 9 ft. 6 in. diameter, six 500-ton blending silos, two 485-ft. kilns of about 12-ft. diameter, and two cement mills each having an output of 32 tons per hour.

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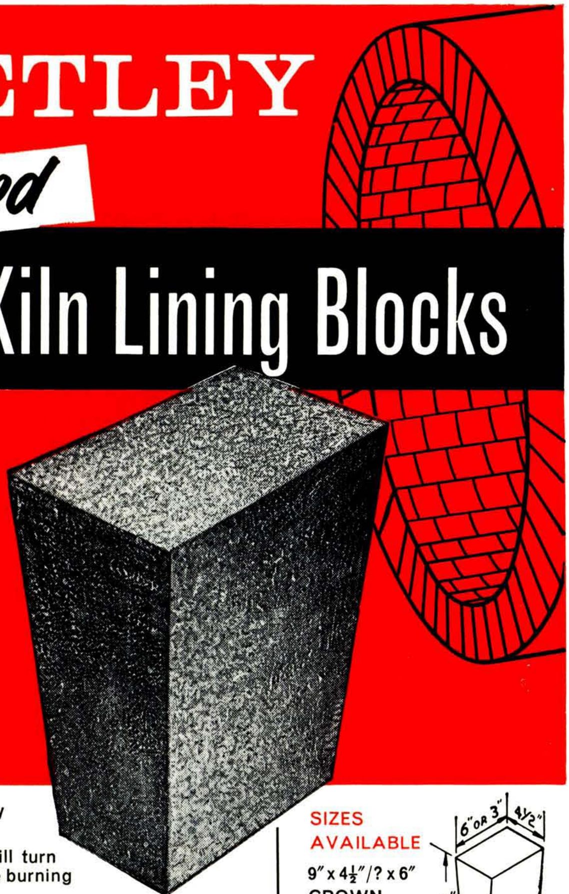

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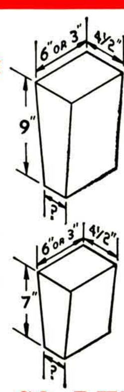

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Specifications for Portland Cement.

TABLES giving the requirements regarding the strengths of Portland cement in accordance with standard specifications of certain countries were given in this journal for July last; these tables (*Table* III) are concluded on pages 80 to 82 in the present number. Tables for Chemical Composition (*Table* I) and Setting Time and Soundness (*Table* II) were published in this journal for May last. The data is up to date to 1961. The notes in the following apply to *Table* III (Strengths).

TYPES OF CEMENT.—Abbreviations denote the various types of cement as follows: H.S., high strength; L.H., low heat; S.R.-L.H., moderate sulphate resistant and low heat; S.R., sulphate resistant; R.H., rapid hardening; O., ordinary; A.E., air entrained.

The Cement Industry in the East.

Cambodia.—A Chinese aid project is the construction of a cement works at Kampot; work is due to start this year.

Thailand.—The Siam Cement Co., is to build a new cement works in South Thailand which will produce 250,000 metric tons annually, and which will be the third of this Company's works. The annual production of the two existing works is 700,000 metric tons.

Provisional quantities of the production of cement in Thailand in 1961 are 802,000 metric tons compared with 543,000 metric tons in 1960.

Indonesia.—The Cresik cement works, which recently produced its five-millionth bag of cement, has commenced operation of a third kiln. The annual output is expected to increase from 275,000 tons to 375,000 tons. It is stated that the annual requirement of the country is 1,000,000 tons. Present regular supplies amount to 800,000 tons, including 300,000 tons which are imported.

Japan.—Cement production increased from 17,269,000 tons in 1959 to 22,539,000 tons in 1960 when there were forty-six works with a total of 169 kilns in operation. The productive capacity was 2,350,000 tons monthly. It is reported in "Cement, Lime & Gravel," that 85 of the kilns are dry process, 21 are wet process (short), 30 are wet process (long), 23 are Lepol kilns, and there are ten shaft kilns. Nearly half the kilns have been in use for more than twenty years. In 1960, the amount of cement exported was 1,632,000 tons, an increase of 12 per cent. on the previous year. Home sales were 21,930,000 tons, an increase of 28 per cent.

