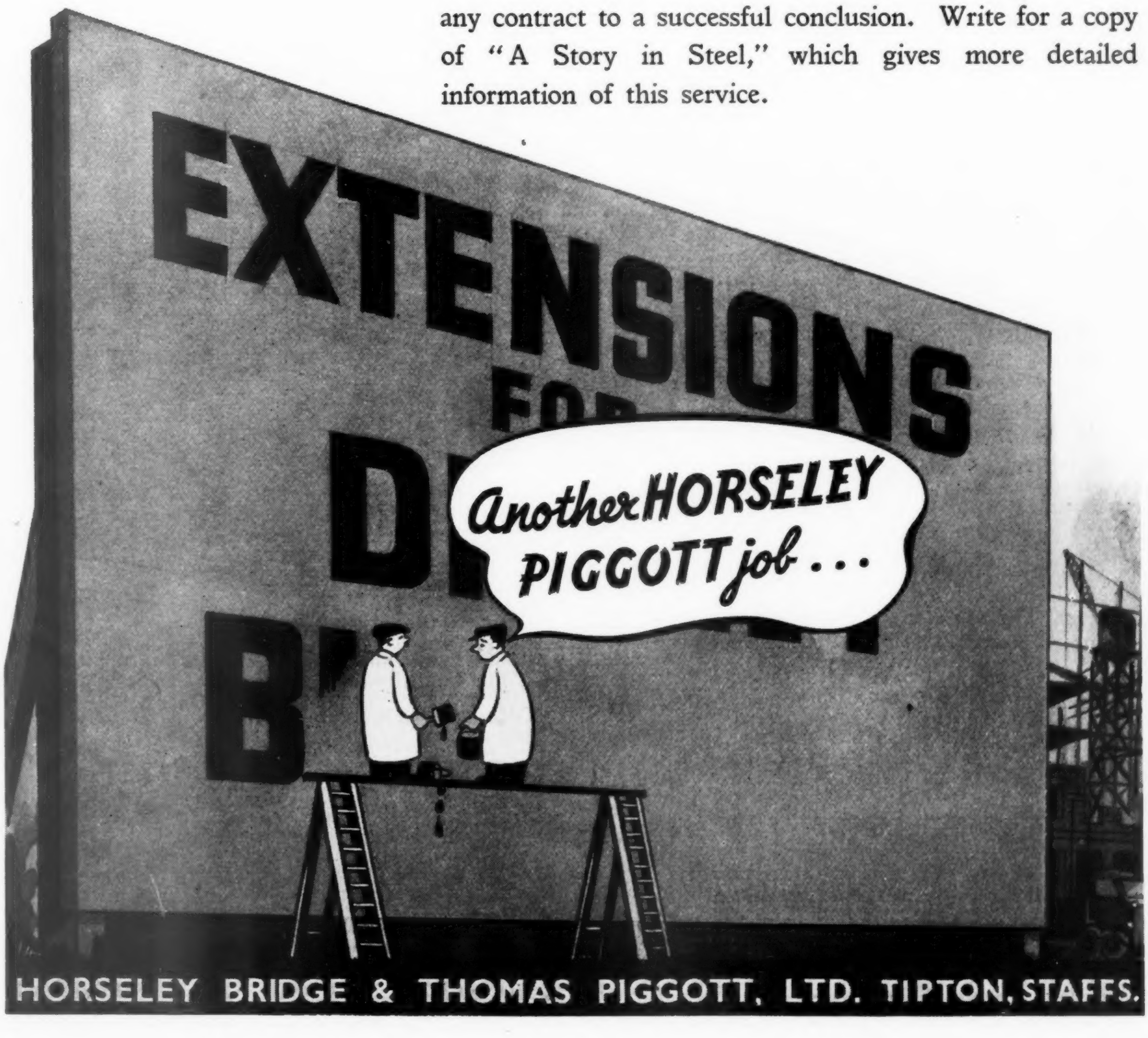
Sooner or later . . .

FOR ALL STEELWORK

. . . every enterprising firm needs new buildings or requires extensions to old ones. Steel is the ideal medium for these purposes. It is quicker to erect, more permanent and more economic than any other material. But the manufacture and erection of structural steelwork requires experience, knowledge and wide resources. That is why it is essential that work of this nature should be placed in the hands of a firm of long standing.

The Horseley-Piggott organisation is exceptionally well-equipped for this class of work. With many years' experience in every phase of design, fabrication and erection we have all the qualifications necessary to carry any contract to a successful conclusion. Write for a copy of "A Story in Steel," which gives more detailed information of this service.



HORSELEY BRIDGE & THOMAS PIGGOTT, LTD. TIPTON, STAFFS.

THE

ARCHITECTS'

JOURNAL

THE ARCHITECTS' JOURNAL WITH WHICH IS INCORPORATED THE BUILDERS' JOURNAL AND THE ARCHITECTURAL ENGINEER IS PUBLISHED EVERY THURSDAY BY THE ARCHITECTURAL PRESS (PUBLISHERS OF THE ARCHITECTS' JOURNAL, THE ARCHITECTURAL REVIEW, SPECIFICATION, AND WHO'S WHO IN ARCHITECTURE) FROM 45 THE AVENUE, CHEAM, SURREY

*

THE ANNUAL SUBSCRIPTION RATES ARE AS FOLLOWS :
BY POST IN THE UNITED KINGDOM.... £1 3 10
BY POST TO CANADA £1 3 10
BY POST ELSEWHERE ABROAD........ £1 8 6
SPECIAL COMBINED RATE FOR SUBSCRIBERS TAKING BOTH THE ARCHITECTURAL REVIEW AND THE ARCHITECTS' JOURNAL : INLAND £2 6s. ; ABROAD £2 10s.
SUBSCRIPTIONS MAY BE BOOKED AT ALL NEWSAGENTS

*

SINGLE COPIES, SIXPENCE ; POST FREE, EIGHTPENCE. SPECIAL NUMBERS ARE INCLUDED IN SUBSCRIPTION ; SINGLE COPIES, ONE SHILLING ; POST FREE, 1s. 3d. BACK NUMBERS MORE THAN TWELVE MONTHS OLD (WHEN AVAILABLE), DOUBLE PRICE.

*

SUBSCRIBERS CAN HAVE THEIR VOLUMES BOUND COMPLETE WITH INDEX, IN CLOTH CASES, AT A COST OF 10s. EACH. CARRIAGE 1s. EXTRA

*

45 The Avenue, Cheam, Surrey
TELEPHONE : VIGILANT 0087-9 (3 LINES)

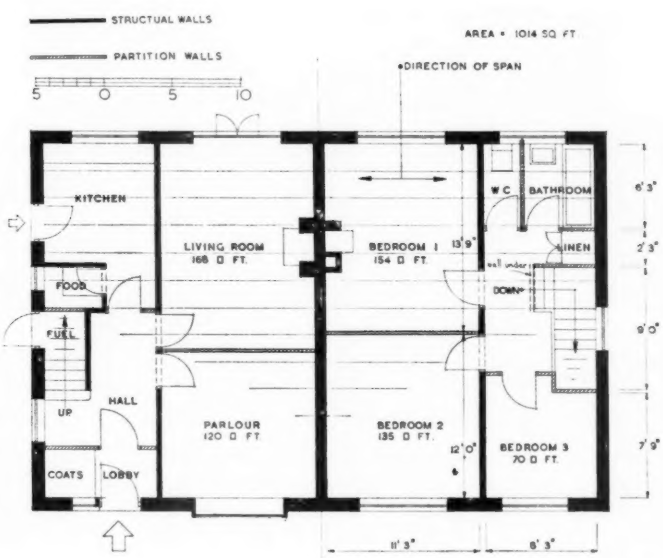
The Editor will be glad to receive MS. articles and also illustrations of current architecture in this country and abroad with a view to publication. Though every care will be taken, the Editor cannot hold himself responsible for material sent him.

THURSDAY, JULY 18, 1940. NUMBER 2374 : VOLUME 92

PRINCIPAL CONTENTS

The illustrations of the store in Christchurch on page 42 are reproduced by courtesy of Callender's Cable and Construction Co., Ltd., who supplied the cables for the building.

PROPOSED HOUSING SCHEME, COVENTRY



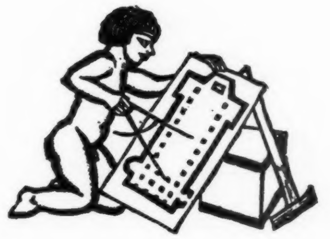
GROUND FLOOR PLAN

FIRST FLOOR PLAN

The Coventry City Council recently decided to proceed with the erection of 2,500 houses, which are to be built of concrete units and asbestos-cement products. The perspective (by R. Myerscough-Walker) and plans of this scheme, designed by Mr. D. E. E. Gibson, Coventry City Architect, shown on this page, are now on exhibition at the London offices of the Cement and Concrete Association.

Air view and main front, by night, of a new store in Tuam Street, Christchurch, New Zealand, designed by Mr. G. A. J. Hart. It is a five-storey building ; the roof has been planned for recreation purposes and provides space for three tennis and three badminton courts. Construction : R.C. ; external walls and parapet are rendered with coloured cements with mica finish ; windows, steel framed.

NEW STORE AT CHRISTCHURCH, NEW ZEALAND



THE NEW BUILDING

ALMOST the whole of this issue is occupied by a survey of methods by which brickwork can be used as a substitute for other materials.

Some of the methods described may come into common and permanent use: but all of them owe their development and immediate importance to the conditions under which the building industry will have to work for the duration of the war—and perhaps for some time afterwards.

These conditions are unique in the industry's history. They demand that a considerable amount of quick, light, cheap building should be carried out without using just those materials, and thus the forms of construction, on which the industry has been accustomed to rely for work of this kind.

From now on, timber and steel will be available only in minimum quantities for works of greater national consequence. Thus the principal materials for light framing are cut off. A great many light covering materials are partly compounded of timber or steel, and others are dependent upon shipping space which may be expected to be curtailed. In consequence, light covering materials and the devices necessary for their fixing will almost certainly become more difficult to obtain.

Nor is this all. The shortage of timber does not only help to deprive the industry of the manifold constructional forms evolved in the last forty years: it also rules out some of the commonest traditional building methods. For all building works of secondary national importance, the building industry will have to develop a new technique; and it requires little thought to see that this new technique must be an up-to-date version of one so old that only architectural students and archæologists will know anything about it. War in this has routed the Modernists, but none of the Old Guard are old enough to take their vacant places.

The main resources which will be at the disposal of the industry in the coming months will be those possessed by the Romans: stone, brick, mortar and concrete. For finishings there will be glass, plaster and a range of proprietary materials whose use will be controlled by the difficulty of obtaining framing or surfaces to which to apply them.

The form which the carcassing of less important buildings must take is therefore obvious. Spans must be the smallest possible spans; all structures must have load-bearing walls and piers; roofs that can be arched must be arched with minimum reinforcement. Where upper floors are unavoidable, they also must be of hollow brick or concrete with minimum reinforcement. And since speed is still of importance, the walls and piers of the new buildings will be generally of brick or concrete blocks.

The new situation will have two main results for the industry. The main carcassing materials are available throughout the greater part of the country, and therefore a very wide distribution of contracts is made possible. Secondly, it will be necessary to discover, with the least possible delay, the most generally suitable structural form for each common type of war building and, thereafter, to make this knowledge available to the whole industry by detailed drawings.

Some of this work has already been done by the Building Research Station, and during the last few months the principal materials' manufacturers have carried out many experiments to determine how their products can best be adapted to the new building conditions.

In this issue the JOURNAL summarizes the preparations which have been made by the manufacturers of bricks and clay products—the most widely used of all building materials in Britain.

These preparations have been of three kinds: the development of brickwork substitutes for other forms of construction; examination of methods by which brick construction can be speeded up; and research into the scientific calculation—as opposed to the rule-of-thumb design—of brickwork structures. And in examining the results—the interim results—of these preparations and experiments, architects and builders should bear in mind the situation which now confronts them. The suggestions put forward in this issue are not peacetime suggestions: they are put forward as contributions to the solution of a wartime problem—and one which will grow greater rather than less. Many materials upon which the building industry has come to rely will become increasingly scarce as the war goes on, but bricks and mortar and concrete will always be available. Therefore it is from these that the new technique of construction must chiefly be evolved.

The JOURNAL hopes to describe in future issues the preparations and ways in which other basic materials are being developed to meet the new situation.

The Architects' Journal
45 The Avenue, Cheam, Surrey
Telephone: Vigilant 0087-9.

NOTES & TOPICS

THE HOUSING COMPETITION

THE competition announced by the R.I.B.A. last week can be guaranteed to arouse the interest of architects to a very special degree. It is the only competition open; it is intended to serve both a wartime and a post-war purpose; its conditions bulge with fascinating problems; and its jury of assessors inspires confidence.

*

The double aim of the competition and the present position concerning building materials impose on each competitor the necessity of taking his scheme through three successive stages—and of carrying out considerable research at each stage.

*

The first aim of the competition is to provide housing for civilian labour transferred for war purposes—such as munition workers. The conditions suggest that each 1st Stage House might provide sleeping, sitting and washing accommodation for 4–8 of these workers, while bathing, feeding and recreational facilities are arranged communally. This is a logical suggestion, but competitors will, I imagine, soon find themselves in need of more detailed information about the administration of such settlements. Workers may vary from girls of 18 to long-married machinists of 50. Six of the former might clean and run their own house: six of the latter might make poor showing—quite apart from the question of what proportion of married workers bring their families with them.

*

The second intention of the competition is that 1st Stage Houses should be able to be transformed, by the addition of a wing or a floor after the war, into family houses of one or other of the types now approved by the Ministry of Health. Planning for this transformation will form the second stage of each scheme: but both first and second stages must remain in roughest sketch form until they are reconciled with the third stage—the choice of materials and forms of construction.

Construction may well prove the most difficult and most interesting part of the competition. The conditions ask for a construction that is quick and cheap—as does everyone who is placing a building contract just now.

*

But this construction, presumably, must make minimum demands on timber, steel and imported materials. Bricks and concrete—the two main materials which fulfil these conditions—do not readily lend themselves to fast construction unless a good deal of plant, skilled labour and careful organization are available: and each of these is difficult to secure at present.

*

The architects who produce a convincing solution to this triple problem will have deserved well of their country.

THE TRAFFIC JAM

Carping at overworked people is poor fun. The following true story is not meant to throw blame on an individual or a department: it is merely additional evidence for the general belief that Civil Service organization and methods were not meant to handle the work now imposed on them, cannot handle it, and should be changed. Designations of departments and sub-departments are fictitious.

*

Compelled to find out what stage in its career had been reached by an application for a licence for one of the temporarily rare metals, I wrote to, and next day rang up, the Board of Y, Extension (f), with whom I had already telephoned and corresponded. They knew nothing about the application, but promised to ring up later. Nothing happened. Next day I rang up again. They still knew nothing, and had now given up hope: try Extension (q).

Nothing known there: try Extension (m). Nothing known: "Operator, put this call through to Extension (q)." Operator refuses. This irritates Extension (m) into the discovery that the application has gone to the Ministry of Z and, after some more bandying about between the coy fauna of the endless corridors, I am assured that Miss Smith of the Ministry of Z will be able to give me all the news I want. I ring her up: she knows nothing about it: will ring back later. Nothing happens. Next day I ring up again. Miss Smith still knows nothing. Side-stepping neatly she lets me by to her colleague. He takes me first bounce with that steady back-hand promise to ring up later. He surprisingly does.

*

I have never felt more like a ping-pong ball.

PENGUINS AND MR. TOPOLSKI

A new version of the eighteenth-century broadsheet has just appeared. It is the first of a series sponsored by the enterprising John "Penguin" Lane, and takes the form of coloured lithographs, drawn by Feliks Topolski, which will provide, it is hoped, a regular commentary on the personalities and events of the times.

*

There will be a limited edition only of each design, and they are to be obtainable at any bookstall, price sixpence. The first, a portrait of Winston Churchill in fighting mood, is already on sale.

*

I was able to see the other day, in Mr. Topolski's studio, his sketches for future broadsheets, and they promise to be a really remarkable set. Mr. Topolski, who was recently appointed official war artist to the Polish army, is well known as a lively draughtsman. He should be equally celebrated for his understanding of the British type and scene.

