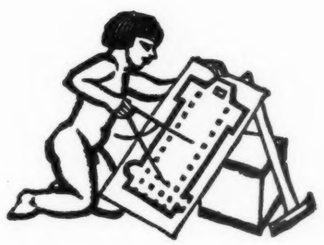
# FALLING WATER

*A photograph of Frank Lloyd Wright's house on Bear Run, Pennsylvania, on view at the Exhibition of American Art, 1609-1938, now being held in the Jeu de Paume Museum, Paris.*

# AIR RAID SHELTER

*Detail and equipment of a surface shelter in reinforced concrete near London.*



# THE A.A.S.T.A. REPORT

THE phrase Air Raid Precautions has now come to mean almost anything. To one or other of a random collection of the country's inhabitants it is a symbol of moral bankruptcy, a system of training in the use of questionable gas masks, a method of resisting aggression, a new strain upon local finances. To architects A.R.P. has so far stood for one or more of these things and for them alone. And in their professional life there has been no need for it to stand for anything at all.

In the last month the situation has changed. The Home Secretary has asked for the co-operation of the profession in the execution of such precautions as the Government think expedient and practicable. There is no obligation upon the profession to accept this invitation. But if architects take their social responsibilities at all seriously it does seem to place upon them a duty of inquiring into the facts, the technical facts, with all the calmness they can muster.

In their architectural aspects A.R.P. appear to fall into three categories: smaller questions of protecting existing buildings; the construction of new shelters of all kinds and sizes; and the greatest questions of evacuation and accommodation and services for the evacuated.

Before considering any of these, architects must inform themselves of the effects of aerial bombardment as they are known or presumed. Only after doing this with thoroughness can their opinion be of weight upon what precautions should be carried out and in what order. Let there be no mistake—the profession as a whole must make up its mind upon matters as large as these; and when it has done so, make its decisions public.

It is to help architects to get to know the facts as so far ascertained that the JOURNAL publishes the Report of the A.A.S.T.A. in this issue. This Report contains the results of an enquiry made during the past year by a committee of architects, engineers and quantity surveyors.

It is an inquiry which, although other professions and manufacturers freely collaborated in it, was organized and carried through by architects. It is the kind of careful summary of information upon a problem of great national importance which the profession might do more often.

The Committee's attitude towards their subject is reasonable and realistic. Civilian populations can be passively protected against aerial attack either by evacuation or by shelters adjoining their places of work or residence. The present report considers only the latter alternative.

After summarizing the known or presumed effects of different bomb types, the Report describes the methods recommended by various European Governments for securing different degrees of protection. These methods are of three types: shelters in buildings, surface shelters (including trenches) and tunnel shelters.

The Report illustrates the planning and construction of shelters of all three types and their probable degrees of protection. But it does more than this. It provides an approximate answer, in terms of normal building organization, to the question of how much protection the citizen can expect for a pound. It is in this that the greatest importance of the enquiry lies.

Public opinion has come to accept the view that complete protection of the civilian population cannot be obtained, both for reasons of direct cost and the enormous dislocation of ordinary civilized life which the provision of shelters would necessitate. The suggestions contained in this issue are necessarily tentative; but they give some cause for supposing that complete protection would be neither so costly nor difficult as has so far been supposed.

Tunnel shelters are admitted to have every advantage save ease of access and low cost. And this Report makes it appear that both these drawbacks have been over-estimated. In the words of Professor Haldane in his foreword: "The fundamental conclusion of this report is that fully bomb-proof shelters for Londoners would cost £11 per head. . . If the figure is anywhere near right it disposes of the argument that adequate protection for civilians would bankrupt the country."

These aspects of the A.A.S.T.A. Report may be of national value. For architects there are two other points of importance about this issue.

It explains the structural and planning problems involved in air raid shelters of all kinds. And it suggests that when new planning problems of a more constructive kind come before architects, the profession collectively might do at least what has been done here. It is an odd commentary on a large and intelligent profession that the slum campaign, ribbon development, trading estates and the rest have not produced any study of the problems involved such as is now produced on Air Raid Precautions by an organization only partially architectural.

*The Architects' Journal*
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# NOTES & TOPICS

### SIR JOHN BURNET

SIR John Burnet, who died on Sunday, was the son of an architect (John 'Glasgow Stock-Exchange' Burnet) who took him into partnership after he had served his Beaux Arts pupilage with Jean Louis Pascal, thereby continuing the Scots-French cultural tradition.

*

The son inherited a big practice from the father, which he proceeded to turn into the biggest in the British Isles. Not since the Adam Brothers has there been a Scottish firm of like fame and ubiquity. As a firm, in fact, B., T. & L. has certain affinities with the Adam menage. It has always been rather bigger, rather more efficient, rather more active, rather more American than any other contemporary partnership—and who could have been more American than the great Robert?

*

Furthermore—again like Robert—the firm has always had a line of its own, a line so individual that it has been widely copied; yet, unlike some others, it has always succeeded in escaping from its own idioms when they became vulgarized by stylization. Which is the more remarkable, the partnership's standardization of methods or its freedom from the standardization of thought of which such methods are generally the product, one hesitates to say. The distance between Charing Cross Mansions, Glasgow (1901) and the Edward VII wing at the British Museum is no greater than the distance between Adelaide House and the Glasgow Exhibition, yet all have come from the same office.

### TAIT AND LORNE

Whether from the same partner is another matter. This generation's interest in B., T. & L. starts with the Kodak building and ends to date in Glasgow, the period of T. S. Tait and Francis Lorne. Sir John's early Scottish period is almost entirely forgotten, yet the output even then was prodigious. The curious thing is that this the most "modern" office in the country must also be the oldest. I don't know when Sir John's father started in practice, but he was born in 1814, and if he was an architect at 25 the firm's hundredth birthday should be celebrated next year. Can anybody beat that?

### THE OFFICIAL ASSISTANT ARCHITECT

The A.A.S.T.A. has published a vigorous booklet about the position of architectural assistants in public offices. It is called a Charter, and its summary of the present position is badly needed.

*

A good many members of the profession may wince at the title to the second page, "The Status of Architecture as a Profession must be Recognised," and wince is just what the profession ought to do. For in public departments it is *not* recognised, and as long as architects collectively continue to pretend that the method by which the individual architect earns his living is purely his own concern, it never will be.

*

Excuses can be put up for the way in which present architectural conditions arose in public offices—the tremendous extension of local authorities' activities, the acquisition of an assistant or two who were embodied in the Engineer's Department, and so on. But the continuance of these conditions is quite another thing.

*

In the near future all architects will pass the same exams. and have the same qualifications. In the eyes of local authorities a man's opinion is worth taking and his work valuable in direct ratio to the salary he receives and the responsibility he possesses. Bluntly, if a man gets £750 a year and is responsible direct to the Council, both he and the services of the profession he represents are important. If he gets £200 a year, temporarily, for doing (so far as the Council know) some odd jobs for the Deputy Borough Engineer, he is not important and neither is the profession of which he is a member.

*

There is no getting away from this. As regards work for local authorities official and private architects stand or fall together, and the sooner they all realise it the better.

### THE MALCONTENTS

Some months ago the announcement was published in this column that the Villa Malcontenta, Venice, had been turned into a residential club. This famous house, designed by Palladio in 1555, was rescued by Mr. Landsberg, its present owner, from the decay which threatened eventually to destroy it.

*

I have now received some further information about the club. Life membership is ten guineas, annual membership three guineas. Daily board varies according to season from 15s. to 30s., and includes all meals and drinks (of Italian origin).

*

You are advised to establish a near relationship with anyone who goes with you, for non-near-relations (not being members) are charged an extra 10s. a day. You also have to pay extra for the use of the State bedroom.

*

Mr. Landsberg has some charming Dalmatian dogs, a blue parrot, and a secretary called Miss Miller who will let you have all particulars about the place.

*Charing Cross Mansions, Glasgow.*

There is a rumour that Cambridge University are to lease the Palazzo for a month every summer as a "study centre." It seems to me that the British School at Rome might well do the same, or even the R.I.B.A. The villa's situation, within easy reach of Venice, Verona and Ravenna, makes it an unrivalled centre for the architectural student.

MODERN SILVERWORK

One can be forgiven for feeling a certain amount of apprehension about an exhibition of modern silverwork, seeing that in all the recent design in industry exhibitions the silverwork has been without doubt the weakest section, showing either the conventional and usually vulgar ornateness of the familiar sporting trophy or a peculiarly seedy variety of mannered "modernism."

*

The current exhibition in Goldsmiths' Hall does, however, contain some examples of honest modern design even if these are submerged by too large a quantity of the other sort of thing, and in any case the average standard is on the rise.

*

The important thing about this exhibition is that someone is doing something about modern silverwork. It is no good just waiting for design to improve, and the Goldsmiths' Company have accepted their traditional responsibilities and sponsored an exhibition in their own hall.

*

The technique of display is also notable. Quite rightly Mr. Howard Robertson, who has designed the display, has made no attempt to compete with Philip Hardwick's noble interior, but has provided instead a range of solid fronted white-painted showcases, containing the exhibits in illuminated pigeon-holes, which stand out from the walls in the form of furniture rather than architecture.

ARCHITECTS AND DEMOCRACY

Stirring things were said when Lord Allen of Hurtwood opened the annual exhibition of the Liverpool School of Architecture and Civic Design in the Walker Art Gallery last week. The Vice-Chancellor, Dr. A. D. McNair, said that Liverpool was particularly concerned with the *social purposes* of architecture. Lord Allen followed this up by saying that the school was training architects who were also "amenity doctors" who could restore the health of town and countryside.

*

"We must begin at the bottom," said Lord Allen, "and concern ourselves with the character of individual citizens. . . . . This means watching over the environment of childhood and adolescence. It means that British democrats must live in towns and villages which nourish leisure and work."

*

Hear, hear. This sounds refreshingly like the A.A. philosophy of bygone days.

*

Lord Allen wanted to know "why we must endure these unrelenting rows of villas, with no cultural centre to stir civic pride and give us the chance of a neighbourly life." The nation, he said, should advertise its democracy, and its achievements with as much vigour as was shown by dictatorships abroad on Left and Right. A very good idea—when we've got the achievements to advertise.

YOUNG WOODLEY, A.R.I.B.A.

From among the boys of Blundells School have been found masons, plasterers, carpenters, draughtsmen, stone-carvers and architects. They have undertaken, according to a newspaper report, to carry out considerable architectural alterations to the school chapel, including the removal of some marble pillars "of doubtful taste and purpose."

*

The work is done out of school hours, and the only outside assistance has been given by Mr. Eric Gill, "who will himself design the outline of the new altar."