Malaya.—A new works, having an initial annual capacity of 180,000 tons and an eventual capacity of 240,000 tons, began operation recently at Singapore.

Pakistan.—In the January number of this journal, reference was made to new cement works to be installed at Manghopir and Gharibwal. The works at the former place will have a capacity of 500 tons daily and will operate on the dry process. The works at Gharibwal will operate on the wet process and will have a capacity of 1,200 tons daily. The consulting engineers for both works are Henry Pooley (Consulting Engineers).

TABLE III.—STRENGTH OF PORTLAND CEMENT *(Continued from July.)*

(For Notes see page 79.)

Country	Type of Cement	Tensile Strength Age of specimen in days				Bending Strength Age of specimen in days			Compressive Strength Age of specimen in days				Remarks
		1	3	7	28	3	7	28	1	3	7	28	
Spain	O.1	—	—	—	—	—	384 27	611 43	—	—	1337 94	2133 150	1500g. sand : 500g. cement : 250g. water (Spain, all four types)
	O.2	—	—	—	—	—	526 37	796 56	—	—	2375 167	3555 250	
	R.H.	—	—	—	—	469 33	640 45	910 64	—	2545 179	3555 250	4977 350	
	S.R.	—	—	—	—	—	384 27	611 43	—	—	1337 94	2133 150	
Sweden	O.	—	—	—	—	427* 30*	640* 45*	924* 65*	—	2275* 160*	3697 260	5972 420	
	R.H.	—	—	—	—	853* 60*	924* 65*	—	2275* 160*	4835 340	5972 420	—	Bending strength at 1 day is (427*/30*)
	L.H.	—	—	—	—	—	427 30	711 50	—	—	2275* 160*	4124 290	Bending and compressive at 90 days: (924*/65*) and (5972/420)
Switzerland	O.	—	—	—	—	—	711 50	924 65	—	—	4266 300	5688 400	
	R.H.	—	—	—	—	782 55	924 65	1067 75	—	5261 370	6968 490	8390 590	
Taiwan	O.	—	149 10·5	275 19·0	338 24·0	—	—	—	—	853 60	1771 125	2986 210	
	M.S.R./M.L.H.	—	125 9·0	250 18·0	325 23·0	—	—	—	—	711 50	1493 105	2986 210	
	R.H.	275 19·0	382 26·5	—	—	—	—	—	1280 90	2489 175	—	—	

Turkey	O.	—	—	313 22	384 27	—	—	—	—	—	4267 300	4978 350	Tensile and compressive at 28 days combined wet and dry storage: (455/32) and (5688/400)
	R.H.	—	384 27	—	484 34	—	—	—	—	4978 350	—	6045 425	Ditto (597/42) and (7466/525)
Uruguay	O.	—	—	—	—	—	—	—	—	—	2133 150	—	
	R.H.	—	—	—	—	—	—	—	1565 110	—	4409 310	—	
U.S.A.	O.	—	150 11	275 19	350 25	—	—	—	—	1200 84	2100 148	3500 246	† Federal.—Compressive at 3, 7 and 28 days: (850/60), (1600/113) and (3000/211)
A.S.T.M. and A.A.S.H.O. Standards. Federal requirements similar except where noted	M.S.R. M.L.H.	—	125 9	250 18	325 23	—	—	—	—	1000† 70†	1800† 127†	3500† 246†	
	R.H.	275 19	375 26	—	—	—	—	—	1700 120	3000 211	—	—	
	L.H.	—	—	175 12	300 21	—	—	—	—	—	800 56	2000 141	
	S.R.	—	—	250 18	325 23	—	—	—	—	—	1500 105	3000 211	
	O.(A.E.)	—	—	—	—	—	—	—	—	900 63	1500 105	2800 197	
	M.S.R./ M.L.H. (A.E.)	—	—	—	—	—	—	—	—	750† 53†	1400† 98†	2800† 197†	† Federal.—Compressive at 3, 7 and 28 days: (600/42), (1250/88) and (2500/176)
	(A.E.)	—	—	—	—	—	—	—	1100 77	2200 155	—	—	
	R.H. (A.E.)	—	—	—	—	—	—	—	1300 91	2500 176	—	—	

