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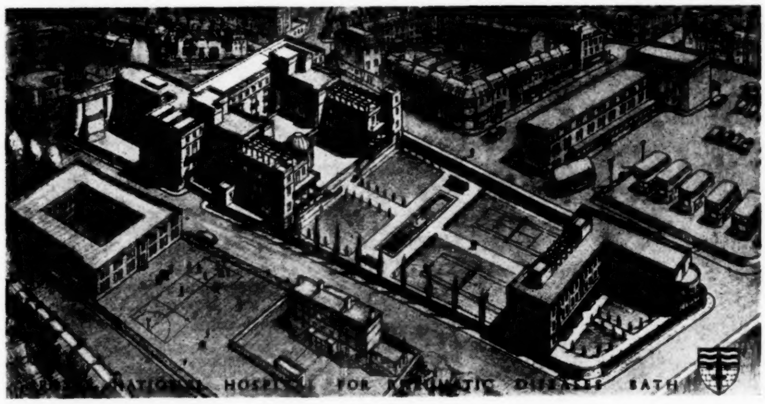
The Editor will be glad to receive MS. articles and also illustrations of current architecture in this country and abroad with a view to publication. Though every care will be taken, the Editor cannot hold himself responsible for material sent him.

THURSDAY, JUNE 8, 1939 NUMBER 2316 : VOLUME 89

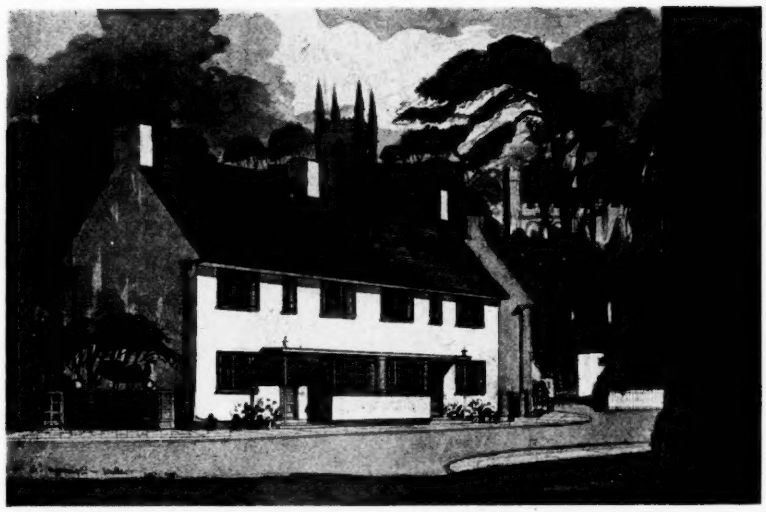
PRINCIPAL CONTENTS

TWO CURRENT EXHIBITIONS

ROYAL ACADEMY



The Royal National Hospital for Rheumatic Diseases, Bath : bird's-eye view. Architects, Adams, Holden and Pearson and A. J. Taylor.



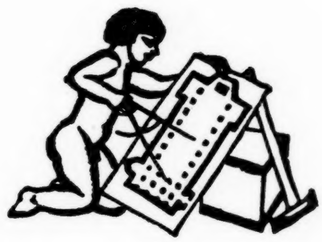
Pair of houses built in concrete. Architect, Raymond Walker.

ZÜRICH

The Textile and Fashion Building at the Swiss National Exhibition at Zürich. The façades are of wood, painted green and white.

FRENCH PROVINCIAL TOWN

From the tower of the cathedral at Clermont-Ferrand, France.



NATIONAL SERVICE

A LETTER (from Colonel Dixon-Spain) published in this issue suggests in words that a child could understand that when fighting services need large numbers of men to raise them to desired strength it does not look well for architects to protest strongly against exclusion from the reserved list. He adds :—

> Nor do I think the R.I.B.A., representing the profession, would honestly consider its members to be properly more or less "exempted from the grim future."
>
> This protest is made having full regard for a certain distressing waste of the early days of the Great War and all the rest of that argument.

A question of some consequence hangs upon these final sentences.

If the situation is in reality that which Colonel Dixon-Spain implies, there will hardly be an architect who will not agree with his conclusions. But if the emergency against which this country is now preparing cannot be so simplified it cannot be taken for granted that wholesale enlistment is the best contribution which the profession can make to defence.

Colonel Dixon-Spain's view appears plain. In the event of war he considers there will be a FRONT on which all major decisions will take place and to which danger of physical injury will be largely confined. He believes that for the R.I.B.A. to try to absolve its members from the necessity of entering this danger area is unpatriotic.

No architect will quarrel with this conclusion if the prior assumptions are valid.

The bulk of available evidence, however, seems to make clear that a future war will be something entirely different. It seems to show that the magnitude of the resources needed must make a quick decision the only successful decision for which an aggressor can hope. This need, in turn, will make the destruction of civilian life, industry, transport and *morale* of far greater military consequence than any partial success in the field. Therefore—for the first few months at least—*the* front will be any or all of the closely populated areas of Britain and the front of 1914 the sideshow.

If this contention is true, and both the weight of evidence and the present policy of the Government points to such a conclusion, it must control all preparations for defence. The objective of such preparations is to convince possible aggressors that they have no chance of winning a quick decision ; for it is already certain, if this danger is removed, that it is impossible for them to win a long war.

This primary objective can only be attained by two separate forms of preparation. One, the organization of all forms of passive defence on a scale that will make it impossible for aerial bombing to disorganize essential activities in this country. Two, the strengthening of the armed forces.

In the view of the majority of the public, and of architects, no strengthening of the armed forces can outweigh the consequences that might result from insufficient organization of passive defence. Not only are fighting services now dependent on industry in ways that are well known, but the *morale* of any expeditionary force will depend also on the safety of the civilian population.

Architects believe that their qualifications enable them to help in organizing defence to a degree which—if properly used before war breaks out and for the first few months afterwards—would be more valuable than any service in which their professional qualifications were not used.

But at this point Colonel Dixon-Spain, or anyone else jealous for the profession's reputation, might ask a further question : Are architects now taking the part they should in passive defence ? To this question the JOURNAL thinks architects will find it difficult to reply with satisfaction to themselves.

There are probably about 10,000 architects over thirty whose various ages and qualifications suit them for jobs of varying kinds. Should war come a very large range of services would need architects—fire, demolition and repair services, camp and shelter construction, camouflage and the extension of vital buildings. The great majority of these 10,000 have placed their names on the National Register and nearly all would welcome the opportunity of preliminary training in work in which they would be needed in the opening stages of hostilities.

The difficulties of any such allocation are obviously very great. But now that a far more vigorous policy of passive defence is being pursued we believe that all architects should try to see that it is carried out. For in one contention Colonel Dixon-Spain is unquestionably right : there is all the difference in the world between doing one's bit and merely announcing one's willingness to do it.

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N O T E S & T O P I C S

VIGILANCE COMMITTEE

THE first thing I had better say this week is that I deplore the mistake that credited London University with four votes instead of its proper eight —a score which raises it to equal-fourth in order of popularity.

*

Mr. Henry Strauss, M.P., adds to a minute analysis of arithmetical errors in last week's score-board another charge. He says that he was *not* asked for British buildings. If he had been he would have substituted the Penguin Pool and Chelsea Bridge for the Rockefeller Centre and the House of German Art at Munich. Explanation : A small proportion of candidates were asked to vote without being told that the voting was to be restricted to British buildings. Mr. Strauss was one of them. His revised list is very welcome, as it gives us another vote for Chelsea Bridge.

LORD DERWENT'S CHOICE

From the information contained in the above-mentioned handsome but, alas, not entirely accurate score-board, I pressed Lord Derwent to select a team. He was to consider himself already nominated Chairman of a proposed vigilance committee (of eleven) whose members were to be chosen by himself. Here is his list :

Mr. James Bone ; Mrs. Hugh Dalton ; Lord Esher ; Dr. Julian Huxley ; Mr. Osbert Lancaster ; Mr. James Lees-Milne ; Mr. Charles Marriott ; Mr. Frank Pick ; Mr. Henry Strauss, M.P., and Miss Rebecca West.

*

The object of the Committee, you will remember, was to pass judgment on the suitability of proposed prominent buildings *before* they were built.

*

This list must be judged on two grounds : Is it as representative of the intelligent public as any list of ten could be when one excludes architects ? Do the buildings chosen by its members make it probable that the members are sufficiently similar, or complementary, in their views on architecture for their criticism to be constructive ?

*

The answer to the first question is " Yes." The answer to the second will be continued in our next.

CURE GUARANTEED

This week has made it quite certain that Sir Alison Russell is not going to have the question of smoking chimneys all his own way.

*

Sir Alison, it will be remembered, made two claims : (1) That a triangular fireplace was an infallible cure for smoky chimneys ; and (2) astonishingly few people were aware of the fact.

*

In a letter published elsewhere this week, Mr. A. R. Rush shows that Sir Alison's triangular grate is well known as the " Old Leamington Grate," and that in Dr. Reid's *Practical Sanitation* (7th edition, 1900) the author stated that he had often recommended this fireplace for its heat-radiating properties.

*

Mr. Rush adds, however, that *he* has an appliance which gives perfect results. I hope he will tell us about it.

*

Sir Alison also suffers at the hands of Mr. R. A. C. Simpson, this time unjustly. Sir Alison Russell did not claim to have invented the shape : he only said no one seemed to know about it. Mr. Simpson knows the shape works well for logs—but for all smoky chimneys " I have my doubts."

*

It is this uncertainty I want to remove. Is the triangular shape smoking-proof or not ? If it is, why is it ?

SIR PHILIP SASSOON

Sir Philip Sassoon, whose death was reported last week, had been First Commissioner of Works since 1937. Not since the days of George Lansbury has the office been filled by a man of such imagination and enthusiasm. Most Commissioners regard their post as an unimportant step on the way up. To him it was a job full of interest and opportunity. The flowers and seats in the parks, the decorations in the Mall, the restoration of Downing Street, the attempts to clean up and re-light the Palace of Westminster, are small but significant signs of the personal interest he brought to his task.

*

He will perhaps be particularly remembered for the series of exhibitions of Gainsborough, Reynolds and European porcelain which he organized in aid of charity at his Park Lane house. His personal taste was for 18th-century portraits and silver, of which he had a distinguished collection, and he had a wide knowledge

Chapel at Invergarry by Ian Lindsay of Orphoot, Whiting and Lindsay.—A Vigilance Committee choice by Mr. George Scott-Moncrieff.

of period furniture. A man of such sensibility and taste is rare in politics, and he will not be easily replaced.

THE RESORT COURTEOUS

Blackpool has responded to my comments on its appearance not with the usual expostulations, but with the resigned cheerfulness of a beer baron on being told that his bottles look old-fashioned.

★

Interviewed by the local newspaper, one Councillor stated that Blackpool was "not nice from an architectural point of view"—"higgledy-piggledy" he called it—and the Borough Surveyor said with some justification that previous generations were to blame.

★

Few towns are so willing to admit their faults. If Blackpool had any enemies they might say it was because the faults were so obvious. Those more generous and optimistic might hope that it meant something was going to be done. An effort has certainly been made with the trams. Well-shaped, silent and brightly coloured, they are quite the best bits of design on the whole front.

★

And the front stretches for seven miles.

GENTLEMAN'S PLEASURE FARM FOR SALE

Sir Edgar Horne wants to sell his Surrey seat at Shackleford, three miles from Godalming, described in a *Times* advertisement as "A gentleman's pleasure farm, with . . . 204 acres, including productive arable and pasture lands and virtually *the whole of the picturesque village of Shackleford*." The estate contains two secondary residences, twenty-three superior cottages, village stores and a fully licensed inn.

★

Hall Place, as the pleasure farm is called, is built in the Jacobethan style of fifty years ago, and is famous for its architectural loot. For instance, the dining-room panels came from the original Cock Tavern of Fleet Street, where Pepys "made mighty merry" with one Mrs. Knipp. Other panelling is made out of pews from a Yorkshire church. A medieval cider-press has been converted into a dove-cote, and there is a studio in the Elizabethan style.

★

Sir Edgar, by the by, is a Chartered Surveyor, and in 1911 was President of the C.S.I.

HOW TO SELL YOUR SEAT

The Field, famed news-organ of the landed gentry, has been handing out advice on how to sell your country seat —"a problem that faces the majority of landowners, sooner or later."

★

Private sale (says the writer), as opposed to public auction, "presents fewer difficulties with regard to planning and ribbon development and is usually effective." The owner is advised not to sell the whole area as one. Selling plot by plot realizes the highest price, but the middle course of selling in blocks is usually most satisfactory.

★

We hardly expect *The Field* to support the shocking principle of public ownership of land. But we do expect it to rise above the get-rich-quick type of estate development and give some enlightened advice on more civilized ways of partitioning the land. After all it is supposed to circulate amongst civilized people.

★

Planning and zoning seem to be regarded as nuisances to be got round. Yet *The Field*, no doubt, would claim to be spokesman for "our greatest heritage."

THE MYSTERIOUS THERMIT

By this time we have all heard the story of the A.R.P. shovel and the wrong kind of incendiary bomb. I myself have watched a test in which the thermit went slick through a thermit-proof patent material: to the chagrin and bewilderment of the manufacturer who had invited me. This week a correspondent tells of tests in which so little damage was done that the thermit was tried on an unprotected R.S.J. to see if it was really trying. There seems a catch somewhere.

★

Even the official description of what an incendiary bomb actually is (see p. 1003) does not solve the problem. Apparently thermit is merely used to start up the real combustible, which is a magnesium alloy. But this alloy, though ferocious to look at when going strong, burns at a lower temperature than thermit and therefore would seem a less severe test than neat thermit. I give it up.

ASTRAGAL

The usual weekly features—Information Sheets, Prices, Trade Notes, etc., are held over from this issue; they will be resumed next week.

NEWS

●

TOWN AND COUNTRY PLANNING IN ENGLAND AND WALES

In order to keep National Fitness Area Committees in touch with the progress of town and country planning schemes, area secretaries are to be supplied with lists of local authorities and joint executive committees which have prepared or are preparing such schemes.

The list will be supplemented by monthly statements issued by the Ministry of Health, copies of which will be forwarded to area secretaries as and when they are received.

PLANNING SCHEME FOR MIDLOTHIAN

A resolution, passed by the County Council of Midlothian, to prepare a planning scheme for the county, was approved on May 30 by the Department of Health for Scotland. The area involved extends to 202,617 acres. It contains the five burghs of Musselburgh, Dalkeith, Bonnyrigg and Lasswade, Loanhead, and Penicuik, and a number of villages, some of which are of considerable size. These burghs and many of the villages contain buildings and other features of great historical and artistic interest.

The power now obtained by the County Council will enable them not only to preserve these buildings and features, but also to guide the rebuilding of the old core of these places. It also enables them to exercise control over other developments in and around the burghs and villages, including the location of residential units, industrial areas, the density of dwelling-houses and the external appearance of buildings.

A.A.S.T.A. TOUR TO THE U.S.S.R.

The time-table of the A.A.S.T.A. tour to the U.S.S.R. (August 19–September 10) is as follows:

Aug. 19 (Saturday)	Sail from London Bridge at about 4 p.m.
Aug. 24 (Thursday)	Arrive Leningrad at about noon.
Aug. 25 (Friday)	Day in Leningrad; leave for Moscow at 9.25 p.m.
Aug. 26 (Saturday)	Arrive Moscow at 10.0 a.m.
Aug. 27 (Sunday)	In Moscow.
Aug. 28 (Monday)	Ditto
Aug. 29 (Tuesday)	Leave Moscow for Rostov-on-Don at 6.45 p.m.
Aug. 30 (Wednesday)	Leave Rostov at 12.20 p.m.
Aug. 31 (Thursday)	In Rostov.
Sept. 1 (Friday)	Leave Rostov at 8.22 p.m.
Sept. 2 (Saturday)	Arrive Dnieproges at 5 p.m.
Sept. 3 (Sunday)	Leave Dnieprogres at 6.20 p.m.
Sept. 4 (Monday)	Arrive Moscow at 9.30 a.m.; continue to Leningrad at 9.40 p.m.
Sept. 5 (Tuesday)	Arrive Leningrad at 10.10 a.m.; embark for London at about 5.0 p.m.
Sept. 10 (Sunday)	Arrive London Bridge.

The fee for the tour is £26 10s. to members of the Association, and £27 to non-members.

NEWS IN BRIEF

● Mr. S. Colwyn Foulkes, F.R.I.B.A., of Colwyn Bay, has been elected President of the North Wales Architectural Society.

● The practice carried on by the late Oliver P. Bernard, at 93 Park Lane, W.1, is being continued at the same address under the title of Oliver P. Bernard and Partners.

● Restoration work has been commenced on the former Troitse-Sergiyevsky Monastery (now an historical museum) in the town of Zagorsk near Moscow. Built in the first half of the fourteenth century, the monastery is a splendid example of Russian medieval architecture.

● The 1939 Hotel, Restaurant and Catering Exhibition, third of this series of biennial exhibitions, will be held at Earls Court from November 23 to December 1.

R.I.B.A.

R.I.B.A. COUNCIL ELECTION

Sir Ian MacAlister writes: "The attention of the R.I.B.A. has been called to a circular letter issued over the signature of Mr. Philip S. Phillips in connection with the R.I.B.A. Council Election. As the form of this circular may have given the impression that it was issued from the Institute, I am requested to point out that it is a purely personal communication and was sent out without the knowledge or approval of the R.I.B.A. The proposed 'Representation Committee' is in no way official or connected with the R.I.B.A. I am also requested to point out that the issue of the circular is in direct contravention of the Council's resolution deprecating organized canvassing for votes at R.I.B.A. Council Elections."

SPECIAL OPEN EVENING AT THE R.I.B.A.

On Thursday, June 15, there will be a special open evening for members of the R.I.B.A. and their guests at the Royal Institute, when the Cotman exhibition will be on view to members, and when Lord Lee of Fareham will give a short informal lantern lecture, followed by a discussion describing the lighting and technical equipment of his picture gallery at Avening, Gloucestershire. Sir Kenneth Clark will be in the chair.

In this gallery, built to house Lord Lee's collection of pictures, remarkable success has been achieved in eliminating reflections and producing ideal temperature and atmospheric conditions.

Many of the leading gallery directors, picture collectors and experts will be present, and it is hoped that a constructive discussion will follow Lord Lee's paper, in which the architects' and picture experts' points of view may be exchanged.

The evening will be entirely informal. Coffee will be served at 8.15, and there will be refreshments after the lecture which will begin at 9. Members of the R.I.B.A. who want to come are asked to write to the Secretary, R.I.B.A., so that some estimate of the numbers may be obtained.

THE ARCHITECTS' DIARY

Thursday, June 8

R.I.B.A., 66 *Portland Place, W.1. Exhibition of Water-colours and Architectural Sketches by the late Sir E. Guy Dawber, R.A. Until June 17. Also (until June 28) an exhibition of the collection of Architectural Drawings and Water-colours by John Sell Cotman, bequeathed to the R.I.B.A. by the late Mr. Sidney Kitson, F.R.I.B.A. 10 a.m. to 8 p.m. (Saturdays 10–5).*

LONDON SOCIETY. *Visit to works of T. Wall and Sons. 3 p.m.*

SCHOOL OF PLANNING AND RESEARCH FOR NATIONAL DEVELOPMENT. *Bedford Square, W.C. Open Forum Meeting. "The Influence of Scientific Discovery on Developments in Physical Planning." Speakers: Professor J. D. Bernal, M.A., F.R.S., and R. Fitzmaurice. A general discussion will follow. 8.30 p.m.*

Monday, June 12

LONDON SOCIETY. *Visit to the Spanish and Portuguese Synagogue, Beris Marks, E.C.3. 3 p.m.*

Wednesday, June 14

INSTITUTION OF CIVIL ENGINEERS. *Great George Street, Westminster, S.W.1. Annual Conversazione.*

REIMANN SCHOOL, 4–10 *Regency Street, S.W.1. "The Planning of Flats." By Wells Coates. 8 p.m.*

LONDON SOCIETY. *Visit to the Beckton Works of the Gas Light and Coke Company. Leave Lancaster House at 1.30 p.m.*

Monday, June 19

R.I.B.A., 66 *Portland Place, W.1. Announcement of result of Annual Election of Council. Informal Discussion of Matters of Professional Interest. 8 p.m.*

LETTERS

COLONEL J. E. DIXON-SPAIN
V. M. CONNAL
HUGH QUIGLEY
R. A. C. SIMPSON
A. R. RUSH
A. P. HODGSON
McDONOUGH RUSSELL
"RUSTAU"

National Service

SIR,—May I humbly but definitely protest against the outcry on the deletion of "Architect" as a reserved occupation and the acclamation of its provisional reinstatement?

I would invite attention to Dr. Herbert Levinstein's remarkable letter, "The Exemption of the Chemist," in *The Times* for May 23.

Jealous of the readiness for service of the profession to which I have the honour to belong, I will not believe that any plea for inclusion would be advanced by the rank and file of the profession.

Nor do I think the R.I.B.A., representing the profession, would honestly consider its members to be properly more or less "exempted from the grim future."

This protest is made having full regard for a certain distressing waste of the early days of the Great War and all the rest of that argument.

J. E. DIXON-SPAIN

Vigilance Committee

SIR,—In common with most of your readers I have been extremely interested in your incursions into the realm of straw ballots to which you were incited by Lord Derwent, but there are one or two criticisms of an arithmetical nature which I venture to put forward on the summary which was published last week.

In the voting summary London University building is shown with four votes, but the detailed lists disclose that in addition to Lord Esher, Dr. Huxley and Messrs. Keynes and Laughton, votes for this building were also cast by James Bone, David Low, Henry Strauss and Joseph Peter Thorp. This brings the score up to eight.

In addition to this, Herbert Read's vote for Ruislip car depot does not appear to be credited to Charles Holden, whose personal score should be nine instead of four.

In Tecton's score, although Mr. Henry Moore and Dr. Vevers in their lists included Highpoint 1 and 2 as one vote, it has been credited separately to the two buildings. If this method of counting were equitable it would, I suggest, be equally logical to count the votes of Messrs. Mortimer and Piper, who voted simply for "Zoo buildings," as having voted separately for the whole number of buildings which Tecton have designed at Regent's Park and Whipsnade. I believe that Messrs. Tecton's score should be reduced to 24.

I would like to add that I was personally delighted to find the very significant appeal which Tecton's work had for the Vigilance Committee, since in their case more than in that of most architects the real collaboration between architect and engineer is so apparent.

I am not an architect, but an engineer, condemned for my sins to design the skeleton on which the architect builds his finished work. Perhaps because of this, or maybe in spite of it, I have a considerable if uneducated interest in the finished product, and I would like to put forward a suggestion which I believe would be of interest to readers of the JOURNAL. Make up a ballot paper of all the buildings which received two or more votes, print it in the JOURNAL and ask your readers to vote. Confine your voters to architects (you will probably have to trust non-architect readers like myself to refrain from voting). The resulting order would be an interesting parallel to the present results.

V. M. CONNAL

Renfrewshire.

[*The error in the Scoreboard concerning the votes cast for London University has been pointed out by many correspondents. We much regret it and apologize to Mr. Charles Holden. Our regret for minor errors is reduced by the knowledge that the results could not be completely accurate, since one or two nominees later changed their minds and others would have done so had they realized sooner that* British *buildings were being asked for* (*see* "*Astragal*" *this week*).—ED. A. J.]

SIR,—It is rather significant that the building which has received the highest praise from your jury, namely, Peter Jones' store at Sloane Square, should provide an almost perfect example of how electricity can be used in modern architecture, from the heating of the building itself to the illumination of the façade.

It is also interesting to note that the second building on the list, namely, Battersea Power Station, should have provided the electricity used in the Peter Jones store.

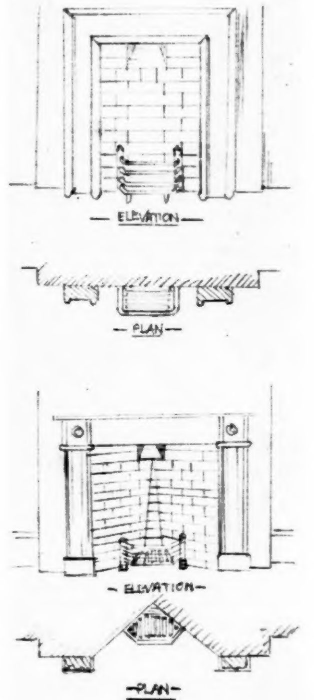
HUGH QUIGLEY

London.

Cure Guaranteed

SIR,—I note in your issue for May 25, under the heading Notes and Topics, the letter from Sir Alison Russell about the cure for smoky fireplaces, with some comments on same by Astragal. It would appear that Sir Alison claims the triangular shape hearth as his own invention, and claims it as a complete cure for smoky chimneys.

I have always understood, however, that the triangular shape hearth was an idea of the late Sir Robert Lorrimer's, as the best type of hearth for burning logs.



The "*Staffordshire*" (*top*) *and* "*Old Leamington*" *grates.*

I built this shape of hearth in the dining room of my own house, and as far as burning logs is concerned, it is ideal ; as a cure for smoky chimneys, I have my doubts. My own certainly does *not* smoke. I have seen others which the owners informed me were not entirely free from down draught.

R. A. C. SIMPSON

Workington.

SIR,—*Re* "Notes and Topics," in the issue for May 25, where reference is directed to "Cure Guaranteed, Cure for Smoky Fireplaces," and the notes following the letter of Sir Alison Russell, by Astragal.

I am pleased to offer to Astragal the help which he asks for, and I refer him to a work of George Reid, M.D., D.P.H., "Practical Sanitation," this is a standard work, and in the Seventh Edition, 1900, which I have before me, I find that in Chapter III, Ventilation and Warming, that on page 63 appears an illustration of the fireplace referred to in your current notes.

The name given to this type of fireplace is that of "The old Leamington Grate" (Fig. 20), which, together with one known by the name of "The Staffordshire Fireplace" (Fig. 19), is referred to in the text as being met with in old houses, and that the combustion and heating power is excellent, and in the case of the "Leamington Grate," the fire does not stand quite so far forward, and as the sides, which are constructed of firebrick, form an angular opening, the apex of which is at the back, a large surface is thus exposed to the fire, and much heat is radiated into the room. The author has in many instances induced householders to adopt one or other of these grates, and has usually had some trouble in convincing them that it would "draw," owing to the distance which separates the fire from the flue (it will be noticed that in both fireplaces referred to, the flue starts backward at a point very nearly as high up as the mantel-shelf), but in no instance in which the suggested change has been made has the verdict been other than satisfactory.

I am pleased to help in a solution and incidentally, remove any misapprehension, that architects are in any way behind the times, rather are they inclined to sacrifice constructional features to satisfy modern trend for appearance.

I hope you will find the above remarks welcome, and thereby reveal to your numerous and competent readers a construction which may perhaps have been allowed to remain in the background.

I attach a drawing of the "Staffordshire" fireplace, also of "The old Leamington Grate," these are taken from the book referred to, permission to reproduce I take it would be given if need be. The name of the publisher is Charles Griffin & Company, Ltd., Exeter Street, Strand.—A. R. RUSH

Northampton.

P.S.—I have made a long study of this problem, "Smoky Chimneys or Fireplaces," and I can assure you that the triangular construction has points in its favour for extra draught creation, but first and last, it is not essential or self-sufficient.

I have, I think, perfected an appliance which will give perfect results, and which of necessity obeys physical science in its principles, I do not hesitate to say that the only argument against most apparatus is that the appearance could not be sacrificed even to a cure, hence, I suppose, the fact that this Leamington Grate appears a novelty to quite a few of us, whereas it is old, and in its heyday quite common.—A. R. R.

A.R.P.

SIR,—There are two points in the admirable commentary on the Air Raid Shelter Code published in your number for June 1 that I should like to comment upon. The first concerns the velocity of falling debris within a building : Messrs. Samuely and Hamann assume that the top storey collapses first, and that the resulting debris demolishes the lower floors in turn, suffering however a check in the speed of its fall at each level. But according to Mr. Skinner's observations in Barcelona, the destruction of many of the buildings there began with the blowing away of the ground floor walls ; in such cases will not debris attain the full velocity corresponding to the height it falls from ?

My second comment is upon the description of the official debris loads as "reasonable." The Government's own experiment at Winchester shows that. the Code figures are theoretically inadequate : for, according to Mr. C. W. Glover, the actual weight of debris was 250 lb. per sq. ft., and the force of impact 362 lb., making 612 lb. per sq. ft. in all. The comparable Code figures are 250 or 350 lb. per sq. ft. (including 50 lb. for the normal super. load) ; the house had two main floors and an attic, and it is therefore not quite clear whether we should treat it as having two or three storeys over the basement ; but even in the latter case (corresponding to the load of 350 lb. per sq. ft.) the total measured load was 75 per cent. greater than what the Code says it ought to have been. It is interesting to note from the remarks of Mr. A. L. Roberts at the R.I.B.A. General Meeting that the Government itself works to higher loads than it advocates : for the figures he quotes in connection with the official design for steel strutting tested at Winchester correspond to 450 lb. per sq. ft.

When we pass from ordinary domestic construction to that usual in other classes of buildings the discrepancy between the Code figures and the loads that may occur in practice becomes even more striking. A building consisting of basement, ground, first and second storeys had floor and roof slabs spanning without beams over a distance of 26 ft. The total weight of the two upper floor slabs and the roof, including all finishes but omitting the contents of the building, was 385 lb. per sq. ft. The weight of the brickwork (omitting that to the ground floor which is assumed to be blown outwards) was 161 lb. per sq. ft., evenly distributed over the shelter roof ; total, 646. If some of the upper brick walls fell outside the building or if the debris formed a natural arch a lesser figure would, of course, be attained ; but have we any right to expect such fortunate accidents in every case ? In the absence of any general information, we may perhaps allow for impact in the same proportion to debris loads as was observed at Winchester, and we thereby obtain a total load on the shelter roof of 1,580 lb. per sq. ft. The corresponding figure according to the Code is 384.

This is admittedly an extreme case ; but between this and the opposite pole represented by the house at Winchester, there will lie many instances in which the actual loads may be expected to attain from one-and-a-half to four times the Code figures. Either drastic revision of the Code, or a conclusive demonstration that the foregoing arguments are fallacious, seems to be called for.

Mitcham. A. P. HODGSON

SIR,—Interest in A.R.P. is so widespread, and there is such a lamentable lack of accurate information about it, that you may wish to define more closely the building materials whose tests with incendiary bombs you illustrated on June 1.

The lath and plaster ceiling consisted of ⅜-in. gypsum plaster lath with two coats of gypsum plaster on the underside. The special heat-insulating powder which so noticeably prevented the spread of sparks was a powdered gypsum filler.

In the second photograph the protection round the R.S.J. was not the material mentioned but a gypsum fireproof cement which is being specially developed for A.R.P. purposes. It is only fair to add that in the last test, where the joist was, as you stated, considerably damaged, the metal was enjoying no protection of any kind.

What actually happened was that the various protective materials were so very effective that even we began to think that perhaps the bombs themselves were not really trying, and we therefore tried a bomb on the unprotected end of the joist to see what effect it would have.

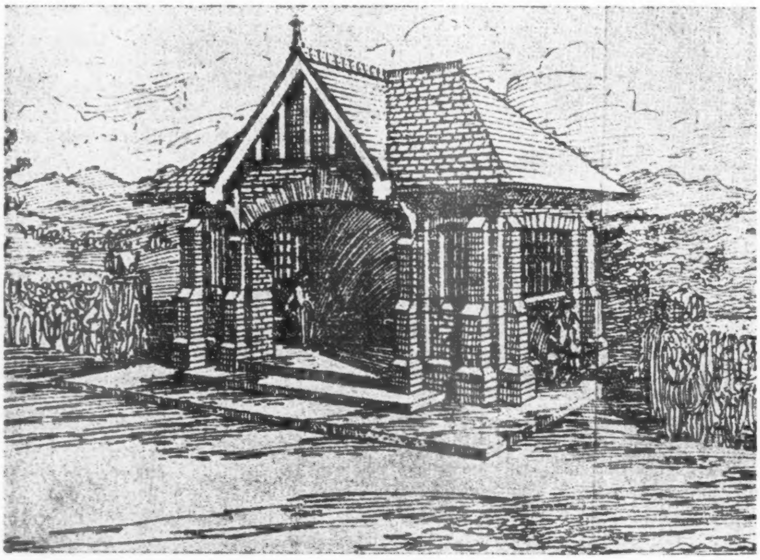
MCDONOUGH RUSSELL
HONEYWILL & STEIN LIMITED
London.

Provincial Jobs

SIR,—I think it is desirable to draw attention to an aspect of certain provincial posts which may be new to many assistants. The writer has come across various cases wherein an assistant in London has been tempted to accept a post in the provinces for the sake of increased salary. So far so good, but it should be pointed out that in some cases this salary is grudged and after a while the initial circumstances are forgotten and the employers commence a "beating down" process on the justification that salaries in the provinces are never so high as in London. "Why should an outsider be paid any more than a local man ? " they reason, and if the assistant is in any way settled down he will often capitulate. The final stage, of course, is that the employee is worse off from every point of view than if he had never made the move at all.

Glasgow. "RUSTAU"

THIS ARSHETECTURE



MEMORIAL TO JOHN PEEL

A move with regard to the proposed erection of a " shelter " memorial to John Peel, at Caldbeck, about which there has been controversy in recent years, was reported at the twentieth annual conference of the Affiliated Associations of Cumberland and Westmorland, held on Monday in Keighley Temperance Hall.

Mr. W. W. Fisher, Oldham (chairman of the John Peel Memorial Committee), announced that a start had been made with the proposed scheme. Through the generosity of Mr. Jennings, who lived in the Caldbeck neighbourhood, the Cumberland and Westmorland Association were now in possession of a piece of ground immediately opposite the Caldbeck Churchyard, on which the shelter could be erected. It was hoped to have the memorial ready by August. Towards the total cost of the memorial they had £252 12s. in hand, and about £35 would still be needed.

Towards the remaining £35, contributions amounting to £30 were promised at the meeting.

Whether the conference should affiliate as a member of the Friends of the Lake District was a point which gave rise to considerable discussion, and it was decided that the matter be referred back to the Associations for discussion before being dealt with by the conference.

The conference decided to give its moral support to the application by Mr. Hugh Machell (Brighton) to the College of Arms for a proper Coat of Arms for the County of Cumberland, at present non-existent.

Major R. Rigg was re-elected chairman and Mr. J. S. Barker, general secretary.—**From the "West Cumberland Times."**

CIVIL DEFENCE-2

THE GOVERNMENT'S POLICY FOR A.R.P. STRUCTURES

AN ANALYSIS BY

FELIX J. SAMUELY AND CONRAD W. HAMANN

IN Part I of this analysis, published last week, the A.R.P. Act, 1937, the Civil Defence Bill as amended in Committee and published on May 24, and a portion of the Provisional Code for A.R.P. Shelters were examined. In this issue the remainder of the Code, the Home Office Memorandum No. 10 and other relevant publications are discussed.

Contents of Issues

AIR RAID SHELTER CODE (continued)

The Provisional Code (H.M.S.O. Price 6d.), of which the first portion was examined last week, is continued below.

For purposes of reference the Code has been subdivided by the authors into paragraphs. These paragraphs are not, strictly speaking, part of the Code.

LIST OF PARAGRAPHS

AIR RAID SHELTERS FOR PERSONS WORKING IN FACTORIES AND COMMERCIAL BUILDINGS

Draft of Provisional Code
[Section 12 Civil Defence Bill]

TEXT OF CODE

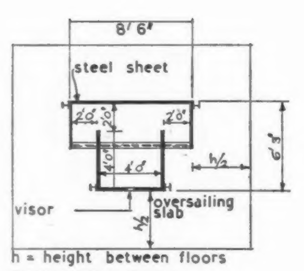
(21) ***Shelters for Special Classes of Personnel.***
Special consideration will need to be given to the provision of shelters near the scene of their duties for special classes of personnel, such as:
(*a*) Key men whose duty it is to remain at their posts tending vital plant and services (for example, boiler-house and switchgear attendants, and men in charge of machinery which cannot be shut down at short notice) and
(*b*) A.R.P. personnel.

(21) *Key Man Shelters.*—A key man shelter should occupy the minimum of space, but at the same time accommodate comfortably two people. Gas proofing, if it should be required, is difficult, because the occupants must have free passage at all times to tend to the machines, etc., in their charge, and air locks are impracticable owing to their size. Occupants must rely on respirators, which should be of the service type.

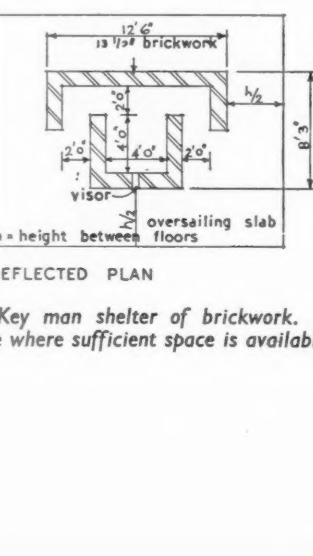
(Figs. 111 and 112)

Shelters may consist of four struts carrying a roof sufficiently strong to withstand debris load, and overhanging the actual shelter by 2 ft. on all sides. Walls of brickwork, reinforced concrete or steel of the adequate thicknesses (*see* paragraph 3) may be used, but steel, requiring the least space, may often be adopted to advantage. Spy holes with double, non-splintering glass of 3 in. diameter should be provided. Traversed or screen wall entrances should be adopted wherever possible, but where blast-proof doors are used sufficient natural ventilation must be provided by other means than the doorway.

The columns at the corners can be carried up to support the ceiling, and a circle of additional struts should be arranged round the shelter. The walls should then be carried up almost to the ceiling to protect the occupants, but where the rooms are high enough to allow a gap at the top for ventilation, a protected vent should be made on one side near the floor, and when this is done space can be saved by adopting blast-proof doors in place of the screen walls (Fig. 113). Another type of shelter, which is portable, is shown in Fig. 114.



111 *Steel key man shelter.*



112 *Key man shelter of brickwork. (Only possible where sufficient space is available.)*

SHELTERS OUTSIDE BUILDINGS

(22) ***General.***
The choice of the type and position of shelters will nearly

(22) *Position of trenches in relation to buildings.*—On sloping ground trenches should, preferably, be on the down-hill side from the building, as this affords more rapid entry of the occupants, but the question

TEXT OF CODE

always be governed by site conditions. No hard and fast rules can be laid down.

Where there is vacant land adjoining the premises the required protection may often be obtained by placing shelters on this land. The land need not necessarily be rendered unsuitable for future building extensions if the shelters are sited with the possibility of future extensions in view. Trench shelters may be so arranged that they come between the rows of stanchion bases or footings of possible building extensions, and, by keeping the top of the trench lining to a suitable depth below the proposed floor level, the shelters need not interfere with the floor layout, or shelters may be so arranged as to form a part of the basement of a future extension. Emergency exits from the shelters would be arranged in the form of manholes or traps set at the level proposed for the building extensions. A scheme where this arrangement has been carried out is shown diagrammatically in Fig. 69.

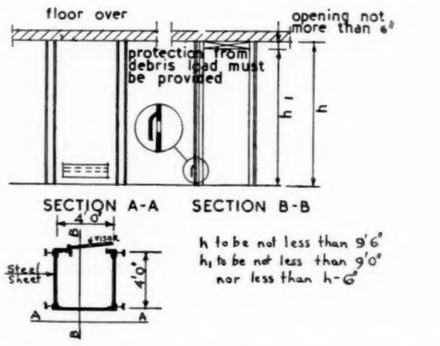
Every advantage should naturally be taken of favourable site features. If there are disused quarries or sandpits adjacent to the premises tunnels can be made in the quarry face. An alternative method, which has been used, is to construct a shelter at the foot of the quarry face and then to bury it completely by throwing down material from the upper part of the quarry face.

Location.

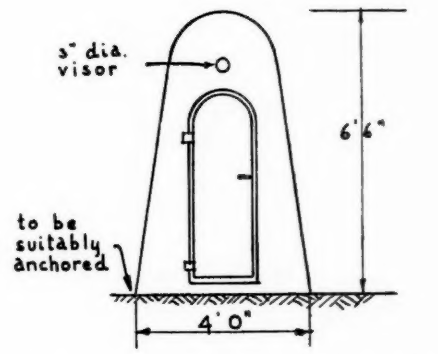
It is an advantage to construct shelters close to the premises, for in that way they can be occupied more quickly and there will be less disturbance of production. There is very little likelihood of the shelters being more vulnerable on account of their proximity to buildings, and the advantage of ease of access outweighs any possible disadvantage in greater vulnerability. The shelters should, however, be kept at a safe distance from high buildings, chimney-stacks, water-towers, etc., so that in the event of a collapse of any part of these structures the shelters will not be damaged by falling debris. Drainage is an important matter, and wherever possible shelters should be constructed on the higher part of the site, or on a slope so that they can be drained naturally.

Layout of External Shelters.