The penetrating light which he throws upon us is not malicious, it is almost affectionate in the way it reveals our national characteristics. In the technique of lithography he shows himself to be a master, and he makes full use of the available materials, the coarse newsprint paper, and simple clear colours.

*

The scheme is experimental and depends for its continuation upon public support. A war commentary of such potential importance should not be allowed to run the risk of failure, and it is to be hoped that John Lane's latest enterprise will have the success which has attended all his others.

NEW EVACUATION ZONES

The changing of certain areas near London from neutral to evacuation areas has produced little effect on the inhabitants.

*

In one Surrey district I accompanied an acquaintance while he tried to explain the change of status to one or two householders. They heard his explanation stolidly, but it seemed to me that the man who showed the most lively interest was one who clung to the belief that, in changing him from a " neutral " to an " evacuee," the Government had put something across him while he wasn't looking.

*

It was a gorgeous afternoon. Children played in many open spaces and the gardens would have warmed Mr. Middleton's heart. My acquaintance confessed that the task of explaining that this unwarlike scene was now a danger zone was not an easy one.

*

Nine out of ten householders, he told me, make one of two replies : (1) What's the use of sending kiddies to the country when all the bombs fall in the country ? . . . much sooner keep them here ; (2) What I say is, if your name's on a bomb you're for it, wherever you are.

*

The second answer was so frequently given in one district that it was put forward as definite evidence of Fifth Column activity. But the police remembered that a somewhat similar attitude was once common long before General Franco invented Fifth Columns.

LIFE DOWN UNDER

An architect in exile with an official department, having read my note of the experiences of the Night Watch at St. Paul's, has sent me a story of more lively air-raid surroundings :

There's no sleeping through an air-raid in this house. The nearest siren is so close it blows the sheets off one's bed, and if that should not be enough there is our landlady—worthy soul—acting as knocker-up and leading the way into the cellar. One's dressing-gown appears to have no arms, and a fountain pen has found its way into the toe of one bedroom slipper. Halfway down the narrow stairs there is confusion—the procession halts and partly reverses as the landlady battles her way back for her hairnet.

*

How quaint is domestic architecture when prolongedly studied from underneath. Why are the joists all of different shapes and sizes, and why are they not stronger ? The hum of 'planes overhead penetrates even to the cellar. Yes, why are they not stronger ? Our Mr. Williams is seen to have a tin hat. We think he ought to offer it to his wife, but he prefers to wear it himself and sits in a corner attending to his gas-mask with a wan expression and a tube of anti-dim.

*

An occasional croompp in the distance keeps the party from becoming too phlegmatic, as does the 5-in. bright pink slug which is suddenly viewed with horror by all present. Whistling bombs are heard clearly, but they turn out to be someone's gastric juices and cause great embarrassment.

*

The four-hour vigil is uncomfortable, but at least it is good practice, and not unprofitable. We are to have a bucket of sand.

MORE ABOUT STARLINGS

A fortnight ago I quoted from the *Daily Express* the story of an architect who was fined £1 for a blackout lighting offence in spite of his straightforward explanation that a starling had flown in and switched on the offending lamp.

*

A correspondent in Surrey has now written to me deprecating the Bench's scepticism : with very good reason.

Until the last year or two (he writes) the rural district where I live was lighted by gas, and the fittings generally were the lever arm type with chains. Returning home one Sunday night from a week-end visit, I was surprised to find the house full of gas. Investigation—without a light—led to the discovery of a starling dead in a bedroom and a gas lamp turned full on. The bird had apparently descended the chimney flue and perched on the lever arm of the gas bracket.

ART OF THE CAMP SIGN . . .

An army camp in the West has abandoned the use of soulless numbers to distinguish its huts, and commissioned the younger members of the West of England Academy to paint boards on the lines of inn-signs. This is a point up to those who maintain that there is more sympathy for the arts in the fighting than in the more sedentary Services. When will the stony labyrinths of Whitehall and London County blossom into pictorial directions for benighted wanderers ?

. . . AND THE SILENT SERVICE

That the Navy also relishes a touch of romance is proved, I think, by the following story. An acquaintance, now serving in the F.A.N.Y.s, is stationed in a large college hostel which is partly occupied by a detachment of W.R.N.S.

*

One morning she was ordered to change the water in some fire buckets on the fifth floor. There was, of course, no lift, and after many breathless flights of stairs she found she had lost count. A passing Wren was hailed and asked if this was the fifth floor. The reply was frigid : " I can't say, but this is D deck of H.M.S. Blankshire."

ASTRAGAL

INFORMATION CENTRE

The restriction of paper supplies, together with the publication this week of BRICKS IN WARTIME, has made it necessary to omit the Information Centre Questions and Answers from this issue.

The feature will be resumed next week in the usual form.

NEWS

R.I.B.A. LIBRARY

The R.I.B.A. Reference and Loan Libraries will remain open during August at the same times as at present : from 10 a.m. to 6 p.m. (Saturday, 10 a.m. to 5 p.m.).

Members of the R.I.B.A. are reminded that books can be borrowed by post by readers anywhere in the British Isles. The R.I.B.A. pays outward postage except to readers in the London area.

CONTRIBUTIONS TO WAR FINANCE

Mr. George Hicks, M.P., General Secretary of the Amalgamated Union of Building Trade Workers of Great Britain and Ireland, has been appointed Chairman of a newly-formed War Savings Committee of the Building, Civil Engineering and Allied Industries. A leaflet describing the most effective way in which firms employed in the industries concerned can take part is under preparation for distribution throughout the country. It will go to some 17,688 member firms of appropriate Federations.

The setting up of this committee is designed to ensure that every employee in building and civil engineering and kindred industries is given immediate facilities for saving and lending to help in the war finance campaign. It is estimated that there must be considerably more than 2,000,000 people employed in these industries.

Honorary secretary of the newly-formed committee is Captain W. T. Creswell, K.C., and other members are : Mr. A. H. Adamson (Messrs. T. H. Adamson and Sons, Contractors, Putney High Street, S.W.15), London Master Builders' Association; Mr. H. T. Holloway (Messrs. Holloway Bros., 157 Millbank, S.W.1), President of the Federation of Civil Engineering Contractors; Mr. H. C. J. Johnson (Leeds Fireclay Co., Ltd., 2 Cavendish Place, W.1), President of the Building Industries National Council; Mr. C. Kerridge (Contractor, Cambridge), President National Federation of Building Trade Employers; Mr. T. A. Macintyre (Messrs. Shanks & Co., 81 New Bond Street, W.1), President of the National Federation of Specialists and Sub-contractors).

The first step taken by the newly-formed committee was to pass a resolution declaring that "This Committee, representing those engaged in the building, civil engineering and allied industries, resolves to support the War Savings Campaign and the principle of voluntary savings, and urges all engaged in these industries to form and join war savings groups."

TOYS FOR CHILDREN

A group has been organized to make educational toys for young children evacuated from their homes, and material is needed for this purpose. Would any architects having old strainers or plywood mounting boards, rollers from paper and tracing linen, wood samples, trimmings of tracing linen and other suitable waste material, please communicate with Mrs. Lanchester, 19 Bedford Square, London, W.C.1 ?

TIMBER CONTROL

The following rearrangement of Timber Control Areas was made on July 15 :

1. With the exception of the County of Bedford, which has been incorporated in Area 5 (London), Area 4 (Kings Lynn) has been amalgamated with Area 3 with headquarters at Nottingham and Mr. W. O. Woodward as Area Officer. A sub-area office to deal with home-grown timber matters has been established at Kings Lynn.

2. Area 6 (Southampton) has been abolished, the territory being distributed as follows :—

(a) Berkshire, Hampshire (excluding the County Borough of Bournemouth) and the County of Sussex transferred to Area 5 (London).

(b) The County of Dorset, the southern half of Wiltshire and the County Borough of Bournemouth have been transferred to Area 8 (Bristol).

3. The Counties of Westmorland and Cumberland have been transferred from Area 9 (Liverpool) to Area 1 (Newcastle-on-Tyne).

THE NATIONAL TRUST

"The National Trust's foremost aim in wartime must be to survive the war with its buildings in sound repair, with its farms productive and in good order, with the beauty of its woodlands and open spaces unspoiled and with its financial stability maintained," states the Annual Report of the Trust, just issued. Report continues :

There can, in fact, be no question that the continuous endeavour to promote the acquisition of new properties must cease for the time being and that efforts must be concentrated on the task of preserving its present properties in their present condition. Many of the hopes of a year ago must be temporarily buried ; the completion of various appeals which had not been brought to a successful conclusion by September 3—Sharpenhoe, Avebury, Wicken Fen Endowment—must be at least temporarily abandoned ; and so too must many other projects which were not sufficiently advanced to be made public.

The national appeal to preserve over 4,000 acres along the west and southern coasts of Pembrokeshire at a cost of about £15,000 had not been completed at the outbreak of war ; but a considerable sum of money had been collected and with this the Trust intends to carry out as much of the scheme as is possible.

WELSH SCHOOL OF ARCHITECTURE

Following awards have been made as a result of the Sessional Examinations at the Welsh School of Architecture, the Technical College, Cardiff. Professor L. B. Budden, M.A., F.R.I.B.A., and Professor R. A. Cordingley, M.A., F.R.I.B.A., were the external examiners.

Fifth Examination : For the Diploma awarded at the end of the Five Years Full-Time Day Course exempting from the R.I.B.A. Final Examination and Qualifying for Registration under the Architects' Registration Acts, 1931 to 1938 : Gedrych, T. D. (Diploma with Distinction in Construction and Thesis). Diplomas awarded to Auckland, N. J., Butler, J. T., Davies, J. S., and Gwilliam, D. A.

Fourth Examination : Phillips, W. J., and Williams, D. C.

Third Examination : For the Certificate awarded at the end of the Three Years Full-Time Course, exempting from the R.I.B.A. Intermediate Examination. Certificates awarded to : Bird, Miss J. N. R., Freeman, D. P., Evans, W. D., Gealy, H., Price, D. L., Roberts, Miss V. J., and Wainwright, K.

Second Examination : Alport, P. G., Culley, Miss R., Kinch, V. G., Lewis, M. D., Mills, W. J. N., Wakelin, R. L., and Roberts, A.

First Examination : Bebb, W. T., Davies, O., John, E. W. W., Mackay, T. L. R., Richards, R. A. K., and Watkins, M. V. H.

THE HOUSING CENTRE

Annual meeting of the Housing Centre took place last week. Sir Reginald Rowe presided.

Sir Reginald referred to the fears the Centre had felt when war broke out that there would be no longer a place for it. These fears had soon been dispelled. It had, he continued, found that social services, many of them relying in part on voluntary organizations such as its own, were wanted more than ever in wartime. Never before had the Centre been busier in certain directions, and it was the Centre's aim not only to maintain its activities but to extend them.

The adoption of the annual report and accounts was proposed by Miss A. M. Lupton, vice-chairman, who spoke in appreciation of those members of the Centre who had helped the Centre to carry on in such a difficult time. Mr. E. J. Carter, A.R.I.B.A., seconded the adoption of the report and described two of the year's achievements in particular. These were the appointment of a joint committee of the R.I.B.A., the National Council of Social Service and the Housing Centre to investigate the problem of community centre buildings, and the calling of a conference at which the 1940 Council, a Council to promote the planning of Social Environment, had been set up. He thought that both enterprises had led to an intelligent centralization and extension of work which was previously diffused.

ANNOUNCEMENTS

Messrs. Stokes and Drysdale have removed to No. 19 Manchester Square, London, W.1.

Messrs. John Murray Easton and Howard Robertson, of Stanley Hall and Easton and Robertson, write : "We feel it desirable, in consequence of the death of our partner, Mr. Stanley Hall, to inform you that the practice will be carried on, as before, at 54 Bedford Square, W.C.1, under the same style and with the assistance of the same staff."

Mr. K. W. Farms, A.R.I.B.A., has moved to "Ridgewood," Nancy Downs, Oxhey, near Watford, Herts.

ARCHITECTURAL ASSOCIATION

Following visit and meetings have been arranged by the A.A. :

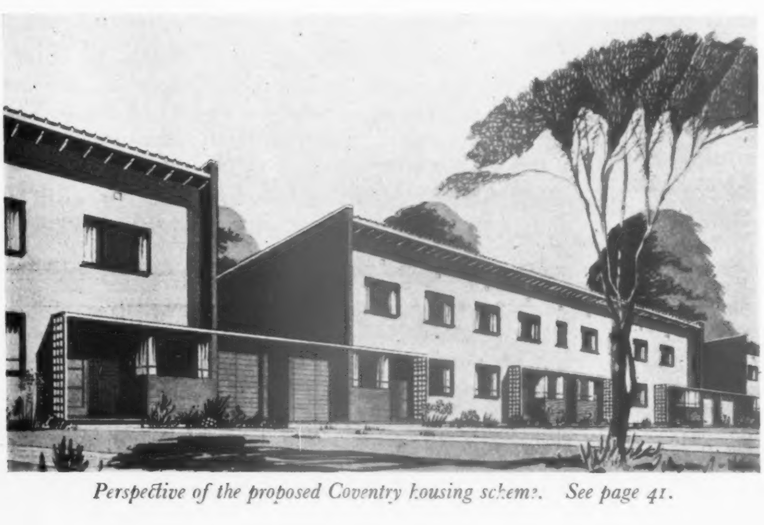
Saturday, August 3. Visit to process buildings, warehouse and offices of The Roche Products, Ltd., Welwyn Garden City. (Architects : Prof. O.R. Salvisberg in association with C. Stanley Brown). The party will meet at 3 p.m. at the entrance in Broadwater Road, which is three minutes from Welwyn Garden City Station. A train leaves King's Cross for Welwyn at 2.5 p.m. Members wishing to attend must inform the Secretary of the A.A., 36 Bedford Square, W.C.1, immediately, as permits have to be issued to all visitors.

General meetings at 36 Bedford Square, W.C.1. Tuesday, October 29, Address by the President. Tuesday, December 10, Mr. Robert Byron on "Persian Islamic Architecture," illustrated by lantern slides.

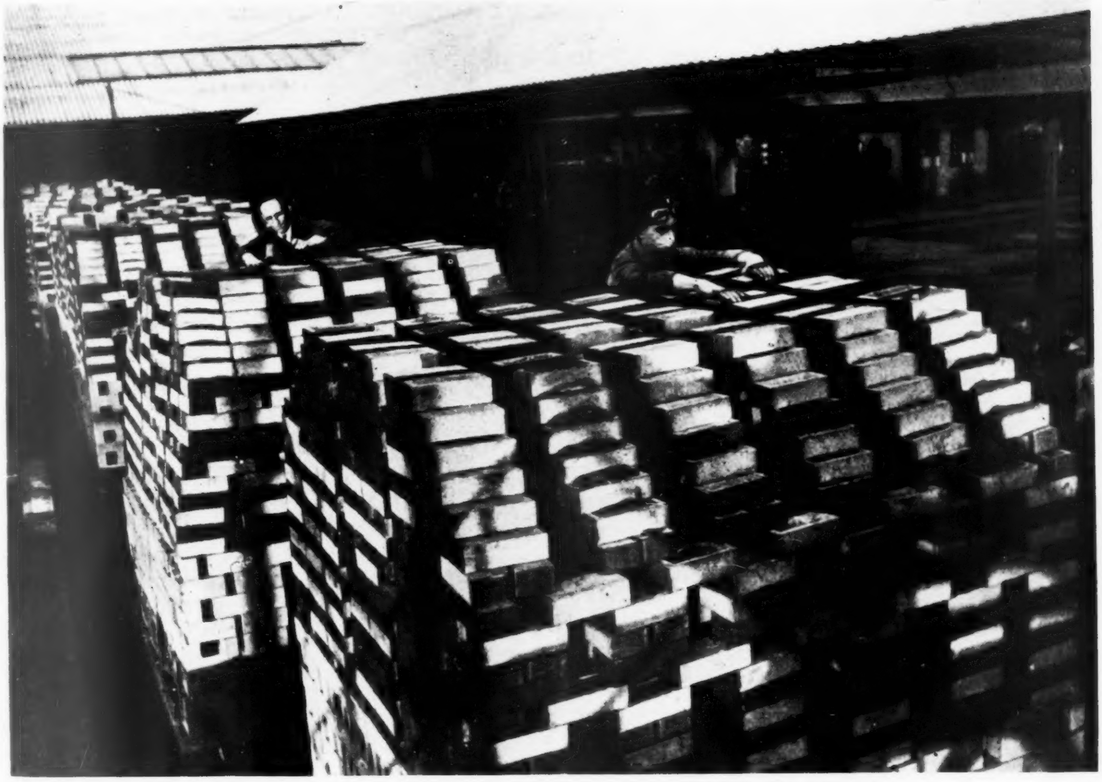
DIARY

Thursday, July 18.—ARCHITECTURE CLUB. At the Charing Cross Hotel, W.C. Supper—Discussion : "How Shall We Plan Our Buildings for Life after the War : In the Country ? " 7.45 p.m.—BUILDING CENTRE, 158 New Bond Street, W.1. Exhibition of Centerless Arch Construction. Until July 26. 10 a.m. to 5 p.m. (Saturdays, 1 p.m.).

