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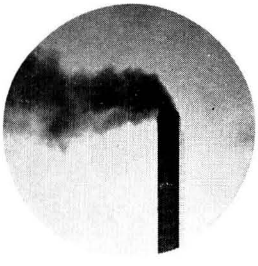

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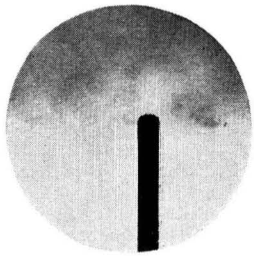

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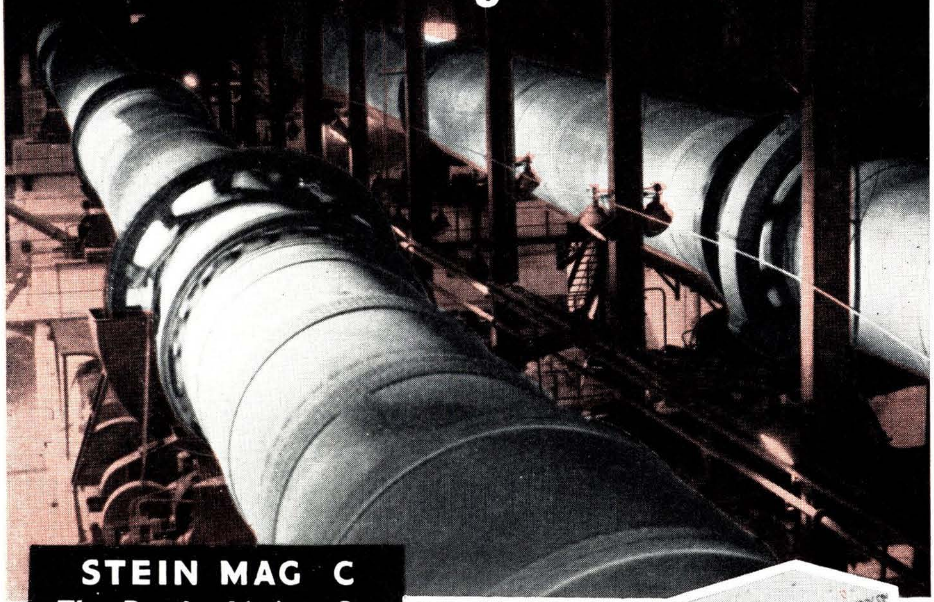

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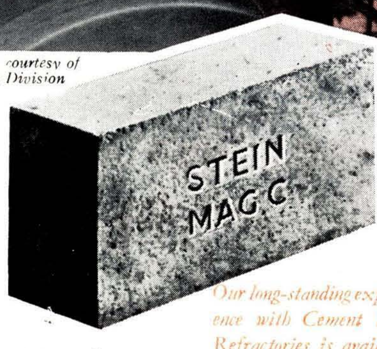

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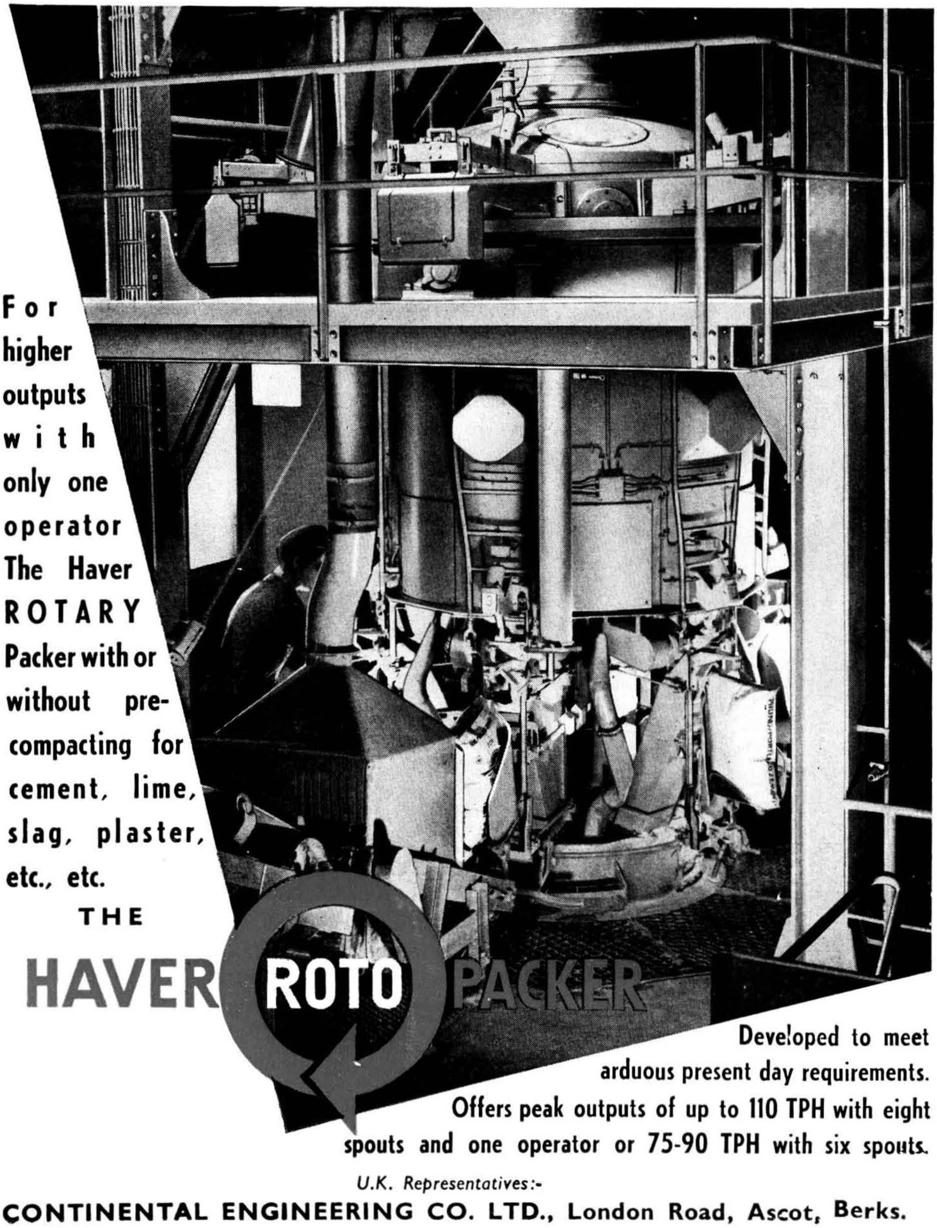