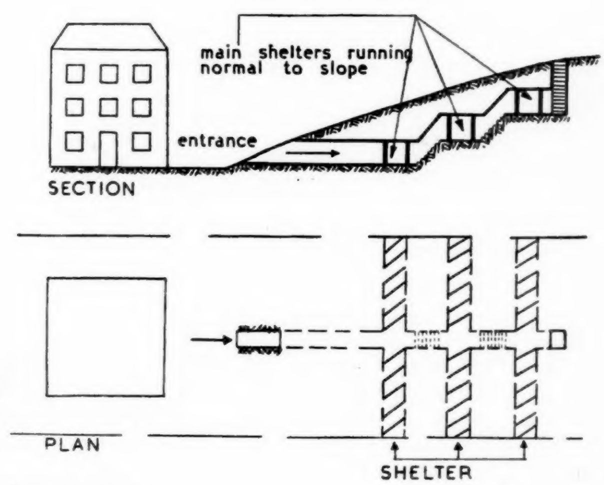
External shelters should not be too closely spaced, and 25 ft. clear should be regarded as the minimum spacing, and 40 to 50 ft. of drainage must also be considered in relation to the siting of a shelter system.



113 *Key man shelter in high rooms, naturally ventilated through slots.*



114 *Key man shelter, transportable, with natural ventilation.*



115 *Steps in shelters under rising ground. If drainage permits, the trench system should be arranged on the down-hill side of the building.*

Where the ground is level and free from obstructions, the layout of shelters will depend mainly on the density of people (*see* paragraph 11), and where this density is small (less than 550 people per acre of available space) trenches can be at 50 ft. distances from each other. Where the density is greater, distances must be reduced ; but the block plan of the code (Fig. 41) remains applicable up to a density of 1,420 people per acre of available space.

Where the density is still greater, the distance of the trenches as set out in paragraph 11 is to be further reduced and the standard of lateral protection to be increased.

The maximum density for trenches seems to be about 2,400 people per acre, and where the actual number of people is still greater, shelters of the basement type must be arranged, permitting of about 4,300 people per acre. Where, as might conceivably happen in populated districts with large shopping centres and office buildings, even that amount of space is not available, shelters of two or more storeys must of necessity be considered, although they are not envisaged in the Code. They are discussed in Appendix VII, page 1014.

The base of the trenches should be horizontal ; but steps or ramps may be included at certain points. (Fig. 115.)

The main trenches should, in such cases, run at right angles to the direction of the slope.

The requirements that shelters be constructed near to the premises which they are to serve and that they should be kept away from buildings, are not, in fact, contradictory, because the distances are purely relative. Even from a building 80 ft. high,

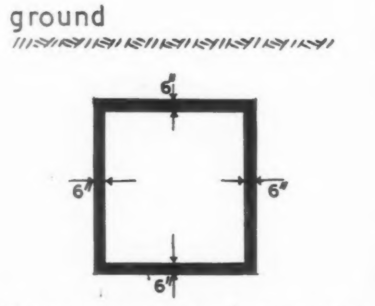
TEXT OF CODE

clear in any direction is to be preferred where space permits. Where space is very restricted as many as 1,200 persons can be accommodated on an acre of ground as shown in the block system illustrated in Fig. 41.

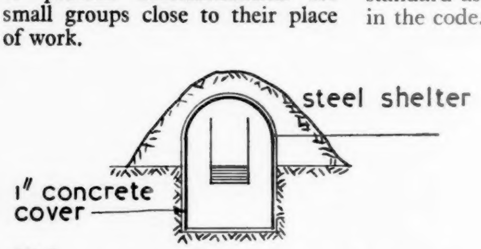
A layout of independent shelters is shown in Fig. 70. By this layout the shelters are spaced at least 25 ft. apart in any direction, and an advantage of this type is that the shelters may be scattered so as to provide accommodation for small groups close to their place of work.

shelters need not be further away than 38 ft., a distance which can be walked in less than 10 seconds. What should be avoided are distances involving walks of several minutes across unprotected areas. Psychologically, a covered corridor connecting the building to the shelters, though itself not adequately protected, will be of great advantage (*see* Fig. 88 and Fig. 94).

Wooded or bushy country may be of definite advantage. The propagation of blast and splinters will be reduced to a certain extent, and a network of branches may cause the explosion of bombs in the air, which otherwise might explode in a shelter. Under such conditions, the overhead protection against blast and splinters should be of the same standard as that of the lateral protection required in the code. *See* Fig 2, paragraph 2, page 926.



117 *Shelter of reinforced concrete, cast in situ.*



116 *Steel trenches, partly sunk in the ground.*

118 *Steel shelter, fully sunk in the ground.*

Continuous trench shelters should be divided up into accommodation for parties of 50 persons by traverses or by changes in direction.

(23) *Construction of Shelters.*

Except where excavated in hard rock, it will be necessary to provide linings for shelters below ground. The linings should be designed to withstand the earth pressures likely to exist on any particular site according to normal engineering principles, and, in addition, should provide the standard overhead protection laid down in Part I of this Code. The linings may consist of concrete cast *in situ*, precast concrete units, or steel units suitably protected against corrosion.

Suitable provision should be made for drainage and removal of water percolating from the ground, and drainage should be so arranged that surface water does not run into the trenches.

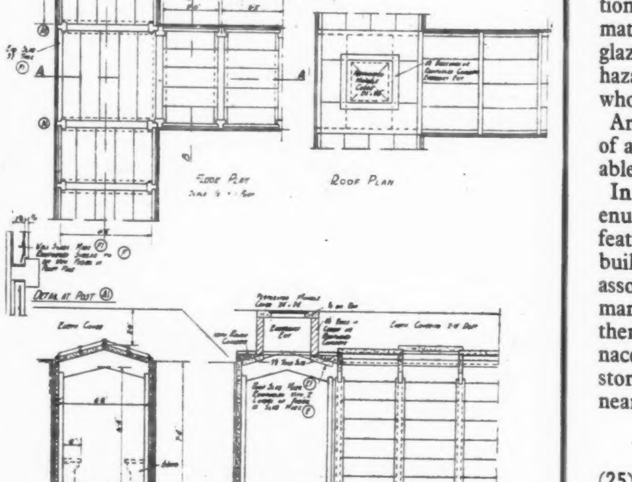
The outside of steel units should always be protected by at least 1 in. cover of concrete. Galvanizing or painting is not sufficiently permanent.

Steel units should be of corrugated or dovetailed sheet not less than 16-gauge (Fig. 116), which gauge is usually strong enough to withstand earth pressure, where the trench is sunk 5 ft. in the ground. Where a trench is fully buried (Fig. 118), 14-gauge should be used, and where more than 3 ft. of earth are on top or where debris loads must be taken into account, even heavier steel might be necessary as required by the calculations. Calculations are advisable in each case for the actual steel adopted.

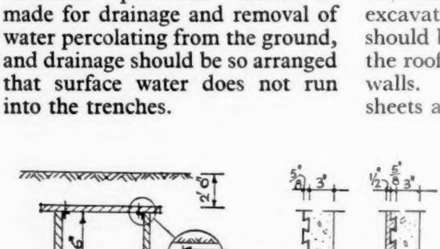
(23) *Construction of Shelters.*—Where trenches are lined with concrete, cast *in situ*, they can usually be 6 in. thick all round (Fig. 117), but again exceptions must be made, as, for instance, where more than 3 ft. of earth are on top or where debris load should be taken into account. Precast concrete can be used in several forms, one of which has been shown in Fig. 119, taken from the Home Office Air Raid Precautions Department's publication, "Specifications, etc. in Regard to Permanent Lining in Trenches."

Another method (Fig. 120) is that of casting concrete on dovetail sheets beside the trenches, and later, after they have matured, of lowering them into the excavations to form the walls. The floor should be 4 in. cast *in situ* concrete, and the roof of a slab similar to that of the walls. For normal cases, 24-gauge sheets are sufficient.

The inside surfaces can be kept painted or they can be covered with ½ in. concrete which also can be applied before the placing of the units.



119 *Lining of precast concrete units for trench shelters as recommended by the Home Office A.R.P. Department.*



120 *Shelters of concrete, precast on dovetail steel sheet.*

TEXT OF CODE

Some form of connection between the roof slab and the walls is very advisable for the purpose of providing lateral restraint to the top of the walls. An arrangement of shoulders on the units may serve this purpose or some form of steel connection as shown in Fig. 120.

SHELTERS WITHIN BUILDINGS

(24) *Preliminary Survey.*

A preliminary survey will usually be made to determine the most suitable position for shelters. The diagram in Fig. 121 shows some characteristic features in an industrial area which are potential sources of danger, and should be avoided in setting out shelters :—

Area A should be avoided since injury to abnormally exposed columns and stanchions would lead to the collapse of the building, resulting in heavy debris loads on the ground in that area, and the provision of emergency exits would be difficult.

Area B is unsuitable for shelter, firstly because it might be rapidly flooded if the canal wall were injured, and secondly because it would be liable to be crushed by the fall of the heavy water tank.

Area C is unsuitable because of its immediate proximity to the base of the water-tank, and because it will rarely be economical to strengthen the roof of the shelter to withstand the fall of the heavy machinery on the upper floors.

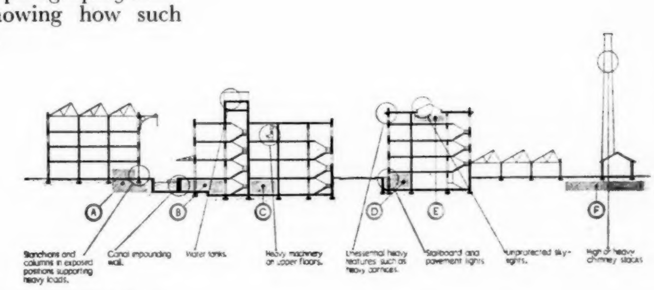
Area D would require special protection of pavement and stallboard lights due to the possibility of collapse of heavy cornice and parapet, which would often make the problem of emergency exits particularly difficult.

Area E.—Inflammable construction or the storage of inflammable material immediately under the glazed roof might present a fire hazard which could endanger the whole building.

Area F immediately at the base of a large chimney-stack is unsuitable for the provision of shelters.

In addition to such items as those enumerated above there may be features peculiar to the particular buildings under consideration, or associated with the process of manufacture carried on within them. Steam boilers, large furnaces, oil tanks and chemical storage tanks would endanger life near them if they were fractured.

(24) *Areas to be avoided for basement shelters.*—Areas A, B, C, D and F, in Fig. 121 (reproduced from the Code), are unsuitable due to their proximities to heavy loads, and if any other places for the shelters are available, they are to be preferred. Sometimes, however, the use of a dangerous area cannot be avoided. In paragraph 9 some examples have been given showing how such dangerous areas may be treated.



121 *Some features of buildings in an industrial area requiring particular attention when surveying for provision of shelters.*

Area E presents a typical case in which rearrangement of the dangerous load should be made, if the area is otherwise suitable for an air-raid shelter. When that is not possible and when inflammable material must be stored at the place indicated in Fig. 121, a reinforced concrete roof would be advisable in place of the skylight.

In addition to the matters set out in this part of the Code, there are several other factors which may render any particular basement unsuitable for shelter purposes. Pipes for services may burst or start leaking as the result even of distant explosions, and much secondary damage may be done. Gas-pipes are particularly dangerous, for fire as well as poisoning may result. Water mains are to be avoided, as these may flood a basement, and drained basements are always to be preferred as the bursting of smaller water pipes would not then cause serious inconvenience. Where a basement is not drained, thresholds at least 6 in. high, and 12 in. high if in the vicinity of main pipes, are advisable at the entrances to a shelter. *See* paragraph 30, Fig. 175.

Sewers and drainage pipes might also prove a source of danger.

In short, if a shelter can be made in an area remote from any pipework, it is that area which should be chosen, provided, of course, that all the other requirements are satisfied.

Electric cables and conduits are not, as a rule, dangerous. On the contrary, very often it will be of advantage to have the switch gear for a building in a basement shelter, thus affording control of the current, at least, for that building. Transformer stations, on the other hand, are dangerous, and 18 in. of brickwork, or an equivalent thickness of other material, should always separate a transformer station from any shelter or accessory space.

(25) *Main Types of Shelters within Buildings.*

There are four main methods by means of which the required shelter within buildings may be obtained :

(*a*) In covered trenches or tunnels constructed under the ground floor of the factory ;

(25) *Types of shelters within buildings.*—In addition to those types of shelters listed, covered trenches can sometimes be constructed under basements of buildings.

For the strengthening of rooms, other than those on the lowest floor, and for notes on the unsuitability of such rooms, *see* paragraph 17. Lean-to shelters are considered in paragraph 29.

TEXT OF CODE

(*b*) In existing basements ;

(*c*) In other suitable rooms, corridors, etc., strengthened where necessary ;

(*d*) In specially built shelters within the factory buildings, or in lean-to's.

(26) (*a*) *Trenches or Tunnels beneath Floors.*

The system of constructing trenches or tunnels beneath the floors provides good protection, and is suitable for adoption in some buildings where, owing to the vital character of the work on which the employees are engaged, it is imperative, in order to avoid serious dislocation of work, that they should have shelter accommodation as near the scene of their normal activities as possible. It offers the advantage that alterations to the structure of the buildings are reduced to a minimum. Cases occur, particularly where buildings are situated on a sloping site and when floor levels vary, where it would be possible to tunnel on one level beneath the concrete floor of a building on a higher level, entrances being formed at either end, one giving access to the floor of the building and the other to the open. The tunnels normally would be kept well clear of stanchion bases, etc. The external openings could be protected by an earth traverse or other form of screen wall in an emergency. In peace time, such tunnels could be used as storerooms or cycle-sheds.

The trench shelters should be distributed throughout the building, and should be placed between the lines of stanchions so that they do not interfere with the footings and foundations. They can be placed conveniently between the rows of machines, and may be constructed to have a cover giving the standard overhead protection laid down in Part I (as at E in Fig. 174), and strong enough to withstand debris from the superstructure. In places where depth of excavation is not of importance the shelters may be constructed so as to have a cover of at least 18 ins. of earth in addition to the normal thickness of floor (as at D in Fig. 174). They can be lined permanently with brickwork, concrete, or other suitable material. Access to them should be from the workshop floor, and an emergency exit should be provided clear of the building. As this exit is only for emergency use, it need not be of large dimensions, and a pipe, 3 ft. in diameter, leading to a manhole would serve the purpose. The emergency exit would also assist in ventilating the trench.

(26) *Trenches under buildings.*—The construction of trenches below the floor of a factory or other building does not, in principle, vary from that of trenches in the open. Such shelters will be applicable to factories as mentioned in the Code ; but, as has been shown in paragraphs 9 and 20, they are to be recommended in a number of other cases also. The advantages of trenches compared with strutted basements are :

1. That they do not occupy any appreciable space that might be used for the purposes of the building ;
2. That they provide better lateral protection, thereby reducing the effective radius of a direct hit ;
3. That overhead protection against falling debris can be so readily afforded that they are applicable below even heavy loads such as water-tanks, machinery, stored materials, etc. ; and
4. That there is more unskilled than skilled labour required, and fewer special materials which might not be readily available.

Against these advantages there is the restriction of the foundation depth, and difficulties caused by any drains.

The rule that no material is to be removed from the zone beneath any existing foundation within a plane at 45° to the horizontal from any edge of the foundation, must be observed in connection with trenches as in any other case. In Fig. 122, for example, the dotted lines show the limits to which a shelter could extend, and if these limits do not allow a trench to be inserted, either the idea of a trench must be given up, or the foundations must be underpinned.

If the distance between foundations is "*a*," their depth "*d*" and the width of the trench, including lining, "*w*," then the height "*h*" from the floor of the basement or room over the shelter to the lowest permitted depth is given by :

$$h = d + \frac{a - w}{2}$$

In general "*w*" should not be much less than 6 ft. nor "*h*" less than 7 ft. 6 in., in which case "*a*" must be not less than "*a (min)*" $= 21 - 2d$; and this expression may be taken as the criterion for the clear distance between foundations.

If a thickness "*t*" of earth is required on top of a trench of the above dimensions, "*a*" must not be less than :

$$a\ (min) = 21 - 2d + 2t$$

Where foundations vary in depth, "*d*" is to be taken as the average depth and the shelter should be built nearer the deeper foundation. (*See* Fig. 123.)

Trenches have usually two rows of seats with a corridor between, and the section of a trench might, therefore, be reduced to advantage to that shown in Fig. 124.

In such a case the minimum value of "*a*" (the clear distance between foundations) can be smaller than previously, namely

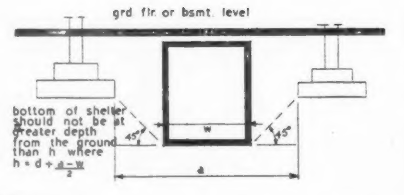
$$a = 18 - 2d + 2t.$$

Where, for example, the depth of foundations is $d = 3$ ft. (it will rarely be less) and $t = 2$ ft.,

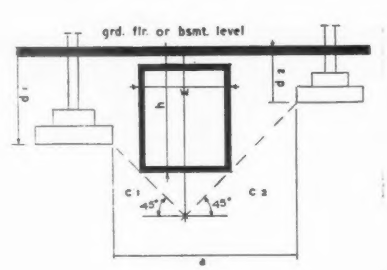
$$a\ (min) = 18 - 6 + 4 = 16 \text{ ft.}$$

But where $d = 6$ ft.
and $t = 2$ ft.

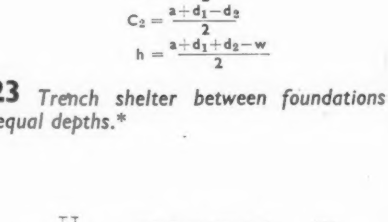
$$a = 18 - 12 + 4 = 10 \text{ ft.}$$



122 *Position of trench in relation to neighbouring foundations.**



123 *Trench shelter between foundations of unequal depths.**



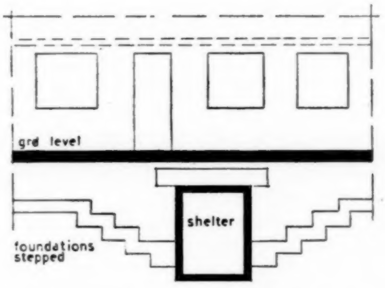
124 *Trench with seating accommodation, affording 3 ft. saving in "effective" depth.**

* "*h*" is the height from the normal floor level to the level of the ground below the shelter.
"*d*" is the height from the normal floor level to the level of the ground below the foundations.

TEXT OF CODE

An existing wall which would intersect a trench offers no great obstacles ; a lintel below the wall over the trench would be required, and the underpinning of the flanks of the wall on either side of the trench is more easily carried out than the underpinning of an isolated footing (Fig. 125).

Care has to be taken to avoid sewers and important drains. If a basement is not drained, and if there is any danger of the bursting of main water-pipes, every entrance should have a threshold 12 ins. high (Fig. 126). Under other conditions, a 6-in. threshold will be sufficient. (*See also* paragraph 24.)



125 *Trench intersecting existing wall.*

(27) (*b*) *Basements.*

If a convenient basement exists it may be used for conversion to a shelter. (Type C, Fig. 174.) Where it is proposed to make a shelter within a building, either in a basement or above ground level, it is necessary to ensure that the roof of the shelter affords not only the standard of overhead protection indicated in Part I, but also that this roof is adequate to support the fall of debris consequent on the demolition of the superstructure. There may be cases when existing floors are sufficiently strong for this, but in the majority of buildings it may be expected that some strengthening of floors will be required. There are two alternatives, (1) to stiffen the floors or to put in new floors, or (2) to shorten the working span of the floors by propping or strutting. The strengthening required should be based on the rules for estimation of debris loads laid down in Part I of this Code.

Care should be exercised in the proper positioning of the struts. This is particularly so in the case of reinforced concrete floors, jack arch floors, etc., since struts incorrectly placed may seriously alter the stress distribution in the various members with the result that the floor may be weakened, instead of strengthened.

The propping or strutting required to support the "debris loads" will often be inconvenient from the point of view of the normal occupancy of the building in times of peace. In such cases the necessary propping or strutting should be designed and the

(27) *Construction of Basement Shelters* (*underpinning*).—Where a basement is adapted to shelter use, three main structural items must be investigated in the portion where the shelter is to be made. These items are :

1. Floors.
2. Beams.
3. Vertical supports (columns and walls).

(1) *Floors.*—Floors may be—

- (*a*) Timber.
- (*b*) Brick, concrete or stone arches.
- (*c*) Flat concrete slabs.
- (*d*) Solid reinforced concrete.
- (*e*) Hollow tile.

(*a*) A normal timber floor does not afford sufficient overhead protection against blast and splinters, nor, in general, does it participate with other materials in doing so. Also, due to its inflammable nature, it should not be reasonable to take it into account at all.

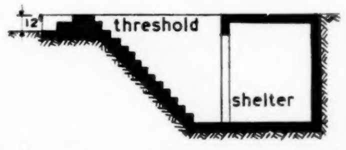
Two exceptions to this rule are the cases of floors for domestic buildings (Air Raid Precautions—Memorandum No. 10), and those rare cases in which concrete can be poured between joists after the manner of pugging for part or all of the floor depth. Such a method, although affording in most cases the required protection against blast and splinters, is not ideal for the reasons that it involves the housing of timbers in concrete in unventilated conditions and that it involves the pouring of the concrete from the top—which usually is to be avoided because of the dislocation of the normal functions of the room.

Nevertheless, in this respect the method is not so objectionable as many involving work from above, because floor boards or other top finish can be removed only at points to admit the concrete.

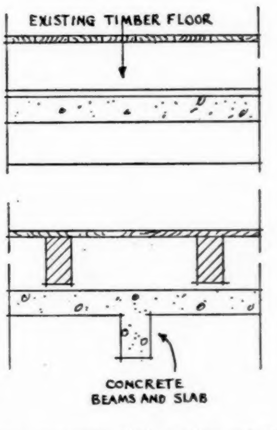
Generally, an entirely new construction must replace or be used in addition to timber floors (Fig. 127).

Either a new floor is to be built, or, below the timber flooring, substantial strengthening must be arranged. Steel or precast concrete may be used, but cast *in situ* concrete is often out of the question as the concrete cannot usually be poured under the existing floor slab.

Where it is impossible to disturb the existing



126 *Entrance to shelter showing threshold.*



127 *New concrete slab under existing timber construction.*

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materials should be stored permanently on the site so that they can be set in place without delay. In peace time only those members would be installed which would not interfere unduly with the normal usage of the building.

Care must be taken to ensure that walls which are used to support the roof over a shelter are capable of carrying their share of the debris loads assumed above. The data for computation of strength of walls given in the Second Schedule of Ministry of Health, Model Byelaws, Series IV, Buildings, 1937, may be taken as a guide from which the need for additional support can be determined.

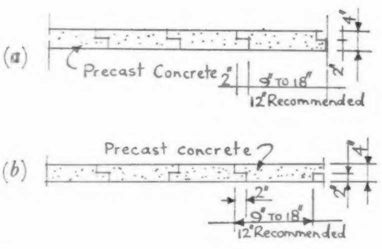
floor, the use of precast concrete units is recommended, although special arrangements must be made because of the weight and the difficulty of wedging the slabs against the existing construction. Sections, suitable for this purpose, are given in Fig. 128.

A material frequently used for the strengthening of timber floors is steel sheeting, applied in accordance with the values in Tables II, III(*a*) and III(*b*) in which are set out the limiting spans for different loads and types of steel sheets. Total load in each case is composed of:

dead load
ordinary superimposed load
debris load.

Total = dead + superimposed + debris.

It must be clear, however, that any steel sheeting (unless it is at least ¼ in. thick) does not provide the required standard of overhead protection. Its



128 *Precast concrete units for floor strengthening affording the normal standard of "overhead protection."*

TABLE II

CORRUGATED SHEETS

Load lbs. per sq. ft.	GAUGE 10	12	14	16	18	20	22	24
250	4′ 6″	4′ 0″	3′ 6½″	3′ 2″	2′ 10″	2′ 6½″	2′ 3″	2′ 0″
300	4′ 2″	3′ 8″	3′ 3″	2′ 10½″	2′ 7″	2′ 3½″	2′ 0½″	
350	3′ 9½″	3′ 4½″	3′ 0″	2′ 8″	2′ 4½″	2′ 1½″		
400	3′ 6½″	3′ 0½″	2′ 10″	2′ 6″	2′ 3″			
450	3′ 4″	2′ 11½″	2′ 7½″	2′ 4½″	2′ 1″			
500	3′ 2″	2′ 10″	2′ 6″	2′ 3″				
550	3′ 0″	2′ 8″	2′ 4½″	2′ 1½″				
600	2′ 10½″	2′ 6½″	2′ 3½″	2′ 0½″				
650	2′ 9½″	2′ 5½″	2′ 2½″					
700	2′ 8″	2′ 4½″	2′ 1½″					
750	2′ 7″	2′ 3½″	2′ 0½″					

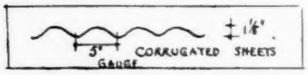


TABLE III (*a*)

FOLDED SHEETS*

Load lbs. per sq. ft.	GAUGE 14	16	18	20
250	5′ 3½″	4′ 8½″	4′ 2½″	3′ 9″
300	4′ 10″	4′ 3½″	3′ 10″	3′ 5″
350	4′ 5½″	3′ 11½″	3′ 6½″	3′ 2″
400	4′ 2″	3′ 8½″	3′ 4″	2′ 11½″
450	3′ 11″	3′ 6″	3′ 1½″	2′ 9½″
500	3′ 9″	3′ 4″	2′ 11½″	2′ 7½″
550	3′ 6½″	3′ 2″	2′ 10″	2′ 6″
600	3′ 5″	3′ 0½″	2′ 8″	2′ 5″
650	3′ 3½″	2′ 11″	2′ 7″	2′ 3½″
700	3′ 2″	2′ 10″	2′ 6″	2′ 3″
750	3′ 0½″	2′ 8½″	2′ 5″	2′ 2″

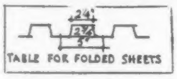
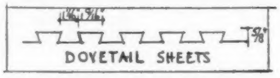


TABLE III (*b*)

DOVETAIL SHEETS

Load lbs. per sq. ft.	GAUGE 14	16	18	20	22	24	26
250	4′ 3″	3′ 10″	3′ 4½″	3′ 0″	2′ 8½″	2′ 4½″	2′ 1½″
300	3′ 9½″	3′ 5½″	3′ 1″	2′ 7½″	2′ 5½″	2′ 2″	
350	3′ 7½″	3′ 3″	2′ 10½″	2′ 6½″	2′ 3½″	2′ 0″	
400	3′ 4″	3′ 0″	2′ 8″	2′ 4½″	2′ 1½″		
450	3′ 2″	2′ 10″	2′ 6½″	2′ 3″	2′ 0″		
500	3′ 0½″	2′ 8″	2′ 4½″	2′ 1½″			
550	2′ 10½″	2′ 7″	2′ 3½″	2′ 0½″			
600	2′ 9″	2′ 5½″	2′ 2″				
650	2′ 7½″	2′ 4½″	2′ 1″				
700	2′ 6½″	2′ 3½″	2′ 0″				
750	2′ 5″	2′ 2½″					



The tabulated values are for sheets 1½ in. deep.
They may be increased by 20 per cent. for sheets 2¼ in. deep.

application in conjunction with timber floors requires additional treatment, such as pugging.

The steel sheeting will usually be supported by R.S.J.s; but precast concrete beams are feasible. (*See also* Figs. 145 and 146.)

Cast *in situ* concrete slabs should not be less than 4 ins. thick, and the reinforcement, required by calculation, is to be incorporated.

Owing to the heavy weight of concrete and the difficult handling, the following rules should be observed:

1. The span should not be too great—5 to 6 ft. at the most.

2. The thickness should not be increased beyond 4 ins., and if particularly heavy bending moments occur, the reinforcement should be increased instead.

3. The slab should be not less than 9 ins. wide nor greater than 1 ft. 6 ins. A width of 12 ins. is recommended.

4. The section should have rebated joints (Fig. 128a).

Where the reinforcement should be equal top and bottom, i.e. for very heavy loads only, the arrangement shown in Fig. 128b is possible.

The weight of a 4-in. slab, 12 ins. wide and 5 ft. long, is slightly over 2 cwts.

As mentioned before, reinforcement rods, as such, offer no protection; but reinforcement becomes a help when used in the form of steel sheet, in conjunction with concrete. Dovetail sheets are to be preferred to corrugated sheets because they provide greater bond.

In Tables IV and V, loads are set out for such

TABLE IV

DS = Gauge of DOVETAIL SHEETING
C = Depth of CONCRETE

DOVETAIL SHEETING + CONCRETE

	DS	18	18	20	20	20	20	22	22	22
	C	4″	3½″	4″	3½″	3″	2½″	4″	3½″	3″
LOAD LBS. PER SQ. FT.	250	10′ 3½″	8′ 11½″	9′ 1″	8′ 6½″	7′ 10½″	6′ 7½″	8′ 1½″	7′ 7″	7′ 2″
	300	9′ 3½″	8′ 2″	8′ 2½″	7′ 8½″	7′ 2½″	6′ 0½″	7′ 4″	6′ 10½″	6′ 6½″
	350	8′ 7″	7′ 7″	7′ 8″	7′ 2″	6′ 8″	5′ 7″	6′ 11″	6′ 4½″	6′ 0½″
	400	8′ 0½″	7′ 1″	7′ 2″	6′ 8″	6′ 3″	5′ 3″	6′ 5½″	6′ 0″	5′ 8″
	450	7′ 7″	6′ 8″	6′ 9″	6′ 3½″	5′ 10½″	4′ 11½″	6′ 0½″	5′ 7½″	5′ 4″
	500	7′ 2½″	6′ 4″	6′ 5″	6′ 0″	5′ 7″	4′ 8″	5′ 9″	5′ 4″	5′ 0½″
	550	6′ 10″	6′ 0½″	6′ 1½″	5′ 8″	5′ 4″	4′ 5½″	5′ 6″	5′ 1½″	4′ 10″
	600	6′ 7″	5′ 10″	5′ 10″	5′ 5″	5′ 1½″	4′ 3½″	5′ 3″	4′ 11″	4′ 7½″
	650	6′ 4″	5′ 6½″	5′ 7½″	5′ 3″	4′ 10½″	4′ 1½″	5′ 0½″	4′ 8″	4′ 5″
	700	6′ 1″	5′ 4″	5′ 5″	5′ 0½″	4′ 8½″	3′ 11½″	4′ 10″	4′ 6″	4′ 2½″
	750	5′ 10½″	5′ 2″	5′ 3″	4′ 10½″	4′ 7″	3′ 10″	4′ 8½″	4′ 4½″	4′ 1″

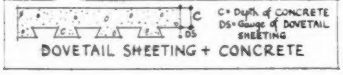


TABLE V

DS = Gauge of DOVETAIL SHEETING
C = Depth of CONCRETE

DOVETAIL SHEETING + CONCRETE

	DS	22	22	24	24	24	24	24	24	24
	C	2½″	2″	4″	3½″	3″	2½″	2″	1½″	1″
LOAD LBS. PER SQ. FT.	250	6′ 1½″	5′ 5½″	7′ 2″	6′ 8″	6′ 4″	5′ 9½″	5′ 3″	4′ 3″	3′ 0″
	300	5′ 9″	4′ 11½″	6′ 6″	6′ 1″	5′ 9″	5′ 3″	4′ 9½″	3′ 9″	2′ 9½″
	350	5′ 6″	4′ 7″	6′ 1″	5′ 7½″	5′ 4″	4′ 11″	4′ 5½″	3′ 7″	2′ 6½″
	400	5′ 2″	4′ 3½″	5′ 8″	5′ 3½″	5′ 0″	4′ 7″	4′ 2″	3′ 4½″	2′ 4½″
	450	4′ 10″	4′ 1″	5′ 4″	5′ 0″	4′ 8½″	4′ 4″	3′ 11″	3′ 2″	2′ 3″
	500	4′ 7½″	3′ 10″	5′ 1″	4′ 8½″	4′ 6″	4′ 1″	3′ 9″	3′ 0″	2′ 1½″
	550	4′ 3½″	3′ 8″	4′ 10″	4′ 6″	4′ 3″	3′ 11″	3′ 6½″	2′ 10½″	2′ 0½″
	600	4′ 2″	3′ 6″	4′ 7½″	4′ 3½″	4′ 1″	3′ 9″	3′ 5″	2′ 9″	
	650	4′ 1½″	3′ 4½″	4′ 5½″	4′ 2″	3′ 11″	3′ 7″	3′ 3½″	2′ 7½″	
	700	3′ 11″	3′ 3″	4′ 3½″	4′ 0″	3′ 9″	3′ 5″	3′ 2″	2′ 6½″	
	750	3′ 9″	3′ 1½″	4′ 2″	3′ 10½″	3′ 8″	3′ 4″	3′ 0½″	2′ 5½″	

combined constructions on different spans. Not all the combinations mentioned, however, can be regarded as conforming to the standard of overhead protection. Only those with not less than 3 ins. of concrete cover are suitable. The only treatment which a sheet should receive is that of painting of the soffit.

(*b*) Existing brick or concrete arches must be checked to verify that they conform to the standard of overhead protection, given in paragraph 5, namely:

6 ins. for concrete.
8½ ins. for brickwork.

If they conform to the above requirement for thickness of material, it should be borne in mind that only very rarely are such arched constructions stressed to anything approaching the limit, and that they may possibly conform in addition to the requirement of the stresses for any increased loads.

Table VI gives the loads at a permitted stress of 20 tons per sq. ft. which concrete arches would be able safely to carry. Good brickwork in cement mortar may be allowed the same loads. Where brickwork of inferior quality is used, the permitted load must be reduced accordingly. Conversely, if the concrete is particularly good, the loads may be increased accordingly.

The loads depend not only on the span but also on the rise. In Table VI, therefore, the vertical columns refer to the relationships of rise to length, and the horizontal columns to the relationships of thickness to length. The loads are total loads, and in applying the table to any particular case the dead and super-imposed loadings are to be deducted from the values given in order to arrive at the safe debris load for that case.

Where it is found from Table VI that the arch is sufficient to carry the load, nothing further need be done about the floor. (Beams are discussed later.) It is, however, important to find out whether the supports of such slabs and the general state of the building allow the end panel to be considered as strong as the centre panels, i.e. when the thrust can safely be taken. If they are weaker, it might be necessary to strengthen them, particularly if they are to form the ceiling of any shelter.

Where existing arches are insufficient to carry debris load, steel sheeting or other bearing material should be provided on the soffit in the same way as has been suggested for the timber floors. Work is simplified in this case if the sheeting spans in the same direction as the arches. New joists can be

TABLE VI*

TABLE FOR LOADS ON ARCHES

[The Load is to include dead and superimposed Load as well as debris Load.] Lbs. per sq. ft.

h/l	t/l				
	$\frac{1}{8}$	$\frac{1}{9}$	$\frac{1}{10}$	$\frac{1}{11}$	$\frac{1}{12}$
$\frac{1}{3}$	620	550	500	450	410
$\frac{1}{4}$	470	420	370	330	310
$\frac{1}{5}$	370	330	300	270	250
$\frac{1}{6}$	310	280	250	220	200
$\frac{1}{8}$	230	210	180	160	150

*See Fig. 133.

arranged immediately below the old (Fig. 129); but they may not actually be required. It is bad construction, and of no practical value, to support the arch in the centre by a beam along the apex.

Where vaults span a room of more than 10 ft. width, and where such arched roof is found to be insufficient to resist the debris load, the strengthening sheets should be arranged at different heights but in such a way that the distance between the soffit of the vault and the sheeting is as small as possible at any point. The lower steel sheets should in that case project for a distance at least $b = \frac{h}{4}$ under the upper sheet (Figs. 130 and 131).

Care must be taken that by strutting an arch any neighbouring arch would not be overstressed, as the resistance to the thrust of the neighbouring arch will have been reduced (Fig. 132).

(*c*) Flat concrete or stone slabs are found sometimes in old buildings. They are of little value in resisting debris load, except where they are of such thicknesses that adequate arch action can develop within their depths (*see* Fig. 133).

The arch thickness in such a case is to be taken as "*t*," and the distance from the lower face to the underside of "*t*" taken for "*h*." The load can then be taken from Table VI.

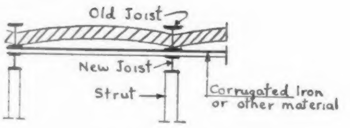
Only in exceptional cases will such a slab be able to withstand any appreciable load. Where a slab is insufficient, corrugated sheeting may be applied to the soffit in the same manner as in the preceding cases.

(*d*) Reinforced concrete slabs will usually be sufficient as far as the standard of protection is concerned, i.e. thickness of material, but owing to the fact that such slabs are usually calculated exactly for certain specified live loads, they will generally be insufficient to carry debris load, unless in the exceptional cases in which the superimposed loads, being as large as the debris load, can never act at the same time as the debris loads. If a reinforced concrete slab is insufficient to carry the debris load, it may be strengthened by means of a beam in the centre of the slab parallel to the existing beams (Fig. 134).

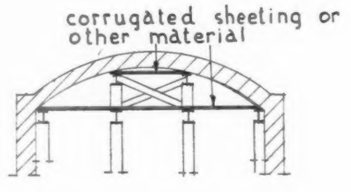
The reinforcement in the slab, as far as quantity and position are concerned, as well as the concrete stresses, must then be checked, on the assumption that the slab is not carried continuously over the stiffening beam, but that it is "simply supported" on the latter. There is usually no top reinforcement to take any tension in the top of the slab over the support (Fig. 135).

A joist strengthening a reinforced concrete slab must be properly wedged to the slab at intervals of not more than 12 ins. in the length of the joist. Further, it should be stiffened horizontally against existing beams or walls. (*See* paragraph 27 (2) for stiffening of beams and Fig. 134.)

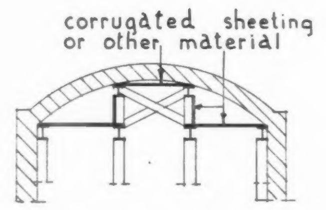
It may often be necessary to stiffen a slab at two points in the same span, when, for example, the debris loads are very heavy (Fig. 136), or where the span is very long.



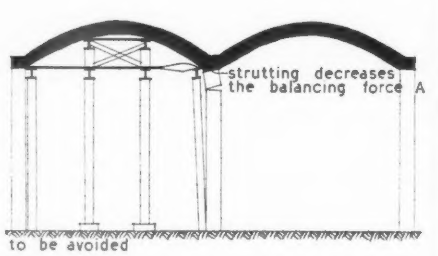
129 *Sheeting under existing arches.*



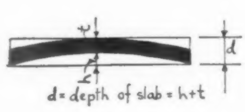
130 *Sheeting under existing arches.*



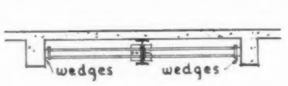
131 *Sheeting under existing arches.*



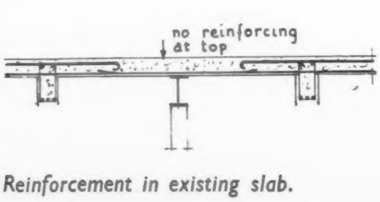
132 *An arch should not be strutted in such a way as to weaken the abutments of an adjoining arch.*



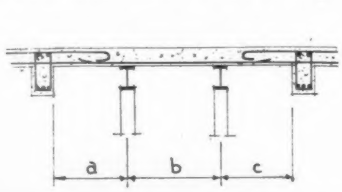
133 *Arch action in stone or mass concrete slab.*



134 *Reinforced concrete slab strengthened by a new joist at the centre of the span.*



135 *Reinforcement in existing slab.*



136 *Reinforced concrete slab, strutted twice in one span.*

In every case the shear stresses as well as bending stresses must be checked, for their relative importance increases with a decrease in the length of a span. The lengths of reinforcing rods may influence the positions of stiffening joists. In the case shown in Fig. 136, for example, there is likely to be much more reinforcement in the centre zone "*b*" than in "*a*" or "*c*," and so it may be found quite reasonable frequently to have "*b*" greater than "*a*" or "*c*." Where reliable drawings of the reinforcement of an existing slab are not available, the reinforcement can be ascertained by removing the cover from the rods at points on the underside of the slab. Any such exposing of bars must, of course, be made good immediately.

Where new reinforced concrete slabs are to be adopted, it is recommended that thicker slabs, rather than a greater amount of steel (provided the headroom permits it) should be employed.

(*e*) *Hollow tile floor slabs.*—Floors of hollow tile construction can be treated in exactly the same manner as are reinforced concrete slabs ; but there must be a thickness of at least 4 ins. of structural concrete at any point on the slab (Fig. 137). The thickness of any screed can be considered as contributing to the required thickness of solid material. Where the actual thickness of solid material is insufficient, and where it is impracticable to add any more material on the upper surface (but even so not in the case of framed structures, for which see immediately below), hollow tile floors should be supported by precast units or sheeting in the way described previously. Such strengthening members should be placed immediately under the floors and not under the beams (Fig. 138).

Sheets may overhang the end supports to distances up to one quarter of their spans between supports (*see* Tables II, IIIa and IIIb). .

In skeleton frame buildings the requirement of thickness for overhead protection of solid or hollow tile floors may be varied on the assumptions that the upper floors jointly provide the overhead protection required against splinters, falling shells, etc., and that the basement ceiling serves only to carry debris load. Such waiving of overhead protection requirements must, however, be bound by the conditions :

1. That no obstacles such as walls, etc., exist in the floor immediately above, within a distance from the shelter of half the storey height (Fig. 139).