Tuesday, July 30.—HOUSING CENTRE, 13 Suffolk Street, S.W.1. Luncheon : "Calverton Colliery and Village." By G. A. Jellicoe. 1 p.m.



Perspective of the proposed Coventry housing scheme. See page 41.



1 **The most widely used building unit—bricks stacked ready for firing**

BRICKS IN WARTIME

SINCE the war began there has been a great change in the conditions under which the building industry has had to carry out contracts for war purposes.

In the autumn the main requirement of every contract was speed in execution. And at that time designers had at their disposal reasonable quantities of all materials used for quick building in peace-time.

In the last few months the position has changed. It is now necessary to minimise the use of imported building materials and very desirable to reduce internal transport of building materials over long distances. More important still, timber and steel can only be obtained for second-line war works—of which

A.R.P. is the most important—in minimum quantities. Speed is still of great consequence : but it must now be speed obtained by minimum use of timber and steel and maximum use of local materials.

The new position must radically change constructional methods and lead to much greater use of the basic home-produced materials.

It is for this reason that the JOURNAL publishes on the following pages a survey of the effects of war on the commonest of these basic materials—BRICK.

The survey summarizes the brickmaking industry's resources and the advantages of brick as a war building material, and describes the ways in which brick manufacturers and their research organizations have sought to adapt their materials and methods to the new conditions of war building.

This survey puts the case for BRICK in the building of the immediate future : and the JOURNAL is indebted to the brickmaking industry for the information it contains and the detailed description of various ways in which brick construction has been developed to supply wartime needs.

1

THE BRICK INDUSTRY'S RESOURCES

DURING the five years immediately preceding the outbreak of the war, the brick industry, including the manufacture of hollow blocks and refractories, was the largest single section of the building industry of this country.

The average output of bricks of all types over this period was in excess of 7,500,000,000 annually, and to this figure must be added the constantly increasing quantities of extruded clay and similar types of hollow partition blocks.

A conservative estimate of the number of skilled and semi-skilled workers employed directly in the manufacture of bricks, and in the bricklaying trades, would be somewhere in the region of 250,000, or over 15 per cent. of the entire building industry.

Despite the very early recognition of the large contribution which brickwork could make both in structural A.R.P. work and in emergency building generally, the demand for bricks for such work did not counterbalance the huge fall in demand due to the almost complete cessation of civil building with the advent of war. As a result of this drop in demand almost all brickworks have, since the war, been operating well below maximum output level,* stocks have been kept low and although brickmakers and bricklayers have been officially reserved from the age of 25, a very large number of them have been unemployed. Now, when the new exigencies of both military defence and enhanced munition factory construction have created an immense demand for home-produced structural material such as brick, there exists a temporary shortage. This shortage, however, should only be temporary, since the brickmaking industry is using every endeavour to restart all its available plant as quickly as possible. What is more, brick has been the principal building material in Britain for several centuries, and therefore there exist all the necessary raw materials, plant and men to produce supplies to meet almost any conceivable demand which the Government's various emergency programmes may make.

Geographically, the production of bricks is widely distributed, and both modern mass-production methods of manufacture and the transport organization already in existence, make the use of brickwork an economic possibility in almost any part of the British Isles.

The use of brickwork for structural A.R.P. and general emergency building purposes makes no call upon shipping, or upon those sections of national industry directly engaged in the production of war materials.

Bricks and other clay products therefore possess two of the greatest possible advantages for all war building purposes. They, and the labour required to use them, are abundantly and ubiquitously available: and they make no call on shipping or foreign exchange.

All that is required is to adapt them to new uses to the fullest possible extent; and the following pages show some examples of how this is being done.

* The output of bricks for the first three months of this year was considerably less than 1,000,000,000, or, say, 4,000,000,000 annually.

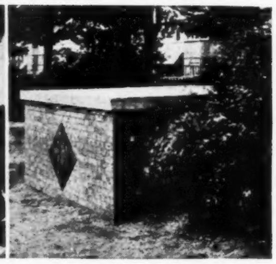
2

BRICKS AND A.R.P.

A: SHELTER CONSTRUCTION

THE use of brickwork for shelter construction is based primarily upon the official decision, after tests, that a 13½-in. wall of brickwork provides a reasonable standard of protection against the effects of blast and flying splinters or secondary debris. The obvious corollary to this finding—

2 Surface-type brick shelter built in accordance with official requirements.



3 Half-sunk brick domestic shelter with mild steel plate over emergency exit.

a box-like structure having 13½-in. brickwork walls, so roofed as to provide a certain standard of protection against falling splinters and debris from demolished buildings—provided the basis for the design of the various types of surface brick shelters, large and small, which are now so common.

As the result of the pre-war (May, 1939) publication by the Home Office A.R.P. Department of a pamphlet " Directions for the Erection of Domestic Surface Shelters," which contained descriptions and specifications of type designs for small surface shelters for six persons built with brick walls and reinforced concrete roofs, and the subsequent inclusion of basically similar notions in the official Code* covering shelters for factory, office and similar personnel, the Clay Products Technical Bureau prepared and issued two Bulletins.† These two publications give complete specifications, dimensional details and analysed costings, for some twenty forms of brickwork shelters (surface, semi- and fully-embedded in the ground) to accommodate groups of 6, 8, 12, 24, 50 and 100 persons. Examples of shelters built in accordance with the proposals contained in these Bulletins are illustrated in the accompanying photographs, 2 and 3.

Since the issue of the official recommendations, and of the Bureau's publications based on those recommendations, the need to conserve our supplies of both steel and timber has become more pressing. In consequence, since reinforced concrete roof construction necessitates the use of both steel and timber (for shuttering) it is desirable to eliminate both in shelter construction, if possible, and to use only materials which are home produced and require neither steel nor timber for shuttering. Of these, bricks and mortar are the most obvious.

That this is possible is shown in the following quotation from the Government publication‡ issued last month: *Air Raid Precautions Memorandum No.* 14: Domestic Surface Shelters (four types) :—

> In the light of experience . . . variations in constructive detail which, without sacrificing any degree of protection, economize on essential materials, and particularly on steel and timber, have been introduced . . . it may be pointed out that the new type design No. 1 is substantially the counterpart, but on a smaller scale, of the original (May, 1939) design; and that designs 2, 3 and 4 present the advantage of requiring no steel for reinforcement or timber for shuttering.

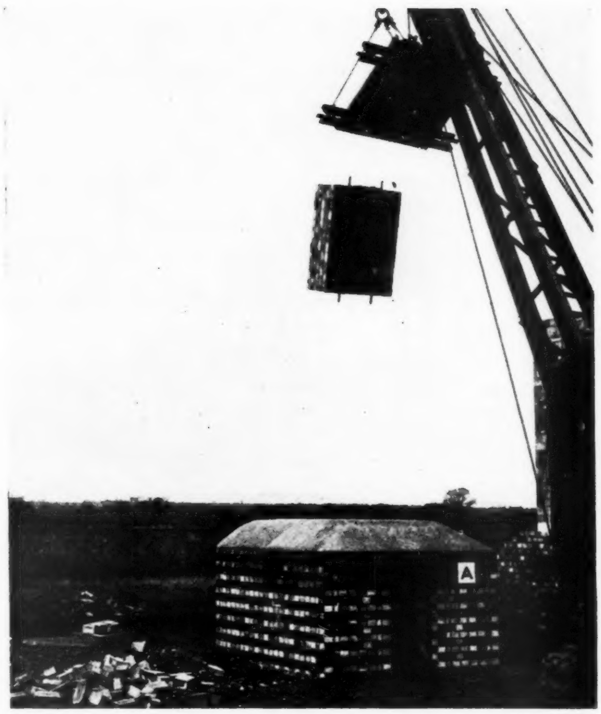
In all of the new types of domestic shelter the standard walling is 13½-in. brickwork, which in one type is corbelled out at the top to form a flat truncated pyramidal roof, subsequently covered to a smooth fill with concrete.

Tests under official supervision which demonstrated the efficacy of such all-brick shelters are illustrated in **4, 5, 6. 4** shows a large mass of masonry (representing falling debris) about to hit a shelter roof; **5**, the absence of exterior damage; and **6**, of interior damage. The

* Statutory Rules and Orders: Air Raid Shelters for Persons Working in Factories, etc.: Revised Code, August, 1939. (Section 13, Civil Defence Act, 1939.) H.M.S.O. 1939. 6d.

† Clay Products Technical Bureau Bulletins A.R.P. 2 and A.R.P. 2A. Brick Shelters.

‡ Issued by the Ministry of Home Security (Air Raid Precautions Department): H.M.S.O. 3d.

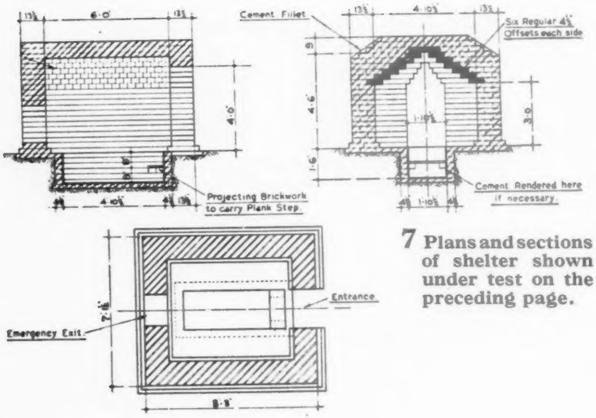


4

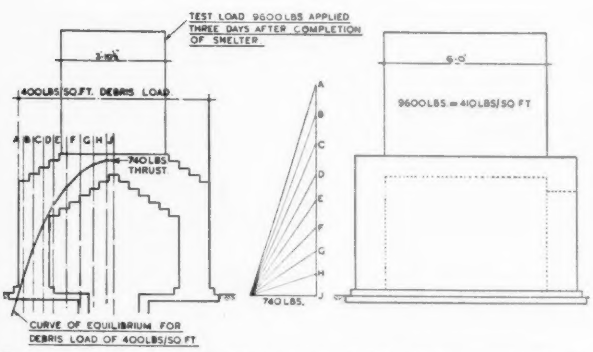
5

6

4—Test of brick shelter, with brick corbel roof, to seat eight persons. 5 and 6 show that the corbel roof was not damaged externally or internally.



7 Plans and sections of shelter shown under test on the preceding page.



8 Stress diagram of eight-person brick shelter under load of 410 lb. per sq. ft.

particular shelters of this type tested were slightly larger than those detailed in A.R.P. Memorandum 14, being designed to accommodate eight persons instead of six. The complete details of this eight-person corbelled brick roof shelter are given in **7**. Its ability to sustain the maximum debris load required by the authorities (viz., 400 lb./sq. ft.) is shown by the stress analysis diagram, **8**.

B: STRUTTING IN BRICKWORK

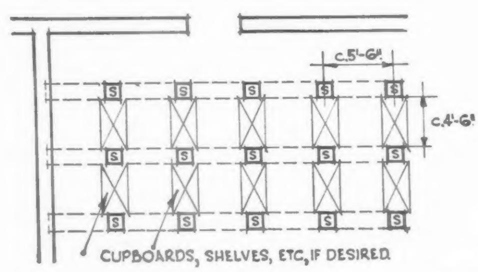
IT is probable that in the near future local authorities, commercial concerns and property owners will put in hand further structural A.R.P. work to protect both personnel and valuable material and records, using as far as possible the basements or lower rooms of existing buildings. The official requirements as regards overhead protection are that the roof of such a protected space must be capable of carrying, in addition to its dead weight and live load, a further debris loading (arising from the collapse of the superstructure) which may be as much as 400 lb. per square foot.

To carry this immensely increased roof loading a variety of methods involving the extensive use of steel (stanchions, joists, concrete reinforcement) or of timber (either as strutting material or for shuttering) have been suggested in official memoranda, notably in the Home Office A.R.P. publications on the subject.

Whilst such materials were plentiful, these methods were entirely practicable. Now that an imperative necessity has arisen to conserve to the utmost our supplies of both steel and timber, it is in the national interest very desirable, and may become obligatory, to use other materials wherever possible. Brickwork columns require no shuttering, propping or steel, and brickwork beams and slabs only straight runs of propped planking as soffit supports (brickwork forms its own vertical shuttering) and a minimum of steel as reinforcement against tensile and shearing stresses, steel being saved by using enhanced effective depths when designing the beams and slabs. Further advantages of brickwork are: practically no other gear than the bricklayer's tools is required for its construction; it is fire-resisting; it provides its own surface finish: alternatively it provides an excellent ground for any desired finish; when no longer required, as will be the case with much A.R.P. construction, it is readily demolished and the bricks have some salvage value.

Such being the case, it is worth examining the strutting of a basement in brickwork. It is assumed that the floor above the basement, including its working load, weighs 150 lb./sq. ft., and is to be strengthened by strutting to carry an additional debris loading of 400 lb./sq. ft.; the strutting system will, therefore, be required to support a total slab load of 550 lb./sq. ft. Further, let it be assumed:—(*a*) that the vertical distance between basement floor and the joists or other load-bearing underface of the strengthened floor above be 9 ft. 6 in.; (*b*) that centre to centre, the vertical strutting members must not be closer than about 5 ft. 6 in., and must provide a series of intersecting aisles whose clear width is not less than 4 ft. 6 in., the arrangement being as shown in plan in **9**; (*c*) that the compressive strength of the bricks available is 3,000 lb./sq. in.*; (*d*) that the amount of steel used must be as small as possible; (*e*) that the amount of timber used for shuttering must be small and, if possible, recoverable for re-use.

To satisfy all these requirements it will be found best to adopt the method of strutting indicated in **9**, viz. a series of symmetrically placed plain brickwork columns (S)



9 Suggested spacing of brick piers for strutting basement shelter.

carrying discontinuous† beams, the upper surfaces of which touch the floor above or are close enough to it to permit contact to be made by packing.

The requirement as to the spacing of a clear span between columns suggests the use of 13½-in. by 13½-in. plain brickwork columns as struts (S), the heads of which will form adequate bearing surfaces for beams about 13½-in. wide.

To economize steel as far as possible, the beam depth must be as great as possible without encroaching on headroom, and for the purpose of this example is taken as about 18 in. to give a clear height of about 8 ft. below the soffits of the beams and thus fixing the height of the brickwork columns at about 8 ft.

Let us now consider the load-bearing capacity of the proposed 8 ft. by 13½ in. by 13½ in. columns built with the available bricks (Requirement (*c*)) whose compressive strength

* According to the L.C.C. Building By-Laws, bricks of this strength belong to Class 5. The strength of most burnt clay bricks commonly available exceeds this figure.

† Separate beams are chosen for construction under existing ceilings in preference to continuous beams to avoid the practical difficulties which would arise in placing the tensile steel necessary in the upper parts of the continuous beams over each column head.

is 3,000 lb./sq. in., and let it be further assumed that to facilitate good workmanship (particularly the complete filling of all joints in the column) and bond, a 1 : 1 : 6 (by vol.) cement : slaked lime : sand mortar be used.* As a criterion of load-bearing capacity let us take the somewhat conservative maximum permissible pressures on piers and columns laid down in the L.C.C. Building By-Laws (Section 60). According to these by-laws such a column laid up in a 1 : 1 : 6 mortar may take 11·2 tons.

The load required to be carried by each column spaced at 5 ft. 6 in. centres due to full live, dead and debris load of the floor above is $5\frac{1}{2}$ by $5\frac{1}{2}$ by 550 lb. (about $8\frac{3}{8}$ tons), plus the weight of two halves, i.e. one, of the proposed $13\frac{1}{2}$ in. by $13\frac{1}{2}$ in. beams. If, as is contemplated, these beams are built in reinforced brickwork which weighs 125 lb. per cubic foot, the further loading on each column due to the dead weight of the beams is about 0·6 ton, making a total load on the column head of nearly 9 tons. Hence the load-bearing capacity of the proposed columns (11·2 tons) is more than adequate†.