TABLE III.—STRENGTH OF PORTLAND CEMENT (*Concluded.*)

(*For Notes see page 79.*)

Country	Type of Cement	Tensile Strength Age of specimen in days				Bending Strength Age of specimen in days			Compressive Strength Age of specimen in days				Remarks
		1	3	7	28	3	7	28	1	3	7	28	
U.S.S.R.	300	—	—	213 15	284 20	—	—	—	—	—	2844 200	4266 300	
	400	—	228 16	270 19	327 23	—	—	—	—	2702 190	3982 280	5688 400	
	500	—	284 20	327 23	384 27	—	—	—	—	3697 260	5404 380	7110 500	
	600	—	313 22	384 27	455 32	—	—	—	—	4266 300	6399 450	8532 600	
Venezuela	O.	—	156 11	284 20	356 25	—	—	—	—	910 64	1806 127	3000 211	2·75 : 1 mortar for compressive test
	S.R./L.H.	—	128 9	256 18	327 23	—	—	—	—	754 53	1507 106	3000 211	
Yugoslavia	O.1	—	—	—	—	—	356 25	498 35	—	—	1422 100	2133 150	
	O.2	—	—	—	—	—	427 30	640 45	—	—	2275 160	3555 250	
	O.3	—	—	—	—	—	569 40	782 55	—	—	3555 250	4977 350	
	R.H.	—	—	—	—	498 35	640 45	853 60	—	2844 200	4977 350	6399 450	

Production Control with Closed-circuit Television Systems.

SEVERAL cement works use closed-circuit television to aid in the control of one or more stages in production. A simple example is the closed-circuit television system installed recently in the dry-process works of the British Columbia Cement Co., at Bamberton, near Victoria, British Columbia, and by means of which there is centralised control of some of the operations concerned with the raw material. The installation reduces labour costs and increases efficiency. For an initial expenditure of about £3000 on the installation, it is claimed that a saving of about £5300 in wages is effected annually.

The installation comprises two cameras, which are focused on the two storage bins, each 80 ft. by 10 ft. and which relay to a 17-in. monitor screen on the control panel of the dry-mill. Each bin contains 800 tons of crushed stone and the operator is able to see the level of the stone in each bin. With this information, he can cause a travelling tripper to move to enable stone to be fed into any of the five compartments into which each bin is divided, and so add stone where it is needed. He can also control the belt-conveyor which is over the bins and is 150 ft. above the control floor. Both cameras are mounted on antenna rotators (*Fig.* 1) which can be moved by the operator who can thus see a complete picture of each bin. The camera which covers the upper bin is mounted in the roof of the mill,

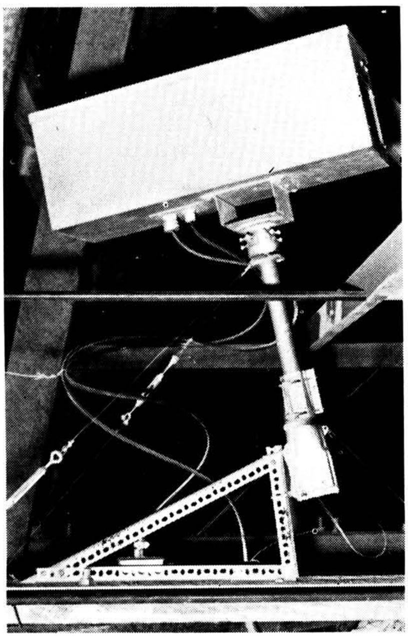


Fig. 1.