2. That every point in the shelter is at a distance from the building line of not less than half the storey height.

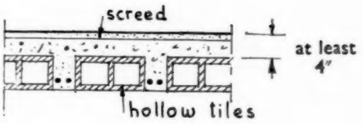
(2) Strengthening beams can be of steel, precast reinforced concrete or timber. Cast *in situ* concrete is not often practicable for the same reason as in the case of slabs, namely, the difficulties of casting them.

Timber is recommended more for domestic work.

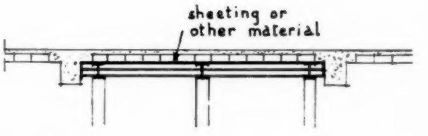
For the purpose of the calculations, beams should always be considered as simply supported, even though they may, in fact, be continuous.

Existing beams, though relieved of a great part of the original live and dead loads, must always be checked for the full debris load which they may have to carry.

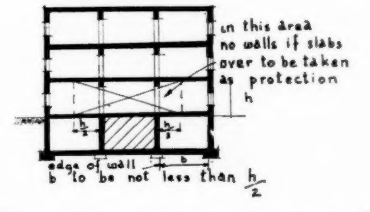
Where beams would otherwise be overstressed, they should be strutted in the centre only or near the third points, etc., as may be required. (Figs. 140, 141.) Asymmetrical strutting should be avoided even when calculations show such strutting to be adequate. Where an asymmetrical strut cannot be avoided a horizontal strut to the nearer adjacent column or wall should be introduced beneath the beam. (Fig. 142.) Where any part of a beam is over a shelter the designer must be



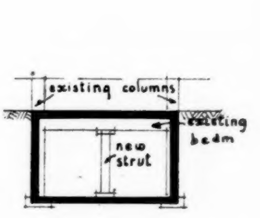
137 *Hollow tile floor slab, providing sufficient overhead protection.*



138 *Sheeting to be on soffit of slabs, not below beams.*



139 *Condition justifying waiver of requirements for overhead protection for shelter in "framed" building.*



140 *Strutting of existing beam at mid-span.*

satisfied that it can carry the debris load for its full length, and that its supports also can safely sustain such loads even if they are well outside the shelter.

For existing continuous beams, this rule applies only to the panel of the beam which is over the shelter and to the supports of that span.

If an existing column, say column "A" in Fig. 143 (*a*) and (*b*) should not be able to carry the debris load, some further struts are to be arranged to relieve it of as much of the load as is necessary. (*See also* the columns in Fig. 144.)

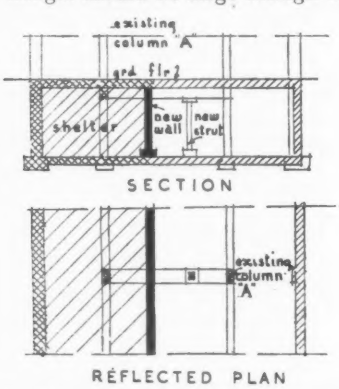
Strengthening beams will more often be of steel than of concrete, particularly so as fire resisting casing is not required. Steel sections must, however, be kept painted and in those factories in which corrosive gases may sometimes obtain, precast concrete beams may be preferable.

When steel sheets are used to stiffen any existing work they can be fixed to the webs of the supporting joists or to precast concrete beams in the manners shown in Fig. 145 and in Fig. 146.

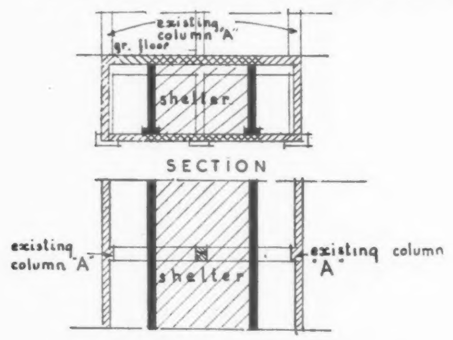
Such stiffening connections should be made at distances centre to centre, not less than 20 *b* where "*b*" is the width of the joists or of the concrete units; but the distance should in no case be greater than the span of the beams between struts.

Where beams support existing concrete members, to which they cannot easily be fastened, horizontal bracing members should be provided at the same spacings as above. (*See* Figs. 134 and 138.) They should be wedged securely against existing beams or walls and may consist of channel or angle sections, of which the sizes may be determined by the formula $r \leq \frac{a}{200}$, "r" being their least radius of gyration.

Alternatively, gas barrel with flange plates screwed or welded to the ends may be employed and the flanges should be large enough to take at

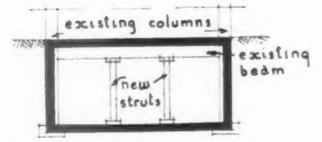


143 *(A): Existing column "A" must be investigated for debris loading although outside the shelter.*

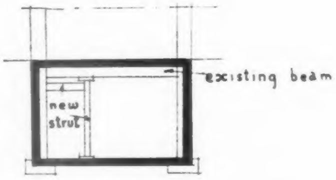


143 *(B) : Columns "A" must be investigated for debris loading although outside the shelter.*

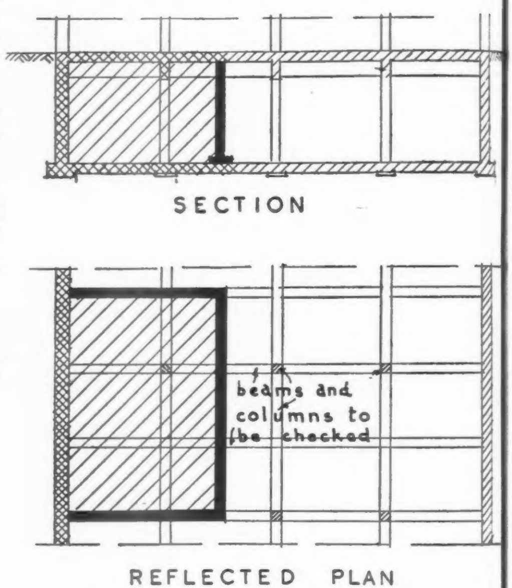
least two bolts. (Fig. 147.) Where bracing members are to be wedged in position steel wedges should be used and after being driven they should be



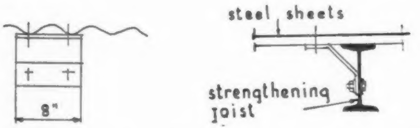
141 *Strutting of existing beam at third points.*



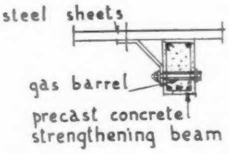
142 *Asymmetrical strutting.*



144 *Showing structural members outside a shelter which would require to be investigated for debris loading and, if necessary, strengthened.*



145 *Fixing of steel sheeting to strengthening joist.*



146 *Fixing of steel sheeting to precast concrete strengthening beam.*

secured in position. When precast concrete stiffening beams are used, the bracing members may also be of precast concrete, but they should be grouted to the beams, preferably with some form of mechanical key in addition. (Fig. 148.)

The loads on steel joists will depend on their spans, the load being determined by bending and shear stresses. Table VII sets out the loads per ft. run on different spans.

In order to find the correct size of joists, the total load per square foot must be multiplied by the spacing of the joists, and from the appropriate span in Table VII, the required size of joist can be found in the left-hand column on the same horizontal line as the calculated value.

It is not required that every joist be supported directly by struts. There may be sufficient headroom for girders below the joists. The joists should, wherever possible, be continuous over the girders or bear directly on the top flanges. (Figs. 149 and 150.) If the headroom is insufficient for this to be done, but yet sufficient for a girder to be introduced, to replace struts under the joists, the girder may be housed partly with the depth of the joists; but under such conditions the strengthening joists must be carried in some manner affording direct bearing on the girder, as shown for example in Fig. 151, and not by transmission of loads through rivets or bolts. (Fig. 152.)

Spans of girders greater than 16 ft. are to be discouraged.

TABLE VII

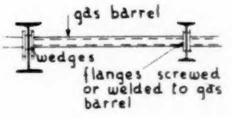
LOAD PER FOOT RUN

Joist in. × in.	SPAN 5′ 0″	5′ 6″	6′ 0″	6′ 6″	7′ 0″	8′ 0″	9′ 0″	10′ 0″	12′ 0″	14′ 0″	16′ 0″
4×1¾	880	730	610								
4×3	1870	1550	1290	1100	950	730					
4½×2	1420	1170	980	840	720						
5×2½	2100	1730	1460	1240	1700	820	640				
5×4½	4800	3980	3340	2840	2450	1880	1480	1200			
6×3	3380	2780	2340	1990	1720	1320	1040	840			
6×5	7250	5980	5020	4280	3690	2820	2230	1810	1120		
7×3½	4930	4060	3420	2920	2500	1920	1010	1230	850	630	
8×4	6650	5500	4630	3950	3400	2600	2050	1660	1160	850	650
8×6	12550	11400	9550	8750	7020	5370	4250	3450	2400	1760	1340
9×4	8680	7100	6010	5120	4430	3400	2660	2160	1510	1110	850
9×7	16100	14700	13450	12400	11300	8680	6830	5450	3840	2020	2160
10×4½	11740	9700	8750	6950	5980	4580	3620	2940	2040	1490	1140
10×6	16120	14680	13420	11600	10000	7650	6050	4900	3400	2500	1920
10×8	17900	16300	14920	13800	12800	10760	8520	6900	4500	3520	2700
12×5	16520	13620	11420	9780	8420	6320	5100	4140	2860	2100	1610
13×5	20400	17700	14900	12680	10920	8400	6620	5586	3720	2740	2090
14×5½	23200	21100	17900	15220	13200	10080	7980	6480	4480	3300	2520
15×6	25500	23200	21100	18700	16100	12320	9720	7890	5480	4020	3070
16×6	28620	26040	23900	22000	18980	14500	11440	9300	6480	4750	3640
18×6	34000	30600	28200	26100	22800	17500	13800	11200	7780	5720	4300

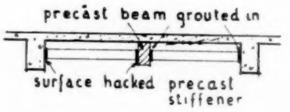
The use of girders is more expensive than that of struts; but nevertheless in other ways advantages may derive, particularly in connection with the clear floor areas left for the normal uses of a basement.

An example of this method of strengthening is given in Fig. 153.

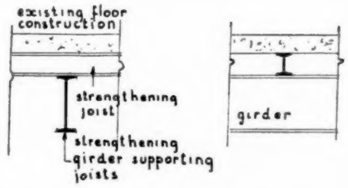
In a basement in which the existing stanchions are at a distance of 17 ft. 6 in. in one direction and 20 ft. in the other, a shelter is to be provided of the shape shown in the figure. In order that there should be as little disturbance as possible, no walls



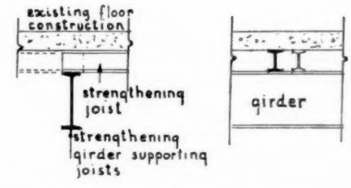
147 *Strengthening joists braced by gas barrel.*



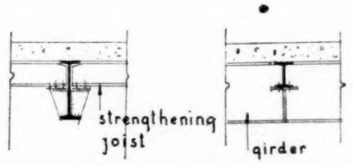
148 *Precast concrete strengthening beam braced by precast stiffeners.*



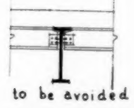
149 *Strengthening joist continuous over a supporting girder, used instead of struts.*



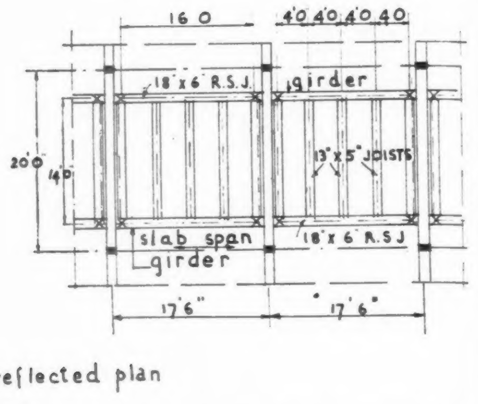
150 *Ends of strengthening joists supported on girder which can be used instead of struts.*



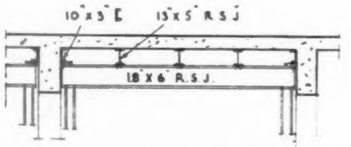
151 *Where the ends of strengthening joists come on to the web of a supporting girder they are to be carried on proper stools.*



152 *Normal cleats should not be relied upon to transmit debris loads to a supporting girder. See Fig. 151.*



153 *Example of strutting of existing concrete floor.*



154 *Longitudinal section of scheme shown in plan in Fig. 153.*

are to be built for the present. The new columns, marked X, will be placed near the existing columns in order to cause the least obstruction, and on account of existing beams, which separate the ends of the girders, two columns have to be arranged near each existing column, one on either side. The main girders will then span 16 ft. and secondary joists at 4 ft. spacing, carrying the concrete floors, which at present span 17 ft. 6 in., will span 14 ft. between the girders.

The loads are :

Dead load	.. ..	90 lb. per sq. ft.
Live load	.. ..	100 ,, ,,
Debris load	.. ..	400 ,, ,,
Total load	.. ..	590 ,, ,,

For each secondary beam the load is :

$4 \times 590 = 2{,}360$ lb. per foot run.

From Table VII :

10 in. × 6 in. R.S.J. (40 lb./ft.) carries 2,500 lb. per ft. run.

13 in. × 5 in. R.S.J. (35 lb./ft.) carries 2,740 lb. per ft. run.

If there is sufficient space, the 13 in. × 5 in. R.S.J. would be used.

Where end beams are required, that is to say, where the existing beams would be incapable safely of sustaining their own shares of the increased load, channels may conveniently be employed (Fig. 154).

For each of the girders the load due to the secondary joists is :

$7 \times 590 = 4{,}130$ lb. per ft. run.

and from Table VII it is found that an 18 in. × 6 in. R.S.J. would carry 4,420 lb. per ft. on a 16 ft. span. This construction is shown in Fig. 154.

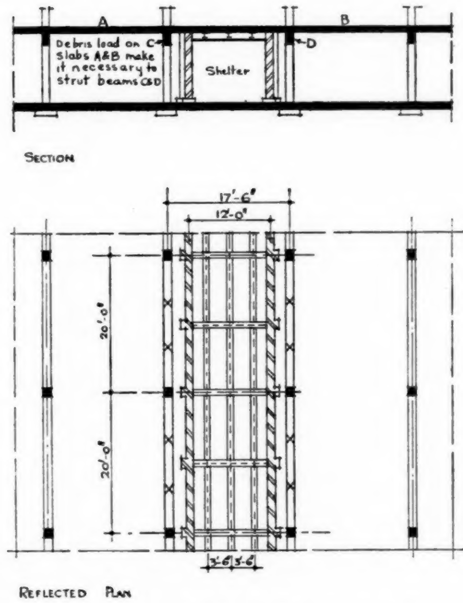
If space were not of great importance, it would be more economical to provide struts under all the joists, eliminating the girders and keeping the joist spans generally to about 10 ft.

As an illustration of another problem which may be met the same example will be taken ; but in this case the projected air raid shelter is to be built in the other direction (Fig. 155). The secondary beams may be arranged at a spacing of 3 ft. 6 in. and with spans of 10 ft. The load on each joist is $3.5 \times 590 = 2{,}060$ lb. per ft. run. A 9 in. × 4 in. R.S.J. would be sufficient (2,160 lb. per ft. run). The girders span 12 ft. and are carried on piers. The width of loading is 10 ft., so that the load is $10 \times 590 = 5{,}900$ lb. per ft. run.

An R.S.J., 16 in. × 6 in., carrying 6,480 lb. per ft., would be sufficient.

Notes on piers are given later (27 (3)).

The main point to note in this arrangement is that owing to the fact that adjoining slabs span on to the existing beams (A), the latter may be over-



155

loaded if the building should collapse, and, by their monolithy with the slab over the shelter, they may threaten destruction of the shelter, in spite of the strutting. In such cases, it is very advisable to introduce struts, as shown at (X) in Fig. 155, under the beams (A).

3. *Strutting to take Vertical Loads.* — Struts can be provided in a number of ways. In the form of :

1. Brick or reinforced concrete walls.
2. Brick or concrete piers.
3. Steel columns.

Timber will be used mainly in connection with domestic work (see Memorandum No. 10 of the Home Office Air Raid Precautions Department).

Brick or reinforced concrete will be the standard materials for external shelter walls and for division walls. Very often such walls can be arranged under a beam, thus strutting the beam either for its whole length (Fig. 156) or at certain points where they intersect the beam. As far as possible, walls should be planned to fulfil this dual purpose when strutting is actually required (*see* Fig. 157).

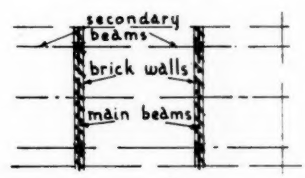
It is to be assumed that brick walls will be used more often owing to the difficulty of concreting in a confined space. Also reinforced concrete has little advantage where ordinary splinter-proof walls are concerned, as the required thickness for lateral protection is only a little less than that of brickwork. However, where division walls are concerned or walls that must carry heavy loads, reinforced concrete calls for considerably less space and, at the same time, becomes more economical.

In all following references, brickwork is assumed to be composed of :

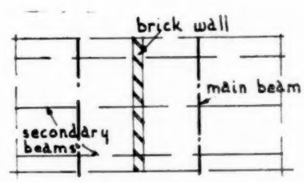
Bricks of a crushing strength not less than 3,000 lb. per square in. laid in lime cement mortar (mix 1 : 1 : 6), the brickwork to have a permitted strength of 10 tons per sq. ft.

Where superior bricks are used, the sectional areas of brickwork for load bearing may be reduced, but not beyond the limits of the required standard of lateral protection. Similarly, references to reinforced concrete are to such material composed of concrete of 1 : 2 : 4 mix with minima of 0·8 per cent. vertical and 0·4 per cent. horizontal reinforcement, taking a load of 665 lb. per sq. in. including the equivalent areas of reinforcement.

Where superior reinforced concrete is used, either by increasing the reinforcement, or by



156 *Main Beams "strutted" by continuous walls below.*



157 *Secondary Beams "strutted" at mid-spans by transverse wall.*

TABLE VIII

Coefficient for stresses in brick and reinforced concrete walls and piers for different ratios of height to thickness (or least dimension in the case of a pier).

		a	
		Brickwork	Reinforced Concrete
Slenderness Ratio	6	1·0	1·0
	7	0·9	1·0
	8	0·8	1·0
	9	0·7	1·0
	10	0·6	1·0
	11	0·5	1·0
	12	0·4	1·0
	15	—	1·0
	18	—	0·9
	21	—	0·8
	24	—	0·7
	27	—	0·6
	30	—	0·5

improving the mix, sectional areas for load bearing can be reduced, but again not beyond the standards required for lateral protection. The load which either brick or concrete walls may be permitted to carry depends also on their heights.

Where the height is less than 6 times the width of a brick wall or pier, or less than 15 times the width of a reinforced concrete wall or pier, the above-mentioned stresses may be adopted. Where the height is greater, the stresses must be reduced by a factor *a* which is given for different slenderness ratios in Table VIII.

Where a girder or joist rests for its full length on a brickwork or reinforced concrete wall, it is reasonable to consider the load as equally distributed to the wall (Fig. 156). Where the wall runs normal to, or at an angle to the beams (Fig. 157), the loads are to be considered as concentrated, but dissipated into the wall at an angle of 45 degrees (Fig. 158).

TABLE IX

LOADS IN TONS TAKEN PER FT. RUN OF WALL DEPENDING ON THE HEIGHT

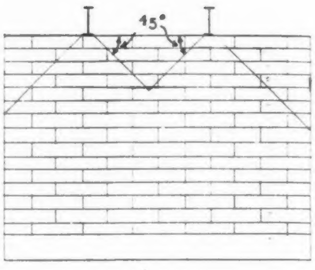
STOREY HEIGHT FROM SOFFIT OF FOUNDATIONS TO GROUND FLOOR	BRICKWORK								CONCRETE						
	13½"	18"	22½"	27"	31½"	36"	40½"	45"	12"	15"	18"	21"	24"	27"	30"
7' 0"	22·0	30·0	37·5	45·0	52·5	60·0	67·5	75·0	43·2	54·0	64·0	75·6	86·4	97·2	108·0
7' 6"	21·0	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,
8' 0"	20·0	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,
8' 6"	19·0	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,
9' 0"	18·0	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,
9' 6"	17·0	29·0	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,
10' 0"	16·0	28·0	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,
11' 0"	14·0	26·0	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,
12' 0"	12·0	24·0	36·0	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,
13' 0"	10·0	22·0	34·0	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,
14' 0"	—	20·0	32·0	44·0	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,
16' 0"	—	16·0	28·0	40·0	,,	,,	,,	,,	41·8	,,	,,	,,	,,	,,	,,
18' 0"	—	12·0	24·0	36·0	48·0	,,	,,	,,	38·9	,,	,,	,,	,,	,,	,,
20' 0"	—	—	20·0	32·0	44·0	56·0	,,	,,	36·0	,,	,,	,,	,,	,,	,,

Immediately below a joist or girder the stresses in a wall are greatest and in certain cases better quality bricks than those in the rest of the wall may be needed locally. Alternatively, distributing beams might be provided either for the full length (Fig. 159) or in short pieces (Fig. 160).

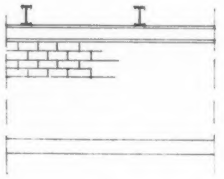
In every case care must be taken to ensure that the joists or distribution joists are in good contact with the wall, and the soffits should be evenly bedded. In addition, the following rules should be observed :

1. Where a wall runs for full length under a beam the wall should be carried up over the lower flange or in some other way be secured to the beam so as to be capable of transmitting any side thrust (Fig. 161). In concrete walls, little difficulty is met in fixing the beam (Fig. 162). With brick walls, however, it may be necessary to add concrete caps which might be expected to develop reasonable bond with the brickwork below ; but even in those cases it is well to provide certain vertical reinforcement in coincident mortar joints of the brick wall and to cast concrete caps round projecting lengths of that reinforcement (Fig. 163). In other cases it may be necessary to secure a beam with straps held by bolts through the brickwork (Fig. 164).

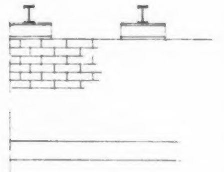
2. Where a wall runs normal to or at an angle to the joists, all cavities between the top of the wall and the soffit of the floor above over the length of wall between parallel joists must be properly filled, in case gas-proofing should later be required.



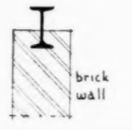
158 *Dissipation of concentrated loads into wall.*



159 *Continuous distribution beam on top of wall.*

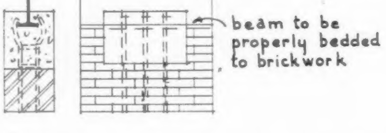


160 *Short distribution beams on top of wall.*

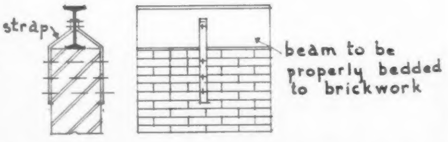


161 *Securing of beam by brickwork when the wall is sufficiently thick.*

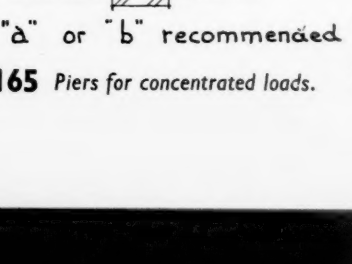
162 *Securing of beam to concrete wall.*



163 *Securing of beam to brick wall by concrete pad cast to reinforcement projecting from the brickwork.*



164 *Securing of beam to brick wall by steel straps.*



165 *Piers for concentrated loads.*

Where a particularly heavy beam produces a concentrated load on a brick wall, it seems advisable to provide a pier immediately beneath it (*see* Fig. 155). The pier should be designed on the same principles as the wall. It may take the form of an enlargement of the wall locally, or even of better quality brickwork of the same thickness as the wall, or of a combination of these two methods (Fig. 165). Walls and piers should have proper footings which must rest either on good ground (Fig. 166) or, where an existing floor slab already rests, on good ground, on that slab which can then be regarded as part of the footing (Figs. 167 and 168).

The size of foundations must be determined by calculations of the actual loads.

Steel Struts.—Steel struts can be of a standard rolled section, but when loads and storey heights are small, steel tubes may be used.

Steel tubes are particularly easy to erect, but calculations show that their application is confined to relatively few cases. Steel struts should have top and bottom bearing plates and joists and girders should be properly attached so that bending moments are not set up in the columns. The determination of the section depends on the load as well as on the length. It is well to keep in mind that struts are usually the weakest part of a strengthening system. Where falling loads occur, struts, being much stiffer than slabs and beams, which yield to a certain extent by deflection, receive much more serious shock.

In order to reduce the risk of damage, the following rules relating to struts should be observed :

(*a*) The slenderness ratio should never be greater than 120.

(*b*) The top of every column should be held horizontally in position where a beam rests on it (Figs. 169 and 170). It is not sufficient that merely the top of the beam is held by steel sheeting—horizontal movement, however small, must be prevented at point *A* (Fig. 171).

(*c*) The base of the strut is to be connected reasonably rigidly to the foundation or ground slab (as is done for any other column not designed to withstand shocks). To insert a hinge at the bottom is to reduce the stability of an otherwise well-calculated and expensive arrangement.

(*d*) The stresses, calculated for the combined live and dead and debris loads, should be well within the permitted limit.

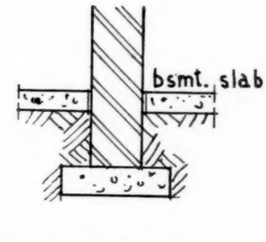
Steel columns, although more expensive than brick piers, will generally be used where free-standing struts are required, in order to save space. Steel columns are not recommended where they are to act in conjunction with walls (Fig. 165).

The restraint of the top of a column will best be afforded by a cross beam, the lower flange of which is at the same height as that of the main beams, and which is connected either to the cap of the column (Fig. 169) or to as low a point as possible on the main joist (Fig. 170).

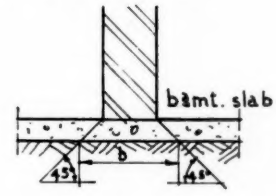
The base of a stanchion should be of such dimensions that the pressure underneath does not exceed 20 tons per sq. ft.

A base may either stand on a mass concrete footing (Fig. 171) or, where the existing ground floor slab rests directly on good ground, on a reinforced concrete base which distributes the load on to that slab (Fig. 169). If the width of the reinforced concrete base is " b " and the thickness of the slab " t " then the width of the foundation can be taken as $b + 2t$. Every strut should be wedged in position, the wedges being grouted in after being driven.

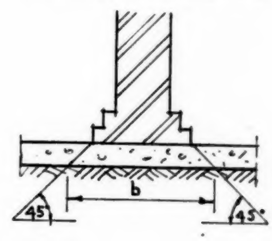
In regard to the extent to which a basement is to be prepared as a shelter, there is certain ambiguity.



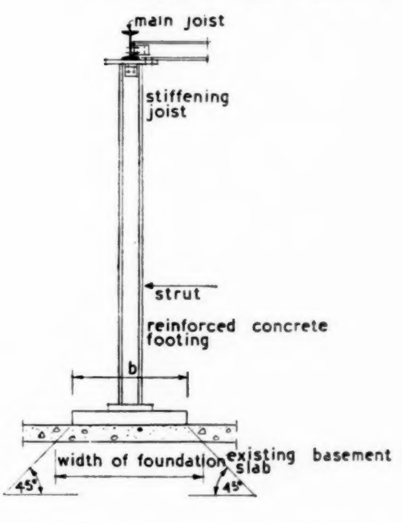
166 *Footing on good ground.*



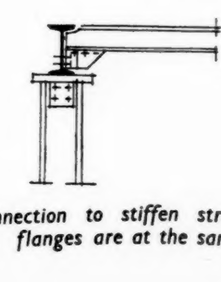
167 *Wall carried on basement slab. (Only where supported by good ground.)*



168 *Wall carried on basement slab. (Only where supported by good ground.)*



169 *Suitable top and bottom fixings for a steel strut.*



170 *Connection to stiffen strut when top flanges are at the same level.*

F

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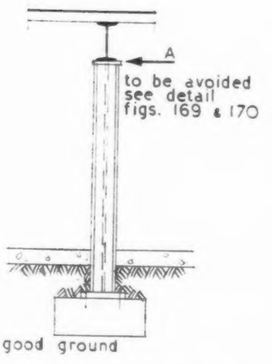
For instance, sub-section (4) of Section 21 of the Civil Defence Bill indicates that the work should be completed without delay, whereas the third paragraph of this subdivision of the Code (at the top of the marginal reprint on page 966) indicates that only part of the work need actually be done at this stage, but that materials for the completion must be stored near at hand. As the Code is subject to revision, however, this matter will probably be cleared up, but it is important that the expert adviser acquaints himself with the final decision. If the second requirement is adopted, it should be kept in mind that practically all building materials, except cement, stand storage for considerable periods. As there is a possibility that cement may become scarce when an emergency arises, due to the very sudden demand, designers should so arrange the work that as little as possible is needed for those parts which are to be erected in emergencies.

All steelwork must be painted before being stored, and again at whatever times are necessary.

Struts may be fixed quite rapidly, but unfortunately shelter walls which usually present the greatest obstruction to the normal uses of premises cannot be built so readily.



171 *Foundation to strut when basement slab not on good ground.*

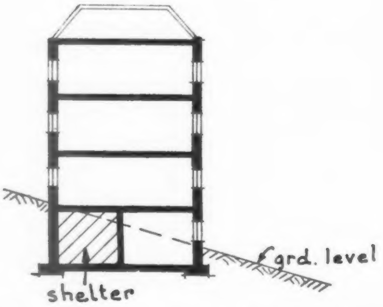
(28) ***Shelters constructed within Buildings by adaptation of existing accommodation above ground.***

Where there is no basement but where there is a substantially built section of the building as, for instance, an office block adjacent to a single storey block with roof lighting, it may be possible to select a room or rooms in this section for conversion to shelters. These rooms should be on the ground floor wherever possible, but if the ground floor has large window openings, such as showrooms or shop fronts, the shelters should be made in inner rooms or corridors protected by adequate walls (as at A in Fig. 174). As the enclosing walls of the shelters should be not less than 13½ in. of solid brickwork, or not less than 12 in. of reinforced concrete, as indicated in Part I, some thickening of the existing walls and protection of door and window openings may be necessary. To block up door and window openings would often be most inconvenient from the point of view of the normal usage of the premises, and it would be appropriate in such cases to prepare details of the work required and to store the materials permanently on the site, so that the installation can be complete immediately an emergency arises. The existing roof may need strengthening up to the standard of protection indicated in Part I, and, as in the case of basements, it may be necessary to provide support for debris loads.

(28) *Ground floor shelters.*—The essential difference between the ground floor of a building without a basement and the basement of another building lies in the fenestration. Wherever shelters are to be constructed in portions of a building where windows occur, those windows must obviously be blocked in such a way as to afford the same standard of protection as that required for the shelter. For ground floor areas this will be a bigger item than in the case of basements; but in the latter case also any windows, even if they are provided below ground level with light areas, must be similarly treated. Where a wall of reasonable construction separates a shelter from windows then the building-in of the openings may not be necessary.

If a building on sloping ground has part of the lowest floor at the ground level on one side and part of it below on another, then any shelter which is required should be located preferably in the area below the ground (Fig. 172).

For the storing of material, see the notes at the end of paragraph 27 above.



172 *Preferable position for shelter in building on sloping ground.*

(29) ***(d) Specially constructed Refuge Rooms in the Factory itself or Lean-to Shelters.***

In some cases it may be found more convenient to erect an

(29) *Specially constructed shelters.*—The difference between the shelters mentioned here and those mentioned before lies mainly in the fact that they have generally their own new roofs, instead of a strengthened floor above (Fig. 173).

173 *Shelter with independent roof.*

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independent shelter room within the building (as shown at B in Fig. 174).

Lean-to shelters may be constructed having walls and roof affording the standard lateral and vertical protection laid down in Part I of this Code (as shown at F in Fig. 174). A lean-to against a single-storey building would not require a heavier roof than that required to give the standard overhead protection, but against multi-storey buildings it is obvious that the structure would need to be sufficiently strong to withstand the debris load consequent on collapse of the wall of the main building. Lean-to shelters can serve in peace time as cycle or store sheds. An entrance can be made to give access directly from the main building in an emergency. (*See* Fig. 174.)

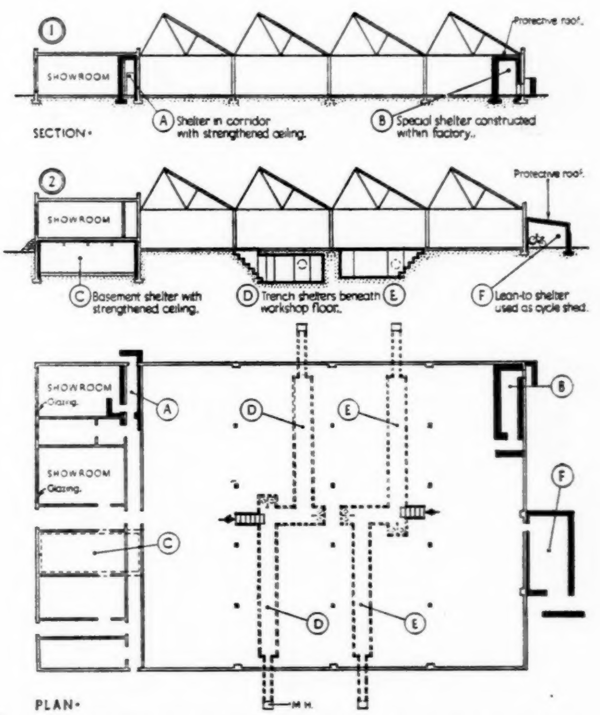
Under the following conditions, such shelters will be practicable :

(1) Where the storey in which the shelter is to be erected is considerably higher than is required to afford the volume and surface area for the occupants (*see* paragraph 10).

(2) Where a ceiling does not lend itself to strengthening. Reference should be made to paragraph 7, where loads were defined in relation to the distance of the shelter roof from the floor or ceiling immediately above.

Where a new concrete ceiling is considered, there should be at least 2 ft. 6 in. space in which to pour it (Fig. 173), unless there is a possibility of taking up the floorboards above and pouring the concrete from the top.

Lean-to shelters have less natural protection than other shelters and they should really be considered only where all other possibilities have been exhausted. (*See* Fig. 174, reproduced from the Code.)



174 —Suggestions for the Provision of Shelters in North-light Factories.

GENERAL REQUIREMENTS FOR THE LAYOUT AND CONSTRUCTION OF SHELTERS

(30) *Diversion of Services passing through Shelters.*

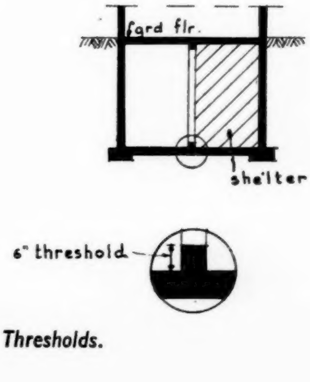
There will be cases where damage to certain of the service pipes in buildings might constitute a danger to persons in a shelter. Steam, gas, compressed air, refrigerants and chemicals generally would be a source of danger under any conditions. If the only possible shelter is in the vicinity of such services, steps should be taken to divert them. In rare cases water mains and sewers of large size may be hazardous and will require special consideration.

(30) *Diversion and avoidance of Services. See also* paragraphs 22 and 24.

In domestic buildings, particularly in hotels and restaurants, service pipes converge usually on the kitchen and where they may be diverted at other points, they still must lead ultimately to the kitchen. Therefore, the vicinities of kitchens are to be avoided. To divert services is usually costly and it is much better to choose a place, in the beginning, where no services are likely to be encountered.

In many industrial buildings, it will be more difficult to keep away from such dangerous points. Actually no general advice can be given for local conditions vary so much ; but in quite a number of cases, the provision of trenches, either under buildings or in the open, will be the easiest solution. Even the underpinning of a few foundations is often cheaper than the rearrangement of services.

To avoid the danger of the bursting of nearby water mains, it is suggested that basement and trenches should be drained. The provision of thresholds (Fig. 175) will, in case of emergency,



175 *Thresholds.*

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give time for the occupants to leave the shelter, before the flooding of the floor makes it difficult. Bursting of sewers will affect only a small area directly, and this danger might be neglected. The secondary effect of reflow in lavatories can be counteracted by valves. (*See* paragraph 16.)

Existing lavatories on the same floor as a shelter, although forming no part of the shelter system, should also be protected in this way.

Attention should also be given to canals, an example of which is given in the Code (*see* "preliminary survey," Area B, paragraph 24). There is little doubt that they should be considered dangerous to much wider areas than are suggested in the Code. In fact, an area although a considerable distance away, lying lower than the canal level, may be affected.

(31) *Emergency Exits.*

The opening of emergency exits should be arranged so that they are as far out from the building line as possible in order to reduce the risk of their being blocked. A good working rule is that the opening should be set back from the building line by a distance equal to half the height of the building. It is realised that this rule cannot be followed in many cases and the important consideration then is that there should be as many alternative emergency exits as possible so disposed as to diminish the likelihood of all being blocked.

In basement shelters in closely built-up neighbourhoods it will often be desirable to form emergency exits into adjacent basements. This can be done by nserting steel or reinforced concrete lintels in peace time; deferring the actual breaking through of the opening until an emergency arises.

In large basement shelters there should be at least one emergency exit, and preferably more than one, additional to the normal entrance, for every party of 200 persons. All doors to entrances and exits of shelters should be made to open inwards.

A selection of tools, shovel, pick and crowbars, should be kept in each shelter so that, if necessary, occupants can dig their way out.

(31) *Emergency Exits.*

See also paragraph 14.

It would seem that it is much better for doors to open outwards than inwards, as is suggested in this paragraph.

The difficulties of securing to the rest of the structure, a door opening inwards, in such a way that it could develop its full potential resistance to blast and any masonry which might be hurled against it, seem very much greater than those in providing reasonable protection for the approach (*see* paragraph 13 and Figs. 55 to 59) and those of the escape of the occupants through the emergency exits if the door should actually be blocked in such a way that it could not be burst open by pressure from the inside.

It is suggested that a blast-proof steel door should be fitted with a steel panel on the outside near the top, which could be removed from the inside by unscrewing the nuts of the bolts holding the panel.

Emergency exits can be protected by:

1. Blast-proof doors (Fig. 176). Blast-proof doors leading directly to shelters are only to be used for shelters with artificial ventilation or which afford the 75 sq. ft. of wall area per person; but they may be used in conjunction with corridors to shelters which are naturally ventilated from another source (*see* paragraph 13 and Fig. 177).

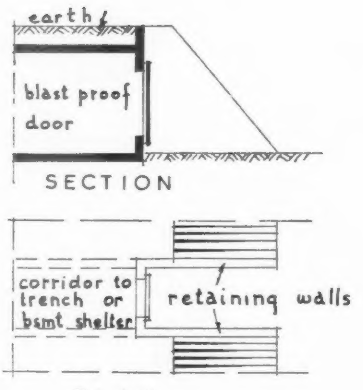
2. Screen walls, often in conjunction with a staircase (Fig. 178).

3. By a manhole with a cover which can be lifted from the inside (*see* Fig. 179).

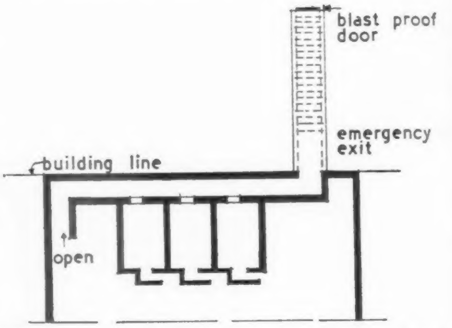
(32) *Emergency Lighting.*

In order to avoid panic and confusion in an emergency due to failure of the ordinary lighting system some form of emergency lighting is desirable in shelters. Electric torches or electric battery hand lamps will be suitable for this purpose and particulars of recommended equipment may be obtained on application to Air Raid Precautions Department, Home Office, or to Regional A.R.P. Inspectors. For large schemes it is preferable to install a permanent alternative lighting

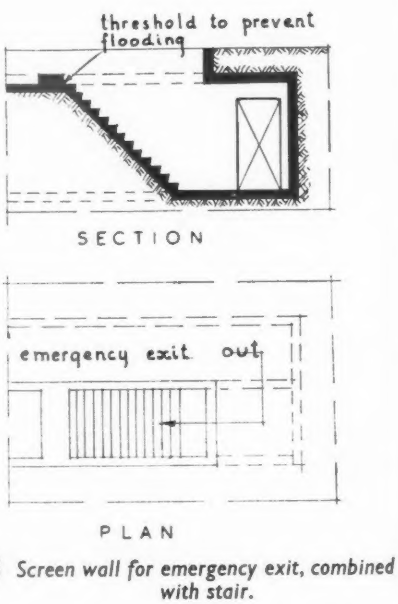
(32) Naked lights or any other form of combustion which extracts oxygen from the air should not be used in shelters. Electric lighting will normally be adopted; but to provide against the failure of the power supply an emergency generator set, manually operated, should be installed. A storage battery system often demands rather more space than can be allowed; but it may nevertheless have certain uses. Separate ventilation for the battery room is required on account of the noxious gases which are produced. The main ventilation system may also operate on power taken directly from the mains; but again, the alternative of manual operation must be provided, and in this case such an alternative is even more important than in the case of the lighting.