It remains to design a reinforced brickwork beam capable of carrying and transmitting to the columns the contemplated maximum floor loading.

The principles and methods of designing such reinforced brickwork beams have been published in detail‡ and have been used to design the reinforced brickwork beam shown in detail in 10. Further points which should be noted are :—

(1) To obviate cutting of bricks, the distance between centres of the columns is increased slightly to 5 ft. $7\frac{1}{2}$ in. (from 5 ft. 6 in.), giving a clear span of 4 ft. 6 in. between column reveals.

(2) While the tension steel is discontinuous, the brickwork is made continuous along the run of the beams.

(3) To facilitate the placing of the light vertical stirrups (shear reinforcement) in the beam, the width of the latter is increased to $14\frac{1}{4}$ in., which means that the beam will overlap the column face by about $\frac{3}{8}$ in. on each side unless, as may be deemed advisable, the top course of each column be corbelled out slightly to give full bearing.

(4) The whole construction can be run straight up as in ordinary brickwork, no pause being necessary except to fix and shore the temporary plank shuttering beneath the soffits of the beams.

(5) In the beam construction the mortar must be essentially a cement mortar but lightly gauged with lime, and **not** the 1 : 1 : 6 mortar used for the columns. A suitable mix is 1 : 1/6 : 3 (by vol.) cement : slaked or hydrated lime : sand. A detailed construction procedure is given on p. 52.

(6) The following is a summary of the material required per beam :—

Bricks ($2\frac{5}{8}$ in.) ...	... ...	135
Steel $\frac{1}{4}$ in. Ø rods	... ...	63 ft. 4 in.
Mortar (1 : 1/6 : 3)	... ...	1/6 cu. yd.

It is clear, therefore, that even if the only bricks available are of but medium strength, a simply designed and constructed combination of plain and reinforced brickwork can be evolved for A.R.P. basement and similar strengthening work of existing structures.

If, as will usually be the case in many parts of the country, the bricks commonly available are stronger, then greater distances between columns can be used. For example, if the bricks available belong to the L.C.C. class 4 (compressive strength not less than 4,000 lb./sq. in.) then the clear span can be increased to 5 ft. 3 in. (distance between column centres = 6 ft. $4\frac{1}{2}$ in.).

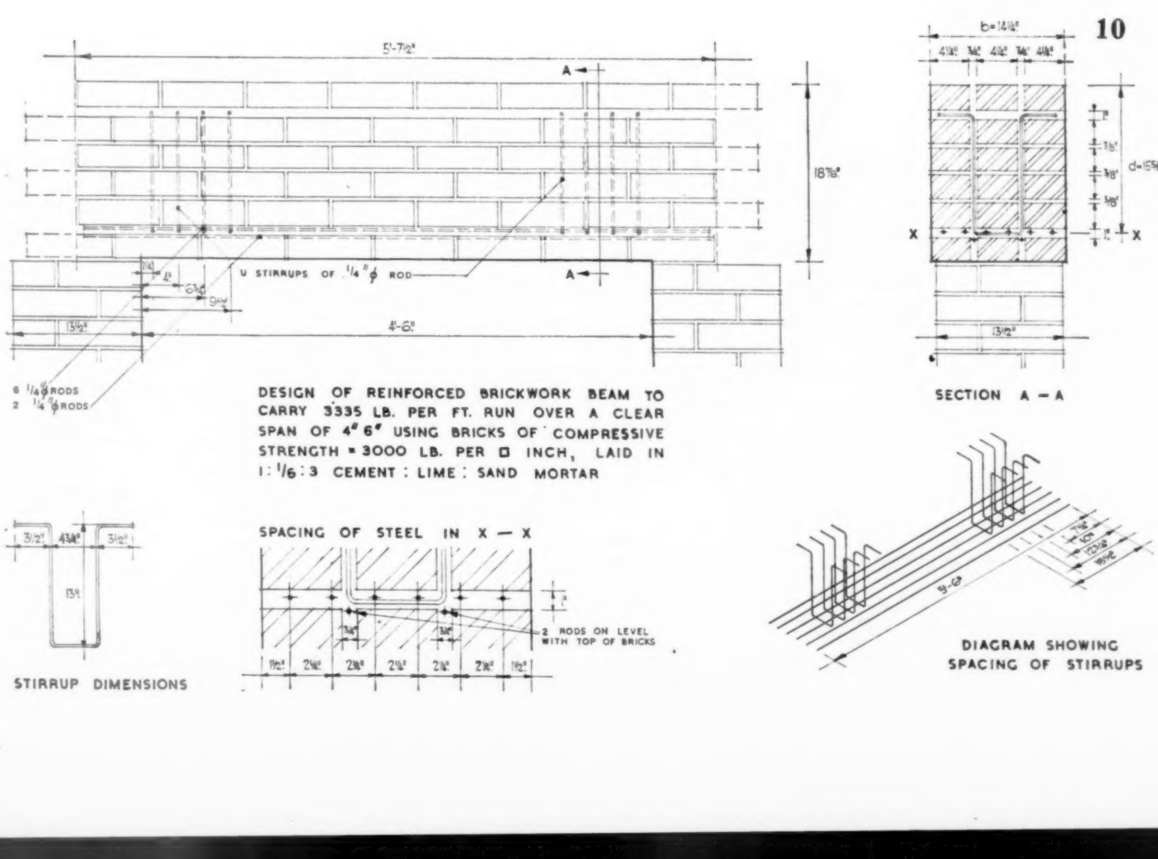
There is, however, one exterior factor which must receive attention if the high load-bearing capacity of such brickwork systems is to be exploited fully, viz. the load-bearing capacity of the underlying floor or soil. For example, in the case of 2,500 lb./sq. in. brick, appropriate measures must be taken at the foot of the column to distribute the incident load of

* Dr. Davey, of the Building Research Station, has reported that the strength of brickwork is hardly affected by the use of such a 1 : 1 : 6 mortar in place of a 1 : 3 cement mortar. (N. Davey : London Congress Inter. Assoc. Testing Mat. 1937. Reprinted as Clay Products Technical Bureau Bulletin No. 6.)

† If the column section be reduced to 12 in. by 12 in. by building it in brick-on-edge (frogs inward and filled) corbelled out to $13\frac{1}{2}$ in. by $13\frac{1}{2}$ in. at the head by two courses of brick laid flatwise, such a column will still take the required superimposed loading, since the maximum permissible load on an 8 ft. by 12 in. by 12 in. column built in 3,000 lb./sq. in. bricks laid in 1 : 4 cement-sand mortar is just under 9 tons.

‡ Hamann and Burridge : "Reinforced Brickwork." *Structural Engineer*, Vol. 17, No. 4, April, 1939, pages 198–250.

10



DESIGN OF REINFORCED BRICKWORK BEAM TO CARRY 3335 LB. PER FT. RUN OVER A CLEAR SPAN OF 4' 6" USING BRICKS OF COMPRESSIVE STRENGTH = 3000 LB. PER □ INCH, LAID IN 1 : 1/6 : 3 CEMENT : LIME : SAND MORTAR

6·9 tons, which increases to 11·3 tons if the 4,000 lb./sq. in. brick be used.

Finally, where it is essential to keep out ground moisture from the shelter, a damp-proof course must be inserted at the foot of each column. In view of the heavy loads and other possible eventualities, it will be safest to form this damp-proof course by inserting two courses of semi-vitrified (engineering) bricks (whose absorption is not more than 3 per cent.) at or near the base of the column. These two courses should be laid up in 1 : 2 cement-sand mortar.

REINFORCED BRICKWORK BEAM CONSTRUCTION: PROCEDURE

(1) *Fix and strut suitable planks to support soffit of beam : top surface of planking to be ⅜-in. above head of column and covered with building paper. Fig.* **11** (*a*).

(2) *Cover heads of columns with ⅜-in. thickness of specified mortar.*

(3) *Lay soffit course of bricks on flat, frog up as shown in Fig.* **11** (**b**) *in stretcher bond* (filling ¾-in. vertical joints *between runs of stretchers* completely with mortar) *to make a soffit course 14¼ in. wide.*

(4) *Cover the whole of soffit course with ½-in. of mortar.*

(5) *Embed therein until just covered the vertical U stirrups placed at correct intervals from columns.* (Note : *These stirrups should preferably be wired to or spot welded to two central horizontal re-inforcing rods at correct spacing.*)

(6) *Place horizontal steel rods at 2¼-in. centres, and cover all steel completely with mortar so that there is at least ¼-in. cover over all steel.*

(7) *Place (frogs up) next course of bricks as shown in Fig.* **11** (c), *taking care that stirrups are centrally placed in ¾-in. vertical joints.*

(8) *Place ⅜-in. horizontal mortar bed and thereon bricks (frogs up) as pattern given in Fig.* **11** (**b**), *keeping vertical stirrups central in ¾-in. joint.*

(9) *Ditto, as pattern given in Fig.* **11** (c).

(10) *As* (8).

(11) *Place 1-in. horizontal mortar joint, making certain that top lugs of U stirrups are completely embedded in and covered with mortar.*

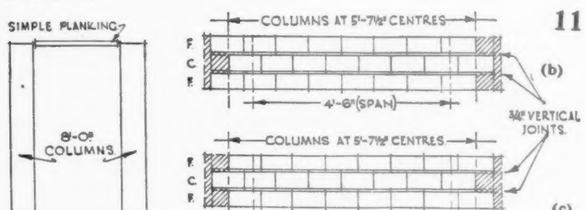
(12) *Overfill all frogs of next course of bricks with mortar : place as Fig.* **11** (c) *setting internal course* (C) *first, fill in all vertical joints and place face courses* (F) *well into ¾-in. vertical mortar renderings of the two faces of internal course* (C) *: ram mortar into vertical joints of face course* (F) *to fill them : run suitable screeding bar over top of beam to get level surface.*

(13) *After mortar of beam has set, fill space between top of beam and floor above with packing.*

N.B.—(A) *Each and every brick must be* completely immersed *in water for at least half a minute immediately before laying.*

(B) *The column height must be adjusted to allow for the exact beam dimensions shown, as* no reduction in the thickness of the horizontal joints in the beam is permissible.

11—Constructional details of reinforced brick beam spanning 4 ft. 6 in.



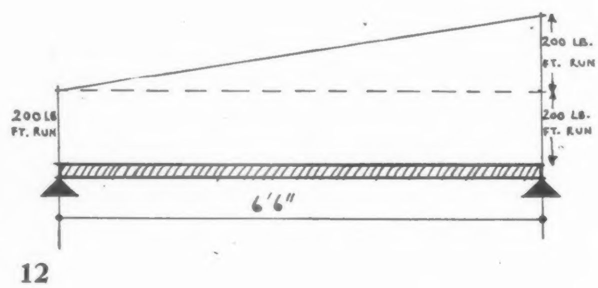
C: BRICK TRENCH LININGS

ACCORDING to the official requirements* a trench lining must be designed to resist the static horizontal thrust of the surrounding earth, which in the worst case contemplated (angle of repose of soil less than 40°) may be as much as 400 lb./sq. ft. at the base, falling to 200 lb./sq. ft. at the top. Here it is proposed to examine to what extent brickwork can be used for this purpose, since it is obvious that, if it is possible to do so, brickwork would soon supplant the only two types of constructional material approved for trench linings in the 1939 Home Office document, viz. reinforced concrete and steel.

Such brickwork linings should preferably be not only resistant to the earth pressure, they should also be as watertight as possible to prevent seepage of ground moisture into the trenches, although the relevant Home Office document states that waterproofness of side members is not essential. This original opinion has, however, apparently been modified in that recommendations for waterproofing trench linings have since been issued. This second factor has therefore been kept in mind.

Resistance to Horizontal Thrust

It is clear from clause 4, page 6, of the official document already mentioned that adequate cross-strutting of the trench walls at the top and bottom is essential. Hence the trench wall is required to act as a vertical slab simply supported top and bottom and subject to bending by a horizontal thrust. The wall may therefore be considered as operating as series of beams of unit width (12 in.), supported at each end and carrying a uniformly distributed load plus a load increasing uniformly towards one end, a condition which is represented diagrammatically for the worst case (400–200 lb./sq. ft.) in **12**.



12

Using normal methods of mechanical analysis, the maximum moment due to such load is approximately 19,000 in. lbs. The question then is to design brickwork which can resist such a bending moment. This can be done in two ways :

(A) *Plain Brickwork*

In normal building practice, such as is governed by the building regulations of the various civic authorities,* plain brickwork walls may not be relied upon to resist shearing or tensile stresses, except that, in lengths varying according to thickness up to a maximum of 45 ft. they may be deemed to take a horizontal load equal to 25 per cent. of the wind pressure. Since the wind pressure due to such a high wind as 100 miles per hour is but 30 lb./sq. ft.,† 25 per cent. of that, viz. 7·5 lb./sq. ft., is negligible when compared to the load now being considered—which is everywhere 200 lb./sq. ft. or more.

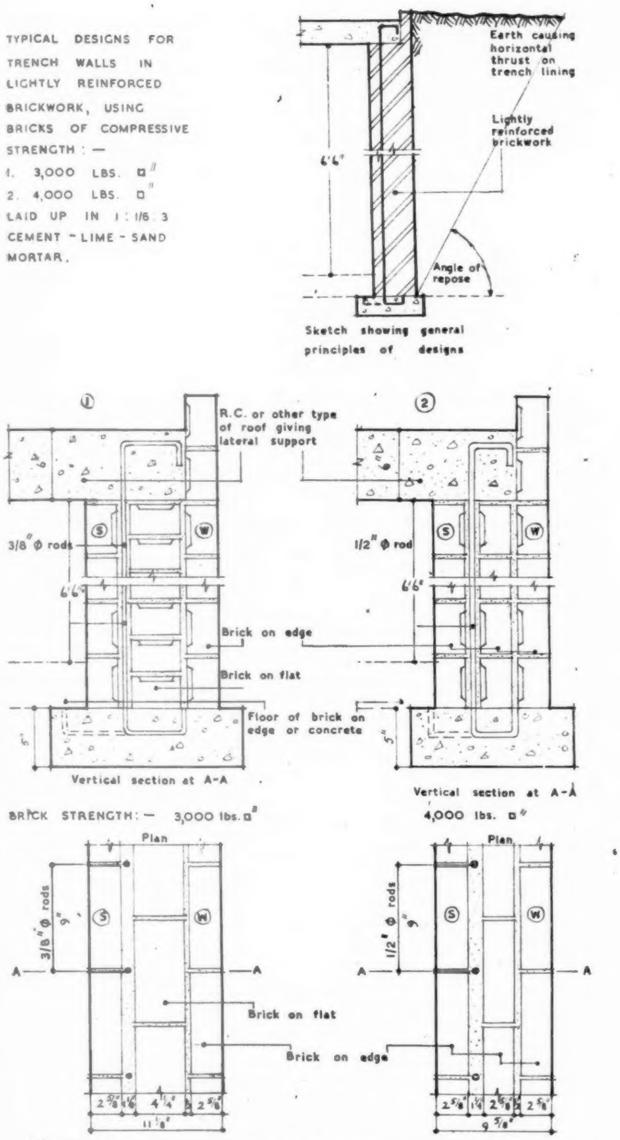
Despite such prohibition, however, there is practical evidence that plain brick walls offer a very definite resistance to lateral thrusts. Consider, for instance, the thousands of area and basement walls which have stood perfectly for many decades.

Unfortunately, no tests have been carried out in this country on the transverse strength of brickwork and the

* Home Office A.R.P. Specifications, etc., in regard to Permanent Lining of Trenches, 1939 (H.M.S.O., 4d.), page 6.

* For example, L.C.C. Building By-laws, 1939, Section 61.

† Computed from $P = 0{\cdot}003V^2$, P being in lb./sq. ft., V in miles per hour.



13 **Details of trench walls in lightly reinforced brickwork.**

published reports of the work carried out in the U.S.A. at the National Bureau of Standards* and by Professor R. E. Davis, University of California, constitute our only guides in the matter. These U.S.A. workers subjected brick panels of various thicknesses (8 in. and 12 in.),† supported top and bottom, to lateral pressures applied at third points and determined the modulus of rupture‡ of such panels.