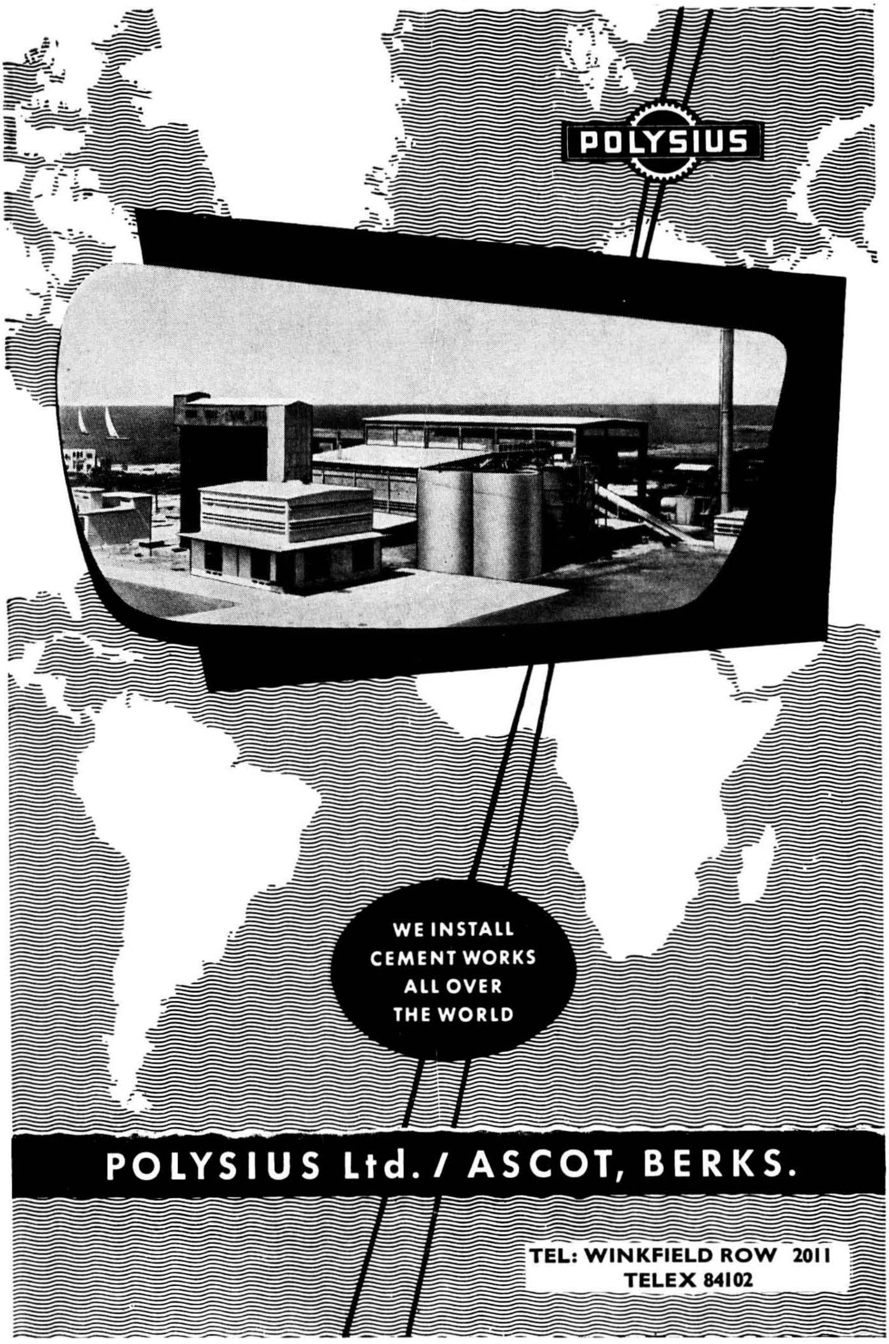

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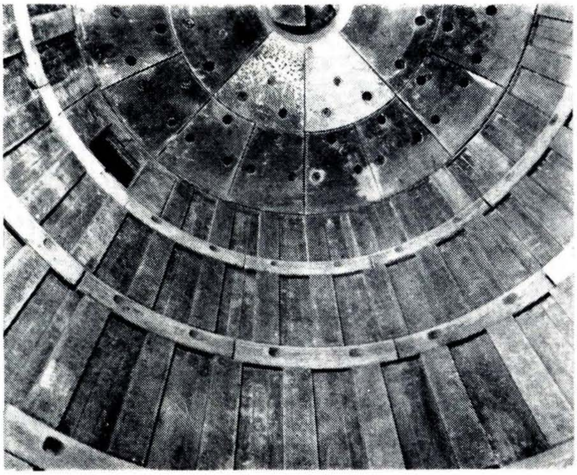

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VOLUME XXXVII. NUMBER 2. MARCH, 1964.

A Pioneer British Cement Manufacturer.

A HISTORY OF MESSRS. FRANCIS & WHITE

CONTRIBUTED BY MAJOR A. J. FRANCIS

MR. CHARLES FRANCIS[1] was born at Newington (then in Surrey) in 1777 and at the age of 14 years was apprenticed to a Mr. Francis Hurlbatt, a well-known South London architect. In the London directories for 1801 he is shown as an importer of "Dutch Terras" at the White Hart Inn Yard, Southwark, this substance being used in the production of early mortars. In 1805 he applied to the Corporation of London to become a broker and was sworn as such in 1806. In directories from 1806 onwards he is shown as carrying on business at Nine Elms, Vauxhall, as a marble broker, shipper of lime and lime-burner. In late 1809, or early 1810, he commenced the manufacture of Roman cement at Nine Elms. Apart from Mr. Parker (who is credited with inventing Roman cement in 1796) and his partner Mr. Wyatt, the writer has been unable to trace an earlier manufacturer of this material which was the forerunner of Portland cement. Mr. Francis was shortly joined by a Mr. John Bazley White then working for a firm of West Indian merchants. Within twelve months, Mr. White, who was the grandson of a Dutch emigrant, was taken into partnership, the business being known as Messrs. Francis & White. In the directories of the period, they are shown as being both manufacturers of Roman cement and marble brokers. To ensure the supply of stone for cement, they acquired the Manor of Shurland in the Isle of Sheppey and, in the Kent directories, Messrs. Francis & White are shown as Lords of the Manor. Portraits of both Mr. Chas. Francis and Mr. J. B. White are shown in *Fig.* 1.

Within the next twenty-five years, the business was built up to considerable proportions and all the evidence so far obtained seems to suggest that, at any rate in the London area, the firm enjoyed the reputation of being the leading manu-

MR. CHARLES FRANCIS

MR. J. BAZLEY WHITE

Fig. 1.

facturers of cement. In 1835, Sir Marc Brunel, F.R.S., read a paper to the Institute of British Architects giving particulars of the " mode of building brick constructions using the Roman cement of Messrs. Francis & White of Vauxhall." At least the greater proportion of the cement used by Brunel in the Thames Tunnel[2] was manufactured by Messrs. Francis & White. Two testimonials by Isambard Brunel to the firm on this subject were published by A. C. (later Sir Charles) Davis in "A Hundred Years of Portland Cement "[3] and the use of the firm's cement for this purpose is mentioned twice in the Proceedings of the Institution of Civil Engineers. The writer has been unable to find evidence of any other firm's cement having been used for this purpose. The " Civil Engineer and Architect's Journal " for February 1838 gives a description of an experimental brick and cement arch erected by Brunel in the yard at the Thames tunnel at Rotherhithe using the Roman cement of Messrs. Francis & White. Iron hooping was provided, but the account says " So confident is Mr. Brunel of the principle of construction and the strength of the cement, that he is of the opinion that even the aid of iron hooping is not necessary."