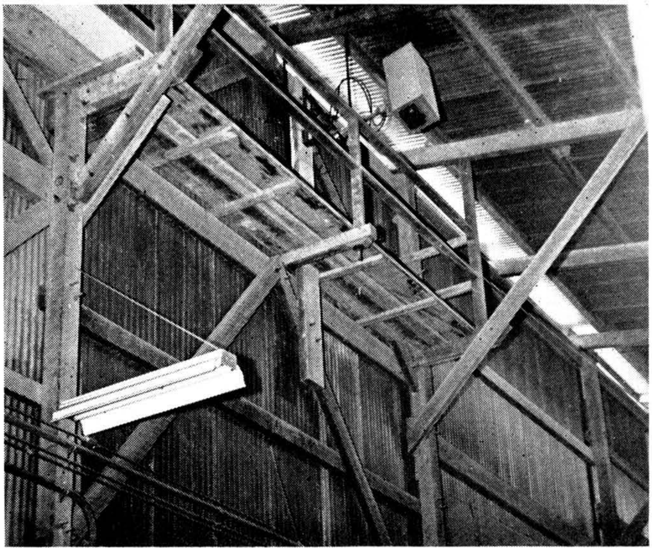


Fig. 2.

30 ft. above the bin (*Fig.* 2). The other camera is at normal eye-level and about 25 ft. to one side of the lower bin. These comprehensive sitings and the rotating mountings are necessary because during trials it was found that cameras in a fixed central position relayed pictures that were misleading to the operator, since they could cover only about half of each bin. A problem in the installation was to place the cameras at the optimum distance from each bin to obtain an overall picture of the level of the stone instead of an unsatisfactory picture of a part of the bins. To get the necessary coverage of the upper bin, it was necessary to raise the roof of the mill building by 12 ft. The lighting is arranged so that irregular shadows fall on the stone (*Fig.* 3), thus ensuring that the contents of the bins are shown in detail on the monitor screen; uniform lighting destroys the shading of the stone as seen in the picture. Light from outside the mill has to be obstructed because, on bright days, errant light patterns can seriously disrupt the image shown on the monitor screen. To give sufficient light for the cameras to operate at maximum efficiency, the upper bin has a battery of twelve R40 300-watt flood lamps arranged along the bin in pairs of lights at six equidistant points. The layout is identical for the lower bin but, because this is naturally darker, there are three flood lamps at each point.

Although the television system usually works continuously, the crushers operate only when crushed stone is required. One minute after the crushers are switched on, a tape-recorder automatically broadcasts over loud-speakers a warning to workers to stand clear. After another minute, and without any further manual movement, the crushing plant begins to work. The television equipment used at this works was supplied by the General Electric Company of Canada.

A more complicated closed-circuit television network operates at the works of the Permanente Cement Co., Waianae, Hawaii. Three systems comprising six cameras and eight monitor screens give the operators of the materials handling, the foremen, the mill operators, and the chemists current information about progress at various stages of manufacture. One system is a single camera mounted above the primary jaw crusher and transmitting to a monitor screen on the control panel of the secondary crusher. Therefore the operator can see any stone that is too large and which might subsequently prevent the even flow of stone to the secondary crushing station, and he can take immediate action to re-establish continuity. In the kiln area, a system of three cameras relays to a treble-monitor control panel where one man supervises the three operations at this stage. A Dage heavy-duty camera in a dust-proof housing gives an overall picture of the kiln. Another camera is permanently focused on the chain-and-sprocket drive and shows any fault in this equipment which might hinder the smooth exit of clinker from the kiln. Any overflow of the clinker from the discharge conveyor appears on the third monitor screen. The mill operators and the chemists responsible for proportioning the feed to the mills are served by the third system, which comprises two Dage heavy-duty cameras. These are protected by dust-proof housings and are mounted over the conveyors carrying the basalt, gypsum

Fig. 3.

Fig. 4.

and silica sand from the storage silos to the mills. Consequently the operators and chemists may check the conveyors periodically to ensure that the passage of the materials is unhindered.

A network of eight closed-circuit television cameras and ten monitor screens has been operating for two years at the works of the Dundee Cement Co., Michigan, U.S.A., and is part of the highly automated production control system at this works. When first opened the works had a production of 1,000,000 tons a year. Only 110 workers on production and fifty other employees are required. The works (*Fig.* 4) occupies about $1\frac{1}{2}$ acres of a 30-acre site adjacent to 1600 acres of land suitable for quarries. Coal arriving by rail is pulverised at the works. The limestone and clay slurry contains 33 per cent. of water. Two slurry mills, which are claimed to be the largest in the world, work in series and reduce the particles to such size that 80 per cent. passes a 200-mesh. The operating of the two rotary kilns, which are each 460 ft. long and from 15 ft. to 16 ft. 6 in. in diameter, is supervised from a central control room. Clinker is discharged from the kilns at 2000 deg. F. and is cooled to 200 deg. F. in a horizontal air-quenching cooler 60 ft. by 10 ft. The cement from three cement-grinding mills and separators is pumped into eight storage silos, each of which is 150 ft. high and has a capacity of 5000 tons. There are also twelve 1250-ton silos for special cements.