When laid up in 1 : 3 cement-sand and 1 : ½ : 3 cement-lime-sand mortars with all joints carefully filled, moduli of rupture varying from 50 to 150 lb./sq. in. were measured, using bricks whose compressive strength (3,200–3,500 lb./sq. in.) is comparable to or less than that of most of the common bricks available in this country.

There is a well-established relationship between modulus of rupture, the breadth and depth of a rectangular beam and the applied bending moment. This modulus, however, represents the stress at failure, so that, for safe design, a safety factor, say 5, must be used. The following table gives the necessary thickness of a plain brickwork wall, so that, under the given bending moment (19,000 in. lb.), the extreme fibre stress shall be one-fifth of the least, the average and the greatest modulus of rupture found by the U.S.A. workers.

Modulus of rupture (R) in lb./sq. in.	50	100	150
Permissible extreme fibre stress (1/5th R)	10	20	30
Wall thickness in inches ...	39·53	27·95	22·8

Even the least thickness (approximately 22½ in.) is obviously uneconomical if some alternative requiring many less bricks be possible. The increasing use of reinforced brickwork offers the required alternative.

(B) *Reinforced Brickwork*

The basic principles and practical methods of designing reinforced brickwork beams and slabs have been dealt with in considerable detail in the technical press both here and abroad. Using the methods and numerical factors given in the most recent British paper* on the subject, the two types of reinforced brickwork trench wall linings detailed in **13** have been designed.

Both are designed to have a high margin of safety against the maximum lateral thrusts laid down in the Home Office publication already mentioned, viz. 400 lb./sq. ft. at the base falling to 200 lb./sq. ft. at the top, and allow for a clear height of 6 ft. 6 in. between the floor and the underside of trench roof. Both floor and roof must be so designed as to provide the strutting support necessary to enable the reinforced wall lining to act as a beam—and the roof must also be able to carry the contemplated earth cover (e.g. a 2 ft. thickness of earth), or, alternatively, be strong enough to give standard overhead protection.

As is indicated, if a stronger brick is available (compressive strength 4,000 lb./sq. in.) a smaller wall thickness is required than if the brick strength be but 3,000 lb./sq. in. Against the resultant saving in the number of bricks and amount of mortar used must be set the additional quantity of steel involved, viz. 4 lb. per ft. run in the thicker as compared with 7 lb. in the thinner wall.

The following points should be noted concerning the accompanying details:

(1) The reinforcing bars are shown as hooked each end. This hooking is not essential from the point of view of anchorage against excessive mortar-steel bond-stress, but the insertion of alternate hooks into the floor and roof is suggested as providing a tie between the horizontal supports (floor and roof) and the beam (the wall) strong enough to resist settlement and a moderate degree of earth vibration or shock.

(2) The reinforced continuous vertical mortar joint nearer the outer (earth-side) of the wall (marked *W*), if properly filled with the specified grout throughout, will act as a waterproofing layer to inhibit seepage of ground moisture through the trench wall. Since it is likely to be always moist, owing to ground moisture, and, in any case, is mechanically keyed into the cross vertical joints every 9 inches, it should be proof against the cracking due to drying shrinkage which vitiates the waterproofness of such a cement mortar when applied as an external rendering over large areas on the exterior of a building.

(3) Accurate spacing of the bricks to give the designed wall thickness and cover the steel is essential, and grouting of the vertical joints to ensure their complete filling is recommended. The grout should be the same mix as the mortar (1 : 1/6 : 3 cement-lime-sand) with only enough water to make it just

* U.S. National Bureau of Standards Report B.M. 55.

† The American equivalents of our 9 in. and 13½ in. walls, using their standard bricks, which are smaller than ours.

‡ Modulus of rupture equals the stress per unit area in the extreme fibre.

* Hamann and Burridge: "Reinforced Brickwork": *Structural Engineer* (April, 1939), pages 198–250.

pourable. All grouting should be topped up after allowing the first pour to settle for 10 to 15 minutes.

(4) The inner skin (marked *S*) is shown in the detail as being of brick on edge. This skin is actually only required as permanent shuttering in lieu of timber. Although this skin, being below the steel in the wall regarded as a beam, plays no essential part in resisting the bending moment, due to earth pressure, before adopting any proposal to replace it by other materials, such as partition blocks or the like, careful consideration must be paid to the fact that the walls are also required to operate as vertical supports for the loaded roof, and the inner skin (*S*) must bear its share of such vertical loading.

(5) Where frogged bricks are used it is essential that the frogs should be placed inwards in order to ensure the full designed wall thickness. In any case it is advisable that the volume of the frog should not exceed 15 per cent. of the gross volume of the brick.

D: ENTRIES TO TRENCH SHELTERS

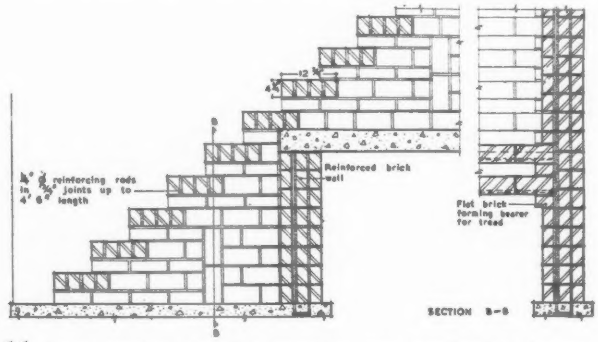
MANY of the first designs for trench shelters advocated simple sloping ramp entries : briefly, their only virtue is that they look simple on paper. Subsequent experience has shown the fundamental inefficiency and extravagance of such modes of entry to a subterranean chamber.

Take the simplest case of a sloping ramp to a shelter whose floor level is 7 ft. below entry level, and assume the slope to be on the steep side, say 1 in 6. The excavation for the ramp alone must be 42 ft. long, and will not only involve the removal of as much soil as will a 21-ft. run of the 7-ft. deep shelter itself but will also render useless for any other purpose its ground plan, which will be 42 ft. long and of a width dependent upon what material is decided upon for the sides of the sloping ramp. Here again simple battering of the earth sides to its angle of repose will usually be extravagant in excavation work and inefficient in practice.

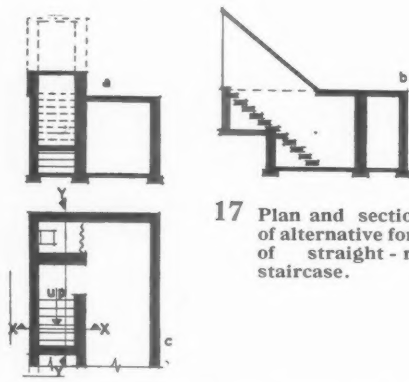
It will be extravagant, because with very firm coherent soils, having a very steep natural angle of repose, although the volume to be excavated will be a minimum (as compared with loose soils) the cost per cubic yard of excavating such hard material will be high. Conversely, with loose soils, having an angle of repose of say 45° or less, the amount of excavation required for batter equals or exceeds that required for the actual ramp itself. In both cases rain, frost and ground vibration due to traffic, machinery, local explosion, etc., are likely to break up the battered surface, so that sudden subsidences may block the entries at the very moment they are needed : in short, such simple battering is likely to be inefficient in an emergency. The only alternative is to build an earth pressure resistant trench lining along the sides of the ramp : this expedient, in the example taken, would require as much lining as one side of a 42-ft. run of trench.

Therefore, any form of ramp entry is inadvisable on account of (1) the waste of ground space involved ; (2) the high cost of excavation ; (3) inefficiency, unless costly measures be adopted to prevent entries being found (in a sudden emergency) to be blocked by subsidence.

Consequently, in many of the recently constructed trench shelter systems staircases have been adopted, usually formed in concrete between retaining walls of reinforced concrete. With the ever-increasing dearth of timber and the necessity to conserve steel, it would be clearly advantageous to employ lightly reinforced brickwork* for these staircases of a similar character to that proposed for the actual walls of trench shelters.† Using lightly reinforced brickwork slabs (12¾ in. by 4½ in.) as treads (which can be precast and laid as units as the brickwork walls of the staircase rise), descent to trench floor level 7 ft. 6 in. below ground level can be obtained by using 12 treads 9 in. wide, supported on the walls and requiring, if a straight run, an excavation 9 ft. long as compared with the 42 ft. of the ramp. Where ground space is limited the staircase can be conveniently turned half



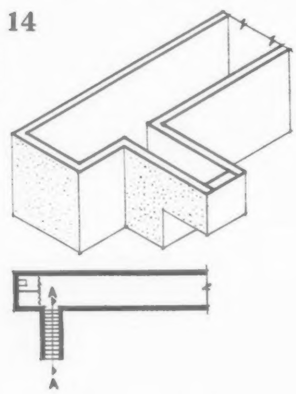
16 Part section through straight run reinforced brick staircase showing bonding and reinforcement.

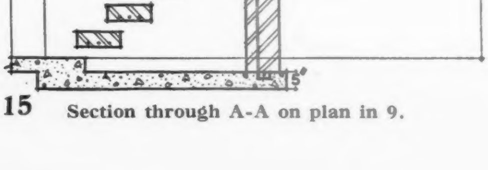


17 Plan and sections of alternative form of straight-run staircase.

14

Isometric sketch and plan of reinforced brick walling and staircase entering a trench shelter.





15 Section through A-A on plan in 9.

* Such reinforced brickwork requires no shuttering whatsoever, only a few pounds of steel per foot run, and no gear other than the ordinary bricklayer's tools.

† See C.P.T.B. note on Brickwork for Trench Linings.

way down and arranged around the end of the trench system. Details for straight runs of brickwork staircase entries are shown in the accompanying figures **14** to **17**.

E: BRICK SHIELDS AGAINST BLAST

THE earliest forms of blast and splinter protection were notable for their lavish use of sheet steel or timber to cover window openings, etc., and of sandbagging for barrier walls and head cover. The millions of sandbags used for these purposes can no longer be salved (our climate has seen to that) and practically everywhere the massive and ephemeral sandbag constructions have had to be replaced by 13½ in. brickwork baffle walls. Such walls, besides being permanent, are officially recognized as affording standard lateral protection against blast and splinters (see page 48).

Brickwork infillings for window openings, etc., are also common features on railways and public utility plants, and their general adoption to replace existing sheet steel or timber coverings to such openings would be doubly advantageous inasmuch as not only would standard protection be ensured,* but also valuable steel and timber would be released for other purposes.

3

BRICKWORK AND WAR BUILDING

[*By R. COTTERELL BUTLER, A.R.I.B.A.*]

APART from shelters, buildings for war purposes fall into two main groups. All wartime building is emergency work inasmuch as speed is of the utmost importance, but from both economic and technical points of view, a distinction may be drawn between those buildings which are required for purely wartime purposes, and those which—while being every bit as urgently required—will be of permanent benefit.

In the first group must be placed buildings of the hutment type, which, while their post-war uses must be considered, are primarily emergency undertakings. Extensions to factories, hospitals, and similar types of buildings fall into the second category.

From a technical point of view, methods of constructing the second type of building may be expected to conform more closely to normal peacetime practice. And apart from considerations of speed and economy, the main departures from peacetime technique will arise from the limitations imposed by material supplies.

These limitations are now extremely important, and bricks and clay products are one of the few materials which are free from them.

This point has been made before, but is worth stressing again in this connection. Brickwork is a reliable proved material, available—together with the labour needed to use it—all over the country in almost unlimited quantities, and its use in no way conflicts with other parts of the war effort. It therefore should be used wherever it is possible: and there may come a time when for nearly all war building purposes it will have to be used exclusively.

At the moment it has other advantages besides those already mentioned: it is permanent, yet is easy to demolish and has considerable demolition value; and it is very difficult for any mistake in the design, or during the execution of, a scheme in brickwork to cause serious delay—which is not the case with less familiar and less adaptable constructional methods.

Brickwork's one *disadvantage* in the past has been held to be slow speed of construction. Since the outbreak of war this question has been examined very thoroughly by the brick industry. And it is believed that slow speed of brick construction in peacetime was caused by lack of demand for speed and not by any inherent difficulty in achieving it.

The aim of the following notes is to show how the organization, and to some extent the technique, of brick construction can be altered without any great difficulty to secure the speed needed in wartime construction.

Structural Organization.

Accepted systems of building in brickwork or hollow block, in which work is carried out *in situ* by a skilled workman who is fed with building materials by one or more labourers, are of course well understood, and where large-scale repetition work is not being carried out, is thoroughly satisfactory. In building walls in brickwork the layer usually proceeds to lay horizontal areas of brickwork, moving around the perimeter of the building as he works.

Where repetition work of single-storey height is being carried out, many improvements in technique may be adopted.

The disadvantages of the traditional system may be summarized as follows:—

The maximum number of skilled layers who may work on a given part of the scheme at one time is limited by the number of courses which may be built above each other without waiting for the bonding material to dry out somewhat, and by the confusion in bonding and among the layers' labourers which may occur.

Working *in situ*, the laying operation is open to the effects of weather conditions, duration of light, rain, frost and so forth.

The system of feeding with materials a workman who is constantly changing his position cannot be super-efficient.

By employing highly systematized forms of organization great increases in speed of operation, with no loss of efficiency, are possible.

The fundamental factor to be considered in attempting to organize a more efficient system is that of reducing as much as possible the amount of work to be carried out *in situ*. The more *in situ* work can be eliminated, the more working conditions of the operative can be made to approach those of the mass-production factory, and the disadvantages already noted be overcome.

The following outline of a scheme of organization is intended to indicate the general lines along which systematization could take place. It cannot at this stage be more than a general indication, for as far as the writer is aware no such scheme has as yet been put into complete practical effect. Much research into this question is, however, being carried out, notably through the organization of the Clay Products Technical Bureau of Great Britain, and innovations of value both in war and post-war construction are very likely to be soon put into practice.

OUTLINE OF SYSTEMATIZED BRICKWORK CONSTRUCTION

Application.—To all large-scale building operations involving single-storey structures, primarily, and to a less extent to two-storey forms.

General System.—Form of structure to be standardized, and to consist of load-carrying piers with infilling of self-supporting preformed panels.

Foundation rafts formed either of concrete *in situ*, or of large preformed elements of reinforced brickwork or concrete.

Main piers built up *in situ*.

* Neither thin metal sheeting nor ordinary planking affords such protection as does brickwork.

Wall elements between piers preformed.
Roof elements in large-size preformed units, or other materials.

Organization.—Preformed work carried out under cover on site in sheds, carefully related to main lines of building.
In situ work carried out to organized system.
Preformed elements transported to site position from sheds by special conveyors, and similarly placed in position.
Full use made of conveyor system for transporting mortar, etc., from sheds to site position.

Labour.—Operatives working as far as possible under normal factory conditions independent of effects of weather, natural lighting, etc.
Operatives supplied with materials by system.
Operatives move positions as little as possible, with work taken to, and brought from, them.

Structural Elements.—Produced in workshop as far as possible. Transport carriers designed to apply only the same directional stresses as the element must withstand *in situ.*
Light reinforcement made use of where desirable.

OTHER APPLICATIONS OF BRICKWORK

The following notes indicate ways in which brick or clay products can be used either to simplify and so speed up construction, or as a substitute for materials which are now scarce and may become more so.

It is fully realized that some of the constructional forms suggested would normally be regarded as inefficient and unsatisfactory. But war building is not carried out under normal conditions; and these suggestions are made because it is probable that within the next three months the advantages of some of them may well outweigh their drawbacks.

Sub-dividing the primary elements of a typical emergency building into three groups: foundations and floors; walls and vertical supports generally; ceilings and roofs—possible applications of brick and hollow block materials may be grouped as follows:—

FOUNDATIONS AND FLOORS

Reinforced brickwork beams, spanning between pier foundations, as support for wall units or floors. (Extensive excavation is thus avoided, and waterproofing or damp-coursing may be limited to the contacting surface between beam and pier foundation.)

Unreinforced brickwork foundation rafts on suitably consolidated subsoils or hardcore, as floors. Waterproofing effected by the use of a screed or waterproof membrane between the raft and the floor finish.

Lightly reinforced brick rafts for floors and foundations, waterproofing as above.

Hollow block flooring units laid on waterproof concrete or brick rafts to provide a floor having a high degree of thermal insulation.

Continuous ground-level reinforced brickwork beams as foundations.