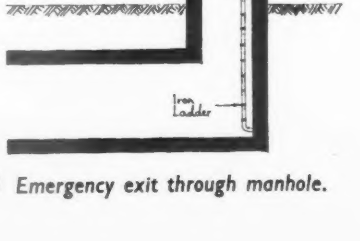
176 *Blast-proof doors for emergency exits.*



177 *Blast-proof door for naturally ventilated shelter.*



178 *Screen wall for emergency exit, combined with stair.*



179 *Emergency exit through manhole.*

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system and the generators or storage batteries should be given as much protection as possible, but they should be isolated from shelters occupied by personnel and should have separate ventilation.

(33) *Entrances to Shelters.*

In order that shelters can be occupied with the minimum of delay, it is important that their entrances shall be wide enough to allow all the occupants to pass in quickly. For large shelters a convenient working rule is to allow one foot width of opening for every 50 persons occupying the shelter with a minimum of 2 ft. 6 in.

This is particularly important in those localities where shelters have to be occupied within a very short period of time. In such cases the actual period should be considered in terms of the air raid warning arrangements operative in the locality, and the entrances should be designed accordingly.

(33) *See also* paragraph 13. The wording of the Code is somewhat vague in regard to the requirements for the width. It should be realised that an entrance or corridor of 6 ft. width does not allow proportionally more people to pass in a given time than if it were 5 ft. wide.

Assuming that a person requires 2 ft. to 2 ft. 6 in. of width, door openings should be 2 ft. 6 in. wide, 4 ft. 6 in. or 6 ft. 6 in., and corridors 3 ft., 5 ft. or 7 ft., when reasonably speedy entrance is needed. If people walk at a speed of 110 yds. per minute, which is a brisk pace, and if each person requires always 1 yd. of length in which to walk without pressing, 110 people per minute may enter a shelter in one line. The number generally assumed is 100 people per minute, and a door of 2 ft. 6 in. or a corridor of 3 ft. will allow that number of people per minute to pass.

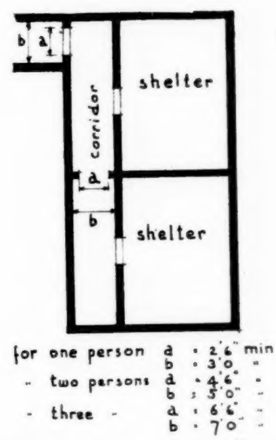
A door of 4 ft. 6 in. or a corridor of 5 ft. will allow 200 people per minute to pass.

A door 6 ft. 6 in. or a corridor of 7 ft. will allow 300 people per minute to pass.

Obvious as it may sound, the fact is frequently overlooked that no corridor or gangway, no matter how wide it may be in places, lets more people pass than the capacity of its narrowest portion, even if that narrow portion is purely local.

The time available for the actual occupying of a shelter is always shorter than the warning time, and varies with the locality. If, for example, trenches are 4 minutes away from the place of work which they serve, and if the total time from the alarm till the danger is 5 minutes, then only 1 minute is left for actual occupation of the shelter and even this is on the assumption that no delays will occur in the evacuation of the place of work. The lapse of time between an alarm and the entry of the first people to a shelter should always be tested in any particular case, and if the entrances are then not sufficient, based on the foregoing figures, to permit of the entry of all occupants in the time that is left (i.e. 5 minutes minus the recorded first entry time) then additional or enlarged entrances must be provided.

Three minutes may be assumed as an average value of the alarm first-entry period, and on this basis entrances should have the capacity per minute of half the total number of occupants.



180 *Widths of access corridors and doorways.*

(34) *Gas-proofing of Shelters.*

The shelters need not be gas-proof but should be so constructed as to be capable of being made gas-proof without undue difficulty should the need be found to arise in an emergency.

(34) The words "undue difficulty" are open to a wide variety of interpretations. However, it is in the interest of everybody that nothing should be done in the design or construction of the shelter system which may have to be undone, at a later date, to meet other requirements which should reasonably have been foreseen; and the expression in this case may be taken to mean that shelters should be so built that nothing in their construction need be demolished if gas-proofing should be required. It follows that actual provisions might justifiably be included in the original construction of a shelter. Neglect of the requirements for gas-proofing may lead to an otherwise satisfactory shelter becoming untenable. For this reason, it was suggested in paragraph 10 that as little use as possible should be made of the permission to

APPENDIX K*

CONSTRUCTION AND EQUIPMENT OF FIRST AID POST AND CLEANSING CENTRE

First Aid Post (uncontaminated cases)

In the calculations which follow, a stretcher case is assumed to require 50 square feet, or 30 square feet when treatment is finished. A sitting case is assumed to require 15 square feet. A post of 200 square feet should serve for a factory employing from 250 to 500 workers.

Warm water is necessary in this room, together with some water-boiling apparatus for sterilizing instruments; but running water is not essential if it is not already laid on. Shelving or cupboards would be needed for dressings and medicaments. It would be advisable to have curtains or screens available to screen off a small section of the room for gassed patients for whom the main treatment might be rest. A slop sink or lavatory should be accessible from this room for emptying pans, etc., of patients under treatment.

Separate accommodation and water closets should be available for patients awaiting treatment and for those who have been treated or are waiting for ambulances. A works which is dependent on outside ambulances will normally require more space for waiting cases than a works which is removing its own ambulance cases.

Cleansing Centre

The sequence is undressing, cleansing and dressing: and the accommodation provided at each stage should be arranged in that order. The most convenient arrangement is for the accommodation provided to be interconnected. If a separate entrance and exit cannot be arranged in each room, it is desirable to erect temporary barriers to avoid the possibility of contact between those entering and those coming out. An essential point is that there should be a separate entrance for contaminated personnel leading straight to the undressing accommodation.

For undressing, what is required is suitable accommodation adjacent to the cleansing room, where contaminated persons can be undressed. If inside accommodation is used, it is useful to have an open shed outside where grossly contaminated articles of clothing can be discarded and the concentration of vapour in the undressing room thereby reduced. Forms should be provided for undressing: bins with close-fitting lids will be required for contaminated clothing: also one or two latrine buckets behind screens, if no w.c. which could be specially reserved is available, because contaminated people cannot be allowed to use w.c.s which might be used by others. The undressing accommodation, because of the presence of vapour, must be completely sealed off from the cleansing and dressing accommodation: and (unless all contaminated clothing is taken off in the open) the

allow only 3$\frac{3}{4}$ sq. ft. per person in certain types of shelter.

The following are the measures to be taken as protections against gas:

1. Installation of ventilation and air filtration, except where at least 75 sq. ft. of surface area are available per person, which will rarely be the case.

2. Sealing of all openings, provision of gas-proof doors.

3. Provision of cleansing-rooms (decontamination) and treatment-rooms.

Considering now these points in detail:

(1) Where blast-proof doors are required owing to lack of space for screen walls, artificial ventilation should be installed at the outset. Artificial ventilation will frequently be found of advantage in conjunction with natural ventilation, for the standard of 25 sq. ft. of surface area per person is extremely low. (*See* Appendix I, page 1006.)

Ventilation of the lavatories should always be provided in the original scheme. With a view to the possible necessity of gas-proofing, every ventilation system should be of the "intake" type, thus providing a slight over-pressure in the shelter.

The following space should be allowed for combined ventilation and air filtration plant:

For 50 persons, about 21 sq. ft.

For 100 persons, about 26 sq. ft.

Where possible the air should be drawn in from a high level and in multi-storey buildings an intake pipe should be carried up to the roof. However, a second pipe or intake duct, normally closed by a valve, should extend to a place outside the building in case the first pipe should be damaged. Delivery from the air plant to lavatories should be kept separate from other delivery ducts, and a valve preventing reflow of air should be introduced.

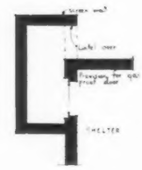
Exhaust ducts must be trapped so that gas cannot flow back under its own weight, if the air plant should fail. Fans are to provide not less than 150 cub. ft. of air per person per hour, and the power required is about $\frac{1}{4}$ h.p. for 50 persons. Air filters are usually incorporated in A.R.P. ventilating plants. The filters should always be introduced between the air intake and the fan; but most plants provide for their being by-passed when not required against gas.

(2) In order that the actual number of openings to be sealed, in an emergency, should be limited, walls of basement shelters should be packed hard against the soffits of existing slabs. All entrances should be provided with recesses so that gas-proof doors can be arranged. (*See* paragraph 13 and Fig. 181.)

Gas-proof doors must be in such positions that they are protected against blast, which means that they must be on the inside of screen walls, etc. (*See* Figs. 56 to 60.) Blast-proof doors are as a rule designed also to be gas-proof. Such possible means of entry of gas as disused drains, etc., should be sealed when a shelter is first constructed.

Drained lavatories are safe against the penetration of gas if they have the normal type of trap in working condition; but means of sealing them should be available.

(3) Cleansing rooms should be located at the entrance to a shelter. (Figs. 182 and 183.) In public shelters everybody should pass the cleansing rooms during a gas attack; but in private shelters in basements of office buildings or factories which are for the occupants of those premises only, or in trench shelters in the immediate neighbourhood for the same purposes, the cleansing centres can be arranged so that only the limited number of people



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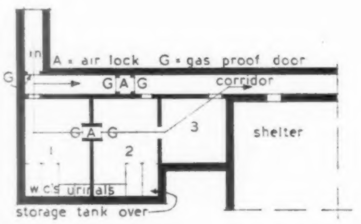
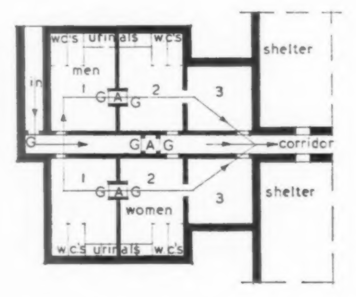


182 *Cleansing rooms for one sex only. 1—Undressing room. 2—Washing and treatment. 3—Dressing room.*



183 *Changing rooms for both sexes. 1—Undressing rooms. 2—Washing and treatment. 3—Dressing rooms.*

entrance to the cleansing room from the undressing accommodation must have an air lock.

In the washing room bleach and eye treatment may first have to be given, followed by washing. For the latter purpose it is suggested that the simplest procedure will be for each person to go under a shower to get wet, withdraw and soap himself, and then pass under another shower before drying. This scheme can most economically be met by two sets of showers with the washing space between. Drainage under the showers may have to be improvised. If the floor is of wood, it can be covered with lino, which should be turned up the walls at the skirtings for about a foot. If there is no fall for drainage, the water can be swept to an improvised drain, either in the floor or in the wall. Alternatively a low sloping platform can be built under the showers, with a drain underneath, and the surface covered with lino, or preferably with lead sheeting.

In the dressing room there should be a store of clothing, also a w.c. for the patients' use.

About 300 square feet (divided in equal proportions between the three rooms) might be allowed for the cleansing centre of a small factory).

Combined Post and Centre

Fig. 11 shows the layout of a first aid post, which provides cleansing facilities. The area figures of the various parts are given in proper proportion. The post consists of :—

(1) *Undressing room for contaminated cases with open shed for removal of grossly contaminated clothing.*

(2) *Washing room for contaminated cases.*

(3) *First aid room for wounded cases, both uncontaminated cases and contaminated cases which have been cleansed.*

(4) *Dressing and waiting room.*

Where both sexes are employed, duplicate provision of all these facilities will be required.

*** Reproduced from Handbook No. 6.**

who may have been exposed to contamination, have to pass them. Every decontamination centre must consist essentially of three rooms, through which people will pass in sequence :

(1) Undressing ;
(2) Washing and treatment ;
(3) Dressing.

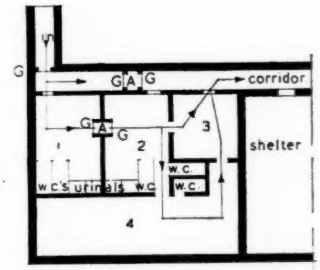
The washing and treatment room should be supplied with hot and cold water ; hot water may be provided from an outside source or from a storage tank. A w.c. and urinals should be connected to the washing room. The undressing room should also have w.c.s or chemical closets (two seats). It should be separated from the outside air by a gasproof door and from the washing room by an air lock. Where a by-pass corridor is arranged, an air lock must be installed between the connections to the dressing and undressing room.

At present the space reserved for the three rooms can be left open, the division walls and air locks being installed later. Each of these rooms takes about 10 ft. × 10 ft. (including lavatory) so that 300 sq. ft. are to be allocated. This provision should be doubled if people of both sexes are to use the shelter (Fig. 183).

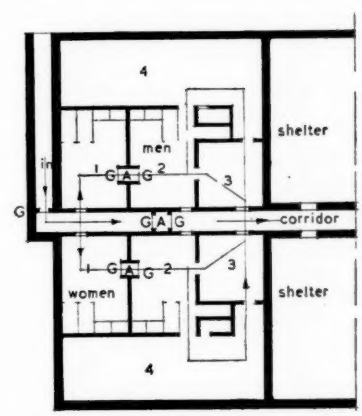
Where more than 500 people will use a shelter the accommodation is also to be doubled.

First-aid posts should be connected to the cleansing centre (Figs. 184 and 185). They must open directly to the washing and the dressing-rooms, but must be entirely separated from the undressing room. No contaminated air must reach the first-aid room. The whole arrangement of undressing, treatment, dressing and first-aid rooms will require about 510 sq. ft. of floor exclusive of walls. It is clear that the whole of these rooms must be within the shelter system, that is to say, they must be protected against blast and splinters in the normal way. Where both sexes are to use a shelter the whole arrangement is to be doubled, as it is also if there are more than 500 people.

First-aid posts may be installed (and this is definitely recommended) for 100 people or more whether gas is likely or not. The space provided for use as a cleansing centre later can serve as an ante-room in the meantime. In extreme cases one first-aid room may be provided for both sexes, and connected to both cleansing centres ; but such arrangement should be avoided, where possible.



184 ***First-aid post in connection with cleansing centre for one sex only.***
1 — *Undressing room.*
2 — *Washing and treatment.*
3 — *Dressing room.*
4 — *First-aid.*



185 ***First-aid post in connection with cleansing centre for both sexes.***
1, 2, 3 } *as in Fig. 183.*
4 — *First-aid.*

TEXT OF CODE

PROVISION OF SHELTERS IN SPECIAL TYPES OF BUILDING

(35) It has already been mentioned that the requirements as regards the provision of shelters in buildings require individual consideration for each building, and the work requires competent technical supervision. There are certain types of building where the adaptation of existing accommodation to the requirements of air raid shelters is easy, but on the other hand there are also types of building which by reason of their location, their planning, or their method of construction present special problems. By way of illustration of the principles involved, a number of typical buildings have been selected, and some methods of adapting them for the provision of shelters are indicated

(35) *Examples of shelters in different buildings.*— The examples given in the Code are clearly explained and no comment is required. *See also* paragraph 20, where general advice on suitable shelters has been given for the most common types of buildings. Such recommendations are, of course, very general, and the conditions obtaining for any particular building and the peculiarities of its construction will have considerable influence on the choice of the shelter (Figs. 186 to 192).

TEXT OF CODE

1. *Mill Building.*

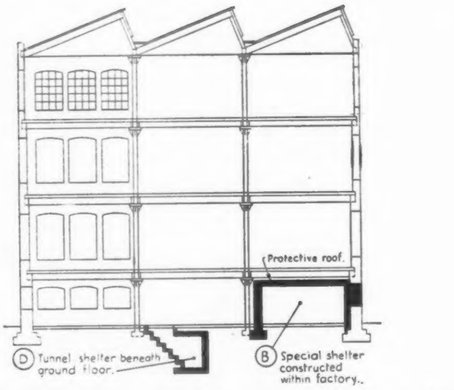
A typical example is shown diagrammatically in Fig. 186. Very often buildings of this kind are to be found situated in congested areas with the bare minimum of vacant ground available. It then becomes necessary to provide shelters for the personnel inside the building. The buildings are often constructed with masonry walls much cut away by window openings, with cast iron columns, and with beams housed tightly into cast caps on the columns. This form of construction is ill-adapted to withstand the shock from a nearby explosion, and there is the possibility to be faced that debris loads on shelters in the lower part of the building may be abnormally heavy. The best form of shelter in such a case would be a tunnel under the ground floor of the building, provided the soil conditions would permit of excavation without risk of disturbance of heavily loaded foundations (as in Type D, Fig. 186). Where the soil conditions are unfavourable, it will probably be necessary to provide shelter on the ground floor by erecting strong walls and a heavy roof slab over, independent of the existing floors (as in Type B, Fig. 186), and using the most suitable part of the building for the purpose. The most suitable part will depend on peace time uses, but, generally speaking, the corners of the building would be best, as providing ease of access and exit and a degree of dispersal of personnel. Very often textile materials are stored in bales in these buildings and the bales could be arranged to augment the resistance of the shelter walls.

2. *Multi-storey Warehouse Building.*

An example is shown in Fig. 187. The building has a reinforced concrete or encased steel frame, with floors designed for heavy loads, and external walls would be of panel construction supported by the frame. Any part of the centre of the building at basement or ground floor level would be very suitable for the provision of a shelter and it will only be necessary to fill in walls up to the standard of lateral protection laid down in Part I and to provide some additional support to the ceiling over.

3. *Office Block with Basement and Area.*

A building of this kind is shown diagrammatically in Figs. 188 and 189. These buildings will usually consist of load bearing masonry or brickwork with heavy timber floors, or in later examples with filler joist and concrete slab floors.

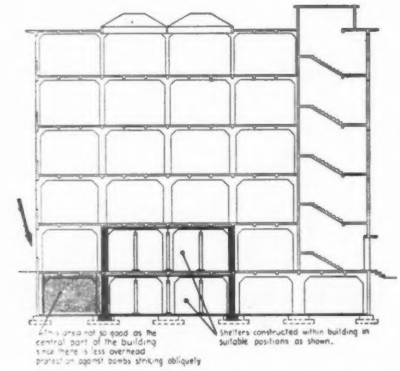


Suggestions for the Location of Shelters in Mill Type Buildings.

186 *Unlike a framed building or a reinforced concrete building a typical mill building would be unable to withstand serious shock and would be in danger of complete collapse if hit by a bomb.*

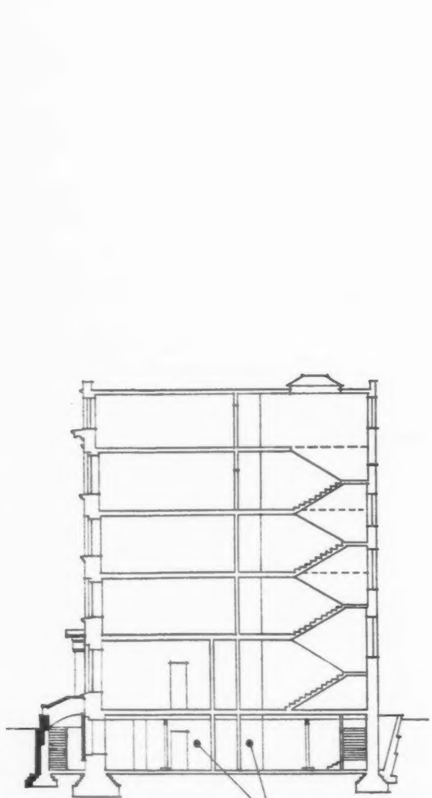
The best form of shelter within such a building, where soil and foundation conditions permit, would probably be one in the form of a tunnel (Type D) beneath the bottom floor continuous throughout the width of the mill with exits at both ends.

The roof of a shelter within the building (Type B) would therefore have to be very greatly strengthened in order to support the heavy debris loads that might come on it.

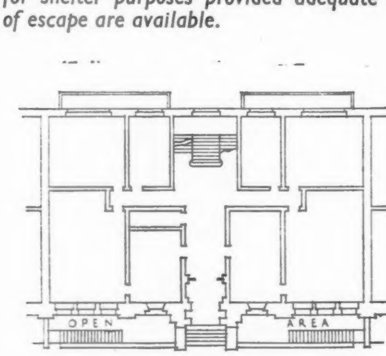


Suggestion for the Provision of Shelters in a Framed Warehouse Building.

187 *A monolithic concrete or steel-framed multi-storied building would offer considerable resistance to shock or to a direct hit, and, with some additional strutting of the ceiling and partitions to give lateral protection, both the inner rooms on the ground floor and those in the basement would offer suitable accommodation for shelter purposes provided adequate means of escape are available.*



SECTION•



GROUND FLOOR PLAN•

188 *Suggestions for the provision of shelters in an office building with basement having open area fronting on to street. (Heavy masonry construction with timber floors.)*

TEXT OF CODE

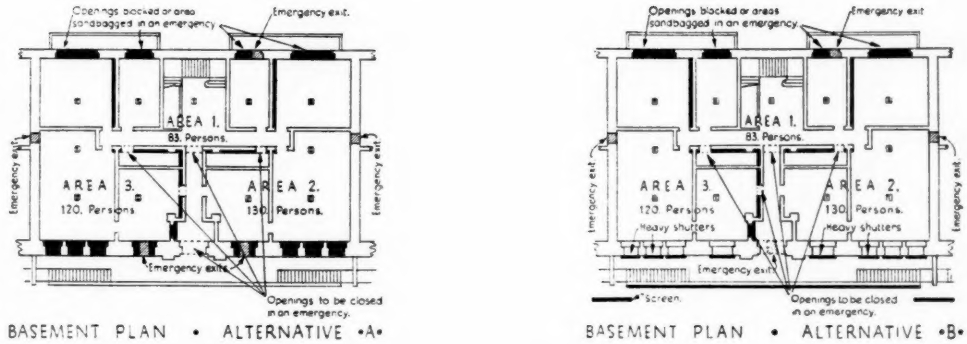
The basement would usually be chosen for the provision of shelter but the lateral protection may fall somewhat below the required standard. Where the basement window heads come above the level of the area wall, as is often the case, it will be necessary to screen these windows and this can often be done by raising the area wall in 13½-in. brickwork. With this arrangement the basement windows should be covered with heavy shutters to minimise effects of blast. An alternative, where the loss of light would not be a serious objection, would be to block up the basement window openings. The floor over the shelter will require strengthening against debris loads.

4. *Shop, on corner site, with basement extending under the pavement and with pavement lights.*

The building is shown diagrammatically in Fig. 190. The external walls and central tower would often be in load bearing masonry, the floors consisting of reinforced concrete or filler joist construction with cased steel beams.

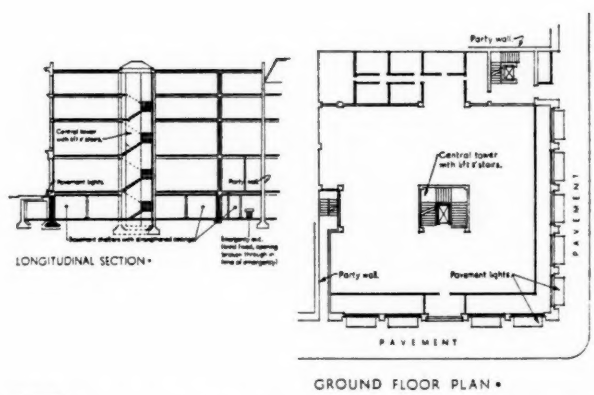
The basement would normally be chosen for the shelter area, but it is somewhat vulnerable on the sides fronting on the streets owing to the pavement lights and large openings below first floor levels. If the area required to shelter the personnel employed in the building is limited in extent, it would then be possible to make the shelters in the area furthest back from the pavement lights (as at A in Fig. 191). If, however, a large number of persons would need to be accommodated it might be necessary to use the whole basement. (With a similar building occupied as offices this might well be the case.) In the latter case it would be necessary to support the pavement to take heavy debris loads resulting from collapse of the front of the building, and a useful alternative would be to fill in the area of the basement under the pavement with earth or sandbags or to block off the area under the pavement (as shown at B in Fig. 192).

Owing to the possibility of collapse of the building on to the pavements, the provision of emergency exits direct to the street is barely sufficient, and in many cases it would be desirable in time of emergency to provide alternative exits to adjacent basements. These need not necessarily be broken through in times of peace, but it would be desirable to put in the necessary lintels and to mark the position of the openings so that they could be cut through by unskilled labour at short notice.

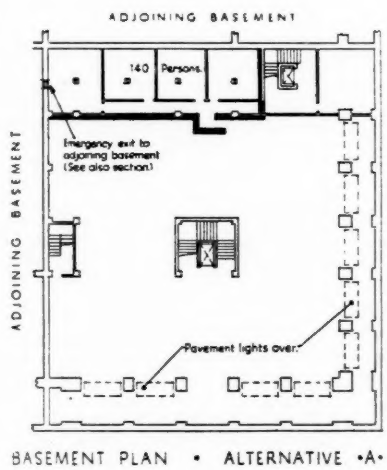


189 *The whole basement may be required for shelter. With brickwork masonry construction debris loads may be heavy and considerable strengthening of floors over basement will be needed.*

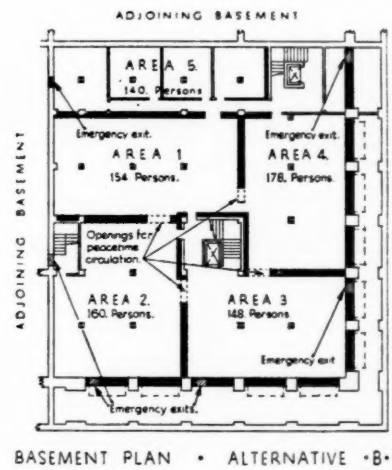
The open area may be blocked by heavy debris from walls and cornice on front elevation and emergency exits to rear or adjoining premises are desirable.



190 *Suggestions for the provision of shelter in a large shop with basement. (Floors and basements not subdivided, central tower with stairs and lift, fronting on to two streets.)*



191 *Where a limited number of persons is to be accommodated the shelter would be placed as far back from the pavement lights as possible. The number accommodated is 140 persons.*



192 *The whole of the basement is required to accommodate a large number—720 persons. The area under the pavement is blocked off and, owing to the possibility of heavy debris over the pavement lights, alternative emergency exits are provided into adjoining basements where possible. Strong dividing walls are placed between the parties.*

SHELTERS IN BASEMENTS

Memorandum No. 10. "Provision of Air Raid Shelters in Basements." Issued by the Home Office (Air Raid Precautions Department). H.M.S.O. Price 6d.

Certain portions of the Memorandum being, more or less, repetitions of the Code requirements, are not reproduced here.

This Memorandum deals mainly with domestic shelters, and shelters for very light structures, although this is not expressed in the title. The general requirements given are practically the same as in the Code and are, therefore, not repeated. There are, however, some additional points which are important and which will be cited and explained. Further, there are some more examples given, particularly for the use of timber, and these will be set out.

As the Civil Defence Bill does not refer to domestic shelters, any suggested treatments of them are to be considered as recommendations only.

There is a curious discrepancy in the Memorandum, in that from a certain point in it the standard of protection suggested is definitely lower than that either in the Code or in the first portion of the Memorandum.

While no explanation for this can be given, it is understood that the Memorandum is to be revised. Whether or not the standards of the Code will be maintained throughout the revised Memorandum, it is to be hoped that people will not be satisfied with any less degree of safety than that provided for by the Code.

The paragraph numbers have been introduced by the authors, and do not appear in the official publication.

TEXT OF MEMORANDUM

A.1.—*Fire Resistance of Roofs over Shelters.*

No special precaution need be taken by way of fire protecting encasement of steel sheeting, steel columns or steel beams introduced to strengthen floors against debris loads. Unprotected timber may also be used where the existing floor consists of :—

(*a*) Slabs of reinforced concrete together with reinforced concrete or steel beams and columns.

(*b*) Slabs of reinforced concrete and hollow tile construction together with reinforced concrete or steel beams and columns.

(*c*) Brickwork or masonry arches alone or in combination with steel or reinforced concrete beams.

(*d*) Concrete slabs and steel joists (filler joist construction).

(*e*) Pugged timber floors.

Where the floors over shelters are of timber construction not pugged precautions shall be taken in the installation of any strengthening work to ensure a reasonable degree of fire resistance of the complete floor system equivalent to a construction offering ½ hour's fire resistance when tested in accordance with British Standard Definition No. 476.

The required degree of fire resistance is deemed to be provided by the following :—

(*a*) Existing timber floor beneath which is laid a *continuous* layer of reinforced concrete or a continuous layer of steel sheeting not less in thickness than 16 B.G.

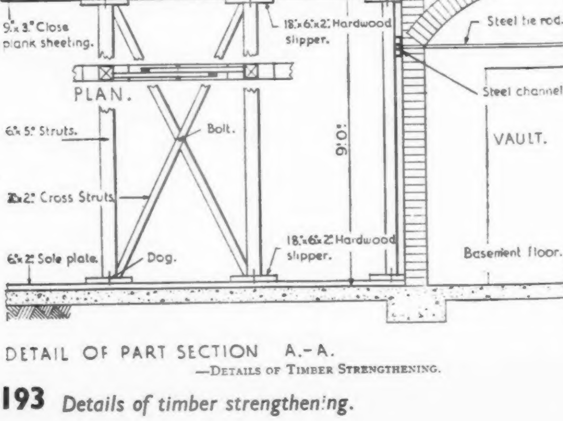
(*b*) Existing timber floor beneath which is placed closely spaced timber sheeting not less than 2 in. in thickness.

(*c*) Existing timber floor with sheeting (not necessarily continuous) of timber, steel or reinforced concrete underneath, with a continuous layer of suitable protective material placed between the existing floor and the sheeting.

A.1.—The reference to the fireproofing of timber floors seems to refer to such buildings in which the overhead standard (see paragraph 3 of the Code) will not be observed. This overhead standard does not include timber floors, and where a new floor of sufficient thickness is arranged under the timber floor there is, of course, no necessity for fireproofing the timber floor over.

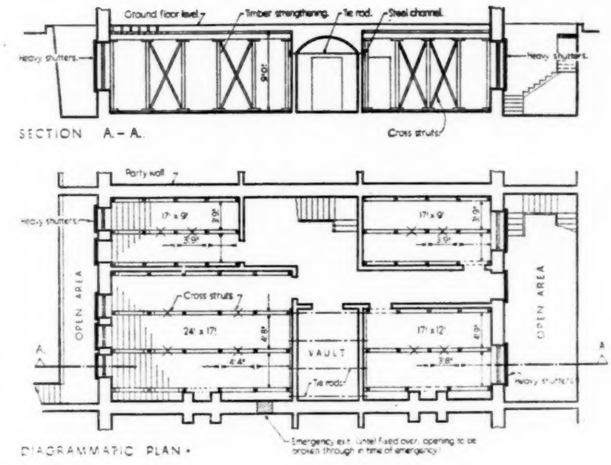
On the other hand, as mentioned before, the requirements of the Code are only recommendations where domestic work is concerned, and it may well be imagined that for one reason or another, in a particular case the requirements for overhead protection might not be satisfied. Fig. 211 shows a floor, with 16g. corrugated steel below conforming with British Standard Specification 476. The standard of overhead protection would require ¼ in. thickness of steel.

Figs. 193 and 194, reproduced from the



DETAIL OF PART SECTION A.-A.
—DETAILS OF TIMBER STRENGTHENING.

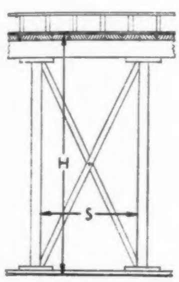
193 *Details of timber strengthening.*



Memorandum, show an existing timber floor with a layer of closely-spaced timbers 2 in. thick. In practice, such boarding can rarely be less than 3 in. (*See also* Tables X, XI and XII.)

Corrugated asbestos cement sheeting will serve the purpose of fireproofing, but such material must be ignored for purposes of load carrying. Neither of the two above arrangements is, strictly speaking, splinter proof, and it is recommended that the standard of overhead protection should not be abandoned.

***194** Example of typical basement strengthened with timber for a debris load of 400 lb. per sq. ft.*



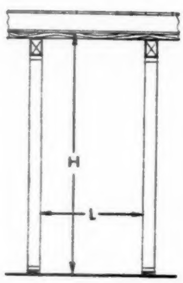
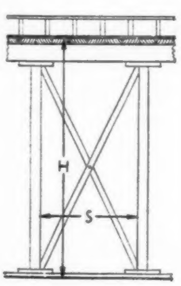


TABLE X
9 IN. × 3 IN. PLANK SHEETING, LAID FLAT AND CLOSELY SPACED

* Debris load lb./sq. ft.	Clear span of sheeting = L (in.)		Size of beams (in.).	Clear span of beams = S (in.)		Sizes of struts (in.) for ceiling height above floor level = H.							
						7 ft. 6 in.		8 ft. 6 in.		9 ft. 6 in.		10 ft. 6 in.	
	f = 800 lb./sq. in.	f = 1200 lb./sq. in.		f = 800 lb./sq. in.	f = 1200 lb./sq. in.	f = 800 lb./sq. in.	f = 1200 lb./sq. in.	f = 800 lb./sq. in.	f = 1200 lb./sq. in.	f = 800 lb./sq. in.	f = 1200 lb./sq. in.	f = 800 lb./sq. in.	f = 1200 lb./sq. in.
200	83	102	6 × 6	42	47	6 × 3	6 × 3	6 × 4	6 × 4	6 × 4	6 × 4	6 × 4	6 × 4
			6 × 9	63	70	6 × 4	6 × 4	6 × 4	6 × 4	6 × 4	6 × 4	6 × 5	6 × 4
300	68	83	6 × 6	39	42	6 × 3	6 × 3	6 × 4	6 × 4	6 × 4	6 × 4	6 × 4	6 × 4
			6 × 9	58	64	6 × 4	6 × 4	6 × 4	6 × 4	6 × 5	6 × 4	6 × 5	6 × 4
400	59	72	6 × 6	35	39	6 × 4	6 × 4	6 × 4	6 × 4	6 × 4	6 × 4	6 × 4	6 × 4
			6 × 9	53	59	6 × 4	6 × 4	6 × 4	6 × 4	6 × 5	6 × 4	6 × 5	6 × 5

NOTE.—*f* = working fibre stress of timber. *Slippers.* Hardwood (oak, beech, birch, rock maple) slippers 6 in. × 18 in. × 2 in. to distribute loads from struts to beams and sole pieces. *Sole pieces.* 6 in. × 2 in. *Cross Bracing.* 3 in. × 2 in. cut to fit and joined at intersection.



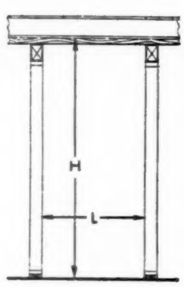
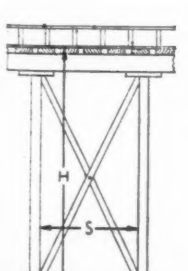


TABLE XI
9 IN. × 4 IN. PLANK SHEETING, LAID FLAT AND CLOSELY SPACED

* Debris load lb./sq. ft.	Clear span of sheeting = L (in.)		Size of beams (in.).	Clear span of beams = S (in.)		Sizes of struts (in.) for ceiling height above floor level = H.							
						7 ft. 6 in.		8 ft. 6 in.		9 ft. 6 in.		10 ft. 6 in.	
	f = 800 lb./sq.in.	f = 1200 lb./sq.in.		f = 800 lb./sq. in.	f = 1200 lb./sq.in.	f = 800 lb./sq. in.	f = 1200 lb./sq. in.	f = 800 lb./sq. in.	f = 1200 lb./sq. in.	f = 800 lb./sq. in.	f = 1200 lb./sq. in.	f = 800 lb./sq. in.	f = 1200 lb./sq. in.
200	96	111	6 × 6	37	41	6 × 3	6 × 3	6 × 4	6 × 3	6 × 4	6 × 4	6 × 4	6 × 4
			6 × 9	56	61	6 × 4	6 × 4	6 × 4	6 × 4	6 × 5	6 × 4	6 × 5	6 × 4
300	78	90	6 × 6	34	37	6 × 4	6 × 3	6 × 4	6 × 4	6 × 4	6 × 4	6 × 5	6 × 4
			6 × 9	50	56	6 × 4	6 × 4	6 × 5	6 × 4	6 × 5	6 × 4	6 × 5	6 × 5
400	68	78	6 × 6	31	35	6 × 4	6 × 3	6 × 4	6 × 4	6 × 5	6 × 4	6 × 5	6 × 5
			6 × 9	47	52	6 × 4	6 × 4	6 × 5	6 × 4	6 × 5	6 × 4	6 × 5	6 × 5

NOTE.—*f* = working fibre stress of timber. *Slippers.* Hardwood (oak, beech, birch, rock maple) slippers 6 in. × 18 in. × 2 in. to distribute loads from struts to beams and sole pieces. *Sole pieces.* 6 in. × 2 in. *Cross Bracing.* 3 in. × 2 in. cut to fit and joined at intersection.



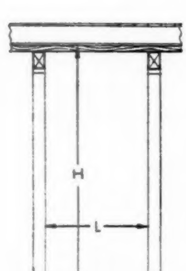


TABLE XII
9 IN. × 3 IN. PLANK SHEETING, LAID FLAT, WITH 3 IN. CLEAR SPACES BETWEEN PLANKS

* Debris load lb./sq. ft.	Clear span of sheeting = L (in.)		Size of beams (in.).	Clear span of beams = S (in.)		Sizes of struts (in.) for ceiling height above floor level = H.							
						7 ft. 6 in.		8 ft. 6 in.		9 ft. 6 in.		10 ft. 6 in.	
	f = 800 lb./sq. in.	f = 1200 lb./sq. in.		f = 800 lb./sq.in.	f = 1200 lb./sq. in.	f = 800 lb./sq. in.	f = 1200 lb./sq. in.	f = 800 lb./sq. in.	f = 1200 lb./sq. in.	f = 800 lb./sq.in.	f = 1200 lb./sq. in.	f = 800 lb./sq. in.	f = 1200 lb./sq. in.
200	72	88	6 × 6	45	52	6 × 3	6 × 3	6 × 4	6 × 4	6 × 4	6 × 4	6 × 4	6 × 4
			6 × 9	68	78	6 × 4	6 × 4	6 × 4	6 × 4	6 × 4	6 × 4	6 × 5	6 × 4
300	59	72	6 × 6	41	46	6 × 3	6 × 3	6 × 4	6 × 4	6 × 4	6 × 4	6 × 4	6 × 4
			6 × 9	61	69	6 × 4	6 × 4	6 × 4	6 × 4	6 × 4	6 × 4	6 × 4	6 × 4
400	51	62	6 × 6	39	43	6 × 4	6 × 3	6 × 4	6 × 4	6 × 4	6 × 4	6 × 4	6 × 4
			6 × 9	58	65	6 × 4	6 × 4	6 × 4	6 × 4	6 × 5	6 × 4	6 × 5	6 × 5

NOTE.—*f* = working fibre stress of timber. *Slippers.* Hardwood (oak, beech, birch, rock maple) slippers 6 in. × 18 in. × 2 in. to distribute loads from struts to beams and sole pieces. *Sole pieces.* 6 in. × 2 in. *Cross Bracing.* 3 in. × 2 in. cut to fit and joined at intersection.

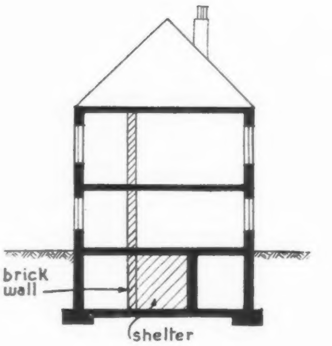
* These loads should be taken as the total loads; i.e. they should include the live and dead loads on the floor.

TEXT OF MEMORANDUM

A.2.—*Strength of Existing Walls.*
It is desirable that the ability of existing walls to support the loads should be checked, and it is appropriate to estimate the load-bearing capacity of the brickwork or masonry from the data given in the Second Schedule, Ministry of Health, Model Byelaws, Series IV Buildings 1937. It is sufficient to assume that the existing walls will have to take the debris loading alone, as the condition in which a wall would have to carry the full debris load plus the normal dead and superimposed loads is most unlikely to arise.

A.2.—Usually, the assumption that a wall never need carry more than the debris load, increased, of course, by the normal superload of the floor immediately over (*see* paragraph 6) is correct. Such conditions obtain in the building shown in Fig. 195.

There may, however, be special cases where part of the existing load will have to be taken into account, and each individual case must be checked by an expert. For example, a shelter might adjoin a party wall which gets heavy loading from the building "A" on one side and little from the building "B" on the other side (Fig. 196). A shelter may be arranged in the basement of building "B," and the roof of the shelter might be supported by the party wall. If this building collapses, the party wall in the basement has to carry as much load as originally, namely, that of the right-hand building and in addition the debris load from the left-hand building. In this case debris load has to be added to the normal dead and superimposed load. This rule for walls applies also to columns, struts and foundations.