In General Pasley's well-known books giving details of his experiments on cement over the period 1836/8, he states that " the natural English cements were either supplied by Messrs. Francis of Vauxhall or from H.M. Dockyard, Sheerness, and that in such experiments as were not tried for the purpose of ascertaining comparative strength, let it be understood that Messrs. Francis' cement only was used." Early in 1836, and at the suggestion of Brunel, Messrs. Francis & White erected in front of their works a beam of bricks and cement designed for the purpose of "testing Roman cement on a large scale." In November 1837, a letter published in the "Civil Engineer & Architect's Journal" reads as follows:

"SIR. Observing an account in your last number of the brick and cement beams which have lately been constructed by Mr. Brunel and by Col. Pasley of the Royal Engineers for ascertaining the strength of materials and their aptness for certain novel applications, I beg to mention an extraordinary example of the kind which stands exposed to the wayside on the road leading from Vauxhall to Battersea Fields. Passing in that neighbourhood a few days since to ascertain the London terminus of the Southampton Railway, I found an erection on a plot of ground which that Company has selected for the purpose of a depot, exactly opposite the Cement manufactory, Nine Elms, which is described by a board affixed as an ' Experimental Brick Beam". (Here follows a detailed description of the beam with dimensions, and the letter continues:) " The wall is raised 6 feet from the ground, each end resting on a pier of brickwork, the length of 21 ft. 4 ins. clear between the piers being without support under which you may walk as under a wooden beam. This I consider as surprising proof of the strength of adhesion of Roman cement. You will observe that more than double the length of brickwork in the experiments mentioned by Col. Pasley is here unsupported. But this is not all; by a chain or other contrivance thrown over the wall at its centre, a cradle is suspended loaded with pig iron and on which is described the weight it contains, viz., 10 tons, 14 cwt., 1 qr., 4 lbs. If there had been the slightest deviation of the centre of this structure forming any segment of a circle, or were there now any depression from the prodigious weight appended to it, there would be evidence of settlement in the joints of the brickwork or more probably of fracture in the bricks themselves; but this is not to be discovered; it is a perfectly horizontal brick beam, stretched as it were from pier to pier over a span of 21 ft. supporting nearly 11 tons at its centre. It is not for me to point out the practical advantage that may be derived from this curious experiment. I would recommend all scientific persons to whom it is accessible to see it, which they may do in riding past, and I should think that the application of this principle in a vast variety of instances must suggest itself to them."

In February 1838, Messrs. Francis & Sons announced "Considerable interest has been expressed by scientific persons as to what further weight the beam will

EXPERIMENTAL BRICK BEAM

ERECTED IN FRONT OF MESSRS. FRANCIS AND SONS ROMAN CEMENT MANUFACTORY, NINE ELMS, NEAR VAUXHALL BRIDGE.

Figs. 1 and 2. Elevation and Plan.

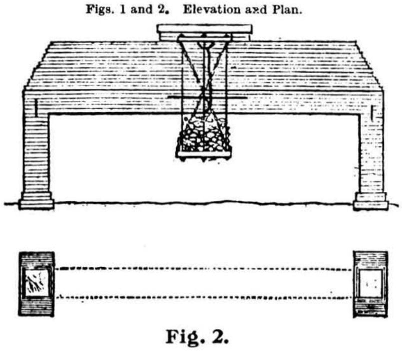

Fig. 2.

carry and an opportunity will shortly present itself to ascertain the fact. The London and Southampton Railway requiring that portion of our premises on which it is erected, we have fixed Wednesday, 14th February at 12 o'clock for the time when we propose to load it until it breaks down and when any who may be so disposed, may witness the operation." The breaking of the beam was witnessed by almost the entire Council of the Institution of Civil Engineers, by a large number of Fellows of the Royal Society, by leading architects and by many other eminent engineers. Two papers on the subject were read to the Institution of Civil Engineers and a detailed description appeared in the leading technical journals of the day. A full description with drawings was published by Gen. Pasley. An illustration of the brick beam, which was reinforced with hoop-iron, is given in *Fig.* 2; this is from the aforementioned journal for March, 1838.

About 1834, or perhaps earlier, Messrs. Francis & White had acquired from Mr. Frost his manufactory of artificial cement at Swanscombe, Kent. In 1837, Mr. White left the firm in order to operate on his own and he took over the Swanscombe works for the purpose, trading under the name of J. Bazley White & Sons with offices at Millbank, London. In 1838, Mr. Francis's elder son and Mr. White's second son were made Associate Members of the Institution of Civil Engineers, the first members of the cement industry to receive that distinction.

Probably about 1840, Messrs. Francis leased land near Newport, Isle of Wight, and built cement works on the River Medina where they made their well-known " Medina " brand of cement. At this period their cement was in great demand. In the Proceedings of the Institution of Civil Engineers, it is mentioned that by far the largest part of the firm's trade came from foreign countries, cement being exported to France, Russia, Trieste, Brazil and elsewhere. At home their cement was used for the foundations of Stephenson's Britannia Bridge in North Wales, for the harbours at Dover and Alderney (Channel Islands), for the tunnels on the London and Birmingham Railway and in many other works. Testimonials from Robert Stephenson, James Walker (President of the Institution of Civil Engineers), Thomas Jackson (a prominent railway contractor) and John Gibbs (an engineer in the service of Russia) are printed in " A Hundred Years of Portland Cement."[3]

The story is well known of the discovery about 1845 by I. C. Johnson, Works Manager to J. Bazley White & Sons, of the proper method of making Portland cement. It is interesting to recall that Mr. Johnson had his first experience of cement in the employ of Messrs. Francis & White. Both Messrs. Francis and Messrs. White exhibited their cements at the Great Exhibition of 1851 and received gold medals. Experiments on the strength of Portland cement were carried out by Messrs. White at the Exhibition. Papers on the subject were read and the details were fully reported in the Proceedings of the Institution of Civil Engineers. It is interesting to note that during this period, a mixture of Messrs. Francis's " Medina " cement and Messrs. White's Portland cement was selected by the French engineers, after a large number of materials had been tested, to form the 45-ton blocks required for the construction of the great breakwater at


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London, 17th March 1887

Fig. 3.

Cherbourg. Full details of the operation were given to the Institution of Civil Engineers by their Secretary, Mr. Manby, F.R.S. From then onwards, Portland cement gradually superseded Roman cement. Production of Portland cement at Messrs. White's works increased rapidly.

Mr. Charles Francis died in 1863 and after his death his two sons parted company, the younger forming a separate company named Messrs. Francis & Co., which took over works at Cliffe, near Rochester, where Portland cement was manufactured. He was shortly joined by Mr. V. de Michele whose name became well known in connection with various appliances he invented to improve the manufacture of Portland cement. Later still the company was joined by Mr. R. E. Middleton, one of the leading water engineers in the country (see "Who's Who," 1916/28). Mr. Charles Francis's elder son died in 1873 and Messrs. Charles Francis & Sons with their works in the Isle of Wight passed out of the control of the Francis family. The letterheadings of the two firms in the last decades of the nineteenth century are shown in *Figs.* 3 and 4 respectively.

During the next twenty years, foreign competition became intense and to meet this, several firms decided to amalgamate in 1900 and these included Messrs.


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CHARLES FRANCIS, SON & Co.

ALL COMMUNICATIONS
TO BE ADDRESSED TO
THE FIRM.

NEWPORT, I.W. 8 July 93.

Fig. 4.

Charles Francis & Sons, Messrs. Francis & Co., and Messrs. J. Bazley White & Sons. Thus was formed The Associated Portland Cement Manufacturers Ltd. Messrs. J. Bazley White & Sons provided its first Chairman, Messrs. Francis & Co., a Managing Director, and Messrs. Charles Francis & Sons, an ordinary director.

Apart from his cement activities, Mr. Charles Francis had been a Justice of the Peace for Surrey, Past Master of the Worshipful Company of Clothworkers, and, for over forty years, a Governor of St. Thomas' Hospital. His death was followed a few years later by that of Mr. John Bazley White. Three of Mr. White's sons became Justices of the Peace and his second son, who succeeded him as head of the family firm, was in addition, a Lieutenant for the City of London and, before his death, the oldest surviving member of the Institution of Civil Engineers. A grandson became Member of Parliament for Gravesend.