WALLS AND VERTICAL SUPPORTS

Various walling arrangements: Brick-on-edge, cavity. Flat brick and brick-on-edge, cavity. Two brick sandwich with waterproofing membrane between. Outer skin brick, inner skin hollow block, cavity. Brick and hollow block sandwich, and membrane. Brickwork and rendering.

Piers: Brickwork piers as supporting elements either simple or reinforced. Brickwork piers constructed *in situ* as jointing elements to preformed panels.

CEILINGS AND ROOFS

Dome roofs in lightly reinforced brickwork or hollow tile. Waterproofing by screed or membrane.

Continuous roof-wall structures in common bricks, special shaped bricks or extruded hollow tiles.

Low-arch roofs in lightly reinforced brick or hollow block materials, designed to deliver no lateral thrust to supporting walls.

Flat roofs in reinforced brickwork or hollow tile construction.

BRICK STAIRCASES

1. *Treads* consist of reinforced brickwork slabs (13¾ in. wide) of bricks laid flat (frogs down) in stretcher bond, ¼ in. ϕ rods being inserted in continuous longitudinal ½ in. mortar joints ½ in. from bottom face. Mortar 1 : 1/10 : 3 cement-lime-mortar. Treads, if precast and matured for 14 days (3 days if R.H. cement be used) can be built in brickwork as it rises without shuttering or support. If built *in situ*, rough temporary support will be necessary.

2. *Rise.*—The rise of 7½ in. has been chosen to fit in with the usual 3 in. rise per course of brickwork, thereby facilitating assembly: each alternate tread slab will thus run with the brick coursing, the intervening slabs being bedded on a 1⅞ in. mortar joint (or a tile or fireplace briquette inset made up to that height). The space beneath the front edge of each slab and the upper surface of the slab below is filled with a brick on edge.

3. *Going.* (*Width of tread.*)—Assuming normal bond of the brickwork the going is total width of slab less thickness of brick on edge plus space behind it (say 10 in.).

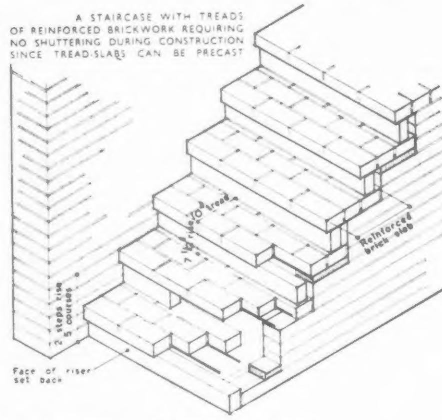
4. *Nosing of tread.*—Whilst the sketch shows ordinary bricks throughout, it will be more convenient in practice to use one of various types of chamfer or bull-nosed bricks for the front course of the tread slab. This will obviate the chipping of the front arris, which might arise if ordinary rectangular section bricks be used, and will facilitate both the subsequent placing of either a cement or granolithic covering of the staircase or the smooth running of stair carpeting if the brickwork be left fairface.

5. *Risers.*—In suitable vertical joints of the brick on edge fillings of the risers wooden plugs can be bonded in to provide anchorage for stair rod fixtures and the like.

6. *Balustrade.*—The 4½-in. brickwork can, if desired, either be carried up above tread level to form a balustrade, or a wooden plug can be placed at the end of the brick on edge risers to supply anchorage for an open banister system.

Design for reinforced brick staircase.

18



Reproduced by courtesy of London Brick Co.

4

CALCULATION OF BRICKWORK

[*By L. W. BURRIDGE, A.I.Struct.E.*]

THE structural members (columns, stanchions, beams, joists, slabs, etc.) which, tied together, form the load-bearing frame of a reinforced concrete or steel frame building are rationally designed. That is to say, the mechanical behaviour of each of the steel or concrete members, alone and when tied to others, has been the subject of such a degree of investigation and test by groups of competent engineers, sponsored primarily by the manufacturing interests concerned, that there exists a complete body of trustworthy data on the subject.

By means of this data, the scientific principles and methods of designing reinforced concrete and steel structures have been so clearly established that they monopolize the major portion of all courses of structural engineering tuition and form the subject of innumerable text-books, design charts, tables, etc., and account for the very explicit requirements regarding structural reinforced concrete and steel to be found in all building regulations.*

As a result of this informed appreciation of their practical capacities, reinforced concrete and steel have in large constructions ousted to a very large extent our traditional constructional material, brickwork, regarding which, it has to be admitted, both the manufacturing interests and the authorities concerned with the examination of our building resources, have been lamentably apathetic.

As a result, now, when the necessity arises to conserve to the utmost our supplies of both timber (used normally for shuttering, floors, etc.) and steel (joists, stanchions, reinforcing beams, etc.), and our minds naturally revert to brickwork as a suitable alternative of long-proven load-bearing capacity, it is found that such guidance as exists on the subject of the rational design of modern brickwork appears briefly in building regulations as an alternative to a long and intricate set of empirical regulations, which fix the thickness of brickwork walls, etc., according to the height and length, regardless of the mechanical properties of the brickwork as determined by its make-up (strength of brick and composition of mortar).

The alternative rational method of designing brickwork given in modern building regulations,† which are relatively unknown to the majority concerned, specifies the maximum permissible loads which may be carried on brickwork walls and columns of various slenderness ratios (ratios of height to cross sectional area), and is rational in that, the stronger the brick and mortar used, the higher is the permissible loading. Examination of these specified loadings, which, according to the findings‡ of the Building Research Board, represent a safety factor exceeding 5, shows that brickwork is capable of taking very high loads.

For example, the Ministry of Health Bye-Laws† permit a laterally supported 13½ in. brickwork wall, 13 ft. 6 in. high, built of bricks of such medium compressive strength as 3,000 lb./sq. in.§ and laid in a cement mortar, to carry a total load of some 7½ tons per foot run, such load being the uniformly distributed combined dead and modified superimposed loads together with pressures due to eccentricity, lateral forces and concentrated loads at girder bearings, etc.

As another instance, the L.C.C. Building By-Laws permit a laterally supported 13½ in. by 13½ in. column of the same height (13 ft. 6 in.) and built with some very ordinary bricks (3,000 lb./sq. in.) laid in a 1 : 4 cement mortar to carry a similar total load of over 5½ tons.

These two examples, from the many variations of rational brickwork design possible, when other bricks‖ and mortar are used, show that, since it is desirable to avoid using timber and steel-consuming structural elements, brickwork rationally designed with a high margin of safety offers a perfect solution to many design problems. The use of brickwork to solve one such problem presented by our present needs, viz., the strutting of basements for A.R.P. purposes, without using timber or structural steel, forms the subject of another section of this survey.

With a view to facilitating the application of that portion of rational brickwork design which is already permissible under existent building regulations, reduced reproductions of two charts prepared by the Clay Products Technical Bureau of Great Britain are reproduced overleaf (Figs. 19, 20 and 21). The actual load-bearing capacity as defined by the relevant L.C.C. Building By-Laws* of brickwork columns and walls of given dimensions and built in bricks of known strength and mortar of definite composition can be ascertained quickly from these charts. Alternatively, if the height and the cross section or thickness of a required column or wall is fixed, the minimum strength of the individual bricks and the mortar composition can be similarly ascertained.

Before giving the examples illustrative of the use of the charts for these two purposes, the principles upon which their construction is based merit consideration. L.C.C. Building By-Law 19 divides bricks into seven different categories on the basis of their wet compressive strength, thus :

TABLE I

Brick Category	Wet Compressive Strength lb./sq. in.
Special	over 10,000
First	10,000
Second	7,500
Third	5,000
Fourth	4,000
Fifth	3,000
Sixth	1,500

L.C.C. Building By-Law 60 gives, *inter alia*, the maximum total pressure in tons per sq. ft. permissible upon brick walls and piers having a slenderness ratio not exceeding 6 for these seven categories of brick laid in various mortars, as follows :—

TABLE II

Brick Category and Strength	Mortar Composition by volume			Brickwork type†	Max. Pressure tons/sq. ft. $P_{max.}$
	Cement	Lime	Sand		
Special (over 10,000)	1	–	2	*a*	$\frac{\text{Str.}}{500}+10$ up to 40
First (10,000)...	1	–	2½	*b*	30
Second (7,500)	1	–	2½	*c*	23
Third (5,000)...	1	–	3	1	16
Fourth (4,000)	1	–	3	2	13½
Fifth (3,000) ...	1	–	4	3	11
Fifth (3,000) ...	1	1	6	4	10
Sixth (1,500) ...	1	–	4	5	8
Sixth (1,500) ...	1	1	6	6	7

And so on for sixth class bricks with weaker mortars.

The same by-law so defines the reduction factor to be applied to the maximum permissible pressure per sq. ft. when the slenderness ratio increases from 6 to the maximum

* e.g. L.C.C. Building By-Laws and Ministry of Health Model Bye-Laws. Series IV. Buildings.

† L.C.C. Building By-Laws, 1939. By-Laws 19, 58–60 : Ministry of Health Model Bye-Laws. Series IV. Buildings, 1939. Bye-Laws 37 (2) *b* and Schedules 1 and 2.

‡ Building Research Board Special Report No. 22, page 11.

§ This strength is below that of most of the common burnt clay bricks available everywhere in this country.

‖ Brick strengths can be as much as 10,000 lb./sq. in.

* See ref. † in col. 1.

† Used only for the purpose of this article : these symbols have no officially recognized significance.

ratio permissible, viz. 12, that the maximum pressure P_x for any given slenderness ratio (S) between 6 and 12 is a definite factor of ($P_{max.}$) listed in the last column of Table II for a slenderness ratio of 6, thus :—

$$P_x = \frac{16 - S}{10} . P_{max.}$$

Taking a specific case from Table II, viz. fifth class (3,000 lb./sq. in.) bricks laid in 1 : 1 : 6 mortar, for which $P_{max.}$ = 10 tons/sq. ft. we get, e.g. :—

Slenderness ratio	6 or less	7	8	$8\frac{1}{4}$	9	10	11	12
P ton s/sq. ft. ...	10	9	8	$7\frac{3}{4}$	7	6	5	4

Graphically, this relationship can be represented by a sloping straight line like any of those shown in either chart.

In this form, however, such lines would furnish but little immediate practical information, because—

1. Slenderness ratio (S) of any storey height (H) of a column of wall depends on the " effective height " of such column or wall, and, in its turn,

2. " Effective height " differs according both to—

   (*a*) Whether or not the structure is laterally supported at the top,

   (*b*) Whether the structure be column or wall.

3. Slenderness ratio (S) is also dependent upon the horizontal cross-section ($T \times W$) of the structure, where T is the dimension lying in the direction of the lateral support and W the other dimension, which, *in the case of columns*, is the actual width of the column, and, *in the case of walls*, is usually taken as 12 inches to get permissible load per foot run.

Table IV shows the slenderness ratio for these various conditions, as defined by the L.C.C. By-laws, when H, T and W are all expressed in the same units.

For those who like algebraical manipulations, these values for S* can be substituted in the equation already given, viz. :—

$$P_x = \frac{16 - S^*}{10} . P_{max.} \text{ tons/sq. ft.}$$

Table IV

Type of Structure	Column: Top laterally supported	Column: Not so supported	Wall: Top laterally supported	Wall: Not so supported
Effective height. L.C.C. definition	H	$2H$	$\frac{3H}{4}$	$\frac{3H}{2}$
Slenderness ratio (S)*	$\frac{H}{T}$	$\frac{2H}{T \text{ or } W\dagger}$	$\frac{3H}{4T}$	$\frac{3H}{2T}$

which, provided H, T and W are expressed in feet and/or fractions of a foot, can be modified for the two types of structure considered (columns and walls) thus :—

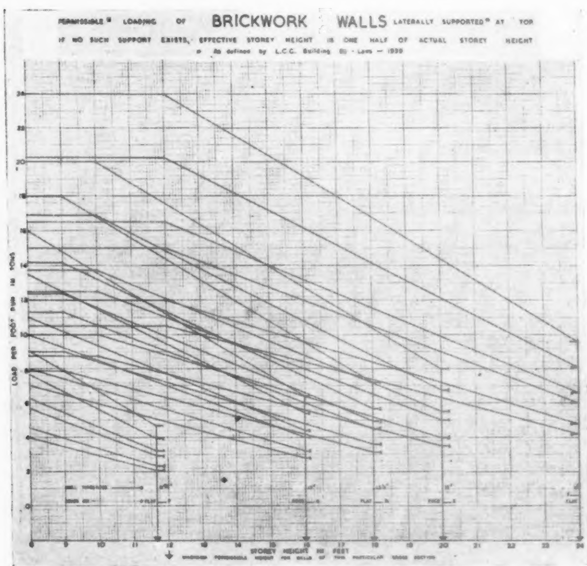
$$\left.\begin{array}{l}\textit{Total permissible load on}\\ \textit{whole area} \text{ of column head}\end{array}\right\} = \frac{T\,W\,(16-S)}{10} . P_{max.} \text{ tons.}$$

$$\left.\begin{array}{l}\text{Total permissible } \textit{load per}\\ \textit{foot run} \text{ of wall } \ldots \quad \ldots\end{array}\right\} = \frac{T\,(16-S)}{10} . P_{max.} \text{ tons.}$$

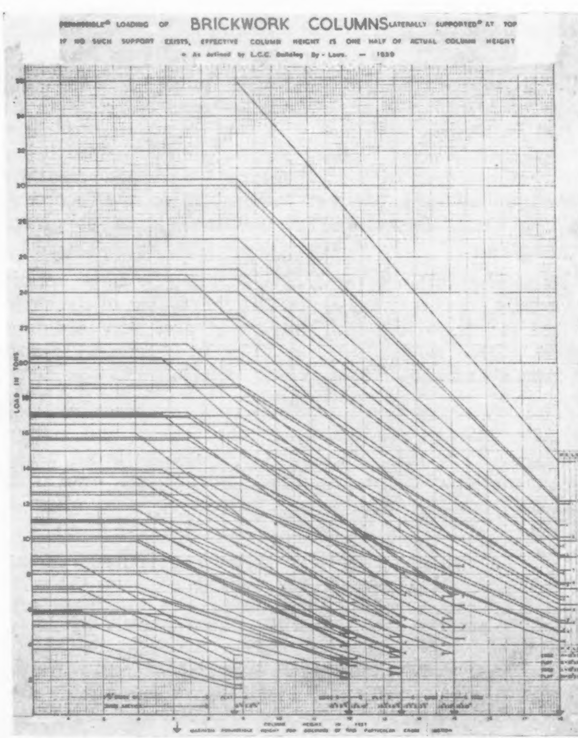
Since, as will be seen from Table IV, S is always some multiple of the storey height (H), these two equations enable a sloping line to be drawn (as is done in the charts) for each type of brickwork (each of which has a different $P_{max.}$) for each combination of dimensions usual with brickwork, e.g. $8\frac{3}{4}$ in., $13\frac{1}{2}$ in., 18 in., etc., for brick-on-flat, and $8\frac{3}{4}$ in., and 12 in., 15 in., etc., for brick-on-edge construction. Now, as will be seen from Table IV, the slenderness ratios for both columns and walls *unsupported* laterally are double that for *supported* structures. Therefore, for each column or

* Must not be taken as less than 6 : if it works out less, then for subsequent calculations it must be taken as 6 : if it works out to be greater than 12, the structure must be dismissed as not permissible.

† Whichever dimension, T or W be the less.



19



20

19 and 20—Reproductions of charts showing permissible loadings for walls and piers of six types of brickwork.

RESPONSIBILITY FOR GLASS

Tests on Protective Measures for Windows

WE have a sense of responsibility about the wartime welfare of the product we manufacture, and we regard it as very properly our business to put before architects, builders and municipal authorities, facts about the behaviour of glass under certain wartime conditions, and to describe the results of tests of various forms of protective measures. Therefore we have used this advertising space in order to issue a report of our observations on a number of tests carried out by our Research Department on protective measures for windows. These tests should be regarded as supplementary to those carried out officially by the Home Office. They confirm the findings set forth in various official publications.

The object of the tests was to observe the behaviour of unprotected window glasses and of window glasses treated in various ways, when subjected to the blast from explosions at different distances. The tests were considered from the point of view of " the man behind the window " and of " the man in the street." We were anxious to discover whether the treatments tried would reduce the risks incurred by either.