The television systems permit complete control of the manufacturing and despatching operations at this works. The operator of the secondary crusher, for example, can remain near his control panel (*Fig.* 5) and simultaneously view on the screens the inlet and outlet of the crusher at the quarry, the reclaimed material in the tunnel beneath the stockpile, and the raw-material conveyor discharging into the bunker in the main part of the works. From a screen in the sales office, the clerk can record the weight of lorries which are loading at the packing house and prepare

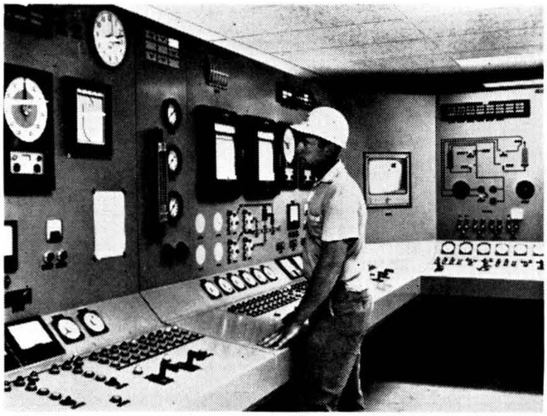


Fig. 5.

documents so that they are ready when the lorry arrives at the sales office. The cameras and five of the monitoring sets were supplied by the General Electric Company of America. The other five monitoring sets, which were manufactured by the Conrac Company and have larger screens, are on the mill control-panel and in the sales office. Initially there was deterioration of the electronic components, high maintenance costs, and unsatisfactory pictures. These defects were found to be due to such causes as fluctuations of voltage, inadequate co-axial cable, and insufficient lighting. Since these faults were rectified, it is said that excellent results have been obtained and that maintenance costs have been reasonable.

Particulars of the installation at the works of the Permanente Cement Co., are abstracted from a recent number of "Pit and Quarry." The description of the installations at the works of the British Columbia Cement Co., and the Dundee Cement Co., is based on information contributed by MR. LEO WALTER. Reference should also be made to the number of this journal for May 1959 in which a television installation at the works of the California Portland Cement Co., is described.

Conference of the Silicate Industry.

THE Seventh Conference of the Silicate Industry will be held in Budapest from June 4 to 7, 1963. The meeting is organized by the Scientific Society of the Silicate Industry and by the Central Institute of Building Material Research of Hungary. The address of the Secretariat is Seventh Conference of the Silicate Industry, Executive Committee, Budapest, V., Szabadság tér 17.

The subjects of interest to cement manufacturers include automation, new types of refractories, thermal ractions of clay minerals, problems of rotary kilns, high-magnesia Portland cement, the hydration of cements, and drilling and blasting in quarries. The official languages of the Conference are English, German, Russian and Hungarian.

Research on Cement in Great Britain.

IN addition to the research carried out continuously by the several cement manufacturers in Great Britain, many investigations are proceeding, either independently or in conjunction with manufacturers, at the Building Research Station and by the Cement & Concrete Association. Some of these investigations, particulars of which are abstracted from the Annual Reports for 1961 issued by both these bodies, are described in the following.

Reactions in the Lime-silica-water System.

Work in progress on the CaO-SiO_2-H_2O system includes an investigation, by the Association, of the nature of the hydrated calcium silicates by methods of inorganic and physical chemistry as distinct from crystallographical methods. The two types of structure proposed for the calcium-silicate hydrates thought to be formed in cement-water pastes correspond essentially to a tobermorite-like structure of meta-silicate chains linked by calcium ions and hydrogen bonds, and an ortho-silicate structure built up of individual SiO_4 tetrahedra. The evidence for the former is derived largely from X-ray diffraction data, and that for the latter from the reactivity of cement gels towards acids. Investigations tending to support the latter proposal include the following.