NOTES

[1] Major A. J. Francis is the great-great-grandson of Mr. Charles Francis.

[2] The construction of the tunnel under the river Thames between Wapping and Rotherhithe is described in "The Tunnel" by David Lampe. (Published in 1963 by Messrs George G. Harrap & Co., Ltd., London. Price 21s.) Several references are made to the use of Roman cement in this work which was constructed in the period 1824 to 1842.

[3] "A Hundred Years of Portland Cement" by A. C. (later Sir Charles) Davis was published by Concrete Publications Ltd., in 1924 on the occasion of the centenary of the invention of Portland cement. It is now out of print.

A Conference.

THE Institute of Electrical and Electronics Engineers Inc., are holding a technical conference at the Huntington-Sheraton Hotel, Pasadena, California, U.S.A., from April 14th to 17th, 1964. In previous years this conference has been of interest to electrical engineers associated with the cement industry as well as to chemical and process engineers. The introduction of automation and X-ray gauges working in the raw-meal stream, and similar equipment, further establishes its potential usefulness. Two cement works in California, which are computer controlled, will be visited.

Further information and the final programme can be obtained from the Institute.

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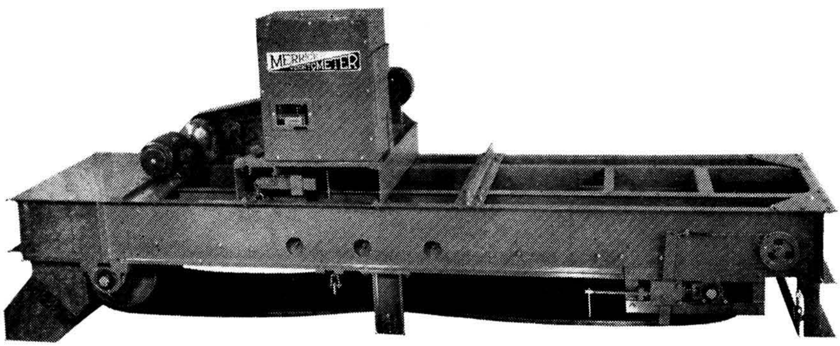

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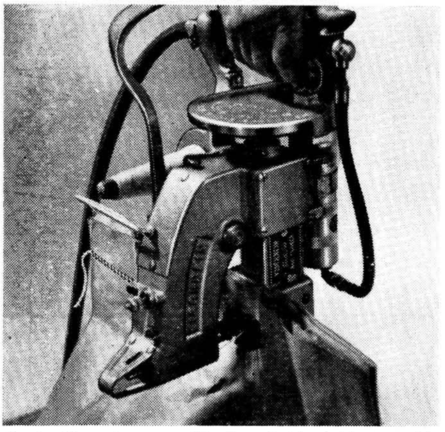

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Recent Research on Cement in Great Britain.

THE annual reports of the Building Research Station and the Cement & Concrete Association, which were published last year, give particulars of research on cement carried out by these two bodies either independently or in collaboration. Some extracts from the reports are given in the following.

High-temperature Studies.

The Building Research Station continues to promote the use of high-temperature microscopes, which it developed, through the manufacturer of the commercial version of the instrument. The high-temperature X-ray camera, based on the same principle as the microscope, is also now commercially available. The basic common feature of the two instruments is a thermocouple to serve the three purposes of heating and holding the specimen and measuring its temperature.

Using these instruments, progress has been made in investigating phase equilibria in the system CaO-Al_2O_3-SiO_2-MgO. One object of studying parts of this quaternary system is to gain information that would promote the utilisation of blast-furnace slag for dense concrete aggregate, work which is being supported financially by the British Iron & Steel Research Association. Over two-hundred synthetic compositions have now been studied to delineate phase boundaries within the partial systems merwinite-akermanite-spinel, merwinite-gehlenite-spinel, and dicalcium silicate-forsterite-alumina. The phase diagram of the last of these systems has been fully established. The intrusive field of dicalcium silicate in these systems, which represents a potential hazard from the point of view of possible instability of the slag, is being carefully delineated.

Cement from Phosphatic Limestone.

Uganda Cement Industries Ltd., have maintained their support for studies designed to gain a better understanding of the manufacture of Portland cement from phosphatic limestone, which work has led recently to establishing the phase diagrams of the systems $2CaO.P_2O_5$-CaO and $2CaO.SiO_2$-$3CaO.P_2O_5$-CaO. The diagram of the former system incorporates a new phase field for $\bar{\alpha}$ $3CaO.P_2O_5$, the highest temperature polymorph of tricalcium phosphate discovered earlier in these studies. The liquidus surface of the system $2CaO.SiO_2$-$3CaO.P_2O_5$-CaO includes a field for $3CaO.SiO_2$ which was not detected by earlier investigators of the system. Compatibility relations between compounds in the system at 1,500 deg. C. have been established. Evidence was obtained for the existence of tricalcium silicate modified by lime and phosphate and of tetracalcium phosphate modified by lime and silica.

Studies of Minor Components.

Studies at the Building Research Station, of the effect of minor components on the calcium silicates have shown that manganous oxide and fluorine together can lead to the presence of trigonal tricalcium silicate, a polymorph not hitherto obtained at room temperatures. The cementing properties of this polymorph are being tested. It has been detected in some Portland cement clinkers.

Research on Portland Cement.

The main constituent of Portland cement is alite, a solid-solution series based on tricalcium silicate, $3CaO.SiO_2$. This mineral occurs as three polymorphic modifications differing in crystal symmetry, one being trigonal, the second monoclinic and the third triclinic. Pure $3CaO.SiO_2$ is triclinic but the addition of various substituting atoms may make the structure either monoclinic or trigonal. These symmetry forms may be determined by X-ray diffraction analysis. Examination of a very large number of commercial Portland cements, the Building Research Station reports, has shown that the overwhelming majority have tricalcium silicate in the monoclinic form, but on rare occasions both the trigonal and monoclinic forms may occur.

It has been shown that the commonest substituting ions in alite are magnesium and aluminium, and a study of the simplified system of $3CaO.SiO_2$ and MgO and Al_2O_3 has shown that the monoclinic form (alite) may be made by the substitution of Mg ions for Ca ions in the structure. Aluminium may also enter into the tricalcium structure, with a change in the cell dimensions but without a change in symmetry, the aluminium replacing silicon and the balance in charge being maintained by the occurrence of aluminium in vacant sites in the structure.

The nearest approach to the alite occurring in commercial Portland cement has been made by combining MgO and Al_2O_3 substitution, giving a formula: $211CaO.11MgO.104SiO_2.2Al_2O_3$.

One point of significance in these studies is the strength-producing qualities of the minerals; taking the strength at seven days of pure dicalcium silicate as 100 per cent., then substituting 7g Mg^{2+} for Ca^{2+}, but keeping the structure triclinic, the strength is reduced by 8 per cent. Further substitution of Mg^{2+} for Ca^{2+} to produce a monoclinic structure increases the strength by 12 per cent.

As part of the Associated Portland Cement Fellowship studies at the Building Research Station, the phase compositions of thirty-six cements have been determined by three methods; the classical method depending on recasting an oxide chemical analysis into standard minerals; a microscopic method, where the phases are estimated by a statistical method of point counting; and an X-ray powder diffraction method. There are considerable differences between the methods and, although good reproducibility may be obtained by the chemical method, it seems that it may frequently considerably underestimate the amount of tricalcium aluminate present.

Hydration of Cement.