With bombs of the type and size used in the tests, the explosion is sufficiently sharp to ensure that practically the whole of the glass is sucked outwards from the window. An effect which is produced by many types of aerial bomb. It is by no means certain that all bombs would have the same effect, consequently the occupant of a room is in danger just as much as the outsider.

Now let us see what conclusions were drawn from our tests.

ORDINARY REINFORCEMENTS

One important point that emerged from the tests was that no ordinary kind of reinforcement such as can be put on to windows by the average person, will protect the window to any appreciable extent against fracture.

This is true whether the reinforcement is in the form of a sprayed coating of varnish, a layer of thick paper stuck on with an adhesive, or strips of adhesive tape such as surgical tape, electrical insulating tape, and so on.

It becomes important, therefore, to consider not so much how the glass itself can be protected against fracture, but rather how the splinters of glass produced when the glass breaks, can be prevented from flying violently either inwards or outwards.

GUMMED TAPE

Of the various treatments which have been adopted by large sections of the public, it may be said at once that the ornamentation of windows by patterns made of narrow strips of thin gummed paper has virtually no protective value whatever. The paper is altogether too weak to keep the splinters together when the glass breaks.

SURGICAL TAPE

Surgical tape, on the other hand, will stick well and, if the strips are not more than 4 in. to 5 in. apart, is sufficiently strong to hold the glass together, even if the window breaks and the glass is completely dislodged from the frame. The value of any treatment of this type depends entirely on strong adhesion to the glass, coupled with strength and toughness of the strip or tape.

VARNISHES

The above remarks apply equally to varnishes. If a varnish is to be of any value it must have the property of adhering strongly to the glass when dried, the film must be of sufficient thickness to give strength, and the varnish must have and must retain that combination of flexibility and strength which will prevent it from cracking when the glass itself breaks. In short, the varnish must be tough and flexible. It must stick well, and it must not become hard on prolonged exposure to light and air.

METHOD OF APPLICATION

Tapes, strips, varnishes, or other protective materials are best applied on the inside of the window where they will be protected from deterioration due to exposure to the weather. When properly applied they do afford a measure of protection against flying splinters, and are equally effective whether glass bursts inwards or outwards.

It must be pointed out, however, that although the glass does not come out as flying splinters, it comes out as a sort of flexible glass mat which can still do quite a lot of harm. Consequently, positions directly opposite a window, whether inside or outside, should be avoided during an air raid.

PROTECTIVE VALUE OF SHUTTERS

Shutters ranging from very light millboard to sheets of three-ply, or even to $\frac{1}{16}$ in. steel, can afford a very considerable measure of protection against injury from flying splinters if tacked to the frame inside the window.

There is, of course, a risk that nailed-up shutters may be torn from the frame and blown inwards in extreme cases. For this reason it is, in many respects, preferable to fit the shutters on strong elastic cords fixed to the top of the window frame, as described in *A.R.P. Memorandum No. 12*.

An alternative is to make shutters large enough to overlap the window opening, and to support them, by means of holes drilled in the shutters, on rods sticking out 4 in. or 5 in. into the room at the corners of the window opening. If the holes are a loose fit on the rods, the shutters slide inwards with a fair amount of friction if the window is blown in, the motion being sufficiently checked for all the splinters to be arrested before the shutter reaches the limit of its travel.

ADVANTAGES OF WIRE NETTING

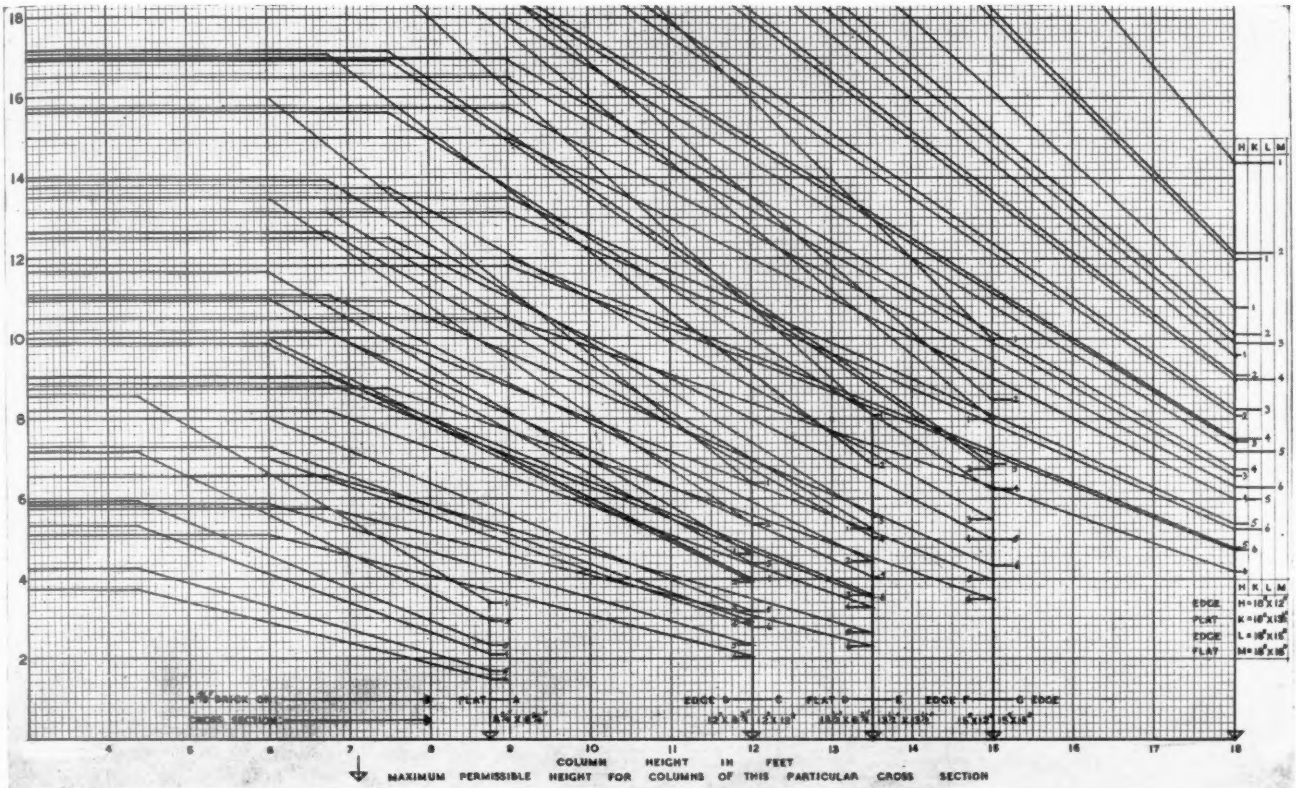
A further protective device which is worth serious consideration is to hang a light framing 2 in. or 3 in. back from the window, and to cover this with small-mesh wire netting, such as is used for chicken coops.

Wire netting of $\frac{1}{2}$ in. or $\frac{5}{8}$ in. mesh, supported in this way, does not greatly reduce the amount of light coming in through the window. Neither does it interfere seriously with vision through the window, though, of course, one has to become accustomed to looking through a grille. Netting fixed in this way will stop practically all splinters from being projected violently into a room, and is one of the most effective safeguards against injury due to broken glass.

* * *

It is evident from our observations that considerable danger still exists, no matter which of the protective measures suggested above is used for ordinary glass windows. But there are other types of glass which eliminate danger almost entirely, such as glass reinforced with wire, hollow glass bricks, toughened glass lenses and "Armourplate" glass. Their powers of resistance to blast and explosion have been tested and the published results will be sent on application. Film records of these tests can be seen by appointment at our London showrooms, 63 Piccadilly, W.1. Our Technical Department, at St. Helens, Lancashire, is always available for consultation on the use of glass in A.R.P. and in any form of structural work.

Issued by Pilkington Brothers Limited
St. Helens, Lancashire



21 **Larger reproduction of lower portion of chart shown in 20. This reproduction is referred to in the examples of brickwork calculation described below.**

wall of given dimensions, it is only necessary to draw one sloping line for each type of brickwork, i.e. that for the more usual "supported" type of structures. Then, to ascertain from the "*supported*" line the maximum load permissible upon the corresponding structure of given storey height when *unsupported*, one takes the load reading corresponding to twice that storey height. Conversely, the maximum storey height of such a structure which may carry a given load when *unsupported* is half the storey height reading corresponding to that load upon the *supported* line.

On combining, in one chart, the various families of lines corresponding to the given type of structure (column or wall) built to various usual cross-sections in the several recognized forms of brickwork (Table II), such a chart can furnish in a few minutes the answers complying with L.C.C. requirements to such questions as :—

1. Given a brick of a certain strength, what is the minimum cross section (or thickness in the case of a wall) necessary to support a given load at a given height?

2. If the strength of brick, load and cross section be fixed, what is the maximum permissible storey height?

3. If the type of brickwork, cross section and storey height be fixed, what is the maximum permissible loading?

4. If the load, cross section and storey height be fixed, what types of brickwork may be used?

5. If the load and storey height be fixed, what cross sections and types of brickwork may be used?

The two charts here reproduced (**19** and **20**), for columns and walls respectively, include families of six lines each (numbered 1 to 6) corresponding to types of brickwork (i.e. brick strengths and mortars) commonly used for ordinary brickwork, i.e. the six types similarly numbered in Table II. The other types of brickwork permissible under the L.C.C. By-laws have been omitted—

(*a*) Because, with 6th class (1,500 lb./sq. in.) bricks for maximum load-bearing structures one would normally use as strong a mortar as possible; therefore, the introduction of lines corresponding to the weaker mortars would but complicate the charts without furnishing information of practical value.

(*b*) Because the strongest types of brickwork built with bricks of relatively high strength (which are less widely available and are usually somewhat more expensive) allow of much higher loads: consequently either the charts would have to be so large as to be unwieldy, or, on a convenient sized chart, the load scale would have to be so reduced as to obscure the more generally interesting information applicable to the more common types of brickwork.

The following are the instructions issued by the Clay Products Technical Bureau on the use of the charts and three examples of such use for brickwork column calculation.

TYPES OF BRICKWORK CONSIDERED

No.	Brick		Mortar Composition by Volume		
	Strength lb./sq. in.	L.C.C. Category	Cement	Lime	Sand
1	5,000	3rd	1	–	3
2	4,000	4th	1	–	3
3	3,000	5th	1	–	4
4	3,000	5th	1	1	6
5	1,500	6th	1	–	4
6	1,500	6th	1	1	6

USE OF THE CHARTS

Example 1.—*Given brick strength is* 4,200 *lb./sq. in.,* 1 : 3 *cement mortar (brickwork type* 2) *load* 8 *tons, what is the minimum cross section necessary for a column which* *is laterally supported in the direction of its larger horizontal dimension at a height of* 13 *ft.?*

On column chart, proceed vertically from height 13 ft. to meet horizontal passing through given load (8 tons): then trace downwards (to the right) each sloping line above this point until one marked 2 is found (F. 2) giving the minimum cross section as 15 in. by 12 in.

Example 2.—*Given* 1,500 *lb./sq. in. bricks laid in* 1 : 4 *mortar (brickwork type* 5) *what is the maximum loading which* 15 *in. by* 15 *in. column supported at a storey height of* 12 *ft.* 6 *in. may take?*

On column chart, proceed up short vertical line marked 15 in. by 15 in. (*G*) to find sloping line marked 5, proceed upwards to the left along that line to spot where vertical through 12 ft. 6 in. cuts it: the horizontal through that point gives maximum load (7·3 tons) permissible on column.

Example 3.—*Required to find the cross sections of an* 8 *ft.* 6 *in. high square section column which, when unsupported laterally, must carry a load of* 11 *tons, when built in various types of brickwork.*

On column chart, fix point where horizontal through 11 tons intersects vertical through twice (because unsupported) actual column height, i.e. through 17 ft.: list all lines above point, then delete from the list those columns whose smaller dimension is less than one-twelfth of the "effective" height (2 × actual height) in feet, thus :—

Line	Cross Section	Types of Brickwork	Deleted
H.1	18″ × 12″	1	Yes
M.3	18″ × 18″	3	No
L.2	18″ × 15″	2	Yes
K.1	18″ × 13½″	1	Yes
L.1	18″ × 15″	1	Yes
M.2	18″ × 18″	2	No
M.1	18″ × 18″	1	No

The remainder (all *M* columns) represent *unsupported* columns capable of carrying the required load.

Note for Column Data

The families of lines given for columns of other than square section give loads for columns so placed that their larger horizontal dimension *T* is in the direction of lateral support: if the smaller dimension *W* of a supported column lies in that direction, and also for all unsupported columns other than those square in section, it is necessary to work with the family of lines representing a square-section column of side *W* equal to the smaller of the two horizontal dimensions of an unsupported column, subsequently multiplying the load given by the square section column by $\frac{T}{W}$: alternatively, if the load be given, this must be divided by $\frac{T}{W}$ before applying to the appropriate square section. (See also Example 3.)

These charts have already proved exceedingly useful in dealing quickly with the design of column struts for strengthening basements of factory walls and roof supports. At a later date, others are to be issued dealing with the stronger bricks and with the additional types of brickwork permissible under the Ministry of Health Model By-laws which include other mortar mixes.

In closing, it must be emphasized that all the discussion and charts in this note are based on the very conservative requirements (i.e. large safety factors) of the L.C.C. Building By-laws. Under war emergency conditions it may be considered justifiable to exceed the maximum loadings indicated, to what extent in any case must be left to the judgment of the designer.

Later it is hoped to deal with those further developments of rational brickwork design involved in the spreading use of reinforced brickwork for beams and slabs, columns and walls: already the Ministry of Health Model By-law 41 allows wall thickness to be reduced where reinforcement is introduced and other official bodies are at present engaged in codifying reinforced brickwork construction.

APPENDIX

In the foregoing contribution I have restricted consideration to those brickwork structures which satisfy the requirements of existent building regulations, such as the L.C.C. Building By-laws and the Ministry of Health Model Building By-laws, which latter are now applicable throughout the country. There is one condition, common to both these sets of regulations, which I consider unduly restrictive, viz. the drastic reduction in permissible load as the slenderness ratio increases from 6 to 12, which amounts to 60 per cent. at the maximum (12). This severe reduction is, in my opinion, quite unwarrantable and is not, to my knowledge, based upon any test evidence. In point of fact, there exists definite test data to show that whilst there is a tendency for the strength of brick masonry *to increase as the slenderness ratio decreases below six* (a condition entirely ignored in our regulations) it remains practically constant from six to twelve. Reporting these tests in *American Society for Testing Materials Proceedings* 38 (1), pages 363–369, Professor Krefeld of Columbia University expresses the opinion that the correction factor for the permissible loadings at various slenderness ratios should be as follows, the loading for a slenderness ratio of six being taken as unity.

Slenderness ratio *S*	1½	2	3	4	5	6	8	10	12
Correction factor to be applied to loading for *S* = 6 ...	1·7	1·5	1·25	1·12	1·04	1·00	0·97	0·94	0·92

It is interesting to compare the last figure 0·92 with the 0·40 prescribed by our building regulations.

In closing, I would add that I find that many other British workers in this field are of my opinion in this matter.

5

A NEW GENERAL PURPOSE BRICK

ALL present-day designers of reinforced brickwork recognize that the rectangularity and standardized dimensions of the ordinary brick set a limit to the extent to which they can achieve maximum economy of design. For example, in a beam subjected to bending stresses, the nearer the tensile reinforcement can be placed to the soffit, the greater the economy. With standard bricks, such as the 2⅝ in., this nearest distance is that thickness, unless the steel be placed in the internal vertical joints of the soffit course, an expedient which may entail considerable widening of such joints if the steel section be large. Similarly, in column construction, such reinforcement as is introduced should be as near the exterior surface as is consonant with reasonable cover. The nearest approximation to that desideratum possible with standard bricks is represented by brick on edge construction, as is shown, for example, in the details for reinforced brick columns given in the official publication, Wartime Building Bulletin No. 1. Economical Type Designs in Structural Steelwork for Single-Storey Factories, Fig. 5, just published (May, 1940). Moreover, if the expedient of using widened vertical joints to accommodate the steel (either tensile or shear) be adopted, normal bonding of the brickwork is sacrificed, which, although usually of minor importance from a mechanical point of view, may nevertheless tend to detract from the æsthetic appeal of fair-faced reinforced brickwork.