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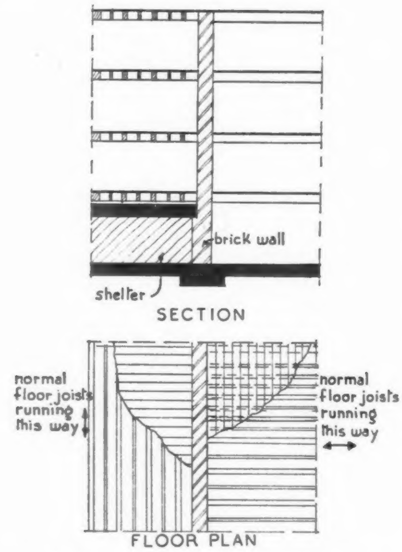


196 *Party wall which would still have to carry loads of building A if building B collapsed.*

PART IV.—PROVISION OF SHELTER IN BASEMENTS.

A.3.—*Cleanliness.*
Attention should be given to the cleanliness of the basement. Rooms in which offensive materials have been stored, or offensive processes carried out, may call for excessive cost in cleaning before they can be made suitable for shelter. They should be reasonably free from vermin or capable of being made so without undue expense. Any connection to drains should be put in good repair before using rooms as shelters.

A.3.—For disused drains *see* paragraph 30 of the Code.

A.4.—*Condition of Building Structure.*
Attention should be given to the condition of the existing building structure especially having regard to the effects of the alterations necessary to adapt it to a shelter. Before commencing adaptation the premises should be surveyed by competent persons to ensure that brickwork and masonry are sound. Basement walls should be at least 9 in. thick, but reasonably sound walls of less thickness may be used, at the discretion of the architect or engineer, if buttressed or otherwise strengthened. Attention should be given to lintels and bressummers, noting particularly the condition of their bearings on walls or piers. An examination should be made of timbers, noting particularly any indication of active dry-rot. This can be recognized by the existence of growing bodies of the fungus in the form of plates or sheets alone or together with yellow, brown or orange patches which may give off powder of a

A.4.—The reference to the thickness of basement walls cannot apply to shelter walls. Shelter walls should be not less than $13\frac{1}{2}$ in. of brickwork; but it is a sound precaution to keep even those walls that are not required for the actual shelter to a certain standard. The debris loads are worked out on the assumption that existing construction provides a reasonable amount of resistance to the collapse of the building. Where that resistance does not obtain, the debris loads might easily be greater than assumed.

TEXT OF MEMORANDUM

similar colour. It is preferable to avoid using buildings where there is active dry-rot, but, if necessary, the fungus can be eradicated by the methods set out in Forest Products Research Bulletin No. 1, "Dry-rot in Wood" (H.M. Stationery Office, price 1s. net.). It is not necessary to attach undue importance to the presence of a certain amount of decay in old wood, provided there is no evidence of active fungus growths.

A.5.—*Hazardous Features to be Avoided.*

There are certain features in buildings in an industrial area which should be avoided in selecting basements for shelter. The immediate vicinity of tanks for storage of inflammable or corrosive liquids or gases is unsuitable for shelters below ground. High chimney stacks, water towers, coal bunkers and the like might give rise to abnormal debris loads and their neighbourhood should be avoided.

Due regard should be paid to the risk of flooding. It is not advisable to provide shelters in basements situated close to such features as canals, large cooling ponds, mill ponds and river banks which, by reason of the relative levels of water and basement floor, might cause a basement to be flooded rapidly in the event of damage to retaining walls or banks.

It is desirable to foresee the consequences of the fracture of large water mains or sewers in the street. Unless the main or sewer is so close that a breach would allow it to discharge directly into the basement, the danger of flooding will only be from flooding of the street which is unlikely to be very deep. In the former case the basement should not be selected for a shelter and in the latter case it is desirable to ensure that there are well-constructed walls to areas at least 12 in. above pavement level, and that any openings to the basement at pavement level can be closed up to the probable height of a flood in the street.

A.6.—*Construction of Shelters.*

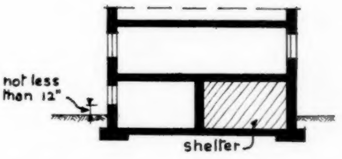
In view of the great variety of existing buildings, it is not possible or desirable to lay down hard and fast rules for the adaptation of basements for air raid shelters. It is necessary to deal with each case on its merits and to leave it to a competent person to decide on the method of construction which is most suitable and economical, subject, of course, to compliance with the requirements laid down in this memorandum.

The main problem is to strengthen the floor over the shelter to enable it to carry the debris loads resulting from possible demolition of superstructure. The choice of the method to be used in strengthening any given floor depends upon individual circumstances, and becomes a design problem very much of the same sort as confronts the architect or engineer in deciding on the type of floor for a new building. It is possible to lay down simple rules for strengthening floors over small basements of the kind found in buildings which were originally used as private houses. The basements of larger buildings, with heavy structural floors over, and with heavy beams and columns of steel or reinforced concrete, are essentially engineering problems and cannot be dealt with by simple rules, but a supplementary note showing a certain number of methods which have been adopted in actual cases will shortly be available.

A.5.—These provisions agree in general with those discussed in paragraph 24 of the Code.

Of particular interest is the requirement that shelter basements should be protected by parapet walls at least 12 in. high (Fig. 197).

An external wall, though not necessarily part of the shelter, should be carried 12 in. above the pavement, without openings, if there is any danger of flooding of the street.



197 *Wall at pavement not to be less than 12 in. high.*

The construction shown in Figs. 198 and 199 is inferior to the generally accepted standard and is, therefore, to be discouraged.

A.6.—These requirements are in general identical with other requirements that have been set out in the Code. It seems, however, that here, as well as in the following examples, the general principle on which all the standards have been based has been abandoned.

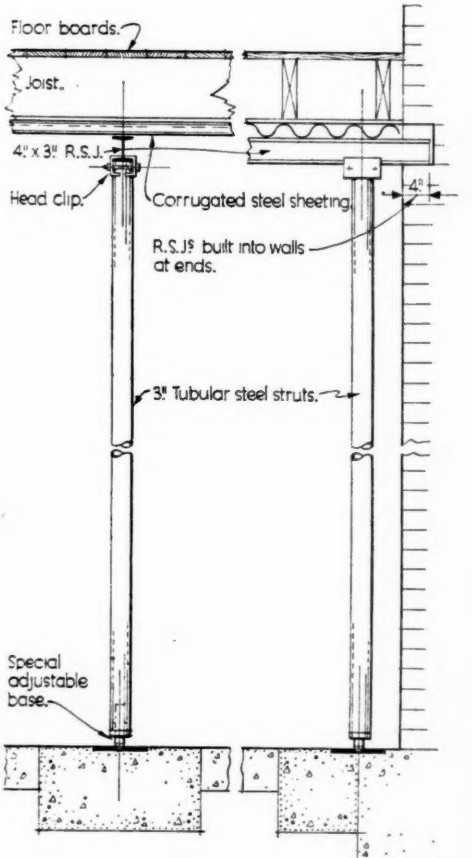
Basements are to be made into shelters and people are to use them, primarily to gain some security against blast and splinters. To give up the standard of overhead protection that has been set out in the Code and in the first part of this Memorandum seems unreasonable. It is understood that the underlying idea is that a bomb which would produce blast and splinters on the roof of a basement of this type would have to be regarded as a direct hit—against which it is not the intention to provide shelter. This would mean, in other words, that such basements are not worth converting into shelters, as every splinter would prove a direct hit.

It might be asked, if it is not to such cases as this, then to which cases do the requirements for overhead protection apply? Fortunately, it is only the insufficient overhead protection that would produce such result.

It is to be regretted that the special cases to which the following examples apply (Figs. 198 and 199, reproduced from the Memorandum) and the limitations of the types of construction set out in those examples have not been sufficiently emphasized; for there is a danger that such constructions may be taken as being generally applicable, whereas a basement strengthened in the ways shown:

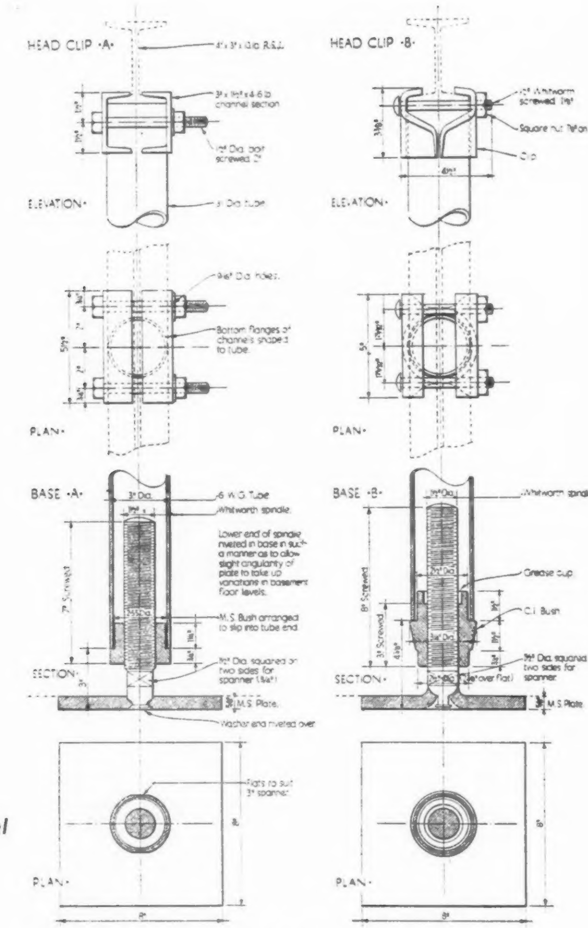
(*a*) Would not conform to the general requirements either of the Code or of this Memorandum (No. 10) itself; and

(*b*) Would afford certain protection against debris loads, but not against blast and splinters.



198 *Details of steel strengthening.*

(Reproduced from the Memorandum.)



199 *Details of tubular steel struts.*

TEXT OF MEMORANDUM

A.7.—*Strengthening Floors Over Basements.*

Rules for the use of timber in strengthening floors over small basements are given in Appendix A below (overleaf). A design for tubular steel strutting, with steel beams and steel sheeting, also for small basements, is shown in Appendix B (given on page 990), paragraph A.10.

Figs. 193 and 194 show a typical basement lay-out and strengthening for a debris load of 400 lb. per sq. ft., which has been worked out for timber strutting. It has been assumed in the examples that ungraded timber is chosen and the maximum working fibre stress is 800 lb. per sq. in. In accordance with the rules in Appendix A below, the following scantlings are required :—

Close sheeting parallel with the existing floor joists in 9 in. × 3 in. laid flat and close up to the ceiling. Since this sheeting is closely spaced, there is no need to provide additional fireproofing.

Timber beams 6 in. × 9 in. spaced 59 in. apart (i.e. the effective span of the sheeting is 59 in.). These beams might be made from two 9 in. × 3 in. bolted together with the heart sides back to back.

Timber struts 6 in. × 5 in. at 53 in. spacing (i.e. the effective span of the beams is 53 in.).

Timber sole piece 6 in. × 2 in.

Alternate bays cross braced by 3 in. × 2 in. bolted or spiked at their intersection and cut to fit.

The beams, struts and sole pieces can be joined by dogs, or bolted straps, and the sheeting nailed to the beams.

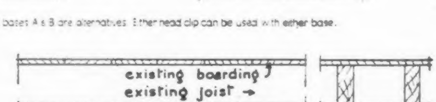
It is desirable to use hardwood slippers of oak, beech, birch or rock maple, etc., at the head and foot of the struts in order to distribute the pressure on the beams and sole pieces and so avoid undue crushing on the

A.7.—Timber strutting for floors has several points in its favour, and it may also be used in place of steel sheeting, on the soffits of existing floors. The tables given in the Memorandum, and reproduced as Tables Nos. X, XI and XII, are valuable. The column headings " debris load " should read " total load," for although in buildings for which such strengthening would be likely to be used, the dead and live loads might be small, they should nevertheless be included in the values set out. In Figs. 193 and 194, the timber sheeting is shown running parallel to the floor joists ; but in order to be effective it should run at right angles to the joists (Fig. 200).

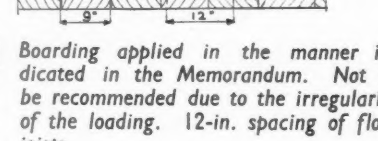
If the boarding should be laid according to Figs. 201 or 202, what would happen is that some of the boards would get certain direct loads, others would be very eccentrically loaded, and some would not be loaded at all.

Usually people will require a splinter- and blast-proof basement, realizing that in order to be safe only against falling debris, all they have to do is to walk out of their buildings. Splinter-proof construction, according to the requirements of the Memorandum, should be provided, and to that end any of the following methods may be adopted :

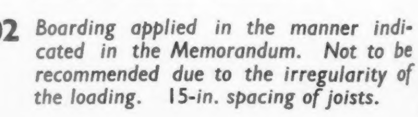
(1) *Pugging.*—The floor boards may be taken up and concrete poured on to the new timber boarding below, and if this boarding is close butted so that its resistance might be taken into consideration, 4 in. of mass concrete, 1 : 6 mix, would appear to be adequate (Fig. 203). Where there is any doubt as to the close fitting of the boarding, 6 in. of concrete would be required. There should be no material of any sort between the boarding and the concrete. The concrete must cover the whole area, and to ensure 4 in. thickness everywhere



200 *Boarding at right angles to existing joists.*



201 *Boarding applied in the manner indicated in the Memorandum. Not to be recommended due to the irregularity of the loading. 12-in. spacing of floor joists.*



202 *Boarding applied in the manner indicated in the Memorandum. Not to be recommended due to the irregularity of the loading. 15-in. spacing of joists.*

TEXT OF MEMORANDUM

side grain. These can be of 18 in. × 6 in. × 2 in. In case of emergency, where the work has to be performed with a minimum of delay, the slippers can be omitted without running the risk of complete collapse, but wherever possible they should be used.

It is not usually desirable to obtain support from old external walls, and although in the case shown in Fig. 193 it might be possible to cut and pin the beams into existing internal walls, there is often some doubt as to the ability of old brickwork to sustain heavy loading and to withstand a considerable amount of cutting away. It is better, therefore, to provide strutting close to all existing walls, but it is a question for local judgment whether the saving in cost of timbering would justify the cost of cutting and making good. By housing beams in the walls, however, it may be possible to dispense with the struts until an emergency arises so that the normal use of the basement is not interfered with. In such cases the struts must be prepared and stored ready for immediate erection.

[APPENDIX A.—Dimensions of Timber Supports to be used in Strengthening Floors over Shelters.

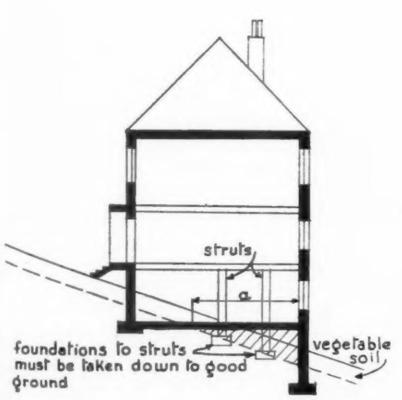
Tables X, XI and XII will assist architects and builders in choosing timber for the strengthening of floors over air raid shelters.

It has been assumed that most systems of strengthening will involve the use of close sheeting under the existing floor which, with timber, will take the form of heavy planks. The sheeting will be supported by beams with struts under, the struts resting on timber sole pieces.

The dimensions of timbers are given in terms of their working span for three different debris loads and for two grades of timber. The lower working stress of 800 lb. per sq. in. is appropriate for the common, carcassing class of European redwood and the higher working stress of 1,200 lb. per sq. in. represents a suitable value for timber equal to No. 1 Merchantable (UKAY) grade of Douglas fir.

Two arrangements of plank sheeting are given. The one provides for close sheeting and the other for 9 in. wide planks spaced 3 in. apart. The latter arrangement has been used on some schemes, and is convenient where there are pipe runs, etc., below the existing ceiling.

Dimensions of struts are given for four different heights of basement ceiling above floor level.]

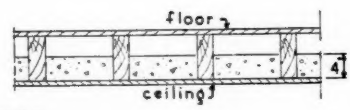


209 *Separate foundations are required for struts on made ground over zone a.*

all floor boards should be taken up while the concrete is being poured.

It has, however, been pointed out elsewhere that this method is not generally to be recommended, for the reasons that the pouring of the concrete will, in almost all cases, cause undue disturbance of the normal uses of the floor above and that timbers cast in concrete under unventilated conditions are always to be avoided.

Pugging of floor.



203

(2) *Combination of Boarding and Steel* (Fig. 204).—Any of the arrangements in Figs. 204 and 205 is possible, and an advantage of this method is that the boards and sheets can be fixed together in the factory to form slabs, thus ensuring a better standard of workmanship than can usually be obtained at the site.

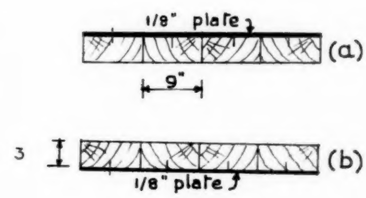
The plates can be screwed to the boards at longitudinal intervals of about 18 ins.

The second and third arrangements (Figs. 204b and 205) lend themselves to easy fastening of the units, one to another. Either the steel plate can be turned at the edge to form a flange which can be bolted to the adjoining flange (Fig. 206), or angles can be provided at about 18-in. to 24-in. centres for that purpose (Fig. 207).

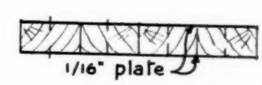
(3) Precast reinforced concrete units or units consisting of concrete in conjunction with dovetail sheeting may be used.

The suggested arrangement of struts, diagonals and a continuous sole plate with slippers appears to be adequate, though a timber 2 ins. thick will have more value in stiffening the base than in distributing any load.

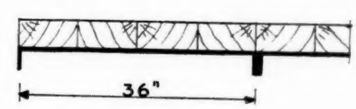
The loading on the subsoil will rarely exceed 1 ton per sq. ft. It should be ascertained in every case that the shelter floor is actually bearing on reasonable ground. Where a floor is suspended—as often happens, particularly when a shelter is provided on the ground floor of a building without a basement—struts must be provided with proper foundations (Fig. 208). The same rule applies where a basement or ground floor slab stands on made-up ground which is improperly consolidated. In the example shown in Fig. 209, the portion of the basement slab "a" would certainly be unsuitable for carrying struts.



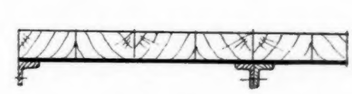
204 *Combination of steel and timber.*



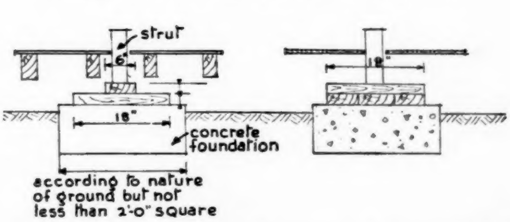
205 *Combination of steel and timber.*



206 *Steel plates turned for fastening of units.*



207 *Angles fitted for fastening of units.*



208 *Foundations for struts where suspended floors exist.*

TEXT OF MEMORANDUM

A.8.

It has been assumed that the existing floor of the basement is suitable to carry the sole piece. The loads are reasonably well distributed and good paving should be quite adequate to carry the sole piece direct. With stone flags or brick paving it is a sound precaution to place a strip of bituminous felt under the sole piece.

A.9.

Where there is an existing wooden floor it is necessary to ascertain whether this is adequate to take the load from the sole piece. If the floor is not strong enough and if the underside of the joists are raised appreciably above ground level it is necessary to insert brick or concrete pads at, say, 18 in. centres to carry the sole piece.

A.10.

A simple method of steel supports for small basements is described in Appendix B and shown in Figs. 198 and 199. The corrugated sheets should be fixed so as to butt as closely as possible against the walls in order to keep out dust in the event of the collapse of the building. Rolled steel joists carry the corrugated sheeting and are cut and pinned into the walls, making it unnecessary to erect the struts until an emergency arises. Three-inch tubular struts are used with a clip at the head which enables them to be attached rapidly to the joists. The base of the strut rests upon a steel baseplate to which is attached a screw-jack which screws into a threaded bush in the base of the strut giving an adjustment of 4 in. In this way the struts can rapidly be placed in position and adjusted for length. When the joists are supported by the walls there need be no interference with the normal usage of the floor of the shelter, and once they are cut and fitted the struts can be stored until an emergency arises. It is necessary to ensure that the existing floor is sufficient to carry the load from the baseplates and in some cases concrete bases must be provided. With old timber floors this will always be necessary.

APPENDIX B.

Special Steel Strutting for Basements.

List of Parts.

The following is a list of the items provided for the strutting of basements by steel.

(1) Corrugated steel sheets, 14 B.G. finished black, with 55 in. corrugations, in lengths of 6 ft., 7 ft., or 8 ft. and in width 2 ft. 4 in.

(2) Rolled steel joists 4 in. × 3 in. × 10 lb. finished with one coat of red oxide or black bitumastic solution.

(3) Struts, consisting of a head clip, a steel tube and a screw-jack base, the latter itself comprising a screw spindle riveted to a base plate and carrying a threaded bush.

The parts and their relationship *in situ* are shown in Figs. 2 and 2*a*.

Placing the Sheets.

The corrugated steel sheets are to be placed in close contact with the existing ceiling joists, the corrugations and joists running parallel.

The sheets are to be lapped at the edges where they meet, the minimum lateral lap being one corrugation, and the minimum longitudinal lap being 1 ft. 6 in.

The longitudinal lap is to be so arranged that it is supported by a rolled steel joist, the centre line of which is not less than 9 in. distant from the end of either sheet.

A.8.—Where stone flags or brick pavings exist, the Memorandum recommends that continuous bituminous felt strips should be provided between the sole plates and the floor. The intention is to prevent the access of moisture to the sole plates; but care must be taken to ensure that the type of bituminous felt actually employed does not permit of any slipping.

Irregular floors should be levelled off by a cement screed, on which sole plates are to be laid (Fig. 210).

A.9.—Wooden floors can so rarely be considered strong enough to carry a sole plate, that it should be taken as a general rule that such floors are inadequate for that purpose. The pads which are suggested and as shown in Fig. 208 afford reasonable foundations; but they should always be arranged immediately below every strut, for the suggested 2-in. sole plate is of quite insufficient strength to transmit the strut loads by bending action to adjacent foundation pads.

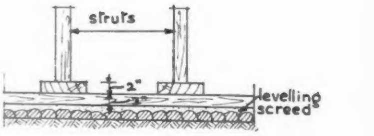
A.10.—It must be realized at the outset that the example given in the Memorandum, and reproduced here as Figs. 198 and 199, is for a particular case, although the text may lead readers to the conclusion that certain of the dimensions and of the members shown, as for example 3-in. tubular steel struts, can be considered as standard. Corrugated sheeting, joists and struts must be calculated, of course, for the conditions obtaining in each particular case and no size can be assumed as standard.

3-in. tubular steel, for example, is adequate for struts in basements of 8 ft. 6 ins. height, floor to floor, and supporting an area of 50 sq. ft. with a total load of 250 lb. per sq. ft. or supporting 25 sq. ft. with a total load of 500 lb. per sq. ft. If a basement is higher, either the permissible load or the loaded area must be reduced. Whilst a tubular section is very efficient from the point of view of buckling, the connections at the top and bottom present difficulties, and the connections shown must, at best, be considered as hinged.

It is highly questionable whether a construction which is to withstand the shock of a collapsing building should not be of at least the standard required for ordinary buildings which have to withstand only static loads. It seems definitely the intention of the Code (and also of the first part of this Memorandum) that such a standard should be maintained. The construction shown in Fig. 199 would normally not be accepted by any building authority in England, and the authors suggest that no adviser should recommend it to his client. Struts of common rolled steel sections with proper base plates and caps should be adopted. (*See* Fig. 169 and paragraph 27 of the Code.) They will be no more expensive, but safer than those suggested in the Memorandum.

The corrugated steel should, as already mentioned in A.7, be placed with the corrugations at right angles to the joists (Fig. 211), and the sheeting should be connected at intervals (*see* Figs. 145 and 146), in order that any horizontal forces that might be set up may not dislodge the joists and columns from their positions.

The corrugated sheets are not splinter proof according to the standard of the Code. Where such protection is required, the corrugated steel might be replaced by one of the types of steel-lined timber (*see* paragraph A.7 and



210 *Cement screed required on an irregular floor below the sole plate.*

211 *Correct direction for steel sheets.*

TEXT OF MEMORANDUM

Placing the Joists.

The rolled steel joists are to be placed at right angles to the direction of the floor joists, at a maximum spacing of 5 ft. from centre to centre, with a maximum distance of 1 ft. 6 in. between the side wall and the centre of the nearest joist, and are to be cut and pinned into the supporting walls a minimum of 4½ in. at either end.

Placing and Erecting Struts.

The struts shall be placed at not more than 5-ft. centres along each joist, and the distance between the side wall and the nearest line of struts shall not exceed 1 ft. 6 in.

The struts are erected as follows :—

The bush is located at the bottom of the screw-spindle, which, together with the attached base-plate, should then be placed in its proper position on the floor. The tube is placed over the spindle to rest upon the shoulders of the bush and adjusted at the top to engage the head clip by which it is affixed to the joist. Adjustment for height is made by turning the bush on the spindle and the adjustment should be such that the joist and tube are in direct contact, without the tube exerting any material upward pressure.

The strut should finally be checked to see that it is truly vertical and in overall height not greater than 9 ft.

If the struts are not to be erected until the basement is needed for shelter, then the positions of head clips and bases should be clearly marked on the joist and floor, and the struts removed to suitable storage.

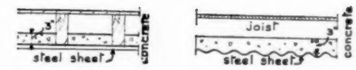
It may be desirable in some cases to mark the struts with references showing their location.

Size of Building and Size of Basement.

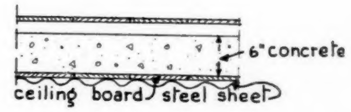
The special steel strutting of the type here described is intended for use in the basements of the smaller type of houses with timber floors and not more than three storeys over the basement. The size of the basements must be such that the maximum dimension parallel to the line of the rolled steel joist shall not exceed 13 ft., and the maximum dimension at right angles to the rolled steel joist shall not exceed 18 ft.]

Fig. 205), or by precast concrete units, or by a combination of dovetail sheets and concrete.

Pugging may be used also, and 3 in. of concrete will be sufficient if corrugated steel of not less than 16 gauge is used. If boards exist on the soffit of a floor, they are to be removed, so that the corrugations can be filled properly (Fig. 212). Alternatively, the pugging can be made fully splinter proof in itself (6 in.), and it then becomes unnecessary to remove the soffit lining (Fig. 213).



212 *Steel sheet made splinter-proof by addition of concrete.*



213 *Concrete pugging separated from steel sheets by ceiling boards.*

A.11.

In Fig. 193 it will be seen that there is a brick vaulted chamber used originally for the storage of wines. This is a common feature of many basements. With proper lateral support at the abutments a brickwork arch is very strong indeed and would normally be adequate to carry debris loads. The example shown in Fig. 193, however, is typical of many isolated vaults in that there is no adequate lateral support at the springing of the arch, and the vault might than be very unsafe under heavy debris load. It is not sufficient to block off the vault, for it might collapse outwards into the shelter and so injure the occupants of the part outside the vault. One method of strengthening would be to provide steel channels and tie rods, as shown in Fig. 193, to take the horizontal thrust at the springing. It is always undesirable to support arches or vaults by a row of bearers along the line of the crown of the arch.

A.11.—No remark.

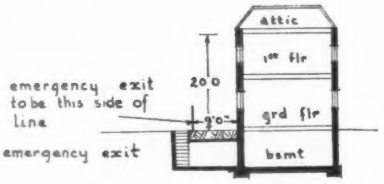
A.12.

Examples of basement shelters in small dwelling houses showing emergency exits are given in Appendix D, p. 1002.

A.12.—The question of emergency exits is very important, and the attention given to this matter in the Memorandum is to be welcomed. It is particularly important that all emergency exits be protected for such a distance from the building that they are no longer within the range of falling debris. In paragraph 31 of the Code, this distance has been given as 0.465 of the height to the eaves, and for the 9 ft. minimum distance suggested in the Memorandum, a building may have a ground floor and one storey under the attic (Fig. 214).

Where a building is higher, it is advisable to increase the length of the protected escape to that given by ·465*h*.

The sizes of exits given in Figs. 215 to 226 (Types A, B, C, D, E, F, G, H, J in the Code) must be considered as minima. In certain cases they may be insufficient. In an emergency, they may have to be used by wounded, frightened and hysterical people who cannot be guaranteed not to cause a jamb. Where they can be provided, exits of considerably greater dimensions than those shown should be made; but any extra height afforded should not be achieved by a reduction of the overhead protection.



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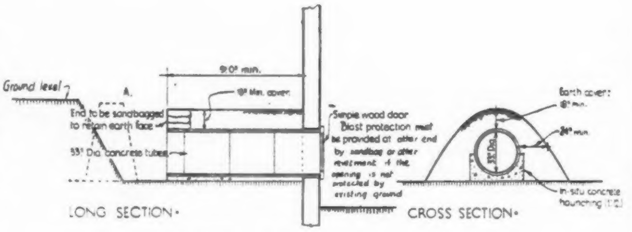


215 *Type "A" and "C." — Straight concrete tube exit ("A" reinforced, "C" unreinforced) used where ground level is not more than 4 ft. above invert of tube.*

The types shown have not each the same values. Types A and C (Fig. 215) will not present difficulties, the exits being straight and leading into relatively open spaces. There is, however, no reason why an arrangement such as that of A should not be used where the difference between ground and invert levels is more than 4 ft. (*see* Fig. 218). This type will be preferable to most others.

Types B and D (Fig. 216) will probably be very difficult for elderly people.

Type E (Fig. 217) differs in two respects from types A and C:

1. By having a lining of steel instead of concrete;

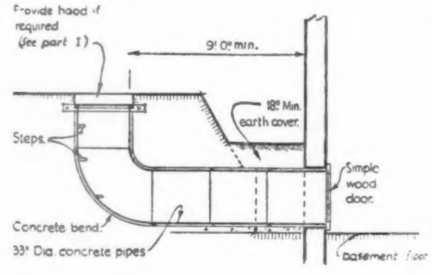
2. By having a smaller difference in level between ground and invert—shown in Fig. 217 as less than 3 ft.

Where there is so little difference in level, it is suggested that the ground level round the opening should be raised in order to afford a certain degree of protection against blast (Fig. 218).

The width of the opening and the danger of blast can both be reduced if a retaining wall is provided opposite the opening (Fig. 219).

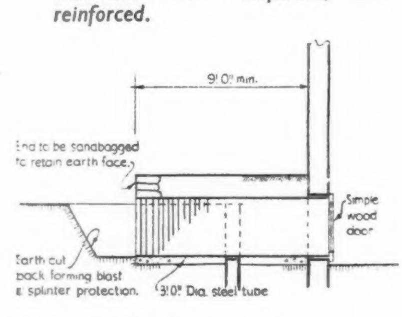
The arrangement of Type F, shown in Fig. 220, should not be as difficult as that of

The arrangements shown in Figures 216, 217 and 221 are to be discouraged.



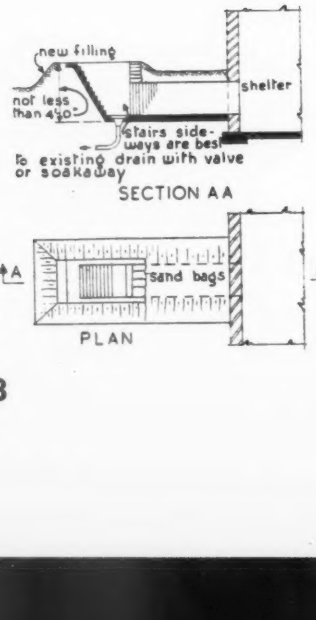
LONG SECTION• (Cross section as A & C.)

216 *Type "B" and "D."—Curved concrete tube exit. "B" reinforced, "D" not reinforced.*



LONG SECTION• (Cross section as F.)

217 *Type "E" corrugated steel tube exit.*



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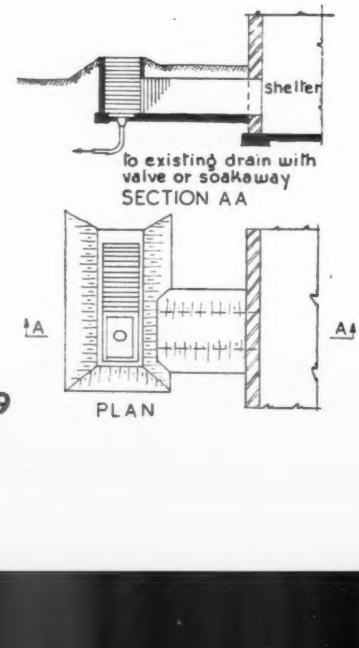
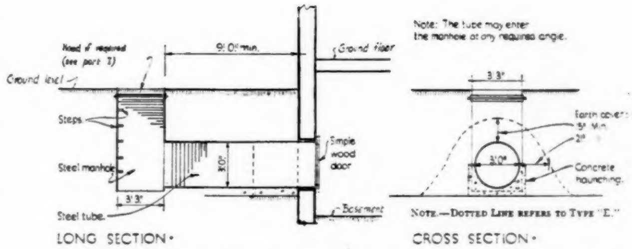


219

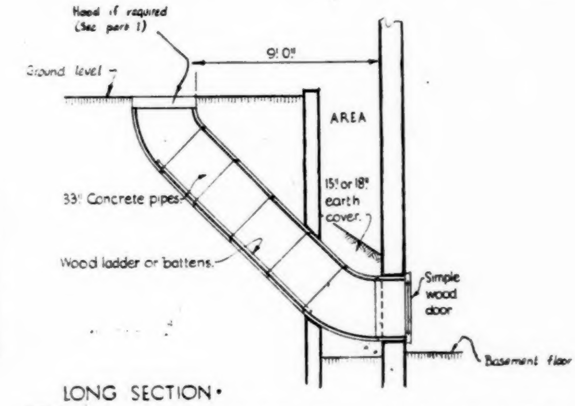
Type B, but it is still less convenient than Type A.

The use of corrugated steel tubes is not to be encouraged because owing to the thinness the sheets may be destroyed very rapidly by rust, which may, in fact, be accelerated by electrolytic action if they are galvanized.

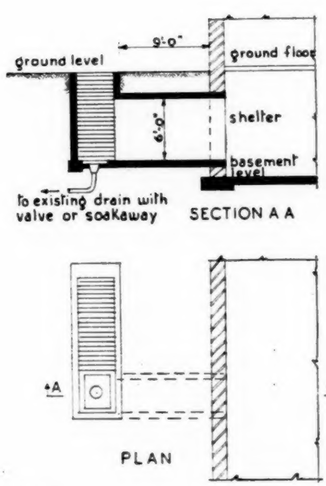
In such cases as G and H in Fig. 221, in which there is ample difference of level between basement and the ground outside, a much more



220 *Type "F"—Corrugated steel tube and manhole exit.*



221 *Type "G" and "H."—Concrete tube exit at 45 deg. or other suitable angle, "G" reinforced, "H" unreinforced.*



222

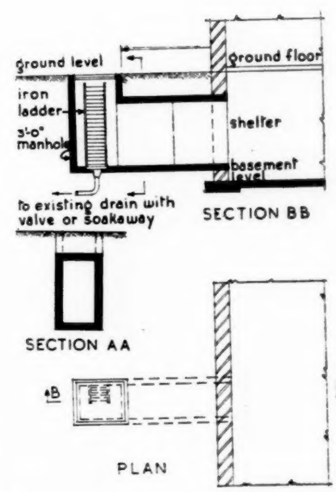
convenient escape can be provided (Figs. 222 and 223.)

Type I (Fig. 224) appears to apply to the exit of a ground-floor shelter. Screen walls should, of course, be arranged in such a case (Fig. 225). The brickwork should be 13½ in. and not 9 in., because the exit should be blast-proof.

The roof slab should be anchored to the walls as indicated in Fig. 226, or by the use of reinforcement projecting from the brickwork (Fig. 227).

Type I is very inadvisable where there is more than one storey above the exit (Fig. 228).

Where there is a higher building over the exit (Fig. 229), neither a 4-in. slab nor any other



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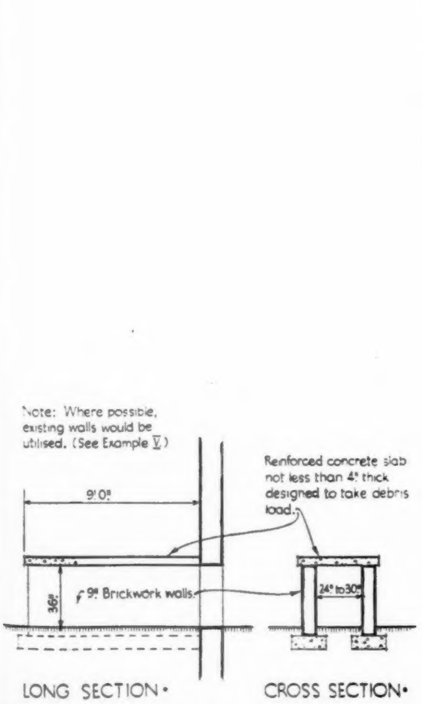
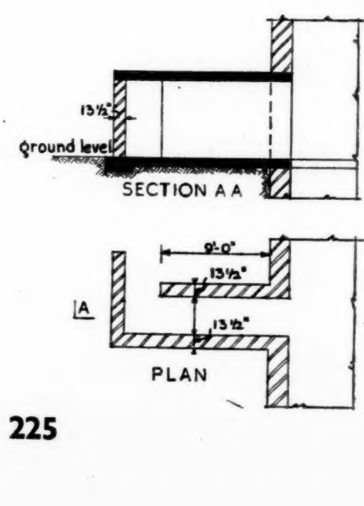


224 *Type "I."—Brickwork and concrete exit.*



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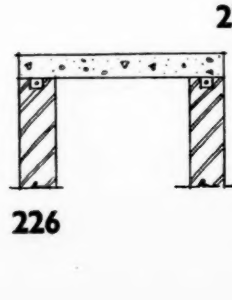

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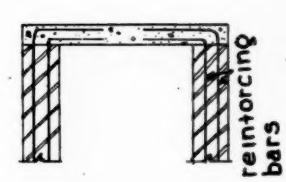

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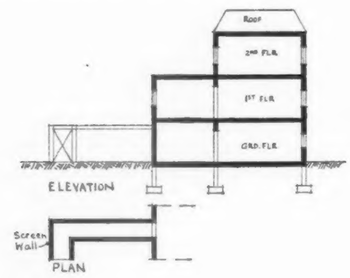

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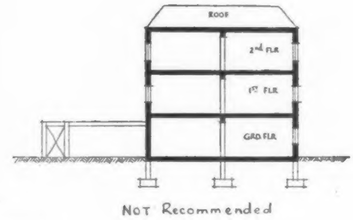

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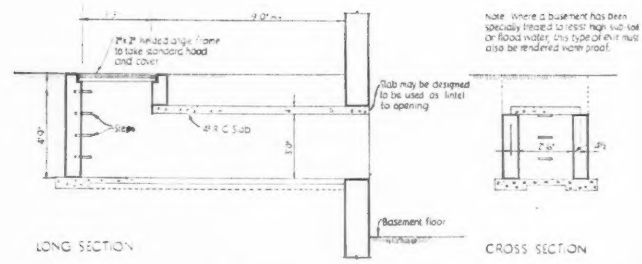
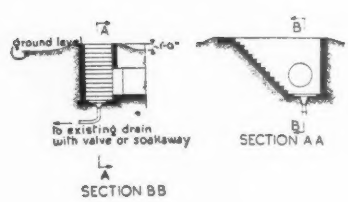


230 ***Type "J." Brickwork and concrete exit with brick manhole.***



231

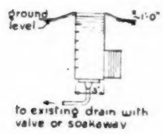
reasonable thickness of slab can be guaranteed to withstand debris load (see also paragraph 9 of the Code and Fig. 33).

There is also no reason why the height of such a ground-floor exit should be reduced to 3 ft. As ground-floor shelters are to be avoided, this type of exit will, of course, not frequently be required.

Type J (Fig. 230). This exit does not present the difficulties of Types B and D, but, again, Type A is the more convenient. Where the basement floor is as low as is shown in the example, an exit of the type shown in Figs. 222 and 223, affording greater headroom, is preferable.

Where any exit leads to a street or any other place which has any possibility of being flooded, curbs of concrete or brickwork projecting at least 12 in. above the outside level should be provided round the actual opening. (See Figs. 231, 232 and 233.) This has been stipulated in paragraph 5 for basement walls adjoining a street. It must be realized that back gardens are often at a lower level than the streets, and the determination of whether 12 in. curbs are really sufficient can be made only by the expert adviser, after consideration of the local conditions and perhaps in collaboration with the local sanitary officer.