SUBURBAN CRACK

An embittered Hammersmith resident has joined in the correspondence in the local paper concerning suitable inscriptions for the new Town Hall. His suggestions are (for the foundation stone), "In for a penny in for £7,000," flanked by "Up the Rates" and "Down the Rate-payers."

PORTENT

I hear from a Bristol architect that as he returned homewards past the Victoria Rooms, Bristol, two hours after the end of the Conference Banquet he saw through the open doors a strange scene.

*

Three ancient charladies were standing in the hall staring down in quiet dismay at a dead cat.

*

Both my correspondent and I feel that this must be richly symbolical of something.

ASTRAGAL

# NEWS

## POINTS FROM THIS ISSUE



## THE ARCHITECTS' DIARY

**Tuesday, July 7**
ROYAL INSTITUTE OF BRITISH ARCHITECTS. *Exhibition of Final Competition Designs submitted for the Rome Scholarship in Architecture. 66 Portland Place, W.1, between 10 a.m. and 8 p.m. (Saturday, 10 a.m. and 5 p.m.). Until July 9.*

**Monday, July 11**
ROYAL SANITARY INSTITUTE. *Health Congress. Portsmouth.*

**Thursday, July 14**
A.A.S.T.A. PUBLIC MEETING. *Discussion on the position of assistants in Public Offices. Speakers: R. D. Manning and R. C. Fisher. Caxton Hall, Westminster, at 6.15 p.m.*

**Sunday, July 17**
ASSOCIATION OF ARCHITECTS, SURVEYORS AND TECHNICAL ASSISTANTS. *Summer Tour to Copenhagen, Stockholm and Gothenburg. Until July 29.*

**Thursday, July 21**
LONDON SOCIETY. *Annual River Trip. To Henley.*

**Friday, July 22**
ARCHITECTURAL ASSOCIATION. *Annual Prize Day. Speech by the Director, Mr. Goodhart-Rendel, and a criticism, with lantern slides, of the prize-winners' work, by Mr. Fernand Billerey. Exhibition of students' work to be opened by Viscount Samuel, 8 p.m.*

**Sunday, September 4**
ARCHITECTURAL ASSOCIATION. *Annual Excursion. To Holland. Until September 13.*

### *ROME SCHOLARSHIP IN ARCHITECTURE, 1938*

The Faculty of Architecture of the British School at Rome have awarded the Rome Scholarship in Architecture for 1938 to Mr. Alexander Buchan Wylie (Student R.I.B.A.) of the School of Architecture, Edinburgh College of Art.

Mr. Wylie, who is 24 years of age, was born in Nyasaland, and was educated at George Watson's College, Edinburgh. In 1933 he entered the School of Architecture, Edinburgh College of Art, and in June, 1938, he was awarded the School Diploma. In 1936 he won the R.I.B.A. Tite Prize.

An exhibition of the competition designs will be held at the Royal Institute of British Architects, 66 Portland Place, London, W.1, until July 9, between the hours of 10 a.m. and 8 p.m. (Saturday, 10 a.m. and 5 p.m.).

The winning design is illustrated on the two following pages.

### *NATIONAL PARKS*

The Standing Committee on National Parks of the Councils for the Preservation of Rural England and Wales have issued a statement emphasizing the value of National Parks and suggesting that certain areas of unspoilt country should be strictly preserved and run as National Parks.

The Committee's policy is, in general, that recommended by the Government Committee in 1931. It is that the Government should declare that National Parks on an adequate scale will be established as a national service; that two National Park Commissions (one for England and Wales and one for Scotland) should be set up, together with a co-ordinating Joint Committee; and that sufficient funds should be supplied.

It has been suggested that a full use of their Town and Country Planning powers by the local authorities in National Park areas should be adequate to secure their preservation as National Parks. The Standing Committee is convinced that this is untrue: they consider that local authority planning has proved, in the years since 1931, quite insufficient to protect National Park areas, and is quite inadequate to secure and maintain National Parks for the following principal reasons: National Park areas are, of their nature, areas of the lowest rateable value and therefore of the financially poorest local authorities; a sufficient prohibition or restriction of building operations cannot be imposed without compensation, which the local authorities are too poor even to risk having to pay; many of the most serious threats to National Park areas—from mining and quarrying, commercial afforestation, water-catchment and water-power schemes, Army and Air Force establishments, overhead cable lines, road development, etc.—fall outside the control of the Town and Country Planning Act.


The functions of the proposed National Park Commissions would be to select the Park Areas, to advise local authorities, to allocate grants, to manage the Parks and to interest the public in the use and maintenance of the areas.

The accompanying map shows the areas which the Committee suggest should be scheduled as National Parks.

### *NEW COMPETITION*

The Finance Committee of Cardiff Corporation has approved of the construction of a building for the Air Raid Precautions Department, at a cost of £70,000 to £80,000. The building will be the subject of an architectural competition with premiums of £500, £300 and £200. The scheme will include a bomb-proof shelter.

### *OBITUARY*

THE JOURNAL regrets to announce the death, at the age of 80, of Sir John Burnet, R.A., of the firm of Sir John Burnet, Tait and Lorne.

To architects Sir John Burnet's greatest qualities were his recognition of the limits of the individual in modern architectural practice on a large scale and his ability to move with the times. Through these qualities he built up a firm which is one of the most efficient in this country, as well as one whose work has a sustained high standard.

Born in 1857, the son of a well-known architect, John James Burnet studied at the Ecole des Beaux Arts, and began his career in Glasgow in partnership with his father.

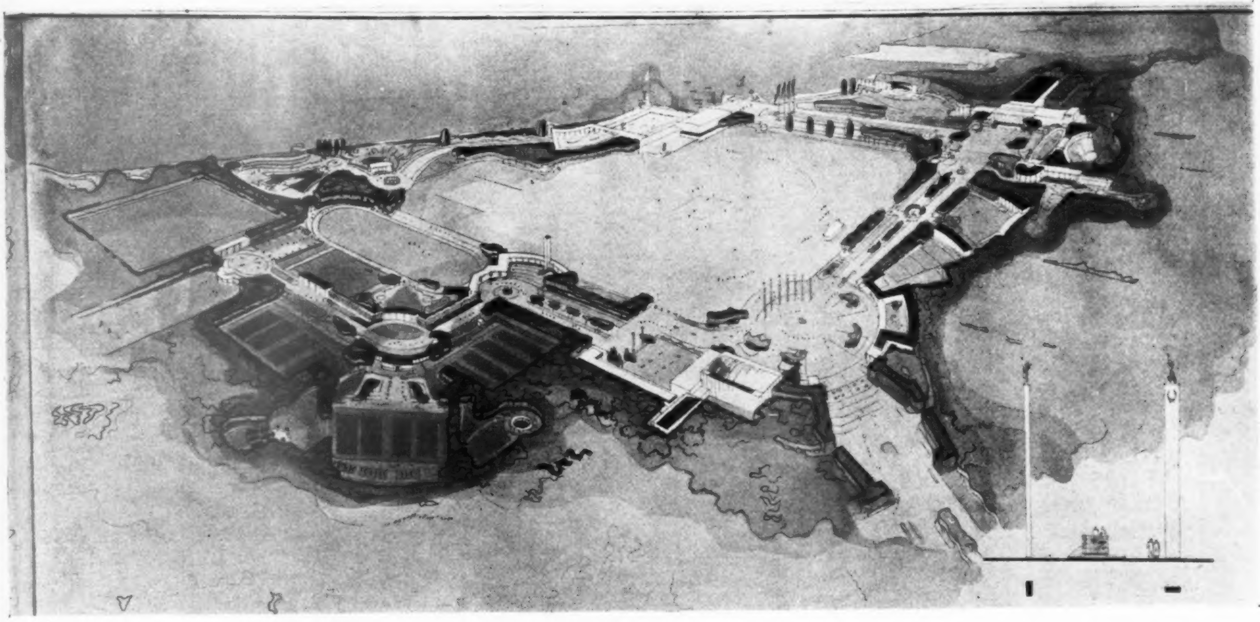
Two of his earliest buildings were the Glasgow Institute of Fine Arts and the Edinburgh International Exhibition, and from then on he designed most of the important work in Glasgow.

One of his first important works in London were the King Edward VII Memorial Galleries in the British Museum, and Adelaide House immediately after the war was one of the earliest and most discussed of the large office blocks. Other buildings in London were the Kodak Building in Kingsway, the General Accident and Life Assurance Company's building in Aldwych, Vigo House in Regent Street, and the extension to Selfridge's. The range of Sir John's practice, which was tremendous, included also war memorials, churches, hospitals, and many other types of work.

For some years Sir John had taken no active part in practice, but his talent for recognising ability in his assistants and his practice of giving these younger men increasing responsibility and acknowledgment, had transformed his firm before his retirement into a group of partners working under his general supervision. And this partnership, by carrying much of the most important work of the last ten years, and the high standard of all its work, forms the greatest evidence of Sir John Burnet's powers as an architect.

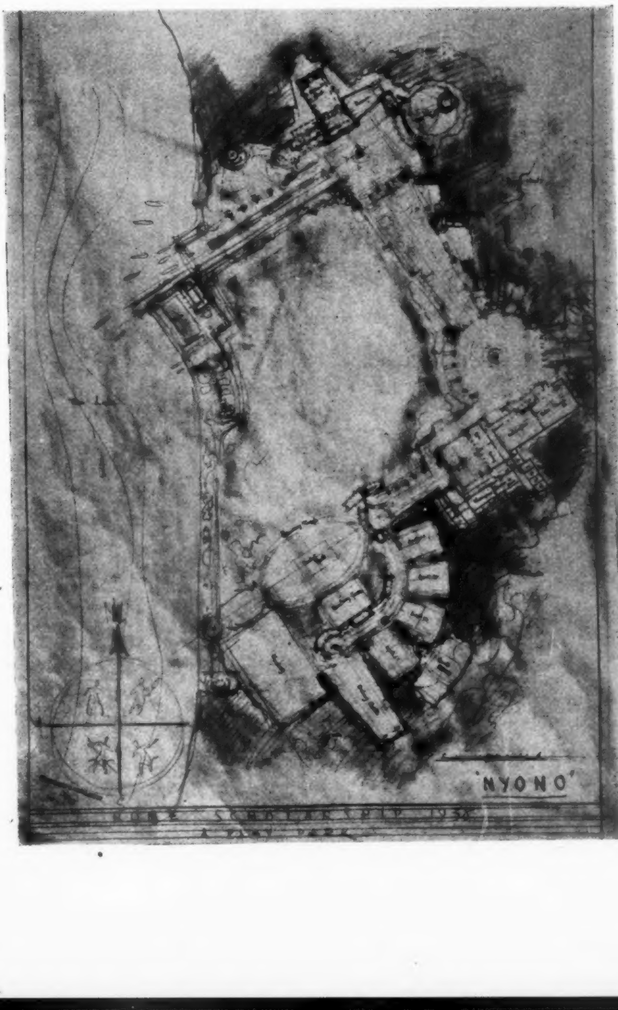
Sir John Burnet was a gold medallist of the French Salon; he was elected an A.R.A. in 1921 and an R.A. in 1925, and was a LL.D. of Glasgow University. He was knighted in 1914, and was a Royal Gold Medallist of the R.I.B.A.