Realizing these economic and æsthetic limitations imposed by the normal brick upon reinforced brickwork design, one of the authors of the comprehensive paper* read last year before the Institution of Structural Engineers designed a modified form of the ordinary perforated brick, which, like the ordinary type, is quite suitable for ordinary brick construction and can also be quickly converted by the bricklayer on the job into a slotted brick, having slots so placed as to facilitate both normal bonding and economical placing of the steel. A convenient version of this modified perforated brick is illustrated in the accompanying diagram. It will be noted that the orientation of the perforations is such that if, for example, that shown isometrically be considered a stretcher, then removal of either of the outer cores (by a simple hammer blow) of the brick shown in plan will convert that into a brick suitable for placing as a slotted header centrally on the stretcher brick. Other variations will quickly occur to the reader.

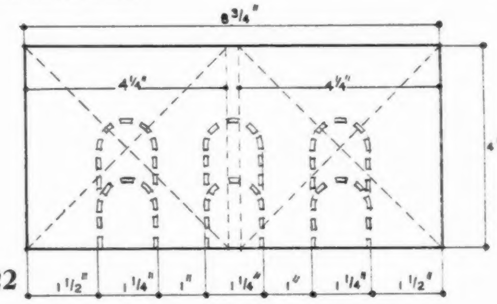
Hence quite a number of vertical steel rods can be economically accommodated near the surface of a normally bonded reinforced brickwork column, portions of a normally bonded wall can be converted into vertically reinforced columns and vertical shear steel can be placed in normally bonded reinforced brickwork beams. Again, used on edge in the soffit course of a beam, such slotted bricks will allow the tensile reinforcing bars to be placed in the most efficient position. Similarly, the brick will facilitate the economical design of reinforced brickwork floor and roof slabs.

As has already been stated, this new type of perforated brick is to be regarded as a general-purpose brick, replacing

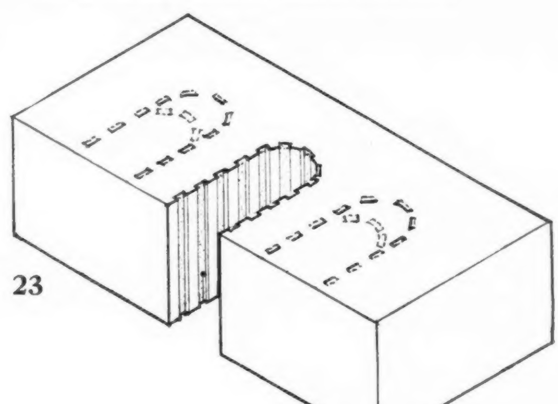
* Hamann and Burridge: Reinforced Brickwork: *Structural Engineer* (April, 1939), pages 198–250.

the ordinary solid brick* for general use, but immediately convertible on the job, if required, into a special brick accommodating reinforcement at any desired place. Even used for plain brickwork, such a specially perforated brick offers definite advantages since, by knocking out the appropriate slots as he goes, the bricklayer can form the necessary chases for lighting, water, gas or panel heating conduit in the bonded brickwork as it rises. It should also be noted that the rough surfaces of fracture of the slots will afford a good mechanical key for the mortar embedment of reinforcing rods, and, in this connection, are preferable to the smooth surfaces of specially slotted or drilled bricks.

* In this connection it is interesting to note that in certain countries abroad, the standard brick is *perforated*, and not solid as here; the perforations are considered as an advantage, giving better mortar bond.



22



23

22 and 23—Plan and isometric sketch of new brick designed for use either as an ordinary or as a slotted brick. A preliminary patent for this brick has been applied for.

LETTERS

Helping Honeymooners

SIR,—In the editorial of your issue for June 13 you draw attention to what you consider a very serious omission from the wide syllabus of the Research Board in which architects and town planners are taking part.

The problem of "Setting-up House" was actually considered before the Research Board came into being, and it was decided that it was of such importance that a special committee was formed as a Joint Committee of Members of the Royal Institute of British Architects and the Incorporated Institute of British Decorators, from whom the original idea came. This committee has held regular meetings for some time and has set up all the machinery to put its scheme into operation.

Unfortunately, the increasing stress of war activities makes it impossible to continue the work for the moment, but directly conditions improve, it will be pushed forward even more comprehensively than you have suggested.

H. S. GOODHART-RENDEL

Chairman, R.I.B.A. Research Board, London, W.1.

Flat Roofs and Air Attacks

SIR,—With over forty years' experience in the use of asphalt in building construction I am surprised that little consideration is given by owners of property to the conversion of flat asphalt roofs into miniature reservoirs for safeguard against fire, in the event of their penetration during air attack.

The process of conversion is simplified by the fact that an asphalt roof is usually constructed to falls, and where it is surrounded by a parapet wall all that is necessary is to block the outlets up to a sufficient height to give an average depth of 3 in. of water over the whole area. In the absence of a parapet wall a 9 in. by 9 in. brick wall or precast concrete kerb waterproofed with asphalt, with 4½ in. high outlets at intervals, would meet the case.

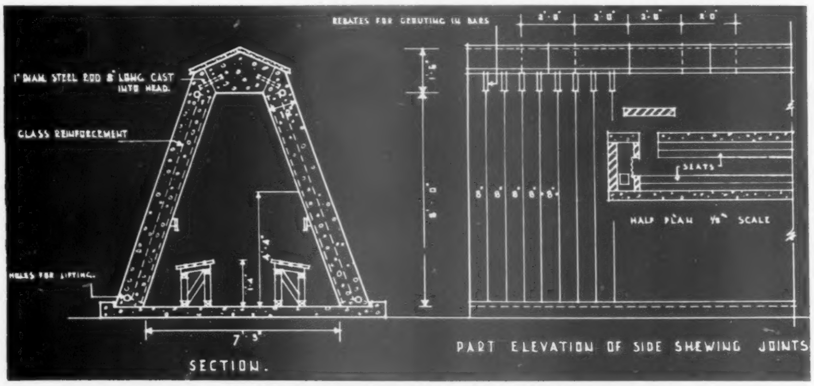
I would further suggest that larger

roofs should be sub-divided into sections by means of strips across the roof of similar construction, so that in the event of an incendiary bomb penetrating the structure sufficient water to extinguish any fire caused would follow in its track, but only one section of the roof acting as a reservoir might be affected.

An average depth of 3 in. of water over 100 square yards of roofing would impose an evenly distributed load of approximately 7½ tons, or 1,687 gallons of water, over the whole area, and such an area could be sub-divided into five or even more separate waterholding sections.

The construction of water-holding roofs is largely practised in the textile industry, and my suggestion is that it could be extended in these times to the protection of civil property.

Berks. S. C. MARRIOTT
(Manager, Building Department, Limmer and Trinidad Lake Asphalt Co., Ltd.)



Design for prefabricated street air-raid shelters. By Soden and Lincoln. See note below.

TRADE ITEMS

It was announced at a meeting held in the London offices of Pilkington Bros. on Friday last that it is now possible to use glass in place of steel reinforcement for concrete. This invention of glass-reinforced concrete has been devised by two architects, Messrs. A. W. Soden, A.R.I.B.A., and John A. Lincoln, and has been patented.

As soon as war began, Messrs. Soden and Lincoln began to search for a substitute for steel for reinforcement. After experimenting for some months they took their plans to Mr. E. H. Paisley, A.R.P. Engineer, Royal Borough of Kensington, who gave consideration to the use of glass-reinforcement for concrete air raid shelters. At his instigation independent tests were carried out on behalf of the Council of the Royal Borough at the City and Guilds College Structural Laboratory, South Kensington. Dr. W. S. Marshall, B.SC., PH.D., A.M.INST.C.E., carried out the tests in the presence of experts of the Building Research Station, the Home Office and the Office of Works. It is stated that the results of these independent tests proved that slabs of glass-reinforced concrete would carry four times the maximum load required by the Home Office for street and other air raid shelters. Further tests are to be carried out within the next month on beams having spans of 10, 12, 15 and 18 ft.

From their experiments the architects conclude that glass actually has advantages over steel—apart from cost—as reinforcement for concrete. They state :

In reinforced concrete beams steel rods are embodied in the lower edge to take the whole of the tension which is equal to the compression taken by approximately the top third of the concrete. The remaining two-thirds of the concrete is mechanically wasted as regards load-bearing and merely acts as a binding agent and shear. It has been found that by substituting glass-reinforcement for steel the neutral axis is lowered and more concrete is brought into play for compression. And as the glass cross-sectional area is three times as much as steel, hardly any concrete is wasted.

The glass-reinforcement is in strips five-sixteenths of an inch thick, the depth being half the depth of the beam which it is to reinforce. An important feature is that one edge of the glass is not cut but is the fire-finished edge, known as the selvedge, in the state in which it comes from the process.

For reinforcement requirements, the architects state, polishing and refining weaken the glass and the cut edge is not capable of taking strain. By placing the glass strips in the beam or slab so that the cut edge is at the neutral axis and the selvedge lowermost, the stress taken by the glass, although only half that of rod form, is practically and scientifically balanced. In this form too the question of shear does not need to be provided for.

In these early stages there are of course certain disadvantages, notably the present limit in span and a lower impact load than steel-reinforcement. Impact load, however, is mainly concerned with the problem of surface air raid shelters, and here the difficulty is easily overcome by a number of methods. Finally, there is the absence of yield before failure. These disadvantages revealed by initial tests will be subjected to further research.

It was thought at first that Armourplate glass would give the best results, but although the glass itself takes much higher stresses than ordinary glass, the effect of pure tension in a straight line, to which a reinforcing bar is subjected, is to add the tension of the beam to the tension already existing in the inner core of the glass. (Armourplate has an inner core which is in a state of tension in relation to the outer crust, which is in compression.) Armourplate or toughened glass would also be uneconomical for reinforcement.

Further researches, however, are being carried out with toughened glasses and with glass fibres which have a comparative tensile strength many times greater than that of steel.

We are informed that a group of individuals and firms interested in building is co-operating with Messrs. Soden and Lincoln in securing the fullest possible application and development of the invention as an aid to wartime building.

•

An exhibition of wartime building is now being held at the offices of the Cement and Concrete Association, Terminal House, 52 Grosvenor Gardens, S.W.1. The exhibition, the main object of which is to show how concrete can be used in place of materials which have to be imported, is divided into four sections : domestic construction ; domestic planning ; the uses of precast concrete for formwork in place of timber or steel ; and a number of photographs showing the general uses of concrete especially applicable in wartime.

Of the four sections into which the exhibits are divided, the most important is that devoted to domestic construction. It shows how houses can be built in traditional styles without using timber, by the adoption of precast concrete units for roof members, floors, stairs and window and door frames.

The central feature of this section is the proposed housing scheme at Coventry, by Mr. D. E. E. Gibson, the city architect, which is illustrated by plans and perspectives (by Mr. Myerscough-Walker). It will be recalled that the Coventry City Council recently decided to proceed immediately with the erection of 2,500 houses of the type designed by Mr. Gibson ; in these houses extensive use will be made of concrete units and asbestos-cement products.

The exhibition will remain open until July 31.

INDUSTRIAL HOUSING COMPETITION

As announced in last week's issue, Mr. Bertram Baden has placed at the disposal of the R.I.B.A. the sum of £750 for use as premiums in a competition associated with the prosecution of the war. The committee appointed by the Council of the R.I.B.A. to examine and prepare conditions of this competition, and to act as assessors, are : Messrs. Kenneth Cross, F.R.I.B.A., Chairman, R.I.B.A. Competitions Committee, R. Fitzmaurice, B.SC. (Building Research Station), J. H. Forshaw, F.R.I.B.A., and G. A. Jellicoe, F.R.I.B.A., who have considered that the architectural profession can make a contribution towards the problems of *industrial housing*, which are causing the gravest concern to public and private authorities. Following prizes will be awarded for suitable designs : (1) for the house, first prize, £250 ; (2) for the estate plan, first prize, £100. £400 in additional prizes will be awarded at the discretion of the committee.

Details of the competition, which is open

to students and members of the R.I.B.A. and members of allied societies, are obtainable from the Secretary of the R.I.B.A., 66 Portland Place, W.1, price 6d.

ROYAL SOCIETY OF ARTS

Council of the Royal Society of Arts has re-elected Sir Atul C. Chatterjee, G.C.I.E., K.C.S.I., as its chairman for the ensuing year. The new Council is constituted as follows :

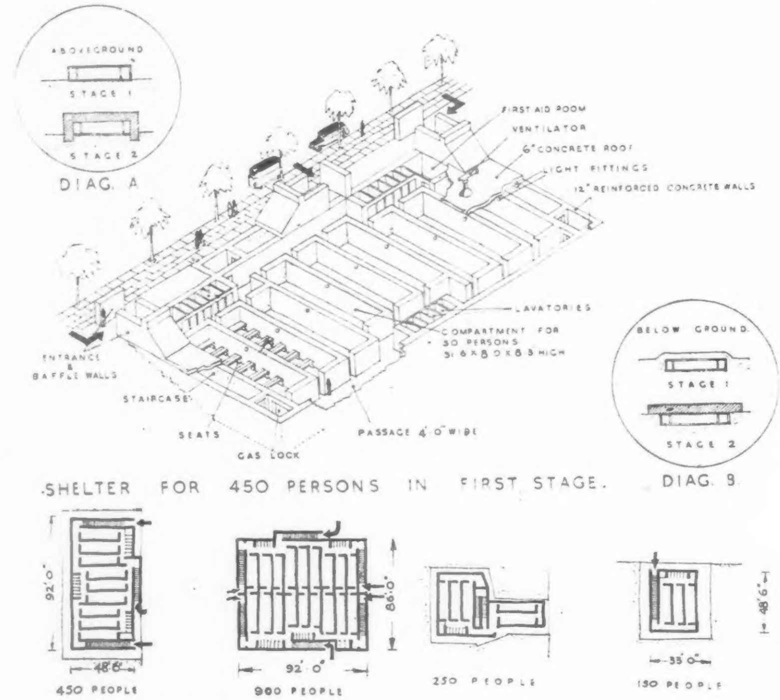
President: H.R.H. the Duke of Connaught and Strathearn, K.G. Vice-presidents: Lord Amulree, P.C., F. H. Andrews, Lord Askwith, Viscount Bledisloe, P.C., Sir Atul C. Chatterjee, Sir Edward Crowe, G. H. Drummond, E. V. Evans, P. M. Evans, Sir Edward A. Gait, H. S. Goodhart-Rendel, C. Geoffrey Holme, Basil Ionides, P. H. Jowett, Lord Kenilworth, Sir Harry A. F. Lindsay, Sir William Llewellyn, Sir David Meek, G. K. Menzies, John A. Milne, Oswald P. Milne, Sir Henry A. Steward, Brig. Sir Edward A. Tandy, Carmichael Thomas. Ordinary Members of Council: Alfred C. Bossom, M.P., Major P. J. Cowan, Prof. E. C. Dodds, Ernest W. Goodale, J. S. Highfield, Lord Huntingfield, L. H. Lampitt, Major Sir Humphrey Leggett, Tom Purvis, R.D.I., E. Munro Runtz, Captain A. H. Ryley, Andre L. Simon, Sir Edward Stubbs. Treasurers: E. F. Armstrong, F.R.S., Sir Henry McMahon.

BETTER SHELTERS

Better Shelters is the title of a pamphlet just issued by the A.A.S.T.A. The pamphlet is written in a popular way and is designed to appeal to the general public.

The first part of the pamphlet contains a concise outline of official policy and the powers of local authorities, e.g. when has a landlord an obligation to provide shelter? for what purposes can local authorities obtain Government grants, etc.? The second part contains a criticism of Government policy and a summary of the A.A.S.T.A.'s constructive proposals. The third section contains immediate proposals for improvements in the design and equipment of the types of shelters at present being constructed by local authorities throughout the country. In addition, there are two pages of illustrations and explanations of the Haldane Shelter, the first stage of construction of which it has recently been stated by Sir John Anderson will be considered as eligible for grant.

Copies of the pamphlet, price 3d. (4d. including postage), are obtainable from the A.A.S.T.A., 113 High Holborn, London, W.C.1. Prices for bulk quantities are : 1s. 3d. for 6 ; 2s. 6d. for 12 ; 10s. for 50.



PLANS SHOWING DIFFERENT SIZES AND ARRANGEMENTS OF SHELTERS

The Haldane Shelter. See note on this page.