In Figs. 234 and 235, exits of Types K and L, giving access to a neighbouring building, are



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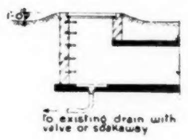

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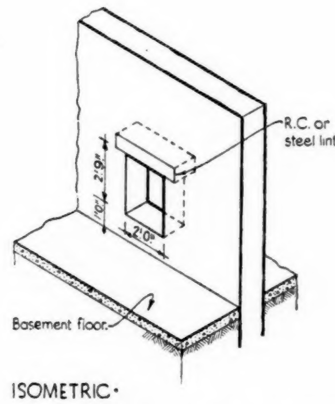
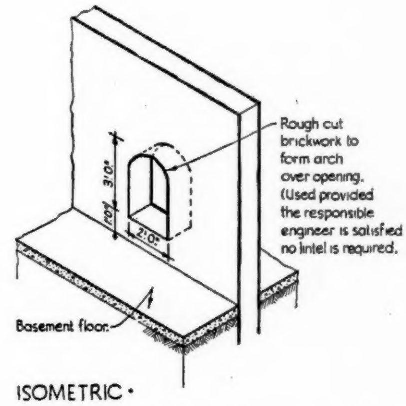


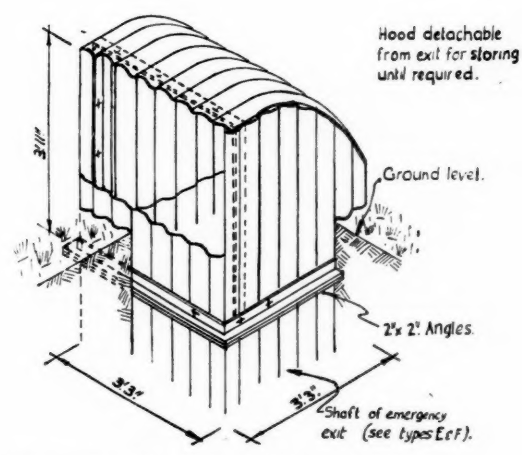
ISOMETRIC·

234 *Type " K."—Exit with lintel in party wall.*



ISOMETRIC·

235 *Type " L."—Exit with rough arch in party wall.*



236 *Isometric sketch of steel hood for emergency exits.*

237

shown. Such exits are of value only if the neighbouring building itself:

(*a*) Has a strutted basement and if this strutting is carried through to the opening;

(*b*) Has an emergency exit.

The opening should be not more than 2 ft. wide; but there seems little reason why it should not be high enough for people to walk through, particularly as little extra cost is involved.

The provision of a steel hood (Fig. 236) will be valuable, particularly where the requirement for the distance of the outlet from the house cannot be satisfied. A hood is, however, an added precaution in other cases also. The opening of a hood should always face in the direction shown in Fig. 237, i.e., away from the building.

TEXT OF MEMORANDUM

APPENDIX C.

A. 13.

Where the basement is in occupation and the floor above is to be strengthened by means of a standard type of steel support, it may be necessary to provide a finish to the soffit of the corrugated sheets.

This may be done in several ways, of which the following are examples :—

Method 1.

All surfaces of steelwork exposed to be treated with primer and painted two coats of oil colour, or alternatively a coat of slurry and two coats of plastic paint (Fig. 238).

Method 2.

To wedge 3 in. × 2 in. bearers at 2 ft. 0 in. centres between the soffit of the corrugated sheets and the top flange of the steel joist and stiffener with 2 in. × 2 in. battens, the whole soffit covered with composition boarding twice distempered (*see* sketch) (Fig. 239).

Method 3.

To wedge 2 in. × 2 in. bearers at 12 in. centres between the soffit of the corrugated sheets and top flange of steel joists, the whole soffit covered with composition boarding and twice distempered (*see* sketch) (Fig. 240).

APPENDIX D.

Examples of Basement Shelters in Small Dwelling Houses, showing Emergency Exits.

A. 14.

The Examples and diagrams in this Appendix do not exhaust all the possibilities but indicate the principles on which basement rooms should be selected and emergency exits designed.

The Examples (I to V) of basement dwelling houses have been selected from actual cases to show the many considerations involved and the typical difficulties in the way of practical solutions. The diagrams A to L illustrate 12 types, and suggested applications of these are shown in the Examples. Following the diagrams A to L is shown a typical steel hood for emergency exits (*see* Figs. 236 and 237). A hood could, however, be constructed in concrete or improvised by a timber structure covered with sandbags.

In all cases exits leading to the outside of the building should be rendered waterproof to prevent water being led back into the house. Steel or concrete tubes should be well grouted in and the joint with the wall pointed in cement mortar.

EXAMPLE I (Fig. 241).

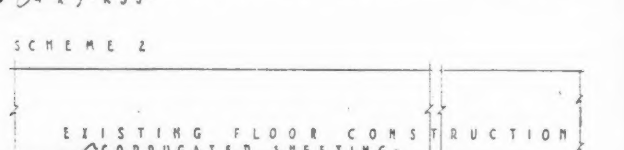
Average number of occupants—24 persons.
Number of storeys—3 over basement.
Height, pavement to eaves—33 ft. 6 in.
Is basement above flood-level ?—Yes.
Refuge-room to provide for: 18 persons (75%).
Floor area—
Required 108 sq. ft. Provided 142 sq. ft.
Volume—
Required 900 cub. ft. Provided 920 cub. ft.
Surface area—
Required 450 sq. ft. Provided 603 sq. ft.

Emergency Exits shown—One exit of type A, C or E and two of type K or L. Also a possible exit through the front cellars, for which purpose the manhole should be enlarged to at least 24 in. diameter and steps provided. The back door would be available as an exit if stairs and front room only had been demolished. Careful consideration should be given to the selection of the emergency exits giving the best protection. The exits of K or L type might be considered essential to the shelter scheme for the whole terrace.

Notes.—This example illustrates well several of the difficulties to be expected. Thus an emergency exit of the types A, C or E

A. 13.—No remarks are required, as this paragraph deals with finishings only. Figs. 238, 239 and 240 are taken from the Memorandum.

238



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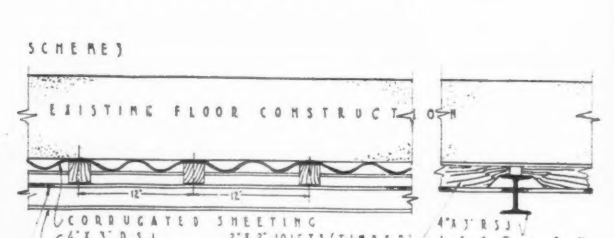
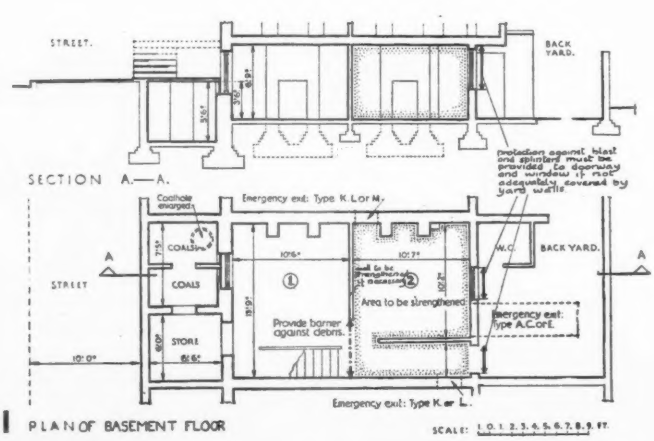


240

A. 14.—Five examples from the Memorandum are reproduced. The arguments advanced in the Memorandum for the choice of one room in preference to another are of interest; but in many cases the standards are much lower than those suggested in the Code, and reference should be made to the comments made on paragraphs A.1 to A.12 (*see* Figs. 241 to 245).



241 PLAN OF BASEMENT FLOOR

SCALE: 1 0 1 2 3 4 5 6 7 8 9 FT.

TEXT OF MEMORANDUM

would render difficult the access to the W.C. in peace time, and the lack of space would necessitate the use of concrete instead of earth as lateral protection to this exit.

Room 2 has been selected in preference to Room 1, because it contains some cooking facilities. Room 1, is, however, slightly better protected than Room 2, though the effective strutting of the fragile wooden staircase is difficult. Dangers from water and gas pipes should also be considered in each case.

The cellars were not selected owing to
(*a*) Insufficient space,
(*b*) Difficulty of emergency exits,
(*c*) Discomfort.

The reduction in the number of occupants shown here and in other examples is assumed to allow for evacuation, etc.

EXAMPLE II (Fig. 242).

Average number of occupants 7 persons
Number of storeys 3 over basement
Height, pavement to eaves 34 ft. 0 in.
Is basement above flood-level? Yes
Refuge room to provide for: 6 persons (86%)
Floor area—
Required 36 sq. ft. Provided 97 sq. ft.
Volume—
Required 300 cub. ft. Provided 700 cub. ft.
Surface area—
Required 150 sq. ft. Provided 300 sq. ft.

Emergency Exits shown. One exit (type K or L) to one adjoining house: another exit of the same type could (if required by shelter scheme for the whole terrace) be provided with the other adjoining house if the passage ceiling and staircase cupboard were strutted. A ladder and manhole (2 ft. 0 in. min. diameter) from cellar 3 into the pavement would provide a possible exit if staircase and rear wall only were demolished. An emergency exit of type I could be arranged by removing the area steps to the position shown and extending the concrete walls to carry a 6-in. slab over.

Notes.—Rooms 1, 2 and 3 have areas of 97 sq. ft., 185 sq. ft. and 40 sq. ft. respectively, and the cost of ceiling strutting would be of the order of £13, £25 and £5 respectively, if indeed, in the case of Room 3, calculations based on careful examination show any strutting at all to be required. Room 1 is far more comfortable than Room 3 though less easy to protect against blast and splinters, but Room 3 falls so far short of the volume requirement (195 cub. ft. against 300 cub. ft.) that it has been ruled out.

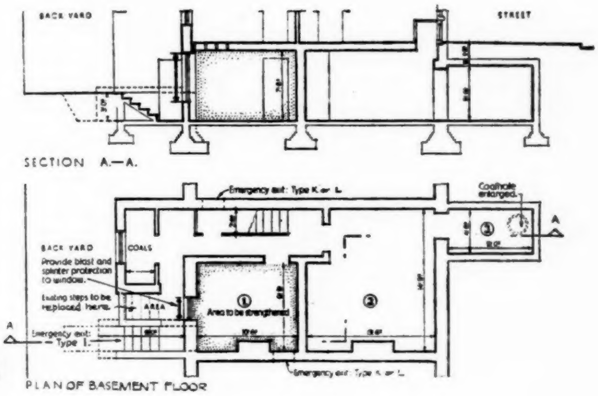
Room 3 would, however, be the most suitable shelter for a smaller number of persons.

EXAMPLE III (Fig. 243).

Average number of occupants 10 persons
Number of storeys 3 over basement
Height, pavement to eaves 31 ft. 0 in.
Is basement above flood-level? Yes
Refuge room to provide for: 8 persons (80%)
Floor area—
Required 48 sq. ft. Provided 212 sq. ft.
Volume—
Required 400 cub. ft. Provided 1,802 cub. ft.
Surface area—
Required 200 sq. ft. Provided 917 sq. ft.

Emergency exits shown. One exit of type K or L on each side only, and an enlarged manhole cover in the coal cellar. If the front of the house only were damaged, an exit might be available through Room 2. If the exits to the adjoining basements were for any reason impracticable, then the roof over the lobby and the coal cellar should be strengthened.

Notes.—Room 1 has been selected. It is easier to protect against blast and splinters than Room 2, and can have a type K or L exit to both sides. Possible danger from



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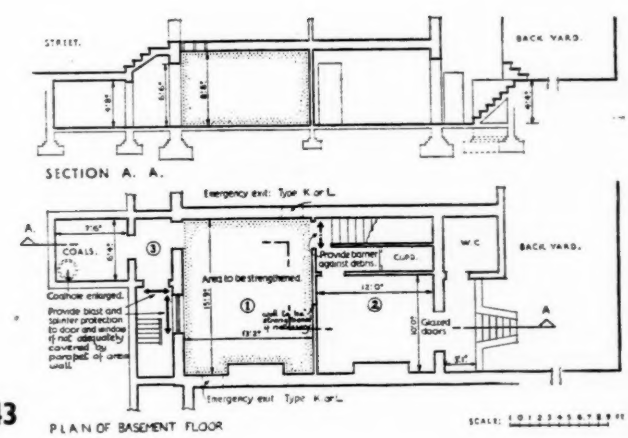


243

TEXT OF MEMORANDUM

broken water pipes and gas pipes should be taken into account as well in deciding which room to select.

Room 2 can have an exit to the neighbouring house on one side only, and is more liable to damage by the fall of debris in the staircase area.

EXAMPLE IV (Fig. 244).

Average number of occupants 5 persons
Number of storeys 2 over basement
Height, pavement to eaves 23 ft. 0 in.
Is basement above flood-level? Yes
Refuge room to provide for : 5 persons (100%)
Floor area—
Required 30 sq. ft. Provided 116 sq.ft.
Volume—
Required 250 cub. ft. Provided 899 cub. ft.
Surface area—
Required 125 sq. ft. Provided 566 sq. ft.

Emergency Exits shown. One type B, D or F tubular exit and one type K or L exit into adjoining house. A second (type K or L) exit into the other adjoining house could be provided under the stairs if necessary for the shelter policy of the whole terrace. In addition, the back door provides an exit if only the front of the house and the staircase were demolished. The provision of a ladder and manhole in the cellar under the pavement could also be considered as an alternative.

Notes.—Room 3 is too small. Room 2 is larger than necessary, has no W.C. facility, and no possibility of a type B, D or F exit.

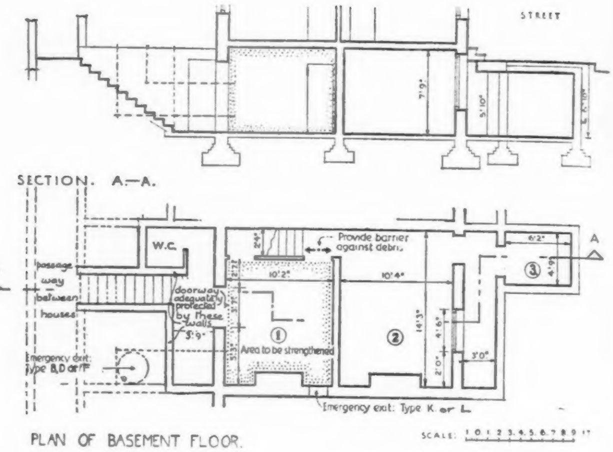
Room 2 would, however, provide better protection against the fall of debris in the staircase well, and if the numbers justified its selection an exit could be provided through a manhole in Room 3 provided the access between Rooms 2 and 3 were strengthened.

EXAMPLE V (Fig. 245).

Average number of occupants 12 persons
Number of storeys 3 over basement
1 over Room 3
Height, pavement to eaves 35 ft. 0 in.
Is basement above flood-level? Yes
Refuge room to provide for : 10 persons (83%)
Floor area—
Required 60 sq. ft. Provided 84 sq. ft.
Volume—
Required 500 cub. ft. Provided 672 cub.ft.
Surface area—
Required 250 sq. ft. Provided 320 sq. ft.

Emergency Exits shown. One type I exit only (see notes below) to rear passage way—could be used as a storage cupboard ; alternatively, if constructed wider and of full storey height it could be usefully adapted to normal purposes. The window would probably offer an alternative escape.

Notes.—Rooms 1, 2, 3, 4 and 5 have floor areas of 160 sq. ft., 115 sq. ft., 84 sq. ft., 70 sq. ft. and 70 sq. ft. respectively. To support the ceiling in either Room 1 or Room 2 would cost some £5 to £10 more than in Room 3, which has a W.C. and also is at least partly outside the area of the heaviest probable debris loading. For this reason only one emergency exit has been shown. The shelter scheme for the whole terrace might lead to Room 1 or Room 2 (together with a portion of the passage) being selected, when exits to each adjoining house could be arranged. Rooms 4 and 5 are (separately) lacking in volume; they would be extremely uncomfortable, and emergency exits would be difficult to arrange. In some cases, however, a pair of such cellars might be rendered comfortable with lighting and ventilation arranged for and emergency exits to adjacent cellars provided ; their ceilings might be found to be strong enough to require little or no propping.



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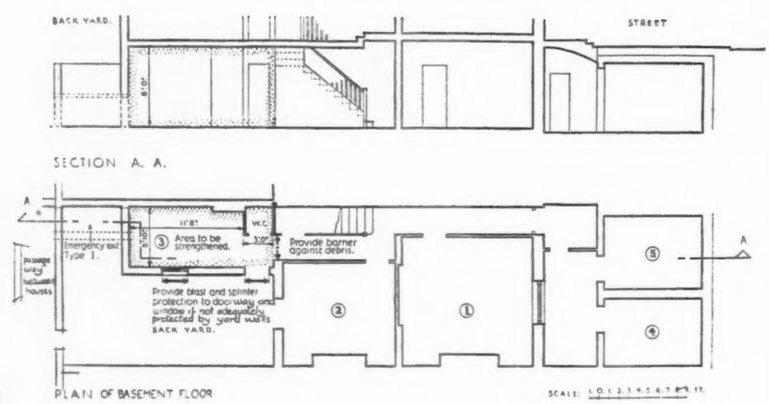


245

DOMESTIC SURFACE SHELTERS

Directions for the Erection of Domestic Surface Shelters. H.M.S.O., Price 2d.

Another pamphlet published by the Home Office, but not forming one of the Handbook or Memoranda series, treats of the construction and disposition of surface shelters for domestic buildings, primarily dwelling-houses. Such shelters for one and two houses are shown in Fig. 246, with and without screen wall entrances, and in Figs. 247 and 248 shelters are shown again with and without traversed entrances for four houses.

Such shelters are outside the scope of the Code, and, being largely standardized, technical experts will rarely be concerned with them. Nevertheless, a technical adviser may on occasions be required to decide the following questions:

(*a*) Suitability as compared with other means of protection.

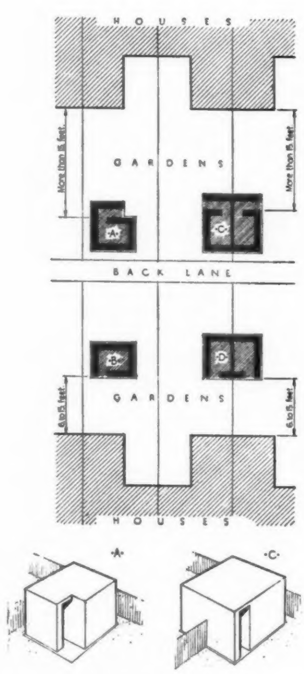
(*b*) Location.

(*c*) Materials of construction.

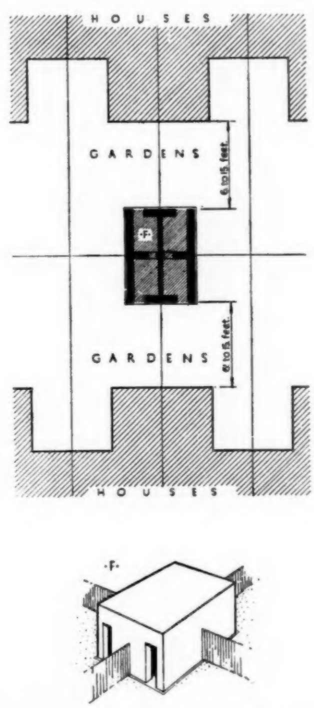
(*a*) *Suitability.*—Surface shelters, as far as protection against blast and splinters are concerned, are definitely inferior to trenches or even to shelters in approved basements. The danger zone, due to the blast of a bomb, is much greater above ground than the danger zone of shock waves due to blast below ground surface. Fig. 249 gives in principle an indication of the danger zones that can reasonably be assumed for a 500 lb. bomb. Outside those zones the standard protections for blast and splinters are accepted as adequate; but a shelter coming within the zones must be considered to have suffered a direct hit. It will be noted that the direct hit zone is very much reduced below ground. This increase in safety for small shelters below ground is even more pronounced in the case of smaller bombs.

On the other hand, trenches might prove more dangerous if gas attacks are made; but as both individual and surface shelters would then have to be abandoned this argument cannot be applied.

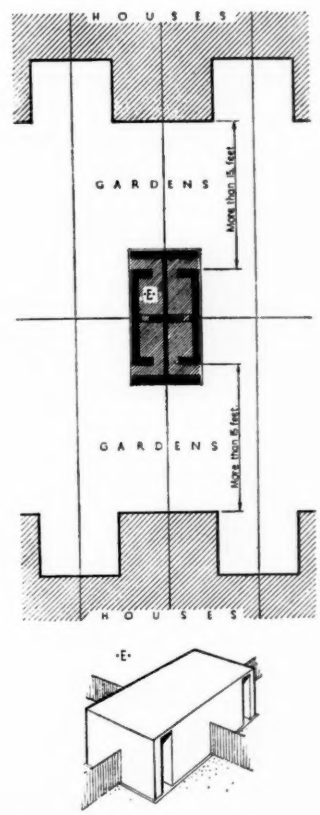
Shelters of Types B and D in Fig. 246 and of Type F in Fig. 247 should be discouraged.



246 *Reproduced from the Pamphlet.*



247 *Reproduced from the Pamphlet.*



248 *Reproduced from the Pamphlet. This is the best of the suggested Types. For minor amendments see Figs. 252 and 254.*

TEXT OF PAMPHLET

DESCRIPTION OF THE SHELTERS

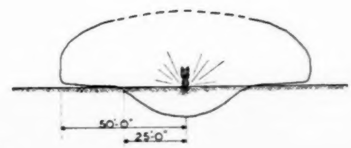
The shelters are made of brickwork, mass concrete, or concrete block masonry, with reinforced concrete roof over and with a concrete floor where the site conditions render this necessary. The single shelter unit has a minimum internal floor space measuring 6 ft. 6 in. by 4 ft. 6 in. These dimensions can be slightly increased if the construction of shelters in brickwork necessitates working to a multiple brick size.

SHELTERS FOR INCREASED ACCOMMODATION

The Standard design provides shelter for 6 persons, but if accommodation is required for a greater number the internal dimensions should be increased as follows:—

For 8 persons.

Shelter 4 ft. 6 in. × 8 ft. 6 in.



249

TEXT OF PAMPHLET

For 10 persons.
Shelter 4 ft. 6 in. × 10 ft. 6 in.
For 12 persons.
Shelter 4 ft. 6 in. × 12 ft. 6 in.

Location of the Shelters

For convenience the shelter should be placed near the house, and within a distance of 6-15 ft. it may be assumed that the house provides sufficient protection for the entrance. At greater distances than 15 ft. from the house or other solidly constructed wall or building the entrance should be protected by a brick or concrete block wall as shown in Figs. 246 and 247 or an earth screen wall.

Shelters may be sited singly or, where it can conveniently be arranged, they may be grouped in various ways. Grouping offers the advantage of economy in cost since some mutual protection is provided.

Erection of the Shelters

The work is normal in character and no special precautions are called for.

The following specification is recommended.

Materials

Concrete.

The concrete for the floors is to be composed of 112 lb. Portland cement complying with British Standard Specification No. 12/1931, and 12 cub. ft. of approved clean hard aggregate containing 25 per cent. of sand by volume.

The precast concrete walling blocks, roofs, lintels, and walls of mass concrete are to be composed of 112 lb. of Portland cement as specified above, 2½ to 3½ cub. ft. of approved clean sand, and 5 cub. ft. of approved clean hard aggregate. The latter shall wholly pass through a ¾-in. mesh sieve and be retained upon a 3/16-in. mesh sieve, and shall consist of approximately equal parts of material between ¾ in. and ⅜ in., and ⅜ in., and 3/16 in.

Clean "All-in" ballast or "All-in" crushed stone of approved quality and grading may be used, in which case the mixture shall be not weaker than 112 lb. Portland cement to 6 cub. ft. of crushed aggregate, including sand.

Bricks.

The bricks shall be approved common bricks. Sand-lime bricks which comply with the requirements of British Standard Specification No. 187 for bricks for ordinary purposes and cement concrete bricks can also be used, providing the crushing strength of the latter, when wet, and with the frog empty, is not less than 1,500 lb. per sq. in.

Concrete Blocks.

The precast concrete blocks shall be of a convenient size for handling, 18 in. by 15 in. by 4 in. is recommended, laid in 4-in. courses for the outside walls, and laid on edge for the internal partitions which occur in the double and quadruple shelters, as noted later.

Mortar.

The mortar used for building the brickwork or concrete block masonry shall be composed of one part of Portland cement, one-tenth part lime putty or hydrated lime, and three parts of approved clean sand by volume.

Floor

Where the shelter is to be built on an existing paving of concrete, flags, brick, or on well-consolidated roadway, no floor should be required. If it is to be built on the soil, the turf should be stripped from the

Ventilation is often an additional problem with some trenches, but when they are arranged in accordance with Fig. 90 difficulties will not arise. Surface shelters will also be felt to be much more objectionable by the occupiers of gardens than underground trench shelters, and wherever possible the latter are to be recommended.

Under certain conditions, however, surface shelters may be necessary. Those conditions are:

(i) Where the ground water-level is high;
(ii) Where the excavation of trenches would be very costly, e.g. in rocky ground; or
(iii) Where extensive underpinning of existing buildings would be necessary.

(2) *Location.*—Although for convenience the shelter should be near the house, it might be argued that, as the distance is in every case relatively small, a few feet extra do not really matter. The chance of debris falling on the shelter is to be avoided, and in this connection a distance of 6 ft. from the house is safe, only if the eaves of the house are not higher than 13 ft. above the shelter roof (Fig. 250). This distance will usually be satisfactory for two-storey houses (with attics); but for higher buildings the shelter should not be nearer a building than a distance "*d*" given by the formula:

$$d = 0.465\ (h_1 - h_2)$$

in which h_1 and h_2 are the heights of the building and of the shelter respectively. (Fig. 251.) Normally, h_2 will not exceed 7 ft. or 7 ft. 6 in.

It can also be inferred from the lay-outs shown in this pamphlet that when the distance is less than 15 ft., no traverse (screen wall) is required for the entrance, the assumption being that the building—independent of the thickness of its walls and the arrangement of doors and windows—is a shelter against blast and splinters. If a bomb should fall on the side of the building remote from the shelter, this assumption is, to some extent, correct: but it would seem that the chances of its falling on the building or near to it but on the side where the shelter is are just as great, and in either of the latter cases the effects of blast, splinters and fragments of building materials would very much outweigh the screening effects of the building.

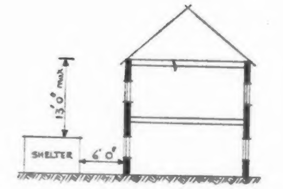
It should also be remembered that a traverse is assumed to give protection against a 500 lb. bomb at 50 ft. distance: but in practice that distance is believed to be only about 30 ft., and for 50 lb. bombs only about 9 ft. It seems unreasonable that this probable additional protection should be abandoned merely for the reason of the slight extra cost (about 13s. per person). It would therefore seem that traversed entrances should be provided in all cases.

Without decreasing the standard of protection in any way, the cost of surface shelters for adjoining premises can be reduced by grouping. An amendment of the arrangement suggested in the pamphlet (Fig. 247) is shown in Fig. 252. If a back lane should prevent this arrangement, then that given in Fig. 253 might be adopted.

The walls separating two shelters may be ordinary partition walls, and there seems to be no reason why a thick wall should be provided in one direction if there are more than two compartments in the one system. The emergency connections may also conveniently be replaced by ordinary doors which need not be double nor of steel. When closed the doors prevent draught, but allow good ventilation when open.

The shelter for four houses, suggested in Fig. 252, compares very favourably in cost with the arrangement "B" shown in the Pamphlet (Fig. 246) for one house.

The shelter "B" in Fig. 246 requires 24 ft. 6 in. of protective wall, whereas the shelter in Fig. 252 requires 63 ft. 6 in., or



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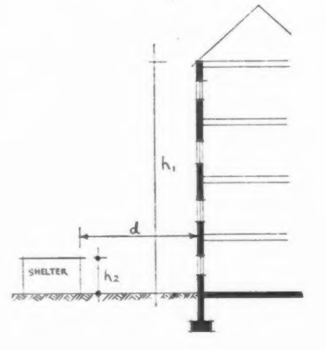

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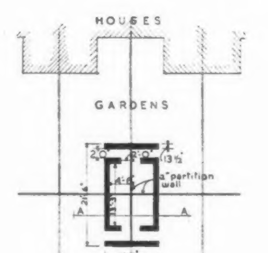

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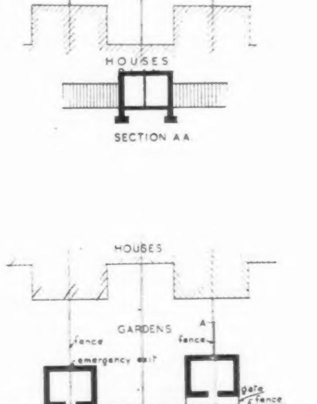

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TEXT OF PAMPHLET

site and the soil should be levelled and well consolidated.

On normal soils the floor may be unreinforced concrete as previously specified, but on less suitable soils the floor should be reinforced where considered necessary.

WALLS

The external walls shall be built of 13½-in. brickwork (nominal thickness) or 15-in. thick precast concrete block masonry, or mass concrete. The internal sizes of the shelters shall be the same in either case.

Internal walls in double and quadruple shelters as shown on Figs. 246, 247 and 248 shall be built of 4½-in. brickwork (nominal thickness) or 4-in. precast concrete blocks or mass concrete.

ROOF

The roof shall consist of reinforced concrete 5 in. thick. It may be cast *in situ* or composed of precast reinforced sections of convenient size with rebated joints.

The reinforcement shall consist of ⅜-in. mild steel rods spaced at 5½-in. centres on the shorter span, and, in addition, in the case of the roof cast *in situ*, at 11-in. centres on the longer span. An alternative reinforcement, consisting of a steel mesh of equivalent value, will be equally satisfactory.

The reinforcement shall be placed 1 in. from the internal face of the roof.

LINTELS

Provide over all openings, except the emergency exits which are protected by steel plates, cement concrete lintels 6 in. deep reinforced with three ⅜-in. mild steel rods at approximately 4-in. centres and placed 1 in. from the lower face, excepting in the shelters made of mass concrete, where no such reinforcing should be necessary.

STEEL PROTECTED EXITS

Form openings as shown on the diagrams by omitting the brickwork or concrete masonry. Provide two ¼-in. thick mild steel plates to each opening fixed in position as shown so that they can be readily removed when the need arises.

A suitable fixing is indicated in Figs. 5 and 6, and consists of four ⅜-in. coach bolts of the necessary length, each with a washer and wing nut. The plates are punched with square holes to receive the coach bolts and prevent them from turning. The wing nuts are fixed on the internal face of the wall.

Other similar types of fixing can be used provided they can be released from the inside.

The space between the plates shall be filled with bricks or concrete blocks laid without mortar.

about 16 ft. for one six-person compartment. It might even be assumed that many people would be willing to separate their compartments by an ordinary fence instead of by partition walls, and to remove the fences entirely in times of emergency. Further costs may be saved, if a common entrance is provided for two cells (Fig. 259). This arrangement reduces the length of walls to 60 ft. 6 in. for four houses (24 persons).

Where there is a back lane the shelters of backing premises can be arranged in such a way that traversed entrances obtain without the actual addition of screen walls (Fig. 253). Entry can be had either from the lane or from gaps between the shelters and the fences of the lane.

Emergency exits must be provided in the lay-out given in Fig. 253.

In Fig. 255 an arrangement for six families is shown, and this proves less expensive per family than the others (36 people).

(3) *Materials: Walls.*—Brickwork 13½ in. thick will be usually the most suitable material for the walls. The reinforcing of such walls will not permit of any reduction of their overall thickness, but it will be of distinct advantage in affording a reasonable attachment of the roof slab to the walls, which attachment is essential if full advantage of the potential box-like rigidity of the whole shelter is to be taken. A force which would overturn one wall can generally be resisted by the stiffness of another wall at right angles, provided that the force can be transmitted to the second wall.

The internal walls, although referred to as 4½-in. brickwork or 4-in. concrete, may be of any other materials—for instance, 2-in. breeze or other block—or they may be omitted entirely as they have no protective function to fulfil.

For the roof ordinary reinforced concrete may be used. Alternatively, it will be found useful to employ dovetail sheeting with ½-in. cover precast underneath, so that the sheeting can act both as shuttering and as reinforcement for 4 in. of concrete cast *in situ* on the top (Fig. 256).

Such sheets can be laid in 10 ft. × 2 ft. units, and for each block shown in Fig. 252 10 units would be required. 26-gauge sheeting can be used to replace the reinforcement given in the Pamphlet, and no additional waterproofing would be required.

The roof should span the shorter distance for single shelters; but where lay-outs similar to those in Figs. 247 or 252 are adopted, the floor can easily span the 9 ft. length, and, in fact, this is to be preferred to a slab spanning continuously over two panels, because top reinforcement should be avoided in such work; but without such top reinforcement over the centre supports slabs may crack and admit water.

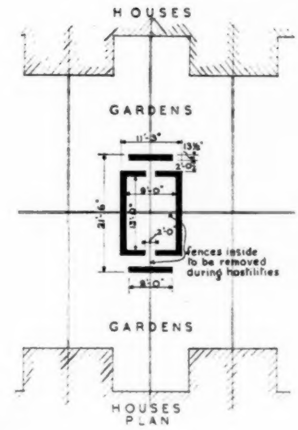
To avoid this behaviour interior walls should be built after the roof slab has been cast and any temporary struts have been removed (Fig. 257).

It is assumed that the cover to the reinforcement on the soffit may be reduced to ½ in., which is the cover normally required.

Where traverse walls are provided (Figs. 246 (A and C), 247, 252, 254, and 255), lintels over the openings may be omitted if the openings are carried up to the roof slab. The slab, however, must be properly secured to both walls. This arrangement is not applicable to the case shown in Fig 253, where reliance is placed on the lintel.

The steel-protected emergency exits can be omitted, of course, where two entrances exist and where there is direct communication between the entrances.

No mention is made of foundations, but the walls of surface shelters should have footings not less than 18 in. and 24 in. deep. The walls should never be carried only on a floor slab (Fig. 257).



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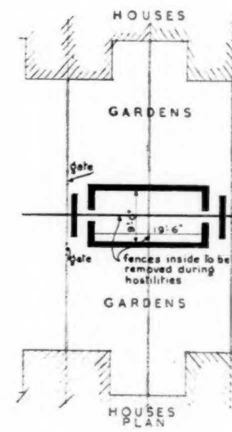

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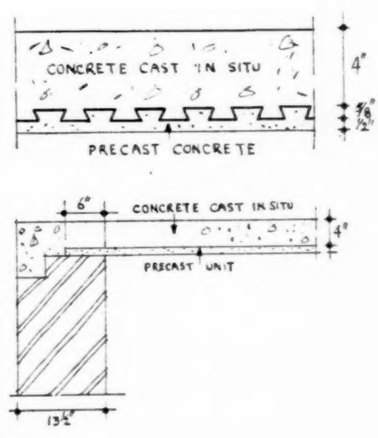

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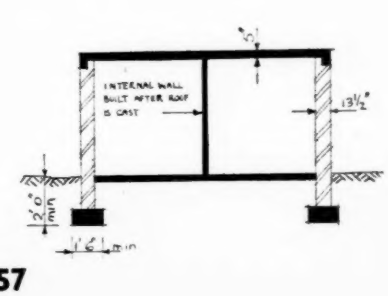

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OTHER OFFICIAL PUBLICATIONS

For full titles of publications mentioned here *see* Appendix, page 1017.

The Home Office have issued nine Handbooks and ten Memoranda, and as those sections which are of importance to the technical adviser have been discussed elsewhere, only a summary of the others need be given :

Handbook No. 1, "Personal Protection Against Gas," deals mainly with civilian and service respirators.

Handbooks Nos. 2 and 3 give a survey of the effects of gas and the treatment of gas casualties.

Handbook No. 4 deals with the decontamination of materials, and although knowledge of the effect of persistent gases on building materials is valuable to the architect and engineer, they contain nothing which influences the design of buildings or shelters, and the handbook is, therefore, not discussed further.

Handbook No. 5, "Structural Precautions Against Bombs and Gas," is still in preparation ; but it is expected that it will be published in the near future. It will supplement the Code, and, it is believed, treat, in addition, of the effects of bombs on objects at varying distances from explosions.

Handbook No. 6, "Air Raid Precautions in Factories and Business Premises," gives a general indication of the aims of air raid precautions. It must be realized that some considerable time has elapsed since the publication of this handbook and that many ideas have changed during that period. As far as they are of structural importance, the principles of this handbook, more or less modified, are contained in the Code. The instructions for "gas-fighting" by the sealing of a refuge room may be considered as out-of-date, as may the references to open trenches.

The requirements as to the standard of protection, ventilation, etc., are all incorporated in the Code. Valuable information is given in Appendix K of this Handbook as to size of rooms and equipment for First Aid and Cleansing Centres, and this appendix has been discussed in connection with paragraph 34 of the Code, p. 980.

Handbook No. 7 deals with Precautions for Merchant Shipping.

Handbook No. 8 deals with duties of Air Raid Wardens.

Handbook No. 9 is of particular importance to technicians, dealing as it does with incendiary bombs and fire precautions. The portion of the Handbook relating to structural precautions, together with descriptions of the bomb and its action are reproduced below and discussed.

There are 10 Memoranda of the Home Office, of which, however, only Memorandum No. 10 contains structural suggestions. For Memorandum No. 10, *see* page 984.

TEXT OF HANDBOOK No. 9.

INTRODUCTION

B.1.

The object of incendiary bombs is to cause fires, and it may be asked, "Why cannot these be dealt with by the Fire Brigades? Why should members of the public be expected to undertake fire fighting?" The answers to these questions can be given in a few words.

The number of fires which might be started by an air raid, or a series of air raids, must be a matter of conjecture, but obviously might be very large. Briefly it may be stated that one large bomber can carry between 1,000 and 2,000 small incendiary bombs, which if scattered over built-up areas, and not dealt with within two or three minutes after falling might start so many fires that no fire brigade could be expected to deal with them all.

Moreover, the water mains might be damaged or drained dry for fire fighting

B.1.—It is maintained by many, that the incendiary bomb will be the most dangerous weapon to combat. Where a shelter is built in accordance with the Code or the other documents mentioned previously, it will be proof against the penetration of small incendiary bombs.

In regard to property, the same cannot be said. Considerable structural precautions in houses should be taken so that the burning of a house if an incendiary bomb attack is made will be the exception rather than the rule. People leaving their shelters after an air raid should have a home to re-enter.

For various reasons, such as the fact that the use of incendiary bombs in Spain was limited and largely unsuccessful, and perhaps for the reason that incendiary bombs are less noisy and dramatic than high explosives, there has been a tendency among technicians to neglect the dangers which might accompany the use of

TEXT OF HANDBOOK No. 9

elsewhere, with the result that there might not be enough water nearby for a fire engine to use; or, again, roads might be damaged by high explosive bombs and so prevent a fire engine from reaching the site of the fire.

Steps are being taken to augment fire brigades for the purpose of dealing with the emergency problem, but it will readily be appreciated that sufficient appliances might not be available to deal with every fire that might be caused by incendiary bombs; and, as each fire left unattended in a building is a potential " burn out " of that and possibly neighbouring buildings, it is obviously of vital importance that as many of the public as possible should be in a position to deal with fires on their own property, before they have a chance of spreading so as to require the assistance of the fire brigade. This is particularly important in the case of factories, works, hospitals, schools, and other large institutions.

It must be emphasized also that dealing with incendiary bomb attack is mainly a question of ordinary fire fighting and ordinary fire precautions, and that much of the information and advice given in the following pages is, therefore, equally applicable to peace-time conditions.

THE LIGHT MAGNESIUM (ELECTRON) BOMB

Several types and sizes of incendiary bomb have been tried at one time or another by different countries, but the pattern which is most likely to be used, on account of its effectiveness, is a bomb commonly referred to abroad as an electron bomb, probably weighing no more than 1 kilo.

Description of the kilo magnesium (electron) bomb.

This type of bomb (Fig. 258) consists of a thick walled tube 9 in. long and 2 in. in diameter, made of an alloy of magnesium with a small proportion of aluminium. On one end of this tube there is a tail 5 in. long to steady the bomb in flight. The tube is filled with a priming composition of the thermite type. The bomb is fitted with an igniter which may be situated either in the nose or in the rear end of the tube.

The bomb weighs about 2 lb. 2 oz. and, with the exception of a few ounces in the tail and igniter, there is no dead weight, the whole being incendiary material. This is an important point to remember when the efficiency of this bomb is compared with that of other types.

How the bomb functions.

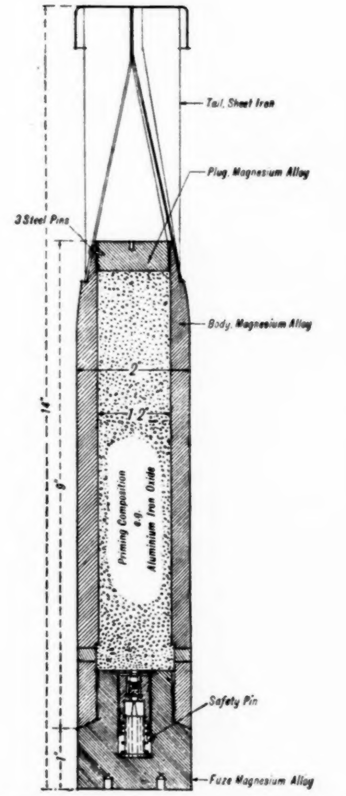
The bomb functions on impact, a needle in the igniter being driven into a small percussion cap which ignites the priming composition. The bomb does not explode.