Measurement of the rate at which equilibrium is established between calcium silicate hydrates and lime solutions.

Observation of the effect of pH and SiO_2 concentration in solution on the crystallinity of calcium-silicate hydrates.

Measurement of Ca^2-ion mobility as the C/S ratio is changed in calcium-silicate-hydrate preparations.

Observation of the structure of dehydration products of calcium-silicate hydrates.

A very rapid adjustment of silica concentration in the aqueous phase in contact with Taylor's CSH(I) after sudden dilution has been found and suggests that the silica present in the crystals of CSH(I) is in a more readily available form than infinite meta-silicate chains. When the composition of the CSH(I) is below C/S of about unity, the composition of the equilibrium aqueous phase does not adjust itself so readily, possibly because the presence of meta-silicate chain species in the solution phase itself causes delay in reaching final equilibrium; or it may be that the solid-phase structure changes fundamentally near C/S = 1 and below this value includes meta-silicate chains in the crystal structure. Both factors may operate.

Other experimental evidence bearing on the crystal structure of CSH(I) has been obtained from the conditions under which it is precipitated in a crystalline form. Sodium-silicate solution and calcium nitrate solution on mixing give well crystallised CSH(I) when the sodium-silicate solution is either of high pH or of low concentration in silica, both tobermorite and CSH(I) have been reported from dehydration experiments. On dehydrating natural tobermorite at 700 deg. C., βCS (β Wollastonite containing meta-silicate chains) is formed. On dehy-

drating CSH(I) at 700 deg. C., βC_2S (dicalcium silicate containing SiO_4 ortho-silicate ions) is formed. An ortho-silicate hydrated compound might be expected to produce an ortho-silicate anhydrous compound; further experiments are in hand.

Work is now in progress on the kinetics of the lime take-up by CSH. Radio-isotope exchange results indicate a considerable reduction in calcium ion mobility at low C/S ratios. A relationship between calcium ion mobility and rate of lime take-up should exist.

X-ray Diffractometry.

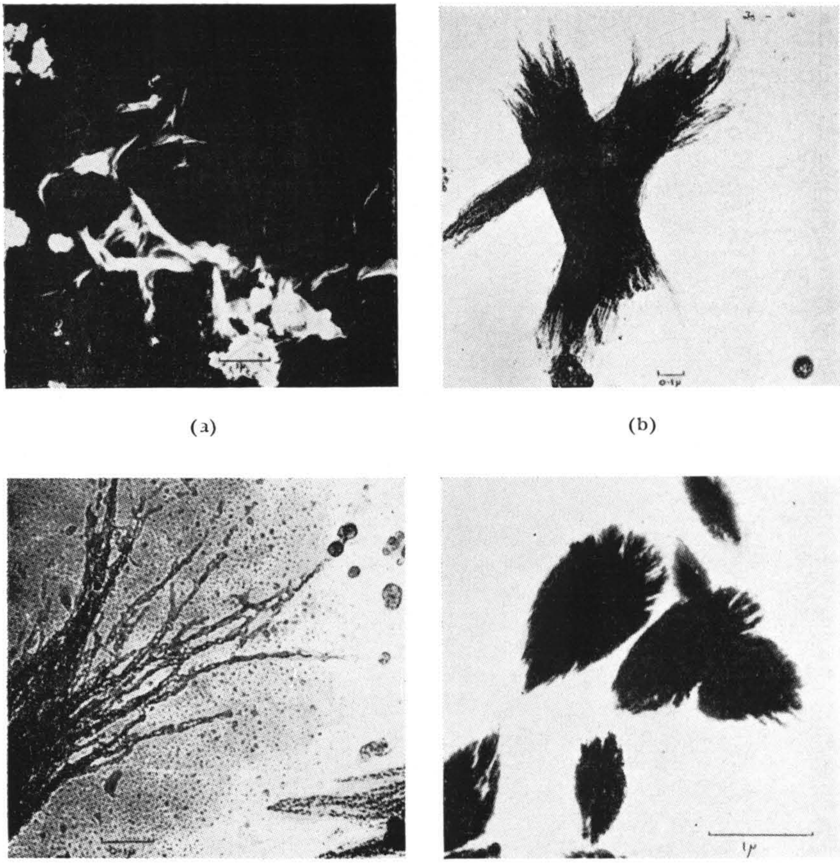
Investigations utilising X-ray diffractometry are proceeding at the laboratories of the Building Research Station and the Cement & Concrete Association. The technique is similar to normal powder X-ray diffraction, but instead of recording the spectrum by means of photographic film a direct record of scattered intensity is obtained by means of a suitable counter and associated circuit. The main difficulties are the small size of specimen (with consequent sampling errors), the varying X-ray reflections obtained with components which differ slightly from one cement to another, and confusion arising from the overlapping of reflections from the many components present.