In order to elucidate the chemical processes in the carbonation of cement products, an investigation is being made, at the Building Research Station, of the equilibria in the system $CaO\text{-}Al_2O_3\text{-}CaCO_3\text{-}H_2O$ at 25 deg. C. It has been found that extreme care must be taken to avoid further reaction of the solids with atmospheric carbon dioxide during the drying of the samples and the preparation of specimens for X-ray examination. For this purpose, a technique has been developed in which X-ray examination is made on the solid in a sealed cell through which carbon dioxide-free nitrogen at a controlled relative humidity is passed. Using this technique at a relative humidity of 81 per cent., only one form of $13H_2O$ hydrate was formed from $4CaO.Al_2O_3.19H_2O$ or $4CaO.Al_2O_3.11H_2O$, whereas from previous work in which there was some very slight carbonation it was thought that two polymorphic forms of the $13H_2O$ hydrate, designated α and β were formed. The $13H_2O$ hydrate obtained under carbon dioxide-free conditions was identical with the previously described β-$4CaO.Al_2O_3.13H_2O$, but on exposure to air at 81 per cent. relative humidity this compound was found to react with atmospheric carbon dioxide forming some of the so-called α-$4CaO.Al_2O_3.13H_2O$. It is indicated, therefore, that the compound previously described as α-$4CaO.Al_2O_3.13H_2O$ is not a pure tetracalcium aluminate hydrate, but a tetracalcium compound containing carbon dioxide in its structure. This conclusion has been confirmed by some additional experiments in which α-$4CaO.Al_2O_3.13H_2O$ was formed when monocalcium aluminate solutions or suspensions of $2CaO.Al_2O_3.8H_2O$ or $4CaO.Al_2O_3.19H_2O$ in mother-liquor, were treated with calcium carbonate, or sodium carbonate, or carbon dioxide, and the results indicated a composition near to $3CaO.Al_2O_3.\frac{1}{2}Ca(OH)_2.\frac{1}{2}CaCO_3.aq$.

Low-heat Portland-blastfurnace Cement.

Considerable interest is being shown in the use of ground granulated blastfurnace slag in the making of low-heat Portland-blastfurnace cement, and accurate assessments of the heat of hydration of such cements were made in several special investigations connected with their possible use in building dams. Determination of the heat of hydration of slag cements presents special problems. First, the extended solution period of slag cements in acid media may lead to gross inaccuracy in estimating the true temperature rise of a sample introduced into the calorimeter. Second, although the water content of Portland cement may be estimated by a simple loss-on-ignition determination, this procedure is inadmissible for slag cements which contain oxidizable components that prevent reproducible loss-on-ignition results being obtained. These problems have been overcome in a new procedure recommended to the British Standards Institution. The water content is determined by absorption in magnesium perchlorate.

Reactions in the System Lime-silica-water.

In the report of the Cement & Concrete Association it is stated, there is a conflict of evidence regarding the structure of the solid phase CSH(I) in the system CaO-SiO_2-H_2O below 100 deg. C. This phase can be prepared by a variety of methods, and can have a $CaO:SiO_2$-ratio extending over a wide range, without marked structural change, as determined by X-ray diffraction methods. The X-ray powder photographs of synthetic calcium silicate hydrates are invariably diffuse and indicate that the solids are poorly crystallised but the same basic structure persists throughout the range of lime-to-silica ratios and is closely similar to that of the natural mineral tobermorite. One of the objectives of the work in this field has been to ascertain in more detail the structure of the solid calcium silicate hydrate and explain how it can apparently take up calcium ions without change in X-ray powder pattern and hence of unit cell size. An important discovery has been that the dehydration product of CSH(I) is not, as hitherto reported, β-dicalcium silicate, but wollastonite. It appears that the strictest precautions have to be taken to exclude carbon dioxide from all material if trustworthy results are to be obtained. By taking extreme care to avoid carbonation it has been shown that CSH(I) with a $CaO:SiO_2$-ratio in the range 0.3-1.4:1 invariably becomes converted to wollastonite ($CaO:SiO_2$-ratio 1:1) on dehydration. Preparations of CSH(I) of $CaO:SiO_2$-ratio below 1·0 appear to retain their basic structure with slight modification up to 760 deg. C. when they change directly to wollastonite. Preparations with a $CaO:SiO_2$-ratio above 1·0 lose their structural identity at about 550 deg. C., becoming amorphous and then convert to wollastonite at 760 deg. C.

These experiments lend support to the theory that the essential structure of the CSH(I) is one in which the lime:silica ratio is 1:1 or close to it (tobermorite has a $CaO:SiO_2$-ratio between 0·78 and 0·86 to 1) and that as the $CaO:SiO_2$-ratio of the solid is increased above 1·0 this structure becomes modified.

The difficulty of explaining on previous experimental evidence how a tobermorite-like material of $CaO:SiO_2$-ratio 1:1 becomes converted to β-dicalcium silicate of $CaO:SiO_2$-ratio 2:1 can be resolved in the following manner. If carbonation of the CSH(I) takes place, this effectively disrupts the basic structure and calcium carbonate as calcite or vaterite and free silica are formed. Subsequent heating causes a heterogeneous solid state reaction between $CaCO_3$ and SiO_2 to form β-C_2S rather than a topochemical reaction in which crystalline CSH(I) is converted directly to wollastonite (CS). If the hydration of cement takes place in an aqueous phase in all but the earliest stages, it will be one which is supersaturated with respect to calcium hydroxide and in which the $CaO:SiO_2$-ratio of any solids formed would be expected to lie above 1·0. It is important therefore to discover whether at these higher CS-ratios the structure of the solid is fundamentally different from tobermorite or whether it is the same basic structure modified in some way to permit excess CaO to be retained.

X-ray Diffractometry.

Work carried out by the Cement & Concrete Association on X-ray diffractometry has been directed principally towards improving this technique for quantitative analysis of the compound composition of cements. An extensive co-operative experiment with other laboratories in this field has been completed and has produced encouraging results for the precision with which the principal components of cement can be determined. Although some improvement in matters of technique can be expected, the stage may shortly be reached where the accuracy of diffractometric analysis will be determined by uncertainties concerning the

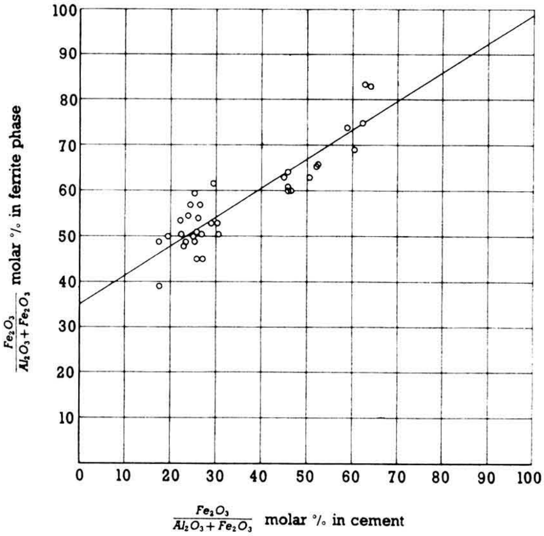

Fig. 1.

structure and identity of the cement minerals occurring in different samples of cement. Although all cement minerals contribute to this uncertainty, the one which has attracted most attention has been the ferrite phase, possibly because of its particular importance in the manufacture of sulphate-resisting cements. It was thought at one time that the iron-bearing phase in Portland cement was the compound brownmillerite and had the composition C_4AF. It has recently been shown that there is a complete solid-solution series extending from C_2F to $C_2A_{0.69}F_{0.31}$ (C_2A does not form) and that there is thus no more reason to expect the formation of C_4AF in a Portland cement than any other composition in the solid-solution series.