It should be noted that, although this bomb is often called a thermite bomb, or a thermite electron bomb, the main incendiary agent is not the thermite composition but the magnesium tube, which is not in itself readily inflammable. The priming composition burns for 40/50 seconds at a temperature of about 2,500 deg. C., and its great heat services to melt and ignite the magnesium tube. The molten magnesium burns for 10 to 15 minutes at a temperature of about 1,300 deg. C.; it may remain active for as long as 20 minutes, and will set fire to anything inflammable within a few feet.

During the first 50 seconds or so while the priming composition is still burning, the bomb looks very violent; jets of flame are emitted from vent holes and pieces of molten magnesium may be thrown as far even as 50 ft. After the first minute the bomb becomes less active because the magnesium tube melts and the pressure within is released.

incendiary bombs in this country.

There are two very important considerations. The first is that the conditions in Spain and those here are wholly incomparable and there is insufficient evidence to show, because incendiary bombs were not in general successful there, that they would not be successful under the conditions obtaining in England. The second is that the ill-effects on the population, if a large proportion is rendered homeless by wide-spread fires, may be greater and more lasting than the worst effects of high explosives. An enemy must be credited with a certain amount of intelligence. If he knows that an intended victim has a gas-proof shelter and a reasonable means of getting to it in safety, it might be assumed that he would not risk his aircraft merely to drop gas. If the result of taking certain precautions against incendiary bombs is to discourage their use, then it seems reasonable that those precautions should be taken. The official view on this question is of particular interest and, therefore, the extract on the left (B.1) should be read carefully.



TYPICAL KILO MAGNESIUM (ELECTRON) INCENDIARY BOMB—SECTIONAL DRAWING.

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TEXT OF HANDBOOK No. 9

The thermite composition contains its own oxygen, and so cannot be extinguished by smothering, but the magnesium must get its oxygen from the air or surrounding materials in order to burn.

Method of attack.

One large bomber could carry between 1,000 and 2,000 of these very light bombs, the number depending largely on the weight of petrol carried. The bombs would probably be dropped from a considerable height, as they do not reach their maximum velocity (about 350 ft. per sec.), and therefore their greatest power of penetration, until they have fallen about 5,000 ft. The bombs would not be dropped singly, but would be released from containers each holding 10 or 20 bombs. The contents of several containers can be released simultaneously. Owing to its lightness, lack of weight preponderance in the nose, and to the fact that it is not properly streamlined, this bomb has very poor ballistics and cannot be aimed accurately. The bombs spread out as they fall, and a group of bombs dropped simultaneously from 5,000 ft. would cover an area of about 100 yards square.

For special targets it is quite possible that a heavier bomb or one of a different type might be used.

Incidence of fires.

As already mentioned, the number of fires which might be started simultaneously cannot be precisely estimated, but the following calculations will give some indication of what might be expected.

In large towns in this country the average proportion of open spaces to built-up areas may be taken to be of the order of five to one, or about 15 per cent. built over. Accordingly, for every six bombs dropped, one might be expected to hit a building, and the remaining five to fall in streets, gardens, yards, etc., where they would burn themselves out without doing any serious damage. Supposing, therefore, that only one bomber carrying 1,000 bombs has reached such a district, one hit in six would mean about 166 hits. But of these, about half might either glance off sloping roofs and not penetrate, or penetrating might fail to function. The remaining 83, or approximately 8 per cent. of the bombs dropped, would probably cause fires. The size of the area in which these fires might occur would depend upon the speed at which the bomber was flying, how quickly the bombs were released, and the height from which they were dropped. For instance, flying in a straight line, at 200 m.p.h. at a height of 5,000 ft. or over, and releasing 20 bombs per second, the bomber would drop its 1,000 bombs in a little under 3 miles, and would start one fire every 60 or 70 yards. Supposing that the bomber were flying at 100 m.p.h. and dropping 100 bombs every 2 seconds, it would have dropped them all in 1,000 yards, and started about one fire in every 12 or 13 yards.

In practice, there is little doubt that attacks would be made by formations, which means, of course, that the number of fires would be many times multiplied.

B.2 —*Effect of bomb hitting a building.*

The 1-kilo bomb appears to have been designed to have poor powers of penetration so that while it will, in fact, penetrate any ordinary roof (including tiles, slates, corrugated iron, and patent roofing materials, even though on close wood backing), it is likely to remain in an upper storey, thus starting a roof fire. This will probably be more difficult to deal with than one on a lower floor owing to the fact that attics and roof

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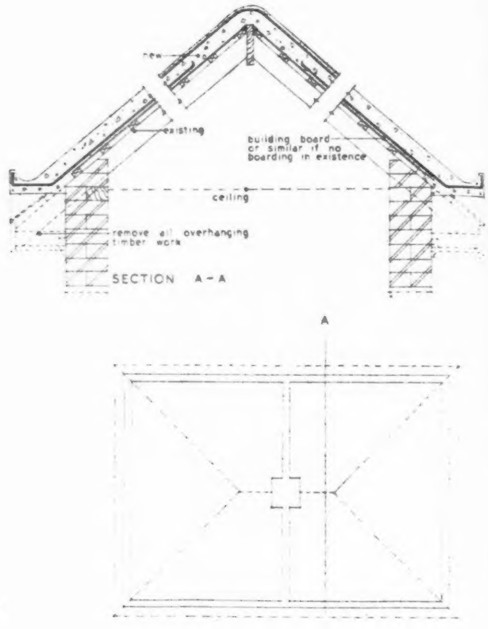

(a)

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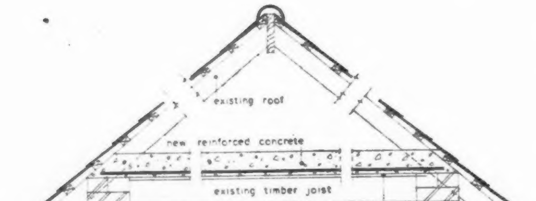


(b)

B.2.—In spite of the fact that at present incendiary bombs seem to be designed in such a way that they will normally stop in the attic of a building, where, owing to inaccessibility, great damage can be done, it is insufficient merely to take precautions for dealing with such bombs in the attic. Safeguard against further penetration is to be recommended, particularly as such bombs which do penetrate to lower floors can burn just as freely as in inaccessible attics, because the occupants of the buildings will be in their shelters or elsewhere.

The most effective means of preventing the penetration of an incendiary bomb is to provide an external covering to the building. This can be done without difficulty in the case of new buildings (*see* Appendix IV), for which a reinforced concrete roof slab of 4 in. thickness is recommended for 2.2-lb. bombs and of 6 in. thickness for 4.4-lb. bombs. For existing houses with flat roofs, the addition of a new reinforced concrete slab on top, if the required thickness of solid material is not already provided, will be neither impossible nor expensive.

TEXT OF HANDBOOK No. 9

spaces are usually less accessible and not so easy to move about in.

If there is a boarded floor immediately below the roof, the bomb would probably fail to penetrate this, but it might burn through in a few minutes into the ceiling below, thus starting a fire in the roof and the ceiling underneath, or molten magnesium may run through the cracks in the flooring and spread conflagration below. If, however, there is only a lath-and-plaster ceiling below the roof, the bomb would probably penetrate this at once; if not, it would burn through in a few seconds and start a fire in the room below, in which event it may not have been *in situ* long enough to have started a fire of any consequence in the roof space. Roof timbers 2 or 3 ft. above the bomb may, however, be ignited within a very short space of time by the radiated heat and by the ascending stream of hot gases.

The magnitude of the fire in the roof space itself will depend largely on the amount of timber or other inflammable material in this area, and the time taken by the bomb to burn through.

The results of tests of various materials for protection against penetration by impact and burning are given in the Appendix immediately below.

APPENDIX

PENETRATION TRIALS

Materials tested for protection against penetration by impact of incendiary bombs of various weights. (The figures indicate the minimum thickness required.)

Bomb	Reinforced Concrete	Sand	Earth	Shingle	Mild steel plate
1 Kilo (Incen.) $2\frac{1}{8}$ lb. ...	$3\frac{1}{2}$"–4"	Abt. 6"	Abt. 6"	Abt. 6"	$\frac{1}{4}$"
2 Kilo (Incen.) $4\frac{1}{4}$ lb. ...	5"–6"	Abt. 3' 6"	Abt. 5'	—	$\frac{3}{8}$"
$5\frac{1}{2}$ Kilo (Incen.) 12 lb.	—	Abt. 4' 9"	Abt. 7'	—	—
10 Kilo (Incen.)	—	Abt. 6'	Abt. 9'	—	1"

The following are among the materials which have been found to be proof against penetration by impact.

Mild steel plate—$\frac{1}{4}$ in. thick.

One layer of sandbags (laid as closely as possible).

$3\frac{1}{2}$ to 4 in. good quality reinforced concrete.

B.3.

As regards *burning*, the action of the bomb on floor boards has been found to vary greatly. Sometimes boards $\frac{7}{8}$ in. thick are burned through in 4 or 5 minutes, but on other occasions the time has been considerably longer.

Lead would be melted almost at once.

Corrugated iron (20 gauge) is proof against burning, but if during the burning of the composition a venthole of the bomb is against the sheet, the blowpipe effect may cause a hole. Also the sheet will get red hot and if in contact with the floor boards may set them on fire.

The following materials, amongst others, also provide protection against burning:

Dry sand, 2 in. thick.

Foamed slag, 2 in. thick.

Household ash, $2\frac{1}{2}$ in. thick.

Earth, 2 in. thick (should be reasonably free from vegetable matter).

Preparations, for instance, of the plaster type, made up mainly of ground rock anhydrite, about $\frac{3}{4}$ in. thick.

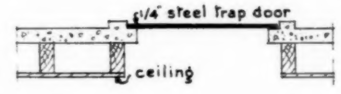
Asphalt (certain types) about $\frac{3}{4}$ in. thick.

Note.—A loose covering, such as sand, will be disturbed and the protecting cover be diminished by the fall of a bomb, but this can hardly be avoided except by unduly increasing the thickness of the layer. The risk is one that must be accepted. It must be remembered moreover, that sand is heavy, and floors might not support the weight.

Hollow tile roof slabs will generally be found to be inadequate, and in such cases, as it is unreasonable to remove the asphalt or other surface finish for the purpose of adding a certain thickness of solid concrete to the top of the slab, the additional material can be applied on top of the finish either in the form of 2 in. or 3 in. of concrete or in the form of flagstones (Fig. 259).

The typical domestic buildings with sloping roofs do not permit of the inexpensive treatment mentioned above. To cover a roof by a reinforced concrete slab spanning from external wall to external wall is possible; but the costs will be prohibitive (Fig. 260 (a)). It would, however, be feasible to provide a slab in the attic so that no bomb could get further than that and any fire which might be caused would be more or less confined to that area and the occupants would still have a roof over their heads (Fig. 260). A layer of sandbags, carried on the ceiling of the top floor, has been suggested for this purpose; but the usual domestic building could by no means carry such a load without being extensively strutted through all floors.

A reinforced concrete slab used for this purpose can span from wall to wall, and can be cast on top of an existing ceiling. Temporary strutting is required until the concrete sets. The access to the attic would best be covered by a steel trap-door $\frac{1}{4}$-in. thick in a concrete frame (Fig. 261).



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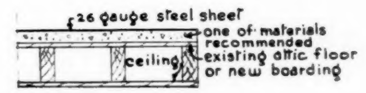

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B.3.—The difference between material that prevents the penetration of a falling bomb, and material that prevents the spread of the incendiary action, should be clearly understood. An asbestos sheet $\frac{3}{4}$ in. thick or a sheet of 20-gauge steel are proof against the downwards penetration of the blaze, but they would not stop the falling bomb.

When expense or other considerations prevent provisions being made definitely to stop a bomb in the attic, it is still worth while to take such measures that will prevent the spread of fire from those bombs which would, in any case, not go further than the attic. The list, reproduced from the Appendix of Handbook No. 9, describes the material required and their weights. The weight is usually the factor which determines the possibility of applying such materials except when a reinforced concrete slab is provided, which, of course, carries its own weight (*see* paragraph B.2).

Practically every existing construction is able to carry the following additional materials which all weigh less than 6 lb. per sq. ft. (equivalent to $\frac{1}{2}$ in. of concrete):

$\frac{3}{4}$ in. asbestos, asbestos wood or asbestos wall board.

$2\frac{1}{2}$ in. household ash.

$1\frac{1}{4}$ in. slate dust.

$1\frac{1}{4}$ in. pumice.

2 in. foamed slag.

20-gauge steel sheeting.

$\frac{1}{2}$ in. kaolin.

1 in. sodium bicarbonate.

Materials in a pulverized form may have less effect due to their being disturbed by the fall of a bomb. This drawback can be counteracted by laying a thin steel sheet, which itself helps to resist the bomb, on top of the material (Fig. 262).

The following combinations are recommended:

2 in. household ash }
or 1 in. slate dust } + 26-gauge steel sheet in each case.
or 1 in. pumice }
or $1\frac{1}{2}$ in. foamed slag }

Materials tested for protection against burning of the kilo magnesium (electron) incendiary bomb

Material	Minimum layer inches	Weight per sq. ft. lbs.	Remarks
Household ash ...	$2\frac{1}{4}$	5·0	
Slate dust	$1\frac{1}{4}$	5·0	As efficient as sand and lighter.
Red ash	1	6·0	
Boiler-house ash ...	$1\frac{3}{4}$	6·0	
Refuse destructor dust	2	11·5	
Brick dust ...	$1\frac{1}{2}$	9·5	
Sodium Bicarbonate	1	5·0	
Kaolin	$1\frac{1}{2}$	5·0	
Pumice (ground) ...	$1\frac{1}{4}$	4·0	
Dry (virgin) earth (sifted)	$1\frac{1}{4}$	6·0	
Dry sand	$1\frac{3}{4}$	13·5	
Foamed slag (ground) ...	2	5·5	Has advantages over sand (much lighter).
Powdered chalk ...	—	—	Not recommended: it will react with the bomb.
Asbestos sheet, ,, wood, ,, wall-board (Types which do not fracture under heat)	$\frac{3}{4}$		$\frac{1}{2}$ in. gives fair protection.
Preparations of the plaster type made up mainly of ground rock anhydrite	$\frac{3}{4}$	—	$\frac{1}{2}$ in. gives fair protection.
Asphalt (certain types)	$\frac{3}{4}$		$\frac{1}{2}$ in. gives fair protection.

A test has been devised for ascertaining the protection afforded by various materials against the burning of a 1-kilo magnesium (electron) incendiary bomb. Further particulars can be obtained from the Home Office, Air Raid Precautions Department.

APPENDIX I

VENTILATION

Specific requirements for ventilation are not set out in the Code; and the requirements as to surface areas refer only to naturally ventilated shelters. Actually there are three conditions to be considered, namely, those of :—

(*a*) Naturally ventilated shelters.
(*b*) Shelters that are artificially ventilated.
(*c*) Shelters that are not ventilated at all (gas-tight).

Only the first group is actually mentioned in the Code; but in two other publications, Handbook 6 and the "Pamphlet on Shelter from Air Attack" (Home Office), requirements are given for the other cases, and it can be assumed that these requirements will be generally accepted.

Considering the above cases in greater detail :—

(*a*) Naturally ventilated shelters.—The requirement that 25 sq. ft. of surface area are to be provided per person is made on the assumption that heat and humidity of the air will usually prove more dangerous than an excess of carbon dioxide. It is intended that the ill-effects of heat and humidity on the human body are to be eased by the process of condensation, and the amount of condensation is assumed to be proportional to the area of all the internal surfaces in a shelter.

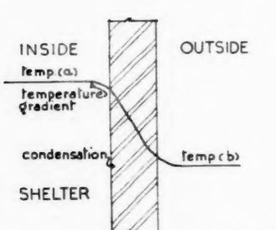
While this assumption is, in principle, correct, the generalization is unsound and may lead to serious consequences.

Two important factors have not been sufficiently considered for shelters of this type :—

1 : No distinction has been made between the effects on condensation of walling and floors, etc., having shelter compartments on both sides and those having a shelter compartment on only one side.

2 : Indications of what constitutes "natural ventilation" have not been given. The fact that a shelter has direct openings to the air does not fix in anyway the amount of air which might be drawn in through those openings.

In regard to the first of these factors, it should be appreciated that condensation is proportional *inter alia* to the difference of the temperatures on the opposite sides of the wall or floor, and that, if a wall or floor is common to two shelter compartments in which, due to simultaneous occupation, the temperature may rise equally, the condensation will fall off rapidly as the dividing wall or floor takes up the temperatures of the compartments. (*See* Figs. 263 and 264.)



the condensation is proportional to (a-b) & b remains practically constant

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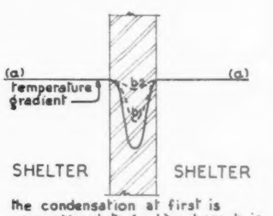

the condensation at first is proportional to (a-b). where b is the original temp. of the wall, b rapidly rises to b1, b2 etc until it becomes the same as "a" when condensation ceases

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A wall or floor, etc., with a shelter compartment on only one side, therefore affords much greater condensation than one with compartments on both sides, and further, the lower the insulation of the material the greater will be the condensation. Of the materials considered for lateral protection, 1½ in. steel is the most efficient for condensation, while the condensation on reinforced concrete (12 in.) is much reduced and that on brickwork (13½ in.) still less, while 2 ft. 6 in. of earth is quite inefficient. It is of interest to note, however, that owing to the heat that can be stored in a material, there is another factor that tends to increase the efficiency of a wall, namely, an increase in its thickness. Such increase in condensation is, however, temporary as long as the thickness of the material is small compared with its length and height. It becomes permanent, where the continuous flow of heat from the wall or floor can be guaranteed. Thus a trench shelter, buried in the earth affords good condensation, as does the floor of a basement provided that the floor slab is not suspended with an air space below it. Shelters, separated by division walls, have lower condensation values.

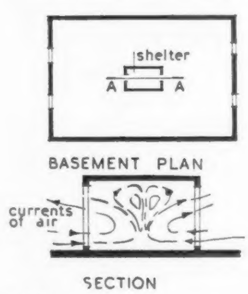
In division walls the efficiency depends only on the capacity of the walls to absorb heat. The average person produces 250 B.T.U. per hour, and if the amount of heat assumed to be dissipated in the wall is divided by the specific heat of the wall, the time for it to reach a certain temperature can be calculated.

As a rule, it can be assumed that division walls of 3 ft. 9 in. thickness will act as external walls, but that the value of a 13½ in. wall as a division wall will be rather low.

Another important consideration is that of the surface finish of the walls. Where such surfaces are glossy, moisture will run down them and may be collected in a channel and drained away. Rough surfaces on porous materials will permit of the absorption of moisture by the wall and such moisture will tend to saturate the wall. Shelters should, therefore, be thrown open to any natural ventilation that can be had at times when they do not need to be sealed, in order that the absorbed moisture may be evaporated and not remain to aggravate the humidity when the shelter is next used.

Returning now to a consideration of the second important factor :—

In systems of natural ventilation advantage is taken of the



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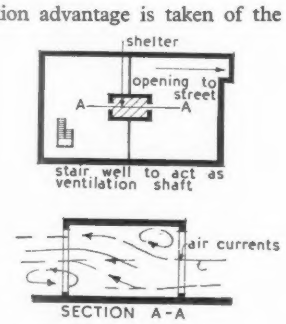

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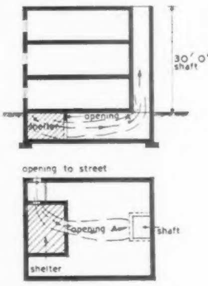
fact that hot air has the tendency to rise. Most air-raid shelters, however, will not be able to take advantage of this behaviour.

If an air-raid shelter has two openings which lead to the same surrounding room (Fig. 265), there is little tendency for the air to move at all, and the extent of "natural ventilation" is questionable. On the other hand, if a basement is divided into two parts, the one of which has an opening to the next floor above (Fig. 266), a draught through this opening will be set up.

It will become more pronounced the higher the opening extends and the aim should be to use a closed shaft extending to the highest possible point. Stair and lift shafts may serve this purpose to some extent, but if it is possible a duct should be provided in such a shaft.

To ensure efficient working of such a system the intake openings should be effectively separated from the outlet duct and only the shelter, or the compartment of a shelter which the duct is intended to serve, should be connected to it. (Fig. 267.)



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It is of interest to compare the requirements for naturally ventilated shelters with the requirements for artificially ventilated shelters (*see* (*b*) later). According to the figures given in the previously mentioned pamphlet of the Home Office, 150 cub. ft. of air per hour are required per person, even for people having at their disposal the surface areas required for unventilated shelters.

To provide the same amount of air by natural ventilation,

VENTILATION (*cont.*)

an uninterrupted shaft of 30 ft. high and not less than 1·5 sq. in. area per person would be required. That would mean, for instance, for 400 people, a section of about 2 ft. by 2 ft. 3 in. Where air has to be drawn through winding corridors that size would have to be increased.

From the foregoing remarks it becomes evident that only in few cases will it be reasonable to rely entirely on natural ventilation and on the prescribed surface areas of shelters. The great danger is that if insufficiently ventilated shelters are provided more damage may be done by overheated moisture-laden atmospheres than would be done by bombs. It is therefore suggested, though not specifically required by the Code, that artificial ventilation should always be installed in basement and such shelters even if there is no danger of gas attack.

(*b*) Artificial ventilation.—The pamphlet gives the following requirements for ventilation, for a period of three hours :—

	Surface area per person in ft.^{2}	Air changes
Shelters over ground	30	450 ft.^{3}/hour
	40	150 ft.^{3}/hour
Shelters under ground	20	450 ft.^{3}/hour
	20	150 ft.^{3}/hour

The explanation why overground shelters require a greater amount of ventilation must lie in the fact that the natural respiration of walls may be affected by a number of factors, as, for example, changes of temperature, sun's rays, etc., which can be neglected in the case of basements.

The figures show that a basement shelter, of either the dimensions given in the Code or with slightly reduced dimensions, requires an air change of 150 cub. ft. per hour per person ; a figure that is about one-third of that which is usually required for artificial ventilation.

The accommodation over ground is to be greater than that required with natural ventilation, even if an air change of 450 cub. ft. per hour and person is allowed. This fact again tends to show that the requirements for naturally ventilated shelters are inadequate.

To provide an air change of roughly 150 cub. ft. per hour for 50 persons and to suck such air through filters ¼ h.p. will be required.

The pamphlet mentions an alternative means of ventilation, the closed system, which consists of an hermetically sealed room, and a chemical plant for replenishing the air. As such arrangement normally (*a*) does not show any advantage and (*b*) is more expensive, it is not further discussed here.

(*c*) *See* paragraph 34 of the Code.

APPENDIX II

LIGHTING RESTRICTIONS

War time Lighting Restrictions for Industrial and Commercial Premises. H.M.S.O. Price 2d.

TEXT OF PAMPHLET ON LIGHTING RESTRICTIONS

Drastic lighting restrictions are an important feature of the precautionary measures to be taken against air attack. The aim is to secure that hostile aircraft shall see no lights which might serve to guide them to a particular objective or to help to determine their position.

In the event of war, a Lighting Order will be issued under emergency legislation, imposing general darkening as a permanent condition from the outbreak of war. The Order will set out the requirements with which lighting will have to comply, and there will be a general obligation on all concerned to observe these restrictions, which will be enforced by the police.

It is proposed that the Order will deal with the different classes of lighting in the manner indicated below.

The pamphlet then lists restrictions on, or total prohibition of, light from the following sources :

Private Houses, Shops, Business Premises and Places of Entertainment; Advertisement Lighting and Illuminated Signs ; Factories and Industrial Premises ; Street Lighting ; Lighting for Essential Services ; Road Vehicles ; Railways ; Shipping, Navigation, and Aircraft Lights.

2. INTERNAL LIGHTING

The provisions of the Lighting Order will call for complete concealment of all artificial lighting inside buildings as a permanent measure from the outbreak of war. Concealment will normally have to be achieved by the screening of all windows and rooflights with suitable opaque materials.

It is, of course, highly desirable that efficient production and working conditions should be maintained in time of war, and if the screening of windows, rooflights, etc., has been effectively carried out, factories should be in a position to retain their normal peacetime standard of internal lighting.

Treatment of Windows, Rooflights, etc., to Secure Complete Concealment of Premises

WINDOWS

Blinds and Curtains

Opacity and Colour.—For windows and vertical glass surfaces

THERE are no detailed rules given for the restriction of light ; there is, however, according to section 39 of the Civil Defence Bill, the requirement that no light shall be visible to aircraft. It is relatively unimportant whether the "Black-Out" will continue for the duration of a war, or whether an alarm will be given in order to produce a black-out for a certain period.

If a light is burning inside a building there are usually two ways of preventing its being visible from outside.

A : By screening near the source.

B : By screening where the light rays would leave the building, i.e. at windows, doors, etc.

It will be found generally that a combination of both systems will be the most suitable.

(A) Probably in the use of light there is more waste than in the use of any other of the mechanical services. Only a minute part of the light from any artificial source is ever usefully employed. If the amount of light for any purpose would be reduced without causing any reduction of its intensity, which can quite easily be done, not only would savings derive but the danger of the passage of the excess light to points where it becomes objectionable would be reduced. The following example may make this clearer. A man may require two 80-watt lamps in a room to enable him to work at a desk. Two 60-watt lamps may be insufficient. However, he need see no more than the small area immediately in front of him, and a parabolic reflector concentrating practically all the light of one 10-watt lamp may afford an intensity of light on that area no less than that afforded by the two 80-watt lamps (Fig. 268). Thus the chances of the light getting through windows, etc., are reduced immediately to one-sixteenth.

But the actual chances can be diminished further, for while the light was radiating in all directions before, the reflector

TEXT OF PAMPHLET ON LIGHTING RESTRICTIONS

generally, dark blinds or curtains may be used. A large variety of suitable materials is available, but opacity is essential. This can be tested by holding a sample of the material close to an electric bulb. It is not possible to lay down definite rules as to the amount of light which should be perceptible through the material, but generally any fabric showing a patch of light would be unsuitable. Small scattered pinholes of light would not generally render the material unsuitable for the purpose in view.

The outside of screening material should be dark in colour; black, brown, green or blue are suitable.

Suitable Materials.—Blinds may consist of dark blue or dark green glazed Holland, Lancaster cloth, Italian cloth, rubberised cloth, or black or thick dark brown paper. These are produced in many different qualities, and, in selecting the material to be used, the governing factors should be durability, permanence of dye and opacity, resistance to heat and damp, mechanical strength, non-inflammability, and, in some cases, resistance to corrosive fumes, steam, etc. Advice on materials is available from the appropriate trade organization, or guarantees may be given by the supplier.

Treatment of existing non-opaque Blinds.—Many buildings already have blinds of some light material. To make such blinds suitable for screening they can be treated with oil-bound water paint or distemper of dark colour. The following mixture is suitable:

1 lb. of concentrated size,
3 lb. lamp black,
½ gill of gold size.

The concentrated size and lamp black, in powder form, should be thoroughly mixed and 2½ gallons of boiling water added. This quantity applied by brush is sufficient to cover 80 square yards.

Where existing blinds do not make a completely light-tight fit, disclosure of light must be prevented by painting the edges of the window with an opaque paint.

Methods of Fixing.—Spring roller blinds have advantages, but cheaper forms of fixing can be obtained with single line flange rollers, or the material can be attached to a lath at top and bottom and carried on hooks when required, being rolled up and stored when not in use. Blinds or curtains can be carried by rings on rods or straining wires, but with some materials deterioration is rapid, due to "bunching," and dust collects in the folds. Most textile and paper fabrics last longer when rolled.

New blinds should overlap the whole window opening, and should be secured in guides or by cords so that they are not displaced by wind if windows are open or are broken. It is of great importance that light should be prevented from showing at the edges of blinds and particularly at the cill.

Improvised Screening Methods

While fixed blinds are preferable, the darkening of premises may be secured in other ways. In many premises packing material, tin plate, corrugated paper, plywood, chipboard, etc., are to hand, and opaque screens could be made cheaply of such material. Suitable screens can also be made from jute treated with bitumen or paint; this is obtainable commercially. For improvised screening, stout waterproof packing paper with a fabric backing is very suitable.

A satisfactory method of screening is to fix the selected material to a light wood framework constructed to fit closely into the window; the whole frame can then be fitted when required and removed by day.

External screens can take the form of permanent hinged shutters or of fabric attached to a wooden frame or to expanded or welded metal. The latter, however, are liable to damage from the weather, and maintenance costs would be high.

Painting

If blinds or screens are not provided, glass windows should be coated with opaque distemper or paint. Though cheap and quick this treatment shuts out daylight so that, wherever possible, blinds or removable screens are preferable. Full advantage of daylight can thus be taken, and disclosure of artificial light if glass is broken is also less likely.

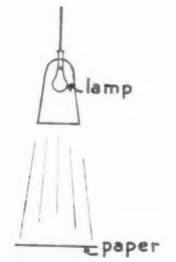
Some distempers and paints deteriorate in store; before stocks are bought, therefore, their durability should be ascertained from the suppliers. Alternatively, the suppliers may agree to hold the stocks in reserve for delivery when required. It would be a wise precaution to use distemper or paint which could be removed as readily as possible.

Distemper should be applied thickly in one coat by a distemper brush or spraying machine. A 1-cwt. keg is sufficient to cover 400 to 500 square yards, and working with a brush, one man could cover about 20 square yards per hour.

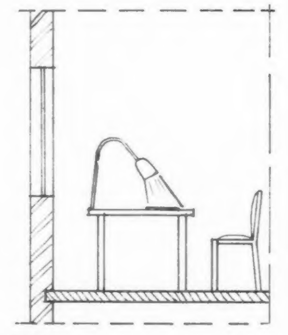
If time permits, glass surfaces should be washed before the application of distemper or paint; if washing is impracticable, they should first be dry brushed.

Instead of distemper, dark-coloured flat paint may be used. Some proprietary compounds are also suitable, while various improvised mixtures will serve, *e.g.* 7 lb. of whitening and ½ lb. black distemper, mixed with water to the consistency of thick cream. Any proposed material can be tested by coating a piece of glass, and examining it for opacity. Its behaviour when exposed to heat and when wetted should also be noted, as the coating may well have to remain effective for a long period.

can be arranged in such a direction that no rays reach the window or other opening directly; but only in the form of reflected and diffused light (Fig. 269).



268 *Concentration of light essential.*



269 *Direct rays should be turned away from a window.*

The conditions are the same in very many other cases, and although for some industrial processes the light cannot be screened at the origin to the extent assumed in the preceding example, even a certain measure of reduction will assist towards the total obscuring of that light. One of the tasks of the technical expert will be to design the emergency lighting system for houses, offices, factories, etc.

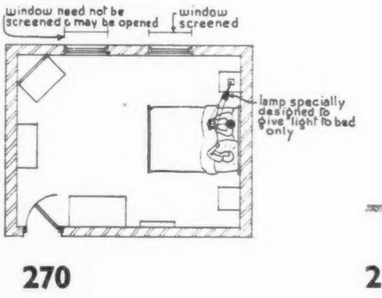
Where possible, any appliances required should be fixed in position, so that no mistaken use of them can be made.

(B) Screening of windows, etc.—The thorough application of the method given in No. 1 above will simplify the screening of windows to a very great extent. In bedrooms, bathrooms, lavatories, and also in many office buildings, it will even be possible to exempt some windows from screening, and when that is possible, it allows proper ventilation to be maintained in the normal way (Fig. 270).

The screening of windows, etc., can be carried out in five ways:—

1: By permanently blocking them.
2: By painting them.
3: By means of dark curtains.
4: By means of a canopy.
5: By means of colour filters.

These methods will now be considered in detail.



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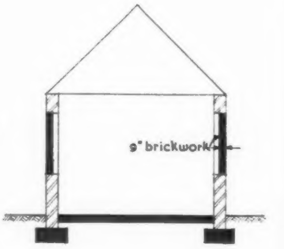


271 *Permanent blocking of window.*

(1) Sometimes, although by no means frequently, window space is redundant; that is to say, it is required neither for lighting nor for ventilating purposes. Where a vertical window is concerned:—

(*a*) It may be blocked completely (Fig. 271). Usually a 9-in. brick wall is most practicable and lends itself to the same outside treatment as the remainder of the wall. The thickness should be increased if the room is to form part of a shelter.

(*b*) It might be blocked behind the glazing when the window is of importance in the elevation of the building (Fig. 272). The wall may be carried out on 4½ in. brickwork, or where little space is available 2 in. breeze or similar material will be sufficient; but the glazed portion should be well closed except for a small gap at the bottom.

(*c*) Rooflights may be blocked by the same material that is elsewhere used for roofing, for example, corrugated asbestos.

TEXT OF PAMPHLET ON LIGHTING RESTRICTIONS

It is understood that successful experiments in rendering windows and rooflights opaque have recently been carried out by spraying rubber latex on the inside of the glass. Supplies of rubber latex are now commercially available.

Combination of Different Methods

It should always be borne in mind that a combination of any of the above methods is possible, and when investigating lighting restriction schemes the most satisfactory combination for individual circumstances should be carefully considered.

Tarpaulins

Tarpaulins should be kept in reserve as temporary covers to prevent exposure of light if glass is broken.

ROOFLIGHTS

Blinds

The general requirements as to colour and material are set out earlier in this section.

For rooflights it is often impracticable to arrange internal blinds close to the glass. It may, however, be possible to fix blinds horizontally beneath the roof, but they need support by means of wires to prevent sagging and the consequent leakage of light. The provision of blinds or movable screens has the great advantage that daylight can be admitted, but against this must be offset the cost of operating the blinds or fixing the screens and removing them daily.

Improvised Screening

Improvised screening by the methods suggested above may be impracticable for large areas of glass roof, but useful for a limited number of relatively small rooflights. Small lantern lights, etc., can be screened by tarpaulins either externally or internally. If fixed internally, the tarpaulins would serve to catch falling glass.

For premises with rooflights of saw-tooth pattern a suitable arrangement comprises a screen of some opaque material suspended from the angle, and operated by cords so that it covers the glass when required, and can be swung back to permit the entry of daylight.

Painting

The uses of suitable type of paint have already been set out.

It is usually more convenient to paint or distemper the outside of rooflights rather than the inside. This would also reduce the possibility of reflection, particularly on moonlight nights. Care should, of course, be taken to choose a brand of distemper suitable for external application. Flat paint should be selected to avoid reflection.

White or green "stippling" to rooflights is unsatisfactory. If sufficiently dense to prevent the emission of artificial light it is also opaque to daylight. Furthermore, light colours have very considerable reflecting power, and would render the building more easily distinguishable from the air on moonlight nights.

Means of access to rooflights must be considered, and the necessary ladders, scaffolding, crawling boards, etc., made available. This equipment should be kept permanently available in time of war, since the work must be maintained in a light-proof condition for the duration of the war.

Combination of Methods

It may often be found that premises can best be darkened by a combination of the methods suggested above, and the scheme adopted should be suited to individual circumstances.

Concealment Measures in relation to the Danger of Widespread Breakage of Glass Roofs in case of Air Attack

In examining the means by which glass roofing may be rendered light-proof, consideration must be given to the serious danger of widespread breakage of glass roofs which would arise in case of air attack. Occupiers should consider the replacement of glass by galvanized iron, felt and boarding, or other non-fragile material (transparent non-fragile materials are available commercially, and may be employed in special cases). If glass is essential the substitution of plain glass by wired glass should be considered, especially when repairs are being made in the ordinary course.

Steps should be taken to protect personnel, machinery, and essential material from the effects of falling glass. Fine wire-netting supported on expanded metal could be used.

In the case of very large glass areas in roofs, the most satisfactory method, where it is practicable, may be to erect canopies over individual machines.

DOORWAYS

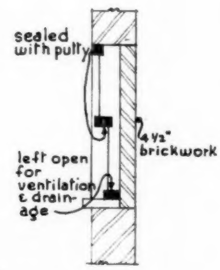
Means must be adopted to prevent the escape of light through doorways, and a suitable arrangement would be to form a vestibule with double doors, so that one could always be closed while the other was open. Alternatively, a heavy internal curtain could be used.

PAVEMENT AND STALL-BOARD WINDOW LIGHTS

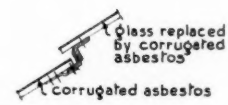
Pavement and stall-board lights are best treated by painting, preferably on the inside.

SUPPLEMENTARY DARKENING MEASURES

In time of war it will be important, in addition to the screening of the glass should be removed (Fig. 273). Where a roof is otherwise fireproof, it is advisable to use fireproof construction to replace the rooflights. No general suggestions can be given as different cases require different treatments; but reinforced concrete slabs used as arches or frames will frequently be satisfactory (*see* Fig. 274).



272 *Blocking of window when glazing must be retained on the outside.*



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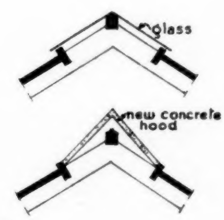

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(2) Painting of windows is a rather unsatisfactory compromise. A window should not be painted a dark colour if light is required in the day time. Practically every window that can be painted could be permanently blocked as shown in Fig. 271, and permanent blocking is preferable, for glass can easily be shattered by distant explosions, and if that should happen, the darkening is lost just when it is most urgently required.

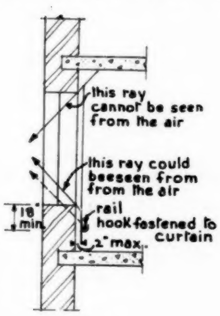
(3) Where windows are required during the daytime removable screens become necessary.

(*a*) In domestic buildings blinds, dark curtains, either newly fitted or replacing lighter curtains, will generally be adequate.

Where such blinds or curtains are used, they should be of ample dimensions so that careless handling would not let rays of light through the window.

Wherever doors must be opened for ventilation, curtains should be sufficiently heavy to hang without opening in the draught. Where the weight of the curtains is insufficient a guide rail and hooks fixed to the curtain should be fitted below the cill.

Most frequently, existing curtain rails can be used, as the shutting off of the light at the top is not so important, for such light cannot be detected by aircraft (Fig. 275).



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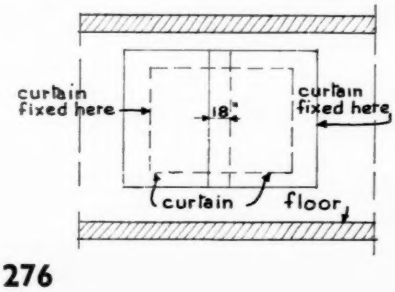
The curtain should continue at least 18 ins. below the cill and also for the same distance at the sides beyond the window opening. The widths of the curtains should be such that if they



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glass roof and window area, to provide a further safeguard against the escape of light as a result of either blinds or screens inadequately covering a window or of breakage of glass or other damage to premises. All internal lights therefore should, so far as is practicable, be shaded so as to prevent direct light being cast above the horizontal or in any direction in which lighting is not required for working purposes. Particular care should be taken to shade lamps so that no direct light is cast on windows. Existing shallow reflectors may be replaced by others of a deeper pattern, or skirts of sheet metal, etc., may be fitted.

An additional safeguard which it is desirable to take is to arrange for all lights to be connected to a single control point, so that they can be instantly extinguished in the event of damage to the premises causing exposure of lighting. It would, in any event, be a wise precaution to arrange for all lights (other than perhaps a few dim shaded lamps over machines, dials, etc., which have to be attended to even during a raid) to be extinguished as soon after the receipt of an air raid warning signal as everyone has taken shelter.

Complete " Housing " of the Sections of Premises in which Work is Conducted during the Hours of Darkness

In cases where a large glass area makes screening a difficult and costly matter, and where the nature of the work permits, it may be practicable to erect light-proof structures over those sections of the premises in which work has to be conducted during the hours of darkness. A suitable canopy can be formed with tubular scaffolding, covered at the top with corrugated iron, plywood, etc. Side curtains could be drawn aside during the day-time.

If this method is adopted no lighting will be permitted in the premises outside the light-proof sections.

Possible means of Achieving " Complete Concealment " Without Resort to Full Screening of Windows, Rooflights, etc.

There may be a very limited number of cases in which work can be carried on as a permanent war time measure with normal lighting extinguished and replaced by a few dim, well-shaded localized lamps so that the screening, or complete screening, of windows and rooflights is rendered unnecessary. Instances of this type of case are electricity power stations, or engine and boiler houses, where only a limited number of specific objects require to be rendered visible for the conduct of the work. In such cases there need only be a few dim, well-shaded lamps illuminating dials, etc., or it may be possible to apply fluorescent paint to these objects, and arrange for the paint to be activated by shaded ultra-violet lamps.

Before any system on the above lines can be accepted as an alternative to complete screening of windows and rooflights, it will have to be established that no lighting is visible from any point outside the premises.