The role of minor constituents in modifying the behaviour of the major hydraulic constituents of Portland cement is being studied at the Building Research Station, because such work is necessary if the chemistry of cement is to be fully understood and an optimum quality of manufacture maintained. For example, though a high proportion of alite (tri-calcium silicate solid solution) in the clinker has always been associated with the development of high strength, some cements containing a very high proportion of alite may have low strength. This may be caused by the solution of minor constituents in the solid alite. Although the alite phase is essentially $3CaO.SiO_2$, it normally contains a little MgO and a trace of Al_2O_3 substituting for CaO.

An unsolved problem of cement chemistry is how to determine the mutual solid-solution limits for the major cementing phases, and investigations are proceeding at the Station by means of quantitative X-ray diffractometry. Pure mixtures of cement composition are synthesized and, after a known heat-treatment, are analysed on the diffractometer; the data obtained from the counter are fed to a computer which analyses the results in terms of the composition of the components in the mixture.

Because of the importance of sulphate-resisting cement and the necessity of a standard specification, attention is being paid to the estimation of low contents of C_3A in cements. This work is being done at the Station by a research fellow appointed by the Associated Portland Cement Manufacturers Ltd.

Quantitative X-ray diffractometric analysis of cement has become a routine method for the examination of cements at the Association's laboratories. It is clear that the anhydrous cement compounds require further study. The precise quantitative information which the method provides enables small differences in the compounds to be detected and it now appears that each of the four



(a) (b)

(c) (d)

Fig. 1.—Electron Micrographs of Tobermorite.

principal compounds can contain small amounts of alien oxides which may alter their crystal structure. Even if there is no structural change, the fact that the compounds can have a variable composition means that calculations of the compound composition of cement from elemental analyses and the traditional two, three and four oxide systems can only be approximate. These small inclusions change the crystal symmetry of alite so that triclinic C_3S becomes monoclinic alite. In the case of belite, a high temperature C_2S phase becomes stabilised at room temperature. In the case of C_3A the effect is merely a change in unit cell size; this change and the capacity for take-up of other oxides is being studied. So far Fe_2O_3 and SiO_2 have been examined and work on the effect of MgO and alkalis is in progress. There seems to be no alteration of crystal symmetry (C_3A

being cubic) and the changes in cell size are small. Fe_2O_3 causes an expansion of the unit cell as expected if Al are replaced by Fe atoms. A decrease in cell size is caused by the inclusion of SiO_2, which is expected if Si replaces Al.

Mineralogical Studies.

The hydration products formed at various stages in the setting of cement have been studied, at the Building Research Station, using X-ray diffraction differential thermal analysis, and infra-red spectrometry. Most information has been obtained by a combination of thermal analysis and X-ray diffraction, both methods being necessary because, in the early stages of setting, the products of reaction are poorly crystallised and do not give clear diffraction patterns. An extensive investigation has been made into the setting of high-alumina cement at various temperatures and there is more understanding of the reaction which causes the cement to lose strength under moist warm conditions. A similar investigation is being made of the setting of supersulphate slag cement, recently introduced as a British product.