Because the size of the crystal unit cell changes as the composition changes, X-ray diffraction measurements can be used to measure the Al_2O_3—Fe_2O_3 ratio in the ferrite phase of a cement. X-ray measurements have been made on a range of ordinary and sulphate-resisting Portland cements and the molar ratio $Fe_2O_3/Al_2O_3+Fe_2O_3$ calculated for the ferrite phase in each cement. This molar ratio has also been calculated from the total Fe_2O_3 and Al_2O_3 as determined by chemical analysis of the cement. *Fig.* 1 shows a graph of these molar ratios and the results follow closely the pattern which theory might predict. Because nearly all cements contain some C_3A, the ferrite phases have a higher Fe_2O_3:Al_2O_3-ratio than that of the cement in which they are formed and in sulphate-resisting cements ferrite phases with very high molar ratios can occur. In *Fig.* 1 the experimental results give points which show considerable scatter about a straight line joining the limiting compositions C_2F and C_6A_2F. It would, however, probably be more satisfactory, particularly for sulphate-resisting cements, when calculating the compound composition of cements by Bogue's method, to take a ferrite composition predicted by this line than to treat the ferrite phase as C_4AF, as is done at present.

The tricalcium aluminate phase of Portland cements is known to differ slightly from pure C_3A and work is in progress to determine the extent to which the compound can take up other oxides without losing its identity. An off-shoot of this investigation has been a study of the system lime-alumina-sulphur trioxide. Close examination of certain tricalcium aluminate preparations revealed the presence of an impurity which has been identified as a compound with the formula $3CaO3$-Al_2O_3. $CaSO_4$ or $C_4A_6O_{12}.SO_4$. This appears to be the only ternary compound in the system CaO-Al_2O_3-SO_3. This compound is interesting since it has been observed, but not identified, as a component of expansive cements and in certain circumstances might be expected to occur in normal Portland cement clinkers. It is of interest because it retains its SO_3 at a temperature well above that at which SO_3 is lost from anhydrite ($CaSO_4$). Under normal atmospheric conditions, $CaSO_4$ is completely decomposed to CaO and SO_3 at 1,270 deg. C., whereas $Ca_4Al_6O_{12}.SO_4$ is only beginning to decompose at 1,400 deg. C.

Other Studies.

Other work carried out by the Cement & Concrete Association includes further research in the hydration of cement and improvements in methods of analysis. These aspects are fully described in the Report of the Association.

Instrumentation in Quarries.

ONE of the papers read at the thirty-ninth annual conference of the Institute of Quarrying, which was held at Brighton last autumn, was entitled " Prospects for the Instrumentation and Control of Quarry Processing Plant." The paper, which was presented by Mr. A. J. Robinson of the D.S.I.R., discussed the automation of quarry plant with special reference to control systems for unit operations and the way in which these methods can be applied to the control of the basic processes. Progress in automatic control in mineral engineering was reviewed, some examples being given, and the probable development indicated.

Another paper, dealing with " Safety and Health in Quarries," was presented by Mr. H. S. Stephenson, H.M. Chief Inspector of Mines and Quarries. The experience of accidents over the past ten years was considered, and particular reference was made to the hazards associated with transport operations. The importance of detailed information on which to assess the safety situation was emphasised.

Copies of the papers are available from the Institute of Quarrying, 62 Baker Street, London, W.1.

The Cement Industry in Japan.

A Cement Plant with a Pre-heater.

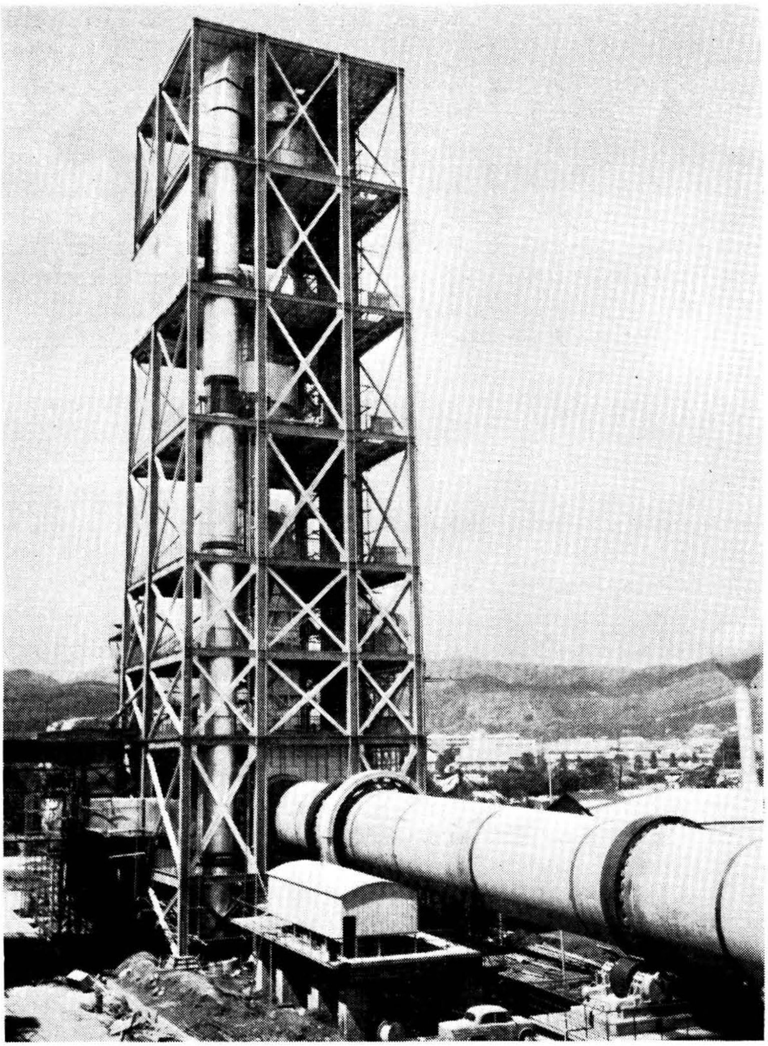

Fig. 1.

ISHIKAWAJIMA-HARIMA Heavy Industries Co., Ltd. (I.H.I.) has recently completed the construction of a cement plant with a pre-heater for the Hitachi Cement Co., Ltd., at Hitachi. The equipment (*Fig.* 1) is made by the Ishikawajima-Harima Humboldt A.G. of West Germany, and has a normal daily productive capacity of 1,000 tons with a maximum of 1,200 tons. This is the second plant of this type constructed by I.H.I., the previous installation being at the Kawasaki works of Daiichi Cement Co., Ltd. It is claimed that, by comparison with the ordinary type of plant, this I.H.I.-Humboldt equipment reduces the heat consumption without loss of efficiency, the heat requirement being normally about 850 k.-cal. per kg. of clinker, although it may be as low as 700 k.-cal. per kg.

The diameter of the kiln is 4·2 metres (13 ft. 9½ in.) and the length is 64 m. (210 ft.). The pre-heating equipment is 15 m. (about 49 ft.) wide, 15 m. (about 49 ft.) deep and 58 m. (about 190 ft.) high.