Use of Coloured Lamps in Conjunction with Filters of Complementary Colours Applied to Windows and Glass Roofs

Various schemes for using coloured lamps in conjunction with filters of complementary colour applied to windows and glass roofs have been put forward from time to time as solutions to the problem of preventing the emission of light from buildings. It has been claimed that, by employing this method, sufficient light for daytime work is allowed to enter, while at night insufficient light is shown outside to render the premises visible; but certain of the schemes already put forward have involved the use of very deeply coloured artificial lighting within the buildings and of dense coloured filters on windows and rooflights permitting ingress of only a relatively small proportion of daylight.

A system of this kind, however, will comply with the provisions of the Order only if it prevents the emission from the premises of all direct or reflected light of whatever colour.

3. External Lighting and Glare from Industrial Processes

External lighting will be prohibited, unless the lighting is essential for the conduct of work of national importance. In such a case the lights must be adequately shaded, reduced in power, and capable of instant extinction at any time.

The principle of complete screening will apply also in the case of works conducting processes involving the emission of glare. Where such processes are conducted inside buildings the screening measures described in Section 2 will apply, supplemented in certain cases by screening of the plant itself. In the case of processes carried on in open or semi-open plant, as high a degree of screening as practicable will be enforced.

Where the exposure of a certain amount of glare after dark is unavoidable in the conduct of work of vital national importance exemption from the full provisions of the Order may be granted on condition that (i) all practicable steps are taken to secure concealment from the air as a permanent measure from the outbreak of war, and (ii) arrangements are made to ensure that the glare is rapidly concealed, on receipt of an air raid warning.

4. Preparations for the Imposition of Lighting Restrictions

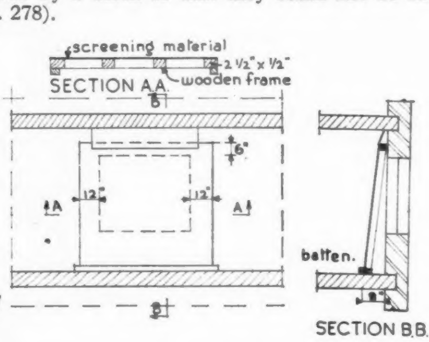
All premises ought to be in a position to complete their lighting restriction measures at a few hours' notice. To achieve adequate concealment may be a lengthy and troublesome business; consequently as much preparatory work as possible should be executed now—particularly as all premises which are not effectively darkened when the Lighting Order comes into force will be required to stop work after dark until they comply with the requirements. Whenever possible, blinds, screens, shutters, etc., should be fitted now. Where, however, immediate fitment is impracticable, it is important, in view of the probable scarcity of darkening material in wartime, that stocks should be obtained now and stored.

were lapped in the centre one would override the other by at least 18 ins., there still being the required overhang at the sides (Fig. 276).

A curtain should always hang as close to the wall as possible, and it should not be more than 2 ins. away for the conditions given above. To rely only on curtains is always unsatisfactory; but curtains in conjunction with screened lamps could be considered adequate protection. Blinds also afford satisfactory screening provided certain simple rules are observed. Spring blinds of dark holland material should be arranged to overlap the window opening by about 3 ins. round all sides. They will normally be held straight by the roller at the top and a strip of wood through the hem at the bottom. Clips to hold this bottom strip in contact with the wall should be provided, and also laths hinged to the wall at the sides so that they can be folded back over the sides of the blind when it is drawn. Venetian blinds will usually prove satisfactory, but greater care must be taken in their use.

(*b*) In factories, particularly where very large windows are to be obscured, movable stiff screens may be employed. They can consist of a wooden or steel frame, with the screening material attached to it. Such screens should extend from the floor to a height 6 ins. over the window soffit and should oversail the walls by at least 12 ins. from the window opening on either side. Such screens stand better on a slight slant and can be finished with tapered pieces of wood on the sides for that purpose. A fixing block projecting 1 in. from the floor is advisable, and for very large screens a piece of steel fixed to the wall at the top of the screen should be provided. There must be enough play that the screen may be lifted over the fixing piece at the bottom. It will be of advantage to fit such screens in the manner adopted for sliding doors and to move them together at night time (Fig. 277).

The shutters should overlap 12 ins. in the centre and should be checked by a block so that they could not be moved too far (Fig. 278).



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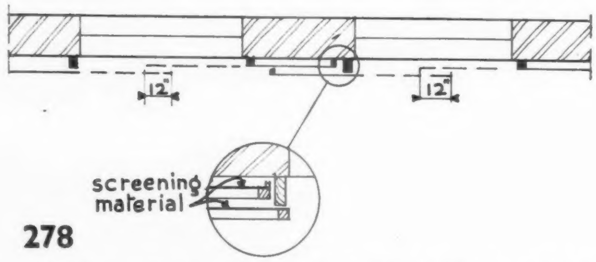

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(4) The provision of a canopy will not often be sufficient. There are, however, such places as loading docks, etc., which may require to be kept open day and night, and usually at least a dim light is necessary in the adjacent areas. Such areas should be well separated from those parts in which a greater amount of light is necessary; but they themselves cannot be very well shut off from the outside. A canopy in front will help tremendously and may be reinforced concrete (Fig. 279) or simply of boarding supported by wooden beams and struts and covered with bituminous felt sheeting. If the width of the opening is " w " and the height " h," the width of the canopy should not be less than $a = 2/3h$ and the length $b = w + 4/3h$.

It is recommended, however, that this arrangement should be tested for its efficiency in darkening provisionally by means of tarpaulins on struts before any permanent work is done.

Tarpaulins under roof lights can be classed as curtains. Where tarpaulins are used under a single row of skylights they should run on two rails, and should oversail the skylight 12 ins. on either side (Fig. 280). Where several tarpaulins are used, they should overlap each other by at least 12 ins. at every joint.

The lower sheet always should overlap the upper (Fig. 281).

In the case of a double skylight (Fig. 282) the upper tarpaulin

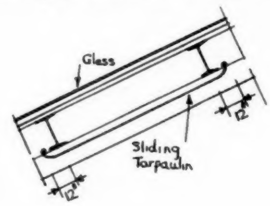
TEXT OF PAMPHLET ON LIGHTING RESTRICTIONS

Any structural alterations which may be required for screening purposes should be completed forthwith, or failing that, should be brought to a point where they can be completed at short notice.

It is also important that clear and definite instructions as to the measures to be taken to complete darkening shall be prepared now and communicated to those to whom the various tasks are allotted.

should be continuous over three rails. The centre rail may have to span the full length of a tarpaulin, and will have to be supported by a joist.

(5) Where extinction of light by means of colour filters is adopted there will usually be no structural work necessary, The ordinary glass will be replaced by glass of a certain colour. and all lights will have to have the supplementary colour.



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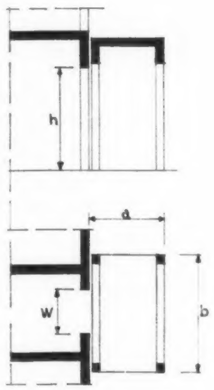

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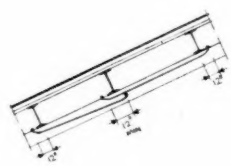

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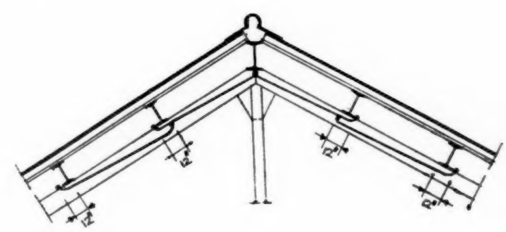

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APPENDIX III

CAMOUFLAGE

THE question of camouflage is being investigated by the Air Raid Precautions Department of the Home Office, and it is understood that recommendations based on their findings will later be published in the Air Raid Precautions Handbook series. It would appear that the masking of buildings and factories in such a way that they cannot be detected from the air is practically out of the question, particularly in view of the advances in aerial survey photography. Nevertheless, certain precautions can be taken which delay the distinguishing of any particular structure or group of structures. The aim, therefore, is to make such use of disguise that any attacker cannot locate his target until it is too late to pick up the line and release his bombs.

In regard to the design of new structures there are certain general principles which might be held in mind. The first is that full advantage of the natural features of the site should be taken. This advantage is not often very great—for sites are generally so restricted that there is little choice, and even when there are alternative positions for the structure the site itself may be so small that little difference is made where the building is placed.

The second is that regular lines and symmetrical geometric forms are to be avoided both in plan and in elevation. In this connection saw-tooth roofs may be cited as being particularly bad owing to the pronounced lines of light and shade which are visible from almost any angle. Sharp, well-defined shadows must not be thrown by any part of a building. Features of the one particular building may not be the only offenders in this respect. The problems of the grouping of buildings are of equal importance. Regular lay-outs and regular ways of communication should not be chosen. Nor is it enough that one building in a group should be camouflaged if the others are not also treated in the same way.

Just as the use of irregular form is of value in helping towards disguise, so, too, is the use of irregular colour.

APPENDIX IV

NEW BUILDINGS

SECTION 29 of the Civil Defence Bill indicates the publishing at some later date of regulations relating to the construction of and the materials to be used in the alterations and extension of existing buildings and in the construction of new buildings with a view to increasing the resistances of those buildings to air attack. It might be assumed that certain definite requirements will be included in addition to certain recommendations.

The requirements will probably relate to the provision of air-raid shelters and of solid fire-resisting roofs, etc., and the recommendations probably to matters of actual construction.

Although such regulations do not at present apply, architects and engineers should, nevertheless, advise their clients to agree to the protective measures which are suggested in the following paragraphs.

Shelters provided for employees will receive grants in the manner as for similar circumstances in existing buildings.

For shelters provided for houses and flats, loans may be given (section 28, Civil Defence Bill) except in the cases of tenement flats erected by corporations, etc., Civil Defence Bill (section 30), and of the cases in which shelter accommodation is provided free of charge. The standard of protection, preparation of compartments, capacity to resist debris loads, etc., will have to be not inferior to those specified in the code. The separation of people into groups of not more than 50, the spacing of such groups by a distance of at least 25 ft., and the provision of 5-in. reinforced concrete roofs might be assumed to be required for new buildings.

Of course, the decision as to whether shelters are to be arranged in a basement or whether trenches can be used must always be left to the expert adviser.

In skeleton frame buildings basement shelters are to be preferred. A separate ventilation shaft, leading to the roof, can readily be incorporated and thus natural ventilation be made much more effective than in most existing buildings.

The floor over the basement must, of course, be made strong enough to carry the debris load as determined under paragraphs 6, 7, 8 and 9 of the code (pp. 930-934).

The recommendations will probably suggest :—

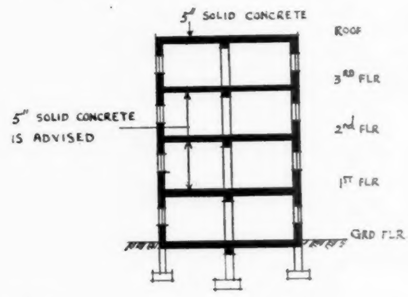
That floors where possible should be made of 5 ins. of fireproof material (Fig. 283).

That skeleton frame buildings should be given preference to other types of buildings.

That 13½-in. brick walls should be used for panel walls in ground floors (Fig. 284).

That a basement shelter should be provided in the centre of the building to get as much protection as possible from the building itself against bombs arriving at low angles, but that such shelters

NEW BUILDINGS (*continued*)



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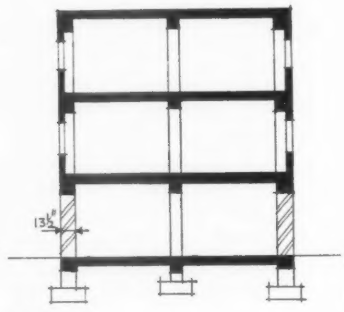

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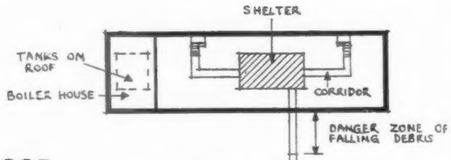

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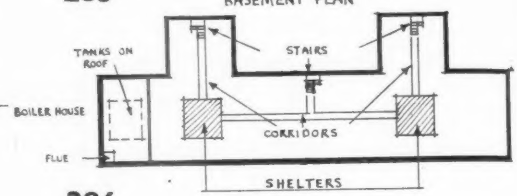
BASEMENT PLAN



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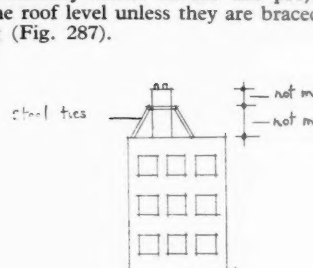
BASEMENT PLAN

should be well separated from the boiler-house and not directly below tanks or lift machinery on upper floors (Figs. 285 and 286).

That cross walls should be provided and be not further apart than 40 ft. in order to stiffen the building. That the use of heavy ornaments such as cornices, high parapets, turrets, etc., should be avoided.

That chimney shafts should not project more than 5 ft. above the roof level unless they are braced to the frame of the building (Fig. 287).



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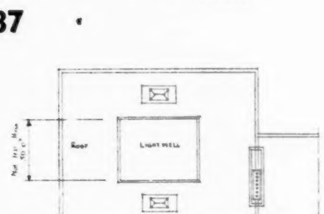

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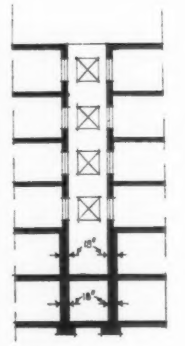
That where brick bearing walls are used, the floors should be securely anchored to those walls.

That entirely enclosed courts, light wells, etc., having either dimension less than 50 ft. should be avoided and that where



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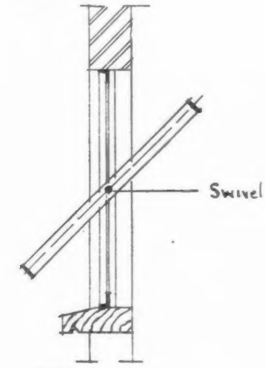

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such enclosures are necessary, their walls should be of particularly strong construction at the ground level, carried through to foundations. They should not be carried on beams (Figs. 288 and 289).

That roof lights should be avoided, but where required should be in framework sufficiently strong to carry any emergency protection required, e.g. sandbags.

That windows should be arranged on swivel frames, pivoting about a horizontal axis, which would enable them to be turned at an angle likely to present the least area to blast (Fig. 290).

That all services—gas, electricity, water, etc.—should be controlled from the one point, and that this central control should preferably be duplicated at remote points.

That bulkheads or other suitable protections are provided against flooding.

That the shelter should communicate directly with all staircases in the building in order that nobody need go out into the open.

That emergency exits should be well below ground, and not give access to the open within the zone endangered by debris.

APPENDIX V

SHELTERS IN HOSPITALS

SHELTERS in hospitals are particularly difficult to arrange. They are dealt with in Memorandum No. 1, Emergency Medical Services (Ministry of Health).

The difficulty lies in the immobility of the inmates. In certain cases in which the patients can themselves move about there is little difference between the problems presented by hospitals and those presented by office buildings.

Where all patients must remain in bed, the difficulties of doing anything really effective under the present cramped conditions in existing hospitals are very great.

Where only a proportion of the patients in a multi-storey hospital are confined to bed, the wards in the ground floor may be used for such patients (Fig. 291), and blast-proof protection given to this ground floor by:

1 : The thickening of external walls to 13½ ins. where they are not already so (*see* code, paragraph 3), p. 926.

2 : Blocking all windows ; sandbags may be used alternatively to brickwork of 13½ ins.

3 : Provision of division walls (*see* code, paragraph 12), p. 937.

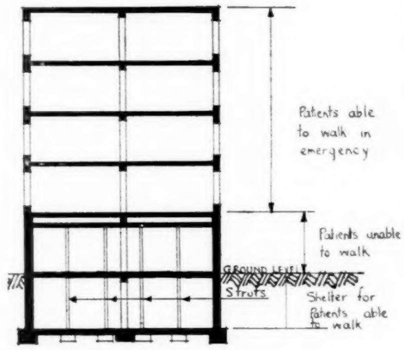
4 : Strutting of the first floor (*see* code, paragraphs 6 to 9), p. 930.

5 : Provision of artificial (pressure) ventilation, the air being taken from the top of the building (*see* Appendix I and code, paragraph 34).

All struts, new walls, wall thickenings, etc., are to be carried through any basements below, which can then be used as a shelter for the staff and for other patients.

Where no basement exists, the staff and the patients from the upper floors must be accommodated in trenches which

SHELTERS IN HOSPITALS (*continued*)



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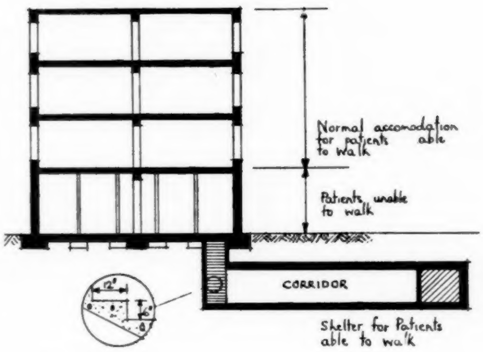

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should, in all cases, be connected by an underground corridor and a staircase to the building (Fig. 292).

Entrances and emergency exits for patients must, of course, be of more convenient form than those for able-bodied people. No staircases should be steeper than 1 in 2, and ramps are to be preferred. No ladders should be used, and emergency exits should have at least 6 ft. headroom.

Depending on the type of hospital, extra accommodation might be arranged in the shelters for beds in which a floor area of 20 sq. ft. for each cot case should be allowed. Extra space will be required for heating and artificial ventilation, which is essential for the shelters as well as for those accommodated in the ground floor.

Where patients on all floors are unable to leave their beds relatively poor measures can be taken. A ward, or part of a ward, on each floor may be made blast-proof, and this can be done by arranging new walls and blocking the windows. Three times the normal number of beds may be stored on a given area during an emergency.

Such blast-proof wards should be one on top of the other, and apart from the required strutting should be so strengthened that a tower is formed, affording extra resistance to blast and collapse (Fig. 293).

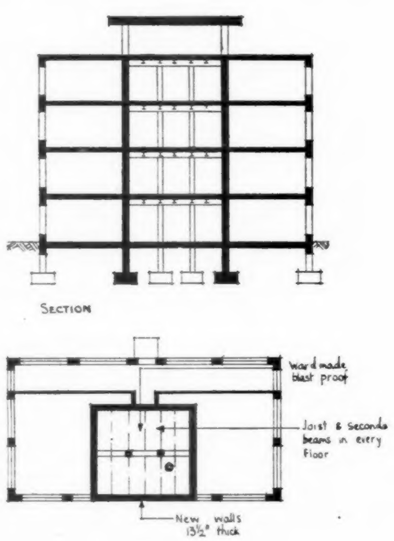
Vertical strengthening should be provided as far as possible by beams rather than struts, in order to permit reasonable movements of beds. Beams up to 16-ft. span are preferable to struts.

If an existing roof is of inadequate construction a new solid roof should be constructed over it.

The foregoing are merely guiding notes, and as the conditions in different hospitals vary considerably, the expert will have to take these local conditions into consideration in arriving at the best solution for any particular case.

For new hospitals, precautions are easier in that a sheltered central tower of particularly strong framework can be incorporated in the original construction. If possible, 18-in. walls without windows should surround it and a projecting roof slab of about 3-ft. thickness of reinforced concrete will afford considerable increase of the safety of the inmates (Fig. 294).

Such a concentration of people on one floor above the other calls for a much higher standard of protection than is otherwise suggested in the code.



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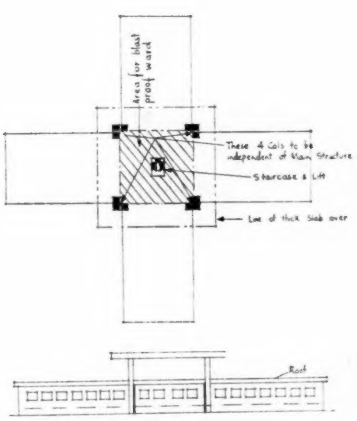

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APPENDIX VI

USE OF SPECIAL MATERIALS

FOR the purpose of arranging provisional shelters, use can be made of certain materials which might be available in the form of stored goods, etc. In general, such shelters are not to be recommended for the reasons that they do not constitute permanent shelters and that the areas occupied by protective material are very much greater than those occupied by the common building materials.

While it may appear attractive to a merchant or manufacturer to reduce the costs of a shelter by using his stored goods for that purpose, it will be found most often that, in practice, there is

USE OF SPECIAL MATERIALS (*continued*)

little advantage. It would be possible in peace time to draw on the stocks of material in extreme cases, provided, of course, that they were replaced immediately because the full protective value must be afforded whenever the shelter is required ; but it will be found that the shoring and strutting which are necessary to ensure the stability of the piles of material usually make the removal and replacement of goods so difficult that they are best left alone.

Some general considerations in the design of such shelters are set out in the following paragraphs.

The main difference between walls constructed of special materials and orthodox walls lies in the fact that the former materials are restrained in their position usually by the effect of gravity only, whereas the materials of a normal wall generally have, in addition, certain mechanical bond between the elements, and between the wall as a whole and the surrounding structure.

A blast wave and also splinters that hit an ordinary wall have to overcome—

1. The resistance of the mass of material, i.e. inertia ; and
2. The resistance set up by the bond or coherence between the different parts of the wall.

A blast wave on a pile of stacked materials will also be resisted by their masses, i.e. inertia, and in addition by certain friction set up in the pile by the weights of the materials ; but there will be no additional internal resistance such, for example, as that due to the bonding and mortar adhesion in brickwork.

It must be understood that the two main types of resistance, namely, that due to inertia and that due to friction or internal adhesion, are not exerted simultaneously. The application of the forces of blast is almost instantaneous ; but collapse due to those forces and to their consequent dislodging effects takes place an appreciable interval after the application of the forces.

The action of the mass resistance of stacked material can be regarded as being the same as that of a normal wall, and the question of dislodging can, therefore, be considered separately.

In the comment on paragraph 3 of the Code (page 928) the formula for required thickness in inches is given as $t = \frac{270,000}{s^2}$ in which " s " is the weight, in pounds, of a cubic foot of the material.

If this thickness is provided, it can be assumed that the required resistance to blast and splinters will obtain ; but additional precautions are necessary to prevent the dislodging of pieces and their consequent dangers. As a rule, it will be best to stack the materials forming a wall in parallel rows round the sheltered area, so that if certain pieces are dislodged from the outer piles, they will fall into the lanes outside the shelter area.

APPENDIX VII

MULTI-STOREY SHELTERS FOR DENSELY POPULATED AREAS

SHELTERS of this type, both public and private, will be necessary where the available area will be insufficient for shelter accommodation of the normal type ; that is to say, where for any reason the likely density of people will be too high.

It has been pointed out in paragraph 25 of the Code that not more than 4,800 people can be accommodated on an acre of available ground in the ordinary way. The proportion of available shelter area to total ground area will be very different in different localities. It may be as high as 60 per cent. in domestic areas, or it may be as low as 5 per cent. in certain areas, due to original overcrowding, badly planned rebuilding, density of service mains and sewers, etc. Where the available area is so small (that is, where shelters for not more than 240 people per acre (total) can be provided in any given block or neighbourhood), and where at the same time, a greater density of people obtains, some other form of protection than the usual will have to be provided. In this connection, however, it must be remembered that it seems definitely to be the policy of the Government not to concentrate people to any greater extent than they may be in normal times.

It can, therefore, be assumed that, in general, only where exact surveys prove that multi-storey shelters are required for lack of space, and not for arguments advanced on the advisability of bomb-proofing, will such shelters be approved.

The area to be considered would usually lie within a circle of 500 yds. diameter, i.e. 40 acres in area, the centre being reached within five minutes from any point in the circle.

The area would have to be properly defined and surveyed, and the number of people to be sheltered compared with the number for which normal shelter could be provided. For the excess number shelters of two or, if required, more storeys should be provided near the centre of the area considered.

Such shelters will be more expensive per person than those normally envisaged, as the construction will necessarily have to be heavier, even when based on the standards specified in the Code. For example, floors will become the equivalent of division walls because they will separate compartments of the shelter. This and many allied problems will have to be considered on the merits of each particular case.

It is important to bear in mind that Section 9 of the Civil Defence Bill allows a local authority to deal with all employees of factories and occupants of commercial buildings, etc., for whom shelters cannot be provided on the premises.

The number of people requiring public shelters in densely occupied areas will be much greater than the normal proportion of people to the available areas for shelters. The obvious procedure for a local authority, therefore, will be to draw up a chart subdivided into squares of about four acres (a square of 440 yds. by 440 yds.) and to mark on each square

(*a*) the number of people to be accommodated.
(*b*) the available shelter area.

(*a*) In order to find the number, the local authority will have to ascertain as soon as possible

(1) Which employers are able to provide shelters on their own premises, the capacities of those shelters, and the number of people who are left.

(2) How many people are likely to be on the street, or in other localities nearby (restaurants, shops, etc.).

(*b*) A survey is to be made, showing

(1) The available public areas, omitting impracticable parts such as roads, where services may prevent the provision of shelters.

(2) The available private areas, in accordance with Section 2 of the Civil Defence Bill, but omitting all such areas which

(i) are required for private shelters.
(ii) are required for other important public functions.
(iii) are impracticable for special reasons, as for example :

Extraordinarily heavy overhead loads,
Services and drainage which cannot be altered,
Danger of flooding from canals, etc.
Impossibility of arranging shelter due to bad quality of construction, or insufficient headroom, etc.

The comparison of the surveys (*a*) and (*b*) for each unit will indicate where shelters, other than the normal, are required.

APPENDIX VIII

EXPERT ADVICE

TEXT OF HOME OFFICE CIRCULAR

(**A**) On April 25 a Circular (91/1939) was addressed by the Air Raid Precautions Department to the Local Authorities in areas provisionally specified (Section 11, Civil Defence Bill), advising them of the arrangements which have been made for the carrying out of the Government's shelter policy, and particularly for the rapid completion of the necessary

(**A**)—*Scope of the Professional Work which may be required of Consultants, i.e. Architects, Engineers and Surveyors in the execution of Government Shelters Policy.*

The policy may be divided into two main heads :—

(1) *Private Shelters.*—The provision of shelters in or in close proximity to homes of those who cannot afford to provide it for themselves.

(2) *Public Shelters.*—The provision of public shelters for persons caught in the street.

EXPERT ADVICE (*continued*)

TEXT OF HOME OFFICE CIRCULAR

Private Shelters.—These may be divided into five classes :—

(*a*) Those houses which have gardens or yards in which it is possible to erect the sectional steel shelters (sometimes known as the Anderson Shelter).

(*b*) Those houses which have no gardens or yards but which have basements.

(*c*) Those houses in category (*b*) which, having basements, are yet unsuitable for propping.

(*d*) Those which have no basements and no gardens.

(*e*) Tenement flats.

In the first instance, it will be the duty of the local authority to survey the area and divide the houses into the above categories, and at this stage it is not expected that the services of professional consultants will be required, as the local authorities are being given power to engage staff to organize this part of the work. It is possible, however, that in some instances the local authorities may wish to engage additional help in respect of this preliminary survey.

In respect of category (*a*) the services of professional consultants are not likely to be required. As regards other categories, the local authorities having ascertained the extent of the problem can then call in the services of consultants. The duties which consultants may be called upon to undertake in respect of category (*b*) will be :—

(I) To examine the building and ascertain if it is suitable for propping.

(II) To select a suitable room for a refuge and measure it up and prepare :—

(*a*) A list of the materials required, in accordance with the standard design for propping.

(*b*) To design the footings for the props.

(*c*) To design the alternative exits. (A memorandum giving suggestions for alternative exits will shortly be available. (*See* Memorandum 10, p. 984.)

(*d*) To prepare estimates of the cost.

(*e*) To submit designs and estimates to the local authorities.

(*f*) After the approval of the local authorities, to arrange contracts for the execution of the work.

(*g*) To supervise the work.

(*h*) To scrutinize and pass the bills for the work done.

With regard to categories (*c*) and (*d*), the consultant may be asked to prepare schemes for providing refuges in or near to houses which have neither basements nor adequate gardens. No standard method of solving this problem can be laid down, but limits of cost, to be worked to if possible, and a memorandum giving suggestions for guidance in particular cases will be issued. The cost per house should certainly not exceed that of propping the basement.

Both in regard to categories (*b*), (*c*) and (*d*), there is likely to be a very large amount of repetition work. For example, the houses in one street and possibly in several streets, will be almost precisely similar, and having designed a solution for one house, it will only be necessary to check up measurements, etc., to see that there are no serious differences. The work which may be expected from the consultant in connection with (*c*) and (*d*) will be similar to that in category (*a*).

Category (*e*). The problem in this case, will vary with almost every block of tenements flats. It may, for example, take the form of building structures in the courtyards which have a peace-time purpose, such as bicycle sheds, playrooms, etc., which can be constructed so as to form refuges against Air Raids. Again, it may take the form of covered underground passages under the courtyards between blocks. As a last resort, it might take the form of evacuating certain rooms in each block and strengthening them to form refuges. These are only three suggestions and the local authorities may call for professional aid to design and carry out the work, within the limits of the Government policy.

Public Shelters.—The local authorities have been given instructions for guidance in the matter of selecting suitable basements, etc., for conversion into public refuges and have also been given instructions as to the number of people to be provided for. The provision of public shelters, may, however, take several forms, such as the adaptation of Railway Arches, digging of trenches, special provision in or under new structures, etc., and local authorities may call for professional assistance in the preparation of schemes and the consultants will have to give the same services as in the case of private shelters.

It is hoped to prepare certain type designs for strutting larger basements for use as public shelters, but in the majority of instances, each case will have to be considered on its merits and designed accordingly.

(B) PROFESSIONAL ADVISORY COMMITTEE (SHELTERS)

With reference to paragraph 12 of A.R.P. Department Circular No. 91/1939, Regional Professional Committees have now been established at the addresses shown in the following list.

For the counties of London, Middlesex, Essex, Hertford, Surrey, and Kent, the Professional Advisory Committee (Shelters), whose office is at The Home Office, A.R.P. Department, Cleland House, Page Street, Westminster, will perform the function referred to in the Circular.

Headquarters	Area Covered	Secretary and Address
NEWCASTLE Tel. Newcastle 28211	Northumberland Durham Cumberland Westmorland	Mr. A. CHEYNE, Assoc.M.Inst.C.E., County Surveyor's Office, County Hall, Newcastle-upon-Tyne 1.

surveys and designs. To advise and assist the local authorities, generally, in these matters, Regional Technical Advisers, under the Chief Engineering Adviser to the Home Office, have been appointed, and the local bodies have been authorized to engage additional technical staffs without further reference to the Department.

It was realized that yet further assistance would be required in the making of surveys and in the supervision of work, and, accordingly, arrangements were made for this help to be given by the Institution of Civil Engineers, the Royal Institute of British Architects, the Institutions of Structural Engineers, of Chartered Surveyors, and the Municipal and County Engineers. It was pointed out that applications for additional assistance were to be made by the local authorities to these Institutions, and a general indication of the work which members might be called upon to carry out was given in an Appendix to the Circular (91/1939)—reproduced in the margin.

(B) A further Circular (110/1939) on this matter was addressed to the local authorities concerned on May 22, giving among other things the addresses of the Regional Technical Advisers and also the addresses of the Secretaries of the Professional Advisory Committees. These Committees had been set up jointly by the Professional Institutions. The appendix to Circular 110/1939 containing the names and addresses of the Secretaries of the Professional Committees is reproduced in the margin.

EXPERT ADVICE (*continued*)

TEXT OF HOME OFFICE CIRCULAR

Headquarters	Area Covered	Secretary and Address
LEEDS	Yorkshire	Mr. NORVAL R. PAXTON, 33, Prudential Buildings, Park Row, Leeds.
MANCHESTER (Manchester and Liverpool Committee) Tel Blackfriars 9404	Lancashire Cheshire Anglesey Caernarvon Flint Denbigh Merioneth Montgomery Radnor	Mr. S. A. GRADWELL, F.C.A., Hollins Chambers, 64A, Bridge Street, Manchester.
BIRMINGHAM Tel. Kings Norton 1174	Warwick Stafford Shropshire Worcester Hereford.	Mr. S. J. DAVIES, Assoc.M.Inst.C.E., P.W.D., Dell Road, Cotteridge, Birmingham 30.
NOTTINGHAM	Nottingham Derby Leicester Northampton Lincoln Rutland	Mr. R. A. L. BEENEY, Assoc.M.Inst.C.E., City Engineer's Office, Guildhall, Nottingham.
NORWICH Tel. March 3232	Norfolk Suffolk Cambridge Bedford Huntingdon	Major R. G. CLARK, O.B.E., M.Inst.C.E., Middle Level Drainage & Navigation, Middle Level Offices, March, Cambs.
BRISTOL	Gloucester Wiltshire Somerset Dorset Devon Cornwall	Mr. N. L. WEBBER, 63, Queen Square, Bristol.
CARDIFF Tel. Cardiff 4690	Cardigan Carmarthen Pembroke Glamorgan Brecknock Monmouth	Mr. IVOR P. JONES, A.R.I.B.A., 6 & 7, St. John's Square, Cardiff.
READING	Buckingham Oxford Berkshire	Mr. A. S. PARSONS, M.Inst.C.E., Borough Engineer's Office, Town Hall, Reading.
SOUTHAMPTON Tel. Southampton 4241 (Ext. 793)	Hampshire Sussex	Mr. G. A. ASHWELL, Dock Engineer's Office, Herbert Walker Avenue, Southampton Docks.
EDINBURGH	East Scotland	Mr. W. F. LANDLES, The City Chambers, High Street, Edinburgh.
GLASGOW Tel. Douglas 2459	West Scotland	Mr. R. H. SHARPE, M.I.Struct.E., 65, Bath Street, Glasgow, C.2.

(C) MEMORANDUM FROM THE PROFESSIONAL ADVISORY COMMITTEE (SHELTERS)

Scale of Fees for Consultants

The Professional Advisory Committee (Shelters), representing the Royal Institute of British Architects, the Institution of Civil Engineers, the Institution of Structural Engineers, the Institution of Municipal and County Engineers, and the Chartered Surveyors' Institute, have drawn up the attached scale of fees to consultants for work which they may be called upon to do for Local Authorities in the execution of the Government's Air Raid Shelter Policy as set forth in A.R.P. Department Circular No. 91/1939.

(C) The scale of fees to professional advisers was also set out, and local authorities were empowered without special reference to the Department to engage consultants provided that the scale fees were not exceeded. The scale is reproduced without comment.

EXPERT ADVICE (*continued*)

TEXT OF HOME OFFICE CIRCULAR

The Committee have approved of this scale on behalf of the Institutions they represent and recommend it for adoption by the members of the Institutions and by Local Authorities. While they consider that this scale is generally suitable for the work described, they understand that the scale of fees actually paid in each instance will be a matter of arrangement between the Local Authority and the consultant employed, and that in exceptional cases and for work falling outside the scope indicated, special fees may have to be settled.

SCALE OF FEES

This memorandum relates only to the classes of work set out in Appendix IV* of A.R.P. Department Circular 91/1939. The scales are generally recommended for adoption, but in exceptional cases Local Authorities must make their own arrangements.

Private Shelters, Class " b "—those houses which have no gardens or yards, but which have basements.

(I) To examine the building, ascertain if it is suitable for propping, and submit a report with such information as may be necessary to support the conclusions reached.

Fee : 5s. 0d. per basement for 20 or more basements.

(II) To select a suitable room for a refuge and measure it up and prepare :—

(*a*) A list of the materials required, in accordance with the standard design for propping.

(*b*) To design the footings for the props.

(*c*) To design the alternative exits.

(*d*) To prepare estimates of the cost.

(*e*) To submit designs and estimates to the Local Authorities.

Fee : 21s. 0d. per house for not less than 50 houses.

(*f*) After the approval of the Local Authorities, to arrange contracts for the execution of the work.

(*g*) To supervise the work.

(*h*) To scrutinize and pass the bills for the work done.

Fee : To be 10s. 6d. per house for not less than 50 houses.

NOTE.—These figures are based on the assumption that there will be a considerable amount of repetition work.

Private Shelters, Class " c "—those houses in Class " b " which, having basements, are yet unsuitable for propping.

Private Shelters, Class " d "—those which have no basements and no gardens.

Where possible, the same rates to apply as for Class " b," but, as it is recognized that this work may greatly vary, the rates suggested are to be varied by agreement.

Private Shelters, Class " e "—Tenement flats.

The fee to be 5 per cent. on the cost of the work.

(See explanatory note below.)

Public Shelters.

The fee to be 5 per cent. on the cost of the work.

(See explanatory note below.)

This fee to apply whether the work consists in the adaptation of existing structures or is in the form of entirely new construction.

EXPLANATORY NOTE

It is intended that the fee of 5 per cent. on the cost of the work is to be paid for all work which in total amounts to a sum of £2,000 or more. The fee is to cover all expenses incurred in designing the work and superintending its construction, but it does not include the cost of taking out quantities or the remuneration of the outdoor staff engaged upon the actual construction.

For works costing less than a total of £2,000 in value, the percentage is to be arranged by agreement locally.

In the event of the repetition of type units, for which no further drawings are required, the fee shall be 1¼ per cent. on the cost of such repeated units, increased by 1 per cent. if supervision is involved.

The inclusive charge for Quantity Surveyor's work, if any, is to be 1¾ per cent. on the cost of the work.

* Reproduced on p. 1014

These circulars 91/1939 and 110/1939 refer only to work done for public authorities. There are no fees set out for professional advice in connection with shelters for employees as required by the Civil Defence Act nor for private shelters, as, for instance, for houses and flats. It may be assumed, however, that the fees for such work would be according to the normal fees for professional advice or to those set out for buildings of Class (e) in the margin on page 1015.

APPENDIX IX

RELEVANT PUBLICATIONS

	s.	d.
• **Air Raid Precautions Act, 1937. (1 and 2 Geo. 6. Ch. 6.) H.M.S.O.** *See p.* 901	0	3
• **Civil Defence Bill (as amended in Committee) (Bill 150). H.M.S.O.** *See p.* 902	1	6
• **Air Raid Shelters for Persons Working in Factories and Commercial Buildings—Draft of Provision Code. H.M.S.O.** *See p.* 925	0	6
• **Civil Defence Bill—Provisional List of Areas to which Part III of the Bill is proposed to be Applied. H.M.S.O.** *See p.* 906	0	2
• **Circular 91/1939. Provision of Air Raid Shelter. H.M.S.O.** *See p.* 1014	0	2
• **Circular 110/1939. Provision of Air Raid Shelter. H.M.S.O.** *See p.* 1015	0	2
• **Directions for the Erection of Domestic Surface Shelters. H.M.S.O.** *See p.* 999	0	2
• **Pamphlet on Shelter from Air Attack. H.M.S.O.** *See p.* 1006	0	2

RELEVANT PUBLICATIONS (*continued*)

	s. d.
• **Pamphlet on Garden Trenches. H.M.S.O.** ..	0 1
• **Specifications, etc., in Regard to Permanent Lining of Trenches. H.M.S.O.** *See p.* 962 ..	0 4
• **War time Lighting Restrictions for Industrial and Commercial Premises. H.M.S.O.** *See p.* 1007	0 2

HANDBOOKS:

	s. d.
• **No. 1. Personal Protection against Gas. H.M.S.O.**	0 6
• **No. 2. First Aid and Nursing for Gas Casualties. H.M.S.O.**	0 4
• **No. 3. Medical Treatment for Gas Casualties. H.M.S.O.**	0 6
• **No. 4. Decontamination of Materials. H.M.S.O.**	0 6
• **No. 6. Air Raid Precautions in Factories and Business Premises. H.M.S.O.** *See p.* 980 ..	0 6
• **No. 7. Anti-gas Precautions for Merchant Shipping. H.M.S.O.**	0 3
• **No. 8. Duties of Air Raid Wardens. H.M.S.O.** ..	0 2
• **No. 9. Incendiary Bombs and Fire Precautions. H.M.S.O.** *See p.* 1002	0 6

MEMORANDA:

	s. d.
• **No. 1. Organization of Air Raid Casualty Services. H.M.S.O.**	0 6
• **No. 2. Rescue Parties and Clearance of Debris. H.M.S.O.**	0 2
• **No. 3. Organization of Decontamination Services. H.M.S.O.**	0 2
• **No. 4. Organization of the Air Raid Wardens' Services. H.M.S.O.**	0 2
• **No. 5. Anti-gas Training. H.M.S.O.**	0 4
• **No. 6. Local Communications and Reporting of Air Raid Damage. H.M.S.O.**	0 4
• **No. 7. Personnel Requirements for Air Raid General and Fire Precautions Services, and the Police Service. H.M.S.O.**	0 2
• **No. 8. The Air Raid Warning System. H.M.S.O.** ..	0 3
• **No. 9. Notes on Training and Exercises. H.M.S.O.**	0 2
• **No. 10. Provision of Air Raid Shelters in Basements. H.M.S.O.** *See p.* 984	0 4
• **"Emergency Medical Service Memorandum No. 1. Structural and other Precautions against Air Raid Risks in Hospitals." H.M.S.O.** *See p.* 1012	0 3

The extracts and illustrations from official publications which have been used in both Part 1 and Part 2 of this analysis have been reproduced by permission of the Comptroller of H.M. Stationery Office.

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