# THE ROME SCHOLARSHIP



## WINNING DESIGN: A PLAY PARK

*BY A. G. WYLIE*

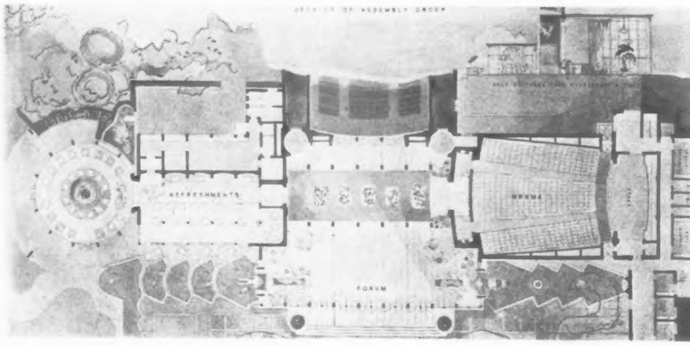



*The subject of the competition for this year's Rome Scholarship in Architecture was a Play Park providing a wide choice of recreations for persons of all ages.*
*The site is on the eastern shore of a large fresh-water lake, in the form of a clearing 500 yards long and 200 deep in a landscape of pine trees and heather.*
*The accommodation required covered almost every form of recreation, together with offices, restaurants and housing for staff.*
*Above is a perspective drawing of the winning design and on the right is the winner's preliminary esquisse.*

# THE ROME SCHOLARSHIP

## WINNING DESIGN: A PLAY PARK

*BY A. G. WYLIE*




*Above, the plan of the assembly hall group of the winning design. Left, the general layout plan.*

## The Architects' Journal Library of Planned Information

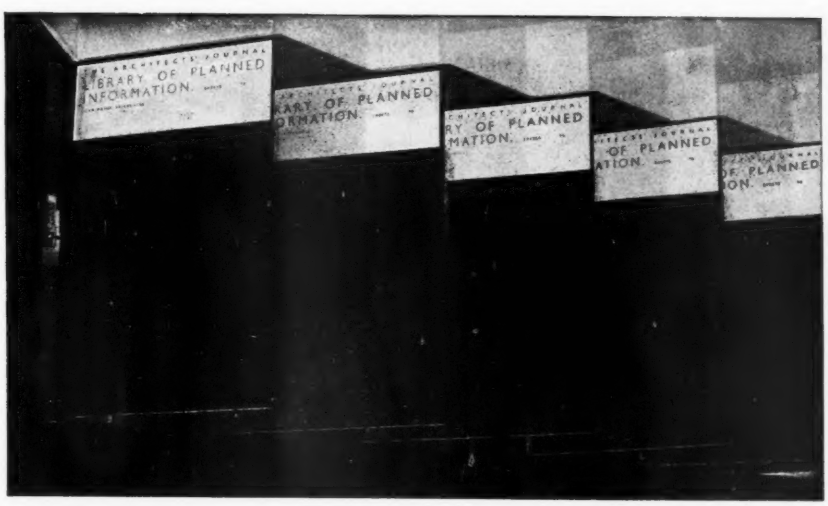
# INFORMATION SHEET

# SUPPLEMENT

## SHEETS IN THIS ISSUE

**641** Sliding Gear

**642** Glazing



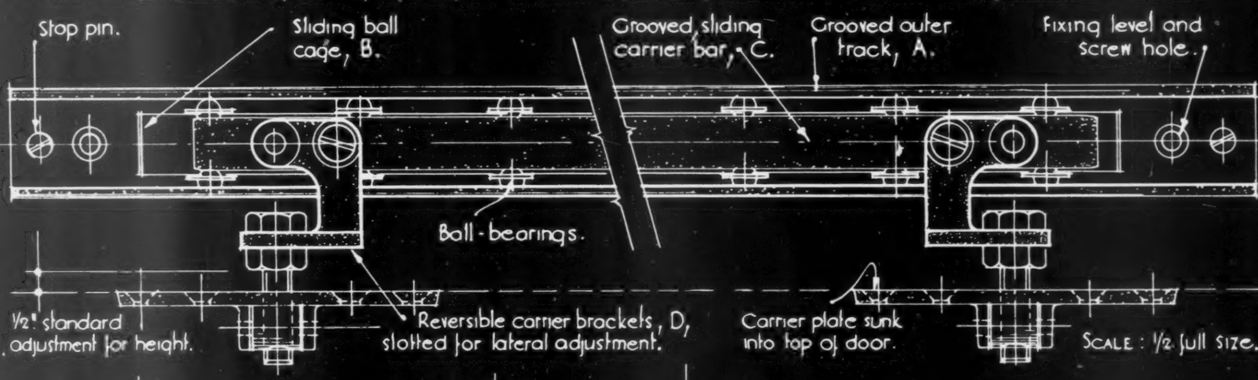
*In order that readers may preserve their Information Sheets, specially designed loose-leaf binders are available similar to those here illustrated. The covers are of stiff board bound in "Rexine" with patent binding clip. Price 2s. 6d. each post free.*

Sheets issued since Index :

807.

THE ARCHITECTS JOURNAL LIBRARY OF PLANNED INFORMATION

DETAILS OF •PERKEO• BALL-BEARING SLIDING GEAR FOR SINGLE, DOUBLE, & PASSING INTERIOR DOORS.
All tracks are for face fixing, but may be adapted for ceiling fixing by bolting to angle brackets placed at intervals.




SCALE: 1/2 full size.

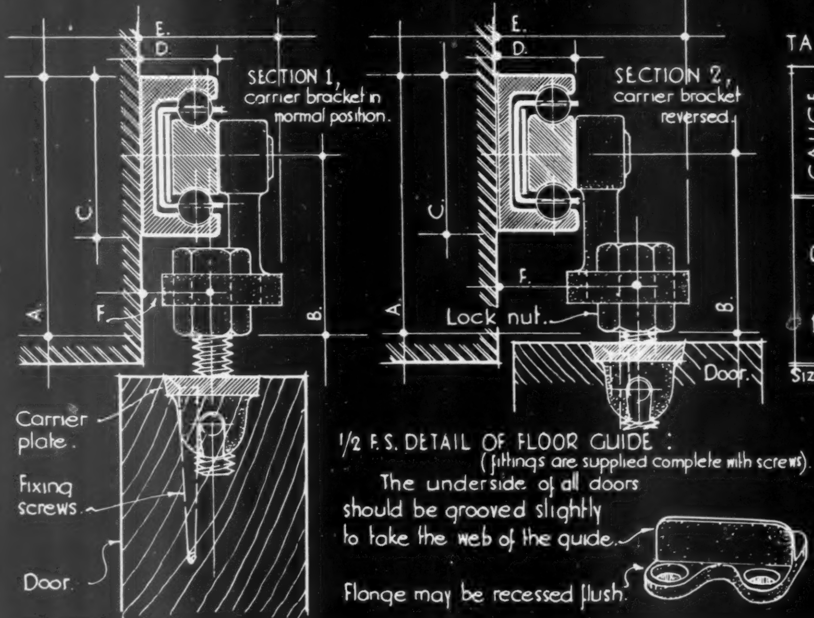



TABLE GIVING SIZES AND CLEARANCES.

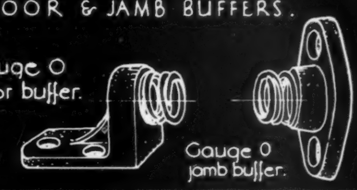
| GAUGE | A. | B. | C. | D. | CARRIER BRACKET. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | SECTION 1. | | | SECTION 2. | | |
| | | | | | E. | F. from | F. to | E. | F. from | F. to |
| 0. | 2 1/8. | 1 1/2. | 1 5/16. | 5/8. | 1 5/16. | 1/2. | 1. | 1 5/8. | 13/16. | 1 1/4. |
| 11. | 2 1/2. | 1 5/8. | 1 11/16. | 13/16. | 1 1/2. | 5/8. | 15/16. | 2 1/8. | 1 5/16. | 1 5/8. |

Sizes are approximate only, and are given in inches.

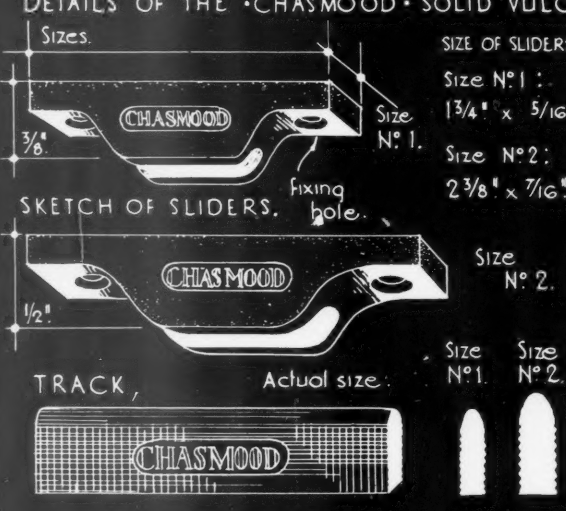
1/2 F.S. DETAIL OF FLOOR GUIDE: (fittings are supplied complete with screws).
The underside of all doors should be grooved slightly to take the web of the guide.

Flange may be recessed flush.

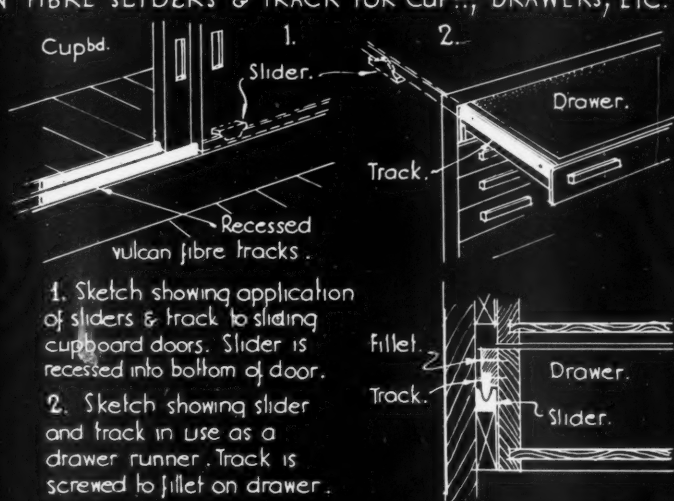
FLOOR & JAMB BUFFERS.