Computer Control at a Japanese Cement Works

THE Japanese cement company, Tokuyama Soda Co., Ltd., is installing a computer control system. Its Nanyo works, Tokuyama City, which is claimed to be one of the most modern in the world, is being extended to include two rotary kilns, each nearly 650 ft. long and over 17 ft. in diameter. The computer control system, which will permit both kilns to be controlled completely automatically, is being supplied by Thompson Ramo Woodridge Computers Co., the American associates of International Systems Control Ltd., of Wembley, England. The system will provide co-ordinated close-loop control of the kilns and the continuous slurry-blending system. The automatic optimisation of plant operation which will be achieved is expected to result in increased production and a more uniform quality of the various grades of Portland cement produced. In addition to determining the most effective settings of the kiln controls, the computer system will schedule raw materials in transit from the silos to the mills, from the mills to the slurry tanks and from the slurry tanks to the slurry basins.

The computer makes calculations on formulæ which have been established to describe the entire cement-making process in order to determine kiln temperature and raw-material composition for given operating data. A programme is provided to adjust the formulæ to match changes in the physical characteristics of the kiln. After adjustments to the formulæ, an optimising programme determines the best operating parameters and control settings for each kiln by considering the characteristics of the kiln and the composition of the slurry. A dynamic regulation programme maintains the desired values of these operating parameters in the face of independent disturbances; constraint equations restrict control actions to within the limitations of the plant.

The annual productive capacity of the Nanyo works is at present about 600,000 tons and, with the addition of the new kiln, this will be doubled.

A Quick-setting Cement.

It was reported recently that a quick-setting cement, having high compressive strength and of lightweight and extremely resistant to water, has been developed by Setsuo Higashi of Irumagun, Japan. It is stated that the basis is a mixture of finely-divided calcium dihydrogen phosphate, zinc silicate and water which produces a cement suitable for use in the building industry or for other purposes.

An Amalgamation.

It has been announced that the Iwaki Cement Co., Ltd., has absorbed Fukushima Cement Co., and Sumitomo Lime Industry.

New and Revised U.S.A. Standards.

SEVERAL new and revised standards relating to the cement and concrete industries have been published in collective form recently by the American Society for Testing Materials. Copies of the publications are obtainable from ASTM Headquarters, 1916 Race Street, Philadelphia 3, Pa., U.S.A., at the prices stated.

Cement.

Much new matter is included in the 1962 edition of "ASTM Standards on Cement (With Related Information) C-1" (price 4·25 dollars). In this volume there are collected together twelve specifications, twenty-six methods of test, and one definition of terms. The five appendices include the comprehensive "Manual of Cement Testing." Twenty of the total of thirty-nine standards in this volume are either new or revised. The new standards include a specification (C 465-62T) for processing admixtures for use in the manufacture of Portland cement, and a specification (C 490-62T) for apparatus for use in the measurement of the volume change of cement paste, mortar, and concrete. Important revisions have been made in the specifications for Portland cement and in a number of the methods of testing.

Refractory Materials.

Sixteen new standards dealing with silica brick, basic brick, carbon brick, and dolomite brick are given in the latest edition of "ASTM Standards on Refractory Materials C-8" (price 4·00 dollars). The manual contains specifications, classifications, methods of testing, definitions, recommended procedures, standard samples of refractory materials, and test data. In addition to the standard documents, the manual also includes data on the latest standard samples provided by the National Bureau of Standards and new information on the petrographic study of refractories. Of particular interest are new classifications for alumina bricks, chrome bricks, mullite refractories, silica refractory bricks, and refractory granular dolomite. The industrial surveys given in previous issues are being completely revised and are therefore omitted from the new edition.

Cement, Aggregates and Concrete.

A revised and enlarged edition of the collection of standards relating to aggregates and concrete, entitled "Standards on Mineral Aggregates and Concrete with Selected Highway Information" (price 6·75 dollars) has also been published. This volume contains 124 specifications, methods of test, definitions, and recommended practices, fifty-one of which are revisions and seventeen are new standards or tentative specifications. Included among the new documents are tentative specifications entitled "Specification for Chemical Admixtures for Concrete C494-62T," and "Test for Compressive Strength of Lightweight Insulating Concrete C495-62T." The latter is the first of a series of special methods of test required to determine the properties of lightweight concrete. The other standards include those for cement, aggregates, concrete, curing materials, and expansion-joint fillers.

New Publications.

"Vom Kalkstein zum Kalk." (Wiesbaden: Bauverlag G.M.B.H. 1963. Price 18 DM.).
IN this book of some 235 pages, which is published under the auspices of the Bundesverband der Deutschen Kalkindustrie (Federation of the German Lime Industry), a comprehensive account is presented of the industry from the winning of the raw material to the preparation of the final product. Technical progress in recent years has been such that the structure of the lime industry has changed due to developments in mechanisation and automation of the burning process, and rationalisation of the discharging, grinding and screening operations. The advances result in less manual labour being required, but higher training of operatives. This training calls for more up-to-date technical literature and, it is claimed, this book will be an aid in filling this need. The user of lime will also find much of interest in this volume which is written in the German language but is well illustrated.

The contents include some preliminary remarks on the importance of lime in various industries and the development of the German lime industry. Then follow chapters dealing with the occurrence and quarrying of limestone and dolomitic rocks, the transportation of the raw material, the equipment for, and operation of, burning-in kilns of all types, and the grinding, packing and despatch of the prepared lime. Other subjects include the maintenance of machines, buildings and other equipment, and the selling and use of the finished product.

"Hochofenschlacke." By F. Keil. (Düsseldorf: Verlag Stahleisen M.B.H. Second Edition. 1963. Price 54 DM.)
THIS book, which was first published in 1948, deals in some four-hundred pages with almost all aspects of blastfurnace slag, and therefore contains information and data not only for those concerned with iron and steel works, but for engineers and chemists in the cement and concrete industries. Some specific subjects are the preparation and use of quickly-cooled slag, foamed slag for lightweight concrete, and the use of slag in iron cement and Portland-blastfurnace cement. In the fifteen years since the first edition was published, there have been considerable developments in the treatment and uses of this material and these are dealt with in sufficient detail to be of practical use to those interested who can read German. It is published as Volume 7 in a series of books on steel and iron.

"Taschenbuch für die Zementpraxis". By O. Labahn. (Wiesbaden: Bau Verlag. Third Edition. 1963. Price 14.50 DM.)
THIS handbook for those engaged in the cement industry contains in the enlarged third edition about 250 pages and 37 charts and tables. Some data of practice, not only in Germany, but in Britain, Spain and Italy are given.

Cement in the Commonwealth.

THE subject of the fortieth report* of the Commonwealth Economic Committee is the production of cement in the Commonwealth. The annual consumption of cement in Commonwealth countries increased by about 15,000,000 tons between 1951 and 1960, and it seems likely that by 1965 there will be a further increase of about 11,000,000 tons. In seven countries, namely, the United Kingdom, India, Canada, Australia, Pakistan, New Zealand and Ceylon, the total home demand for cement may reach 42,000,000 tons by 1965, an increase of about one-third since 1960.

In the United Kingdom, an important influence on the demand for cement was the long decline in exports. With a large part of former British export market for grey cement now lost, the total demand in the future is expected to follow more closely the growth of the home demand. In response to this new situation, the report states, the British cement industry is now among the most rapidly growing of the Commonwealth cement industries. The decline of cement exports from Britain since 1952 is associated with the general rehabilitation and expansion of the cement industries of European countries and countries in the Far East, and therefore transport costs again had a major influence on international trade. The loss of markets due to the industrialisation of developing countries, however, is to some extent compensated for by the growing stake of British companies in the cement industries of other Commonwealth countries.