An E.M.6 electron microscope, which has been installed at the Station, is capable of a resolution of 7-10Å, and has been primarily used for the study of the products of cement hydration. Examination of calcium-silicate hydrates has revealed structures that are generally in accord with electron micrographs, but high-resolution investigations have shown that some supposed differences between the various forms are not, in fact, real. Pictures of the calcium silicate hydrate particles from a set commercial Portland cement show that tobermorite can co-exist in many of its habits in one sample. High-resolution pictures (*Fig.* 1) have shown much more detail than hitherto and this may result in a better understanding of the mechanism of the setting of cements.

At (*a*) in *Fig.* 1, the typical twisted shape of the crimpled foils of tobermorite gel is clearly seen. Fibrous tobermorite, from a set cement, is shown at (*b*); the crystals are produced by precipitation from solution. The widths of the thin wispy fibres at the end of a crystal of fibrous tobermorite shown at (*c*) are only about 100Å. At (*d*) is shown tobermorite from a sample of hydrated tricalcium silicate; the crystals, which exhibit an outer rim of tobermorite, were formed by topochemical reaction, tricalcium silicate being replaced by calcium-silicate hydrate.

Cement Industry in New Zealand.

As part of a transport modernisation programme developed by Wilsons (N.Z.) Portland Cement Ltd., new loading and unloading facilities have been installed at the works at Portland, near Auckland. This company is the largest manufacturer of cement in New Zealand and produces about 300,000 tons annually. The works is situated adjacent to Whangarei Harbour, from where cement is shipped in bulk in the Company's cement carrier M.V. " John Wilson " (see this journal for July 1961) and delivered to coastal towns in New Zealand where it is unloaded into silos and later transported by road to inland areas. The harbour is very silted so that, to obtain sufficient depth of water for the vessel, a 4000 ft. wharf has been constructed.

Refractories in Kilns.

RECENT major developments in kilns have resulted in greater production with a reduction of costs. Kilns are longer, the diameters tend to be greater, the intake of fuel has increased, and liquid fuels are being used. Conditions in the clinkering zones of many kilns are now such that it has been necessary to replace traditional refractories by bricks of greater chemical resistance. This matter is discussed in a paper entitled " New Approach to Portland Cement Kiln Refractory Problems" by H. Parnham, which is given in "Edgar Allen News" for May 1962.

Publication Received.

"PROJETO DE UM FORNO ROTATIVO DE CIMENTO." By J. F. de Assumpção Santos. (In Portuguese; published in Sao Paulo, 1961.) This book of about 100 pages describes the fundamental computations related to a particular wet-process rotary kiln, the dimensions of which are calculated from the thermodynamical data of a mixture of clay from Aratú, Bahia, and limestone from Pindoba, Sergipe, in north-eastern Brazil. The fuel is a typical bunker C oil, the chemical composition and other properties of which are known. The horse-power requirements are based on selected, but generally accepted, formulæ.

New Approach to Hot Zone Linings

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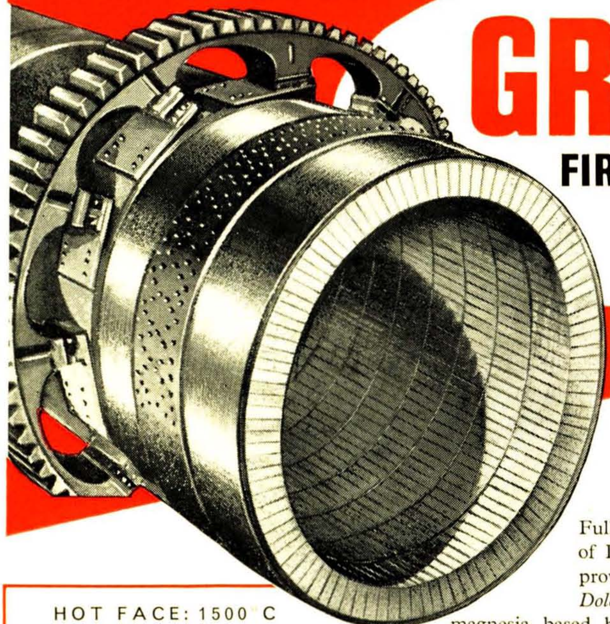

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	C COOL FACE (THEORETICAL)			
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7″	355	255	380	280
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