DETAILS OF THE •CHASMOOD• SOLID VULCAN FIBRE SLIDERS & TRACK FOR CUPBDS, DRAWERS, ETC.




SIZE OF SLIDERS.
Size No 1: 1 3/4" x 5/16".
Size No 2: 2 3/8" x 7/16".




1. Sketch showing application of sliders & track to sliding cupboard doors. Slider is recessed into bottom of door.
2. Sketch showing slider and track in use as a drawer runner. Track is screwed to fillet on drawer.

*Information from Charles P. Moody.*

INFORMATION SHEET: TYPES OF SLIDING GEAR FOR INTERIOR DOORS, DRAWERS, ETC.

SIR JOHN BURNET TAIT AND LORNE ARCHITECTS ONE MONTAGUE PLACE BEDFORD SQUARE LONDON WC1 • Oscar A. Bayne.

THE ARCHITECTS' JOURNAL
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# INFORMATION SHEET
# • 641 •
# SLIDING GEAR

Product : Perkeo Sliding Door Gear and Chasmood Sliders and Track

**General :**

This Sheet deals with the Perkeo silent and smooth running ball-bearing sliding gear for interior doors, and Chasmood solid vulcan fibre sliders and track for cupboard doors, drawers, etc.

**Perkeo Gear :**

This consists of four parts :—

A, Solid steel outer channel, grooved inside the top and bottom flanges.

B, Pressed steel sliding ball cage.

C, Solid steel carrier bar, also grooved top and bottom, corresponding with A.

D, Door carrier brackets.

The carrier bar C runs freely between the chrome steel balls in the top and bottom grooved track of A and C, being retained in position by the ball cage B, this principle giving absolute freedom from wear and jamming, perfect silence and exceptionally smooth action. Strong brackets are bolted to the carrier bar ; these are reversible and slotted for lateral adjustment. The height of the door can be varied after fixing by screwing the carrier bolts up or down into the carrier plate which is fixed to the top of the door. Incorporated in these plates is a patent device which ensures the door hanging plumb.

**Fixing :**

All sets are face fixing, but adaption for ceiling fixing can be made by bolting the track to angle brackets placed at intervals.

For double doors two ordinary sets are required.

For passing doors two sets are required ; one set is fixed above the other, the upper set being provided with cranked brackets to allow necessary clearance.

**Fittings :**

All sets are complete with floor and jamb buffers, floor guide and screws. The guide is screwed to the floor (recessed if desirable) at the foot of the door frame ; it is not visible at all. The bottom of the door is grooved to take the guide. When the door is open it rests on one half of the guide : when closed, on the other half. No bottom track is necessary or supplied, therefore the door opening is free from obstructions and dust traps.

**Finish :**

All gear is supplied ready for fixing in cadmium rustproof finish.

**Sizes :**

The gear is supplied in the following straight lengths only as table below. The length of the track is governed by the width of the door and cannot be varied.

**Prices :**

*Gauge 0*

| Size ... ... ... ... | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|
| Width of door ... ... | 1′ 6″—2′ 0″ | 2′ 0″—2′ 6″ | 2′ 6″—3′ 0″ | 3′ 0″—3′ 6″ | 3′ 6″—4′ 0″ |
| Length of track ... ... | 3′ 5″ | 4′ 5″ | 5′ 1″ | 5′ 11″ | 6′ 9″ |
| Carrying capacity ... ... | 105 lbs. | 125 lbs. | 145 lbs. | 165 lbs. | 185 lbs. |
| Price ... ... ... ... | 36/- | 40/- | 44/- | 48/- | 52/- |

*Gauge II*

| Size ... ... ... ... | 14 | 15* | 16* | 17* | 18* |
|---|---|---|---|---|---|
| Width of door ... ... | 4′ 0″—4′ 6″ | 4′ 6″—5′ 0″ | 5′ 0″—5′ 6″ | 5′ 6″—6′ 0″ | 6′ 0″—6′ 6″ |
| Length of track ... ... | 7′ 7″ | 8′ 7″ | 9′ 7″ | 10′ 5″ | 11′ 1″ |
| Carrying capacity ... ... | 240 lbs. | 260 lbs. | 280 lbs. | 300 lbs. | 320 lbs. |
| Price ... ... ... ... | 75/- | 85/- | 95/- | 105/- | 115/- |

* These sizes are fitted with three carrier brackets

The carrier brackets and gear will carry much greater loads than those given in the tables above, provided the wall fixings are adequate.

**Lighter Doors :**

Tracks for lighter doors are also available. The Renova gear, also ball-bearing, operates on much the same principle, is made in three sizes with carrying capacities ranging from 70 to 110 lbs., and is for doors from 2′ to 3′ 6″ wide.

A still lighter gear is the Dorma, also manufactured in three sizes, with an average carrying capacity of 112 lbs. : this gear is for doors from 1′ 6″ to 4′ 6″ wide. The Dorma gear consists of a heavy gauge steel track and two independent carrier brackets which run on ball races and can travel the full length of the track. In both types the carrier brackets provide for adjustment of the height of the door and the distance of the door from the wall. The prices of both types are considerably lower than the Perkeo.

**Chasmood Track and Slider :**

These fittings are for use with sliding cupboard doors, wardrobes, showcases, drawers, etc., and are manufactured from selected grades of solid vulcan fibre. Both sliders and tracks are hard wearing, smooth in action and noiseless. They are easily fixed and since they can be butt jointed at any point short lengths can be used to avoid waste.

(*a*) *Doors*.—The base of the door frame is grooved to take the track, which may be glued in if required, the slider being screwed into a groove cut in the underside of the door.

(*b*) *Drawers*.—The track is screwed to a wood fillet fixed along the top side of the drawer, with the half round part pointing downwards. The slider is fixed with the groove upwards, and is housed in another wood fillet attached to the side of the drawer framing. One slider only is required for each side.

**Sizes :**

Chasmood sliders and track are supplied in two sizes.

| *Sliders Size 1* | *Sliders Size 2* |
|---|---|
| $1\frac{3}{4}'' \times \frac{5}{16}'' \times \frac{3}{8}''$ | $2\frac{3}{8}'' \times \frac{7}{16}'' \times \frac{1}{2}''$ |
| *Track Size 1* | *Track Size 2* |
| $\frac{1}{2}'' \times \frac{3}{16}''$ | $\frac{9}{16}'' \times \frac{1}{4}''$ |

The track is obtainable only in lengths from 5′ 6″ to 6′ 6″.

**Prices :**

| *Sliders* | *Track* |
|---|---|
| No. 1 ... 36/- per gross. | No. 1 ... 31/3 per 100 ft. |
| No. 2 ... 48/- per gross. | No. 2 ... 43/9 per 100 ft. |

**Manufacturer :** Charles P. Moody

**Address :** 33, Finck Street, Upper Marsh, London, S.E.1

**Telephone :** Waterloo 6782

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## STANDARD LETTERING IN THERMOLUX GLASS :

For variations in technique see notes on the back of this Sheet.

STYLE OF ALPHABET : MODERN BLOCK : REF. Nº T. 1A.

ABCDEFGHIJKLM
NOPQRSTUVWXYZ

abcdefghijklm
nopqrstuvwxyz
& 1234567890

STYLE OF ALPHABET : MODERN BLOCK with interspaced outline: REF. Nº TOO. 1A.

ABCDEFGHIJKLM
NOPQRSTUVWXYZ

abcdefghijklm
nopqrstuvwxyz
& 1234567890

STYLE OF ALPHABET : MODERN BLOCK with shadowline: REF. Nº TOS. 1A.

ABCDEFGHIJKLM
NOPQRSTUVWXYZ

abcdefghijklm
nopqrstuvwxyz
& 1234567890

STYLE OF ALPHABET : MODERN BLOCK in borderline : REF. Nº TB. 1A.

ABCDEFGHIJKLM
NOPQRSTUVWXYZ

abcdefghijklm
nopqrstuvwxyz
& 1234567890

STYLE OF ALPHABET : DOUBLE-TRACK BLOCK : REF. Nº T. 6A.

ABCDEFGHIJKLM
NOPQRSTUVWXYZ

abcdefghijklm
nopqrstuvwxvz
& 1234567890

STYLE OF ALPHABET : MODERN FANCY BLOCK : REF. Nº T. 2A.

ABCDEFGHIJKLM
NOPQRSTUVWXYZ

abcdefghijklm
nopqrstuvwxyz
& 1234567890

STYLE OF ALPHABET : MODERN FANCY BLOCK in borderline : REF. Nº TB. 2A.

ABCDEFGHIJKLM
NOPQRSTUVWXYZ

abcdefghijklm
nopqrstuvwxyz
& 1234567890

*Information from The Thermolux Glass Co Ltd.*

INFORMATION SHEET : STANDARD LETTERING IN THERMOLUX GLASS : Nº 1.

SIR JOHN BURNET TAIT AND LORNE ARCHITECTS ONE MONTAGUE PLACE BEDFORD SQUARE LONDON WC1

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# INFORMATION SHEET
# • 642 •
# GLAZING

**Subject :** Standard Lettering in Thermolux Diffusing Glass, No. 1

**General :**
This is the first of two Sheets setting out the standard lettering adopted for use in Thermolux glass. This lettering can be specified by reference number, and can be executed in any size at the established rates given in the price list below.

These standards do not, however, limit the variety of letters obtainable in Thermolux glass—lettering can be executed to architects' details and special designs are prepared by the Company to order.

**Thermolux Glass :**
The glass is a combination of two sheets of plain clear glass with a layer of glass fibre between. For full details of the glass and of its light diffusing and heat transmission resisting qualities see Sheets Nos. 372, 373 and 499.

**Decorative Thermolux Glass :**
The glass is the same in construction as the standard Thermolux, but the interlayer is formed in coloured glass fibre, one or more colours being used to form any pattern or design required.

**Lettering :**
There are five different methods of obtaining lettering in the glass, and in each method the lettering itself is on the inner side of the plain glass sheets, and is therefore permanently protected from dirt and weathering agencies and will not deteriorate or lose its freshness of colour from these causes.

Lettering may be formed in any of the following ways :—

(*a*) By cutting the glass fibre forming the "field" and setting into it letters cut from glass fibre of a different colour. The lettering is then formed purely by the glass fibre and both letter and field are translucent.

(*b*) By painting the outline of the letter on the inner side of the glass and filling in the body of the letter with glass fibre of a colour the same as or different from the colour of the field. This gives a translucent field and letter, and the painted outline of the letter may be either translucent or opaque.

(*c*) By painting in the letter solid on the inner face of the glass. The letter may then be either translucent or opaque.

(*d*) By a combination of (*a*) and (*b*) by which a translucent letter is made of different colour from the field and a painted border-line is provided for definition inside the perimeter of the letter formed in the glass fibre, i.e. the coloured glass fibre letter fills in the body within the line and also forms a margin outside it.

(*e*) By a combination of translucent and opaque painted work.

Wherever work is painted, the area to be painted is first sand blasted to give a permanent key and a slight recess in which the paint can lie.

**Schedule of Lettering :**
The following schedule sets out the alphabets shown on this Sheet and those derived from them by variation of technique. For Roman, Old English and other types of letter, see Sheet No. 2. In the descriptions given in this schedule "translucent letter" means (unless noted to the contrary) a letter formed in translucent paint.

All opaque work is formed in paint.

| Reference Number | Description | Price per inch of height s. d. |
|---|---|---|
| | *Style of Alphabet—Modern Block* | |
| T.1A ... | As shown on this Sheet. Opaque letter | 0 4¾ |
| T.1B ... | Alphabet as T.1A. Translucent letter... | 0 6¼ |
| TD.1B ... | Alphabet as T.1A. Translucent letter formed in coloured paint and backed with a white interlayer, the general background consisting of a coloured interlayer ... ... ... ... | 0 10¼ |
| | *Style of Alphabet—Modern Block with Interspaced Outline* | |
| TOO.1A | As shown on this Sheet. Opaque letter with opaque outline ... | 0 9½ |
| TTO.1A | Alphabet as TOO.1A. Opaque letter with translucent outline ... ... | 0 11 |
| TOO.1B | Alphabet as TOO.1A. Translucent letter with opaque outline ... ... | 0 11 |
| TTO.1B | Alphabet as TOO.1A. Translucent letter with translucent outline ... | 0 11 |

| Reference Number | Description | Price per inch of height s. d. |
|---|---|---|
| | *Style of Alphabet—Modern Block with Shadow Line* | |
| TOS.1A | As shown on this Sheet. Opaque letter with opaque shadow line ... | 0 8 |
| TTS.1A... | Alphabet as TOS. 1A. Opaque letter with translucent shadow line ... | 0 9½ |
| TOS.1B | Alphabet as TOS.1A. Translucent letter with opaque shadow line ... | 0 9½ |
| TTS.1B... | Alphabet as TOS.1A. Translucent letter with translucent shadow line | 0 9½ |
| | *Style of Alphabet—Modern Block in Borderline* | |
| TB.1A ... | As shown on this Sheet. Opaque letter | 0 4¾ |
| TB.1B ... | Alphabet as TB.1A. Translucent letter | 0 6¼ |
| TX.1A ... | Alphabet as TB.1A. Opaque line with body formed in an interlayer different in colour or direction of fibres from the general background | 0 8¾ |
| TX.1B ... | Alphabet as TB.1A. Translucent line with body formed in an interlayer different in colour or direction of fibres from the general background | 0 10¼ |
| TN.1A ... | Alphabet as TB.1A. Translucent letter formed by an opaque borderline and separated from an opaque, painted background by a translucent interspace of about $\frac{1}{16}$ in. ... ... | 0 4¾ |
| TN.1B ... | Alphabet as TB.1A. Translucent letter formed by a translucent borderline and separated from an opaque, painted background by a translucent interpsace of about $\frac{1}{16}$ in. ... ... | 0 6¼ |
| | *Style of Alphabet—Double-track Block* | |
| T.6A ... | As shown on this Sheet. Opaque letter | 0 6¼ |
| T.6B ... | Alphabet as T.6A. Translucent letter | 0 8 |
| | *Style of Alphabet—Modern Fancy Block* | |
| T.2A ... | As shown on this Sheet. Opaque letter | 0 6¼ |
| T.2B ... | Alphabet as T.2A. Translucent letter | 0 8 |
| TD.2B ... | Alphabet as T.2A. Translucent letter formed in coloured paint and backed with a white interlayer, the general background consisting of a coloured interlayer ... ... ... ... | 1 0 |
| | *Style of Alphabet—Modern Fancy Block in Borderline* | |
| TB.2A ... | As shown on this Sheet. Opaque letter | 0 6¼ |
| TB.2B ... | Alphabet as TB.2A. Translucent letter | 0 8 |
| TX.2A ... | Alphabet as TB.2A. Opaque line with body formed in an interlayer, different in colour or direction of fibres from the general background | 0 10¼ |
| TX.2B ... | Alphabet as TB.2A. Translucent line with body formed in an interlayer different in colour or direction of fibres from the general background | 1 0 |
| TN.2A ... | Alphabet as TB.2A. Translucent letter formed by an opaque borderline and separated from an opaque, painted background by a translucent interspace of about $\frac{1}{16}$ in. ... ... | 0 6¼ |
| TN.2B ... | Alphabet as TB.2A. Translucent letter formed by a translucent borderline and separated from an opaque, painted background by a translucent interspace of about $\frac{1}{16}$ in. ... ... | 0 8 |

**Uses of Thermolux Lettering :**
Since lettering in Thermolux glass need not affect the light diffusing properties of the surrounding glass in a panel, a lettered panel may be used both as a sign board and as an efficient lighting medium, such as a fanlight or shop transome. This combination is of particular value in shops where good daylight is required on the showcases or displays, and where shop signs are required at a low level where they can be easily read.

Lettering on translucent glass does not vary greatly in visibility with different lighting conditions. If suitable colours are used such lettering will stand out strongly, both by daylight from the outside and by artificial light from the inside. It seems very likely that great economies in night lighting of shop signs can be effected by the judicious use of low powered lights behind letter panels of this kind.

**Manufacturers :** The Thermolux Glass Co., Ltd.

**Address :** 1 Albemarle Street, Piccadilly, London, W.1

**Telephone :** Regent 8171

*Professor Haldane's opinion of the possible effectiveness of Air-Raid Precautions has special significance at the present time. His reputation as one of this country's foremost scientists, his work at Cambridge and latterly as Professor of Bio-Chemistry at University College, London, would, in any case, make his opinion of the physiological effects of attack from the air of great importance. But, in addition, he has visited all the fronts in Spain and during a period of some months in Madrid experienced a number of air raids.*

# A.R.P.

## FOREWORD

### *By Professor J. B. S. Haldane*

IT is very difficult indeed to exaggerate the importance of this Report. Gas was shown to be ineffective against towns by the Hamburg explosion of 1928, when 11 tons of phosgene killed 10 people. After six weeks' experience on Madrid the German Air Force found light incendiary bombs ineffective, and gave up their use except in special cases. The one big danger is the high explosive bomb.

The fundamental conclusion of this report is that fully bomb-proof shelters for Londoners would cost £11 per head. I confess that, having been in more air raids than Mr. Pinckheard, I would willingly pay £12 to be at a depth of 60 feet, instead of 50, which is the depth that he assumes! But if the figure is anywhere near right, it disposes of the argument that adequate protection for civilians would bankrupt the country.

The question of air-raid protection is quite literally one of life and death for every citizen of this country. This report is by far the most important document on the subject so far published. I trust that every reader, regardless of party, will force his M.P. to read it and to take action on it.

*BY the publication of the detailed report on the following pages the* JOURNAL *aims to inform architects of what are believed to be the facts concerning air raid precautions of a structural kind and to give some idea of the cost of shelters offering varying degrees of protection.*

*This issue containing the A.A.S.T.A. report, following closely upon the Conference at the R.I.B.A. on June* 13-15 *and the summary of recommendations there made in the* R.I.B.A. JOURNAL *for June* 27, *might, however, give the impression that two programmes for collaboration in A.R.P. are being placed before architects. This is not so. The two surveys are complementary.*

*The R.I.B.A. Conference confined its recommendations chiefly to the immediately practicable forms of protection about which architects are likely to be consulted in the immediate future.*

*The A.A.S.T.A. have considered the whole problem of structural protection as reflected in the recommendations of various European countries, and have examined the planning, construction and cost of all types of shelter.*

*It is necessary, for architects to consider protection against aerial attack from both these points of view.*—Editor, A.J.

*Guernica*

# THE REPORT

*THE following report has been prepared by a Committee appointed by the Council of the Association of Architects, Surveyors and Technical Assistants to enquire into and to make recommendations upon the design, equipment and costs of shelters for the protection of the civilian population against air attack. A second report on the subject of the evacuation of towns in time of war is at present in course of preparation.*

*The Committee has worked under the Chairmanship of Mr. J. Pinckheard, A.R.I.B.A., and in close collaboration with Mr. O. A. Davis, P.A.S.I., Mr. M. F. Kensit, B.A. (Eng.), and Mr. R. T. F. Skinner, A.R.I.B.A., to whom the Association is indebted for their generous help.*

*The Council of the Association wishes also to acknowledge its thanks for assistance rendered by Mr. K. Montgomery-Smith, B.Sc., A.M.Inst.C.E., and by the following firms and organizations: Carrier Engineering Co., Ltd.; Cement and Concrete Association; Chatwood Safe Co., Ltd.; Chloride Electrical Storage Co., Ltd.; Richard Costain, Ltd.; Crittall Manufacturing Co., Ltd.; Dover Engineering Works, Ltd.; Hunziker (Gt. Britain), Ltd.; Mellor Bromley & Co., Ltd.; Nissen Building, Ltd.; Rapid Floor Co., Ltd.; Solent Engineering Co., Ltd.; Stent Precast Concrete, Ltd.*

ADEQUATE protection against possible air attack is fast being recognised as an urgent national necessity. Architects, engineers and surveyors, with their specialist knowledge of design and construction, have a particularly important part to play in this work in applying their technical knowledge to the solutions of problems upon which there is as yet all too little information available.

We have been asked in this, our first report, to confine ourselves to an enquiry into the design, equipment and costs of shelters to protect the civilian population against air attack.

We have therefore avoided broader issues and political or controversial matters, such as, for example, the possibility of providing a certain standard of protection for any particular section of the population, although we believe that architects, as ordinary citizens, owe a duty to the community to take the utmost interest in these questions.

In preparing this report, we have taken the view that air raid precautions must be directed first and foremost to the saving of human lives, and not merely to the allaying of fears. It is in this spirit, we believe, that architects, surveyors and engineers should enter into the work of air raid defence.

Mr. Duncan Sandys, M.P., Chairman of the Parliamentary Air Raids Precautions Committee, recently made a tour of inspection in Northern Spain, and on his return wrote*: "Those who are responsible for the organisation of air raid precautions in Great Britain would do well to study in the minutest detail the technique of air raids in Spain and the measures which the Spanish people, under the stress and strain of actual war, have found it necessary to adopt in order to protect themselves against the menace of the modern bomber."

We have been able to carry out this advice by collaboration with Mr. R. T. F. Skinner, A.R.I.B.A., who, on our behalf, visited Barcelona in May, 1938, and who obtained much useful information, part of which has already appeared in the form of two articles in THE ARCHITECTS' JOURNAL, June 16th and 23rd.

* *Daily Telegraph*, 9-4-38.

In addition, we have had translated and have collated a wealth of information from the official government handbooks and from magazines and publications from a number of European countries. The government publications of France, Spain, and Switzerland, have been particularly helpful.

As a result of our researches covering a period of some six months we have arrived at a number of conclusions regarding the design, equipment and costs of air raid shelters, but we have made no attempt to apply these conclusions to a general scheme of protection. This is a much wider subject involving such questions as the defining of danger zones, evacuation and the degree of protection appropriate to different areas. We have tried rather to present in concise form the general principles arising from a comprehensive survey of the information published in this and other European countries on the subject of air raid shelters.

Our research, bearing in mind the experience of Spain, has compelled us to lay the main emphasis on the danger from high explosive bombs which we are convinced constitute the greatest menace to cities subject to aerial bombardment. It is unquestionable that among civilians in Spain, the overwhelming majority of those killed in air raids died from the effects of high explosive bombs.

We hope that, in view of the air raids precautions programme at present being undertaken in this country, our conclusion will be of interest and value, especially to local authorities and their technical staffs.

The prices given in this Report are those which might be expected from ordinary contractors at the present time. Prices are for work in the London area and include overhead charges and profit.

It has been assumed that all excavations would be in London clay and that the work would be done by manual labour. It should be borne in mind, however, that some savings might be effected by the use of mechanical excavators, if conditions were suitable. This particularly affects the comparison of costs between shelters below and above ground and the costs of trenches.

*Aerial torpedo used on Madrid front.*

# AERIAL BOMBARDMENT

## METHODS OF ATTACK

THE development of warfare from the time of the Roman *balista* has faithfully reflected the march of science and invention. Today the scientist and the engineer, by evolving newer and ever more destructive weapons, are outrivalling the soldier in influencing the course of warfare. Modern warfare becomes increasingly dependent on the products of industry, on the industrial population, and in general on the whole internal organization of the country at war. Indeed, an efficient wartime functioning of industry is so essential to the prosecution of war that in the words of Major-General J. F. C. Fuller* "to attack these sources of military power is even more important than attacking the enemy's armies."

The aims of an aerial bombardment are therefore twofold: first, to destroy important industrial, military and administrative centres, such as arsenals, munition factories, power stations, aerodromes, railway termini and Government buildings; and second, to sow such destruction among the civil population that they will press their Government to make peace.

The development of the bombing plane itself has proceeded apace since 1918.

The modern heavy bomber carrying a load of from one to three tons of bombs can fly at a speed of over 200 m.p.h. Medium bombers can attain speeds of 300 m.p.h. A diminution of the bomb load (which is normally about one-fifth of the weight of the aeroplane) makes possible a longer range.

Even larger bombers, carrying greater loads of bombs, will certainly be developed. It was recently stated that "it is even possible to build a four-engined bomber in the 40,000 lb. class which will carry five tons of bombs over a range of 2,000 miles."†

This means that any European State can be bombed by air by any other European State. It means that a bomber can reach London within 12 minutes of crossing the coast, and Manchester within 25.

The weapons of aerial attack are high explosive bombs, incendiary bombs, gas bombs and spray and machine gun fire. While this latter form of frightfulness has been used on fleeing civilian populations,‡ it is not likely to be effective against people in buildings. We have confined our inquiry, therefore, to attack by bombardment.

* "The Dragon's Teeth." London, 1932.

† William Courtenay, *Evening Standard*, March 16, 1938.

‡ See *News-Chronicle*, April 26, 1937, for an account of the bombing and machine-gunning of Guernica.

## TYPES OF BOMB

### HIGH EXPLOSIVE BOMBS

HIGH explosive bombs range in weight from half a hundredweight to one ton, and even heavier in very exceptional circumstances. The heaviest bombs so far used on Barcelona have weighed half a ton, but six hundredweight bombs are frequently dropped.

High explosive bombs are of two main types. They may be "percussion" bombs, which burst on impact, or they may be "delayed action" bombs which penetrate before exploding.

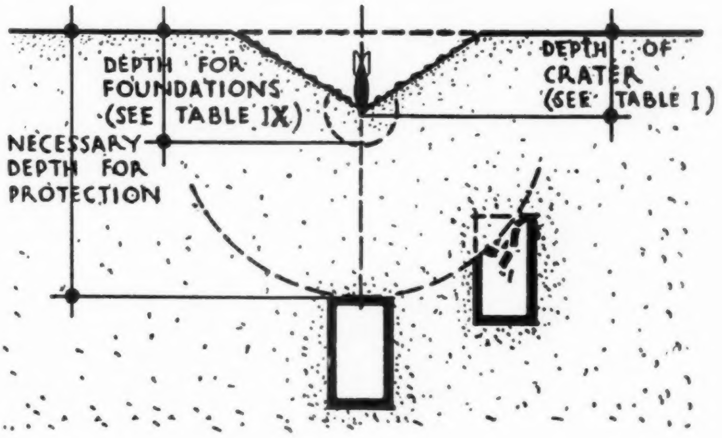
In addition to the "general purpose" bomb there are "armour piercing" and "semi-armour piercing" types. A bomb of the latter type, which is always fitted with a delayed-action fuse, will penetrate a considerable distance into the earth, or right through a high building, before actually exploding. The high cost of armour piercing bombs in relation to the general purpose type will probably restrict their use to important targets.

The explosive charge in a bomb is generally little more than half the total weight, although in armour-piercing bombs, owing to the necessarily more robust shell, the proportion of explosive material is considerably less.

The penetrative power of the bomb depends to a large extent upon its velocity at impact, which in turn depends upon the height from which the bomb is released. A bomber can maintain an altitude of more than 20,000 feet, although at this height accurate aiming is difficult.

The effect of anti-aircraft guns is to keep attacking aircraft at a high altitude, and it is probable that over defended towns bombers will drop their bombs from a height of over 12,000 feet, in which case the bombs would reach a velocity of at least 1,000 feet a second on impact.

Bombs do not descend vertically but at an angle depending on the height and speed of the bomber. The angle of a bomb reaching the ground from a height greater than 12,000 feet would not be likely to exceed 20° from the vertical, but in the case of a low-flying aeroplane it is possible for the bomb to strike at more than 45° to the vertical. The importance of this, especially from the point of view of the architect, is that bombs are likely to strike the walls of a building as well as the roof.




**1**—*Diagram showing penetration and presumed destructive radii of bombs.*

*The Effects of High Explosive Bombs*

(*a*) *Direct Hits.*—When a high explosive bomb bursts its effects depend on both the type of bomb and the target. When a bomb strikes the earth it forms a crater illustrated diagrammatically in Fig. 1.

In the case of a percussion type bomb the explosion occurs immediately on impact, forming a relatively small crater.

● *While the size of bombs is limited only by the carrying capacity of the aeroplane, which increases daily, one can hazard that in the event of war the smaller bombs will be most used if only because they are more economical.*

If the bomb has a delayed action fuse, its action in making the crater is two-fold. The bomb, by virtue of its weight and velocity, penetrates a certain depth into the material and only then does it actually explode, forming a much larger crater. In practice this sequence is so rapid that the two events are almost simultaneous. Armour-piercing bombs are designed to penetrate still more deeply before exploding.

The theoretical depth of penetration (before explosion) may actually be less for a heavy bomb than for a light bomb,* the reason being that the larger cross-section of the heavy bomb meets with greater resistance from the material.

Table I, taken from an official handbook prepared by the Swiss Federal Commission on A.R.P. gives theoretical depths and diameters of craters.†

The depths of craters in Barcelona and Madrid vary enormously according to the type of bomb. The deepest craters are not more than twenty-three feet deep and these were probably made by half-ton bombs, the heaviest so far used. On the other hand bombs of the "percussion" type have been used in Barcelona which have practically no penetrative power and produce only a shallow crater about four feet deep.

When a bomb with a delayed action fuse strikes a building it usually penetrates several floors and may even reach the basement before exploding. Professor J. B. S. Haldane, writing on his experience in Spain, states: "Even small bombs weighing 50 pounds or so will greatly damage the houses on which they fall. Five hundred pound bombs will go through six floors before bursting and will demolish even a large house unless it is made of ferro-concrete, in which case it is shattered but not generally brought to the ground." (*Reynolds News*, 16/1/38.) The extent of the damage will depend to a considerable extent on the type of building. A building with supporting walls of brick or masonry will be damaged far more than a framed building, and most of those in Spain are of the former type. The effect of a delayed action bomb on a typical 5–7 storey Barcelona house is always to destroy the entire building. The bomb explodes at about the third floor, causing the upper storeys to collapse owing to their support being blown from under them. The lower floors collapse with the weight of debris. One 6 cwt. or ½-ton bomb can easily demolish two seven-storey houses in this way. While the size of bombs is limited only by the carrying capacity of the aeroplane, which increases daily, one can hazard that in the event of war the smaller bombs will be most used if only because they are more economical. Table II,‡ which gives the effect of a ton of bombs of different weights, illustrates the point.

(*b*) *Blast.*—When a high explosive bomb bursts, air impulse waves are set up which cause a violent disturbance of buildings and other objects. This air pressure is almost immediately followed by suction which may be even more damaging. The air pressure generated by the explosion of a heavy bomb might be several hundred times normal wind pressure, but is of extremely short duration. The general effects of blast are to dislodge masses of masonry and even completely to demolish near-by buildings. Windows, doors and plaster ceilings and light structures are damaged over a wide radius. A.R.P. Handbook No. 6 states: "In general it may be said that within 50 feet of the explosion a building must be of substantial construction if it is to withstand the blast of a medium or heavy weight bomb." Again, steel-framed buildings most effectively withstand the shock.

A type of bomb of "enormous explosive power" recently used in Barcelona has been described by Mr. Duncan Sandys, M.P., Chairman of the Parliamentary A.R.P. Committee: "In the recent raids§ on Barcelona two sizes of high-explosive bombs have been principally employed, the 220-pound bomb and that of 650 pounds . . . considering the weight of these bombs, they appear to have extraordinarily little penetrative power. The craters which they have made where they have fallen in the streets are remarkably small. But in contrast to this their explosive expansion in a lateral direction is devastating . . . Sometimes several hundred yards away windows and doors were blown in, steel shutters crumpled up, balconies ripped off and partition walls, ceilings and floors knocked down by the terrific blast of the explosion." (*Daily Telegraph*, 8/4/38.)

* "Refugios," Barcelona, 1937.

† "Technische Richtlinien für den Bauichen Luftschutz," Berne, 1936.

‡ From Gibrin and Heckly.

§ March 16, 17 and 18, 1938.

**TABLE I**

*Theoretical Depths and Diameters of Craters*

| Weight of bomb | Soft rock | | Ballast, compact gravel | | Sandy earth | | Soft sand, dry earth, clayey earth | |
|---|---|---|---|---|---|---|---|---|
| | H. ft. ins. | D. ft. ins. | H. ft. ins. | D. ft. ins. | H. ft. ins. | D. ft. ins. | H. ft. ins. | D. ft. ins. |
| 1 cwt.... ... | 4 7 | 14 9 | 5 7 | 16 5 | 8 6 | 18 1 | 11 6 | 19 8 |
| 2 cwt.... ... | 4 11 | 19 8 | 6 3 | 21 4 | 9 2 | 23 0 | 12 6 | 26 3 |
| 6 cwt.... ... | 7 7 | 27 11 | 9 6 | 31 2 | 14 1 | 34 5 | 19 8 | 39 4 |

**H.—Depth of crater.**

**D.—Diameter of crater.**

**TABLE II**

*Effect of a Ton of Explosive Bombs on a Mass of Concrete*

| Weight of bomb | Number of bombs | Radius of Destruction ft. ins. | Area destroyed by each bomb (sq. ft.) | Total area destroyed (sq. ft.) |
|---|---|---|---|---|
| 1,000 kg. ... ... ... | 1 | 6 6 | 136 | 136 |
| 250 kg. ... ... ... | 4 | 4 3 | 57 | 228 |
| 100 kg. ... ... ... | 10 | 3 0 | 27 | 270 |
| 50 kg. ... ... ... | 20 | 2 4 | 16 | 320 |

(*c*) *Splinters.*—When a bomb bursts splinters of metal produced by the fragmentation of the shell are projected in all directions. They can cause death to people as far as four hundred yards away, and are the cause of enormous loss of life when a bomb falls in a crowded street. Splinters from a medium weight bomb could certainly penetrate an ordinary nine-inch brick wall fifty feet away.

(*d*) *Earth Vibration.*—The bursting of a bomb, in addition to setting up air impulse waves, sets up similar waves in the earth, causing damage to buried pipes and to basements. The effects do not, however, extend over such a wide radius as those of blast. The walls of the dug-out shown in Fig. 1 immediately below the crater have collapsed due to earth pressure. It would be necessary for safety to excavate below the radius at which the earth pressure makes itself felt.

(*e*) *Indirect Effects.*—A large proportion of those killed in air raids in Spain die as a result of the indirect effects of bombs rather than as a direct result of blast and splinters. Buildings which suffer a direct hit or which are demolished by blast, collapse and bury their occupants in the debris.

*Protection Necessary*

In the almost complete absence of experimental results it is necessary to fall back either on theoretical calculations or on the tables published in the handbooks of several European governments.

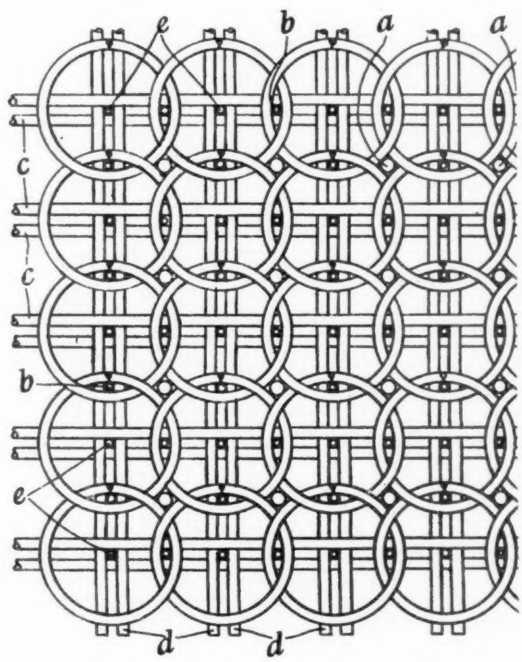
Formulæ for calculating separately the depth of penetration and radius of explosion have been advanced by Peres, Stellingwerff and others. Since, however, different formulæ give somewhat varying results we have preferred to adhere to tables given in official handbooks for the information in this section Tables need to be used with circumspection, since conditions will vary in every case. For example, the effects of different types of bomb vary considerably. Again, the velocity of the bomb, which affects its penetrative force, will vary according to the height of release.

● *Splinters from a medium weight bomb could certainly penetrate an ordinary nine-inch brick wall fifty feet away.*

● *The bursting of a bomb, in addition to setting up air impulse waves, sets up similar waves in the earth, causing damage to buried pipes and to basements.*

With the exception of those otherwise indicated, the tables given below are from the Swiss handbook previously referred to.

To give protection against a direct hit a thickness of material is required equal to the depth of penetration and explosion plus a certain allowance for safety.




**2**—***Plan of special reinforcement for bomb-proof shelters. (Courtesy of the Chatwood Safe Co., Ltd.)***

The "specially reinforced concrete" in the second column of Table III is described as being reinforced in both directions with ten to twenty millimetres (·4 in. to ·8 in.) diameter rods at fifteen centimetres (6 in.) centres. This cross reinforcement is to be in layers 15–20 cms. (6–8 ins.) apart, each layer being connected at frequent intervals to the next layer. It will be seen that the concrete is reinforced throughout from top to bottom and in all directions. We understand that practical tests have demonstrated the superiority of "all way" reinforcement for resistance to bombs.

A method of reinforcing a slab in a somewhat similar manner, but more heavily, has been devised by Messrs. Chatwoods, in which horizontal, vertical and diagonal rods are held in position by a "mattress" of interwoven coils (Fig. 2). We are given to understand that a 4 ft. 6 in. thick slab reinforced in this way is capable of stopping a heavy armour piercing bomb falling from the normal height of bombardment.

The roofs of concrete shelters should be covered with no more earth than is necessary for planting, etc. An earth cover which in itself is insufficient to give protection against the bomb is worse than useless in that the earth serves only to confine the effect of the explosion, with a consequent greater destructive effect on the roof of the shelter.

**TABLE III.** *Thicknesses Required for Roofs or Slabs over Shelters*

| Weights of bombs | Specially reinforced concrete (A) | Reinforced concrete (B) | Mass concrete (C) | Tunnel construction | | |
|---|---|---|---|---|---|---|
| | | | | Soft rock | Ballast, gravel | Dry earth, Sand |
| | ft. ins. | ft. ins. | ft. ins. | ft. ins. | ft. ins. | ft. ins. |
| 1-cwt. ... | 2 4 | 4 3 | 4 7 | 11 6 | 18 1 | 21 4 |
| 2-cwt. ... | 3 8 | 5 7 | 6 11 | 16 5 | 24 7 | 29 6 |
| 6-cwt. ... | 4 7 | 6 11 | 9 2 | 24 7 | 36 2 | 42 8 |

**Where the crushing strength of cubes of concrete after 28 days in**
**A $\geqq$ 5,690 lb./ins. sq.**
**B $\geqq$ 3,140 lb./ins. sq.**
**C $\geqq$ 2,130 lb./ins. sq.**

● ***It is claimed that a slab of reinforced concrete 6 ft. 3 ins. thick gives actually less protection than a top slab of 3 ft. and a second slab of 10 ins. to 12 ins.—a saving of one-third.***

In cases where a shelter is situated under a building of several storeys it is possible to reduce the thickness of the roof of the shelter by taking into account the resistance to penetration of the superimposed floors, as in Table IV, which should be read in conjunction with Table III.

Similar tables are given in the French handbook ("Instruction Pratique sur la Défense Passive." Annexe No. 4. Des Abris, Paris 1936). (Table V.)

In the French handbook permissible reductions in respect of superimposed floors are rather higher than the Swiss figures given in Table III.

It will be noticed that the tables are based on the principle of a single thick more or less homogeneous slab which is strong enough to resist the bomb. The theory that two thinner slabs separated by an air space are more effective than a single thick slab is advanced by Stellingwerff in his book* on air raid shelters.

Proceeding from the theory that a bomb penetrates into a solid in two distinct stages—penetration due to its weight and velocity, followed by explosion, he first calculates the thickness of the concrete slab required to stop the bomb and then of the slab which would be sufficient to stand up to the explosive charge in the bomb. By disposing the two slabs with a free air gap in between he claims that a considerable saving in material is made. The object of the air space is to liberate the gases generated by the explosion. When a bomb penetrates into a solid slab the explosive charge is buried and confined and therefore a more damaging explosion results, and it is precisely this which the double slab method of construction sets out to eliminate. It is claimed, for example, that a slab of reinforced concrete 6 ft. 3 ins. thick gives actually less protection than a top slab of 3 ft. and a second slab of 10 ins. to 12 ins.—a saving of one-third. Illustrations of the application of this theory are given in the sections on shelters.

In cases where it is desired to protect an underground shelter or tunnel it may be found that there is insufficient earth cover to give the required degree of protection. In such cases a detonating slab could be used (Fig. 3). This is a slab of reinforced concrete or other material sufficiently thick to exhaust the penetrative force of the bomb. Thicknesses of detonating slabs placed respectively horizontally and at 45° are given in Tables VI and VII.

* Protezione dei Fabbricati dagli Attacchi Aerei. Milan, 1936.

**TABLE IV**

*Reductions which can be effected in the Thickness of Roofs of Shelters, taking into account the Floors of the Upper Storeys*

| Reduction in thickness of roof of shelter when constructed of | Floors of upper storeys | | | | |
|---|---|---|---|---|---|
| | Wood or iron joists | R.C. slab with normal reinforcement | | | |
| | | 2 ins. | 4 ins. | $4\frac{3}{4}$ ins. | 6 ins. |
| Special R.C. (A) ... ... | uncertain | $\frac{3}{4}$ in. | $1\frac{1}{2}$ ins. | 2 ins. | $2\frac{3}{8}$ ins. |
| R.C. (B) ... ... ... | uncertain | $1\frac{3}{16}$ ins. | $3\frac{1}{8}$ ins. | 4 ins. | $4\frac{3}{4}$ ins. |

**TABLE V** (from "Instruction Pratique sur la Défense Passive")

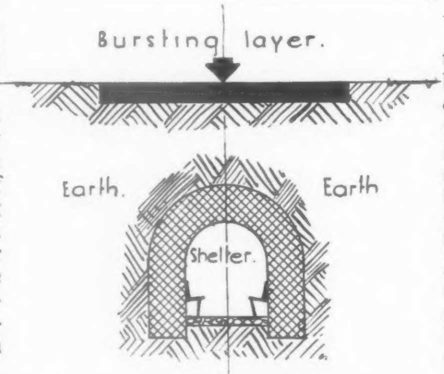
*Thicknesses Required for Roofs or Slabs over Shelters*

| Weight of bomb | Reinforced concrete | Mass concrete | Brickwork | Normal earth |
|---|---|---|---|---|
| | ft. ins. | ft. ins. | ft. ins. | ft. ins. |
| Light bombs up to ¼ cwt. ... | 0 10 | 1 4 | 2 6 | 9 10 |
| Medium bombs | | | | |
| 1 cwt. ... ... ... | 2 4 | 3 3 | 4 11 | 16 5 |
| 2 cwt. ... ... ... | 3 8 | 5 7 | 8 3 | 26 2 |
| Heavy bombs | | | | |
| 6 cwt. ... ... ... | 4 7 | 6 11 | 13 1 | 39 4 |
| 1 ton ... ... ... | 6 7 | 9 10 | 19 6 | 65 8 |

**TABLE VI**

*Thickness of Horizontal Detonating Slab to ensure Complete Stoppage of the Bomb*

| Weight of bomb | Special R.C. (A) | Reinforced concrete (B) |
|---|---|---|
| | ft. ins. | ft. ins. |
| 1 cwt. ... ... | 1 8 | 2 2 |
| 2 cwt. ... ... | 2 6 | 2 9 |
| 6 cwt. ... ... | 3 1 | 4 1 |




3—*Diagrammatic view of a detonating slab over a shelter.*

**TABLE VII**

*Thickness of Detonating Slab inclined at an Angle of 45° to ensure Complete Stoppage of the Bomb*

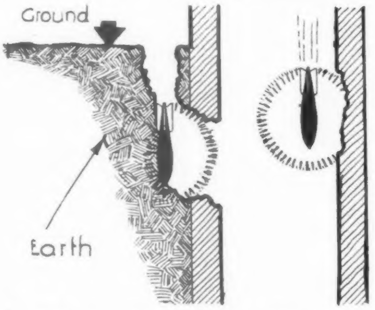
| Weight of bomb | Special R.C. (A) | Reinforced concrete (B) |
|---|---|---|
| | ft. ins. | ft. ins. |
| 1 cwt. ... ... | 1 2 | 1 6 |
| 2 cwt. ... ... | 1 8 | 2 2 |
| 6 cwt. ... ... | 2 4 | 2 11 |

Opinion is by no means unanimous on the subject of detonating slabs (or bursting layers) (Fig. 3). The original object was to cause the bomb to break up before detonation occurred. Bombs now in use, however, can withstand the effects of impact and are able to penetrate before detonation. The detonating slab therefore will not cause the bomb to break up, but it may be utilized to reduce the required earth cover over a subterranean shelter. There should always be a minimum of 10 ft. of earth between the shelter and the detonating slab.† Should the bomb penetrate the

† Bauverwaltung, 1936, No. 52, and A. Winter. Bauwelt, 1936, No. 25.

detonating layer and explode underneath it, the confining effect on the explosion will cause greater damage to the shelter. In Germany for this reason detonating layers are required to be composed of small units—loose stones, bricks, hardcore, etc.—which would be easily displaced by an explosion underneath.

The thickness of basement walls required to resist the effects of bombs bursting beside them is also influenced by the fact that the surrounding earth has a confining effect on the explosion (Fig. 4). The following experimental




4—*Effects of bomb bursting beside a wall below ground and above ground.*

results are of interest in this connection.*

A medium weight bomb was exploded 3 ft. 3 ins. away from a reinforced concrete wall 1 ft. 8 ins. thick. A second identical bomb was exploded the same distance from the wall of an underground shelter 10 ft. below ground. In the first case an area of about 3 ft. 3 ins. diameter was damaged, although the greater part of the concrete remained adhering to the reinforcement. In the second case an area of 8 ft. across was badly damaged, the reinforcement was broken and the concrete crushed.

According to one author a reinforced concrete wall 3 ft. 3 ins. thick and sufficient to resist the effect of a bomb bursting beside it, would need to be 4 ft. 3 ins. thick if it were below ground. The confining effect of the surrounding earth can be minimised if a layer of dry hardcore to help liberate the gases generated by the explosion is interposed between the wall and the earth. The Swiss figures quoted below are based on the assumption that a hardcore filling (Figs. 20 and 21) at least 1 ft. 8 ins. thick at the bottom is used, in which case it is stated that the same figures are valid for walls above the ground.

**TABLE VIII**

*Thicknesses of External Walls constructed in specially Reinforced Concrete required to counteract Earth Pressure (with 1 ft. 8 ins. of Hardcore to liberate Gases)*

| | ft. ins. |
|---|---|
| 1 cwt. bomb requires ... | 1 10 |
| 2 cwt. bomb requires ... | 3 4 |
| 6 cwt. bomb requires ... | 4 11 |

* A. Winter, " Bauwelt," 1936, No. 25.

● *Should the bomb penetrate the detonating layer and explode underneath it the confining effect on the explosion will cause greater damage to the shelter. In Germany for this reason detonating layers are required to be composed of small units —loose stones, bricks, hardcore, etc.—which would be easily displaced by an explosion underneath.*

In order to protect the floors of shelters it is necessary that the encircling wall should be carried down somewhat deeper than the maximum penetration of the bomb (Table IX).

If it is not possible to carry the wall down to this depth it is necessary to provide a floor at least as thick as the walls.

(*b*) *Against Blast and Splinters.*—For protection against splinters the Home Office give the thicknesses quoted below in Table X.†

† A.R.P. Handbook No. 6. Home Office, 1937.

**TABLE IX**

*Depths of Foundations necessary to counteract the effects of High Explosive Bombs (1 ft. 8 ins. deeper than the greatest depth of penetration)*

| Weight of bombs | Soft rocks | Compact gravel | Sandy earth | Loam |
|---|---|---|---|---|
| | ft. ins. | ft. ins. | ft. ins. | ft. ins. |
| 1 cwt. | 6 3 | 7 3 | 10 2 | 13 2 |
| 2 cwt. | 6 7 | 7 11 | 11 2 | 14 2 |
| 6 cwt. | 9 3 | 11 6 | 16 5 | 21 8 |

To ensure protection against blast the Swiss handbook recommends that the external wall be at least 8 ins. thick and calculated to withstand a lateral pressure of 135 lbs. per square foot.

(*c*) *Protection against the Collapse of Buildings.*—In cases where basements or lower floors of buildings are used as blast proof shelters, it is necessary to ensure that in the event of the collapse of the building the ceiling of the refuge room is adequate to carry the debris. The following table gives the design loads corresponding to the weight of debris in buildings of various heights :—

**TABLE XI**

*Load on Roof of Shelter due to collapse of Superstructure.*

| No. of floors in addition to ground floor | Building with floors and roof of | |
|---|---|---|
| | R.C. slabs | Wood joists |
| | lb./ft. sq. | lb./ft. sq. |
| 4 ... ... | 1,125 | 1,025 |
| 3 ... ... | 900 | 820 |
| 2 ... ... | 675 | 615 |
| 1 ... ... | 450 | 410 |

**TABLE X**—*Protection against Splinters. Recommended Thicknesses.*

| Material | Thickness | Remarks |
|---|---|---|
| Mild steel plate ... | $1\frac{1}{2}$ ins. | Special steels may give increased resistance. |
| Stock bricks in cement mortar. | $13\frac{1}{2}$ in. solid<br>$15\frac{1}{2}$ ins. hollow | 2 in. cavity. |
| Unreinforced concrete (not weaker than 6-1 mixture) ... | 1 ft. 3 ins. | |
| Reinforced concrete | 12 ins. | Normal structural reinforcement. |
| Reinforced concrete | 10 ins. | Specially reinforced to resist the punching shear effect of the splinters which induces tensile stresses between the front and rear faces of the concrete wall. Rectangular links (connecting front and back reinforcement) of $\frac{1}{4}$ in. diameter rods at 12 ins. centres is a suggested arrangement which has been tested successfully. |
| Sand or earth ... | 2 ft. 6 ins. | This should be the minimum thickness, for example, at the top of a traverse or revetment. |

*The bomb burns for three to fifteen minutes, reaching a temperature of 3,000° C. The bomb contains within itself the necessary elements for combustion and cannot therefore be extinguished by ordinary means. Attempts to extinguish it with water or chemical extinguisher may cause an explosion.*

This gives the following thicknesses for P.C. Roofs :—

TABLE XII

*Thickness of Roof of Shelter required to withstand the collapse of Superstructure allowing for Live Load. (The lower figure is for freely supported, and the higher for ends fixed slabs.)*

| Span | Thickness of roof in inches | | | |
|---|---|---|---|---|
| | Four storeys | Three storeys | Two storeys | One storey |
| 13 ft. by 13 ft. ... ... ... | 9–10 | 9 | 8¼ | 8¼ |
| 16 ft. 6 ins. by 13 ft. ... ... | 10¾–11¾ | 9–10¾ | 8¼–9½ | 8¼ |
| Continuous slabs, 13 ft. span... | 11¾–15½ | 10¾–13¾ | 10–12¾ | 8¼–10¾ |
| Continuous slabs, 16 ft. 6 ins. spans ... ... ... ... | 14½–19 | 13–17½ | 12¼–15¾ | 10¼–13½ |

Compared with other official recommendations, these figures are rather high ; for example, German regulations originally gave figures less than half these and have subsequently reduced them still further. The present German regulations give the loads in Table XIII for debris (including both impact and static loads). The floors are assumed to be designed for a live load of 100 lbs. per square foot. The values do not include the dead load and designed live load of the shelter roof itself.

**TABLE XIII.** (From German Regulations)

*Debris Loads for Buildings with Solid Walls*

| No. of floors not including ground floor | Debris load lb. per sq. ft. |
|---|---|
| 1–2 ... ... ... ... | 200 |
| 3–4 ... ... ... ... | 300 |
| More than 4 ... ... | 400 |

These figures are identical with Home Office recommendations for unframed buildings.

## INCENDIARY BOMBS

INCENDIARY bombs are relatively small, weighing from 22 lbs. to 60 lbs. The smaller types are more likely to be used, and a single bomber could easily carry 1,000 of these. The bomb is filled with incendiary compounds, principally thermite, which are ignited when it strikes its target. The case of the bomb is either of aluminium or elektron, an inflammable alloy of magnesium, aluminium and zinc.

*Effects*

The penetrative power of these bombs is very small, and although they will penetrate an ordinary wooden roof, they are generally brought to rest by a concrete roof of normal thickness.

The bomb burns for three to fifteen minutes, reaching a temperature of 3,000° C. The bomb contains within itself the necessary elements for combustion and cannot therefore be extinguished by ordinary means. Attempts to extinguish it with water or chemical extinguishers may cause an explosion. Smothering with sand or earth is the only effective means of controlling the bomb. The intense heat generated makes it impossible to approach close to the bomb to smother