Between 1951 and 1961, the manufacture of cement was initiated in Cyprus, Uganda, Nigeria, Jamaica, Trinidad and Malaya. In 1962, it began in Singapore and Fiji. Expansion of productive capacity is now taking place, or is expected soon to take place, in Australia, Ceylon, India, Jamaica, Nigeria, Pakistan and Tanganyika, as well as in the United Kingdom. Plans concerning the establishment of cement industries in Ghana, Sierra Leone and the Bahamas have been announced. The growth of cement industry in many of these countries has been helped by the British cement industry, and the report gives many other examples of intra-Commonwealth and international co-operation, including the part played by Canada and New Zealand, through the agency of the Colombo Plan, in the establishment of two cement works in Pakistan. Among other notable developments between 1951 and 1961, was the expansion of regional export markets by Canada, Kenya and Trinidad, in each of which countries British capital is playing a useful part in the cement industry.

Among the more interesting directions in which the consumption of cement is extending are the precast concrete products industry and ready-mixed concrete; these two uses account for about 70 per cent. of deliveries in the U.S.A., some 40 per cent. in Australia, and over one-third in Canada and the United Kingdom.

* "Cement in the Commonwealth". (London: H.M.S.O. 1963. Price 7s. 6d.)

Blaine Fineness Test Apparatus.

A NEW type of apparatus for making the Blaine fineness test is being produced by Soiltest Inc., of Chicago. The apparatus is shown in the accompanying illustration.

The apparatus, which conforms to the requirements of ASTM C-204 and AASHO T-153, comprises a U-tube manometer containing liquid which provides a pressure difference and indicates the volume of air flow during the test. The graduated manometer has an interchangeable ground joint with a stainless steel test-cell, stop cock and air belt. The test-cell is fitted with a brass perforated disk, stainless steel cell body and Bakelite plunger to provide the required volume inside the cell. The operating components are mounted on a sturdy metal base.

Lime Works for Yugoslavia.

Yugoslavia has ordered the equipment for a fifth lime works from Hungary, which State will supply the crushing and screening installations and the shaft kilns. The works will be fired by oil instead of the traditional gas. Delivery is expected this year. The necessary steelwork is being made in Yugoslavia, and erection will be done by Yugoslavian firms under the guidance of Hungarian engineers.

Two of the earlier lime works are now in operation, the other two being in course of construction.

A New Bulk Transporter.

THE Fruehauf Trailer Co., of the U.S.A., has developed recently a new vehicle (*Fig.* 1) for transporting cement in bulk, which embodies the advantages of the "Airslide" method* of unloading in a strong lightweight vehicle. The transporter has a capacity of up to 20 tons of cement which, it is claimed, can be unloaded in seven minutes. In the single unit form, the 24-ft. container is housed within a framed structure, within which it can be located backward or forward to give the most effective distribution of the load. Unloading is accomplished on the "Airslide" principle by means of which air is forced through a specially woven fabric to agitate the cement so that it will flow downwards at a surface angle of about 4 deg. When unloading, the container is tilted at an angle of 7 deg. on a 20-in. "Airslide" panel. The "Airslide" consists of a U-shaped trough which is covered with the fabric through which the air seeps causing the contents to flow to the discharge point at the rear of the vehicle. The unloading device is operated by a 10-h.p. air-cooled engine located in a weatherproof compartment in the nose of the vehicle, and equipped with a self-starter, high-speed blower and an air filter.

With the single-panel unit the overall length of the vehicle is 32 ft., the overall height being 11 ft. 3 in. It weighs about 5 tons when mounted on a tandem-axle chassis. To assist speed of discharge, there is a quick-coupled sock, seen at the rear of the vehicle in *Fig.* 1, the sock being equipped with a weathertight hinged

* See page 42.

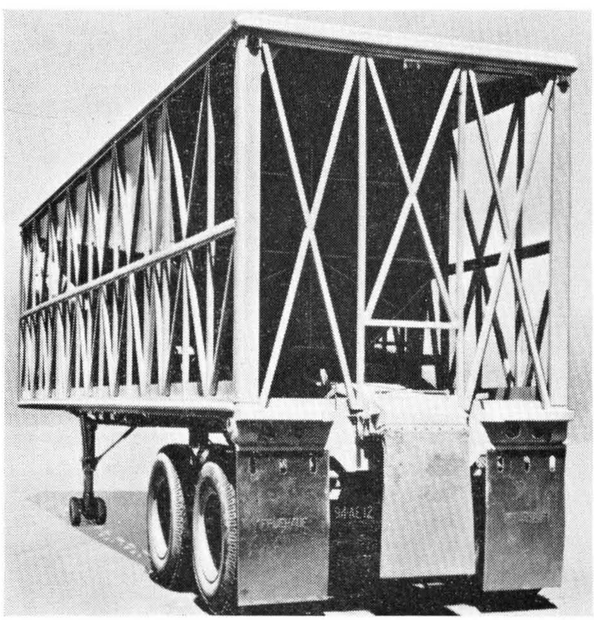

Fig. 1.

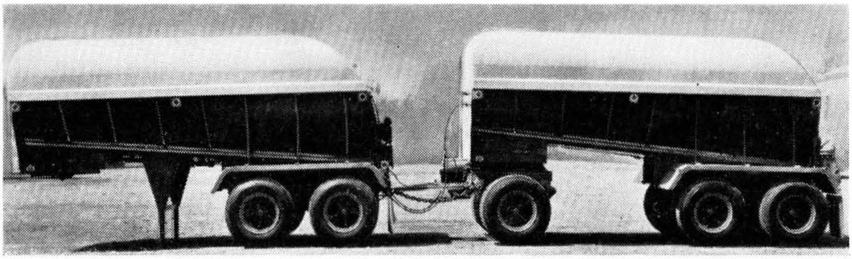

Fig. 2.

cover and an inside damper, and capable of being folded away when the vehicle is in transit.

A twin-panel transporter is also supplied and can be used either singly or coupled together in a train (*Fig.* 2). If used in a train, each unit has its own engine-driven high-speed blower in a weatherproof compartment in the nose for " Airslide " unloading. The twin-panel unit is obtainable in capacities from $12\frac{1}{2}$ to 21 tons. The overall length varies from 18 to 24 ft., and the overall height is 10 ft. 10 in. The unit discharges at the rate of $1\frac{2}{3}$ to $2\frac{1}{2}$ tons per minute. When designed for operation in a train, the units have a capacity of $16\frac{2}{3}$ tons each and are 18 ft. long.

Portland-blastfurnace Cement in Scotland.

In this journal for November last, the closure of the cement works of the Coltness Iron Co., Ltd., at Newmains, Lanarkshire, where Portland-blastfurnace cement was made, was reported. Large quantities of this type of cement, however, continue to be made by the Caledonian Cement Co., Ltd., at their works at Gartsherrie, Coatbridge, Lanarkshire; this is the Caledonian brand which in all respects conforms to the requirements of British Standard 146 for Portland-blastfurnace cement.

"Airslide" Air-activated Conveyors.

THE term "Airslide" is the trade mark for air-activated (or fluidising) gravity conveyors and related parts and accessories of the Fuller Company, of Catasauqua, Pennsylvania, U.S.A., and is registered as such in several countries including Great Britain (Reg. No. 712,768), Canada (Reg. No. 46635/183), and the U.S.A. (Reg. No. 533,150). The sole registered users of the trade marks "Airslide" and "F. H. Airslide" in the United Kingdom are Constantin (Engineers) Ltd.

This type of equipment is used at the new Dunbar cement works (see page 10 of this journal for January last) and in the vehicles described on page 41 of the present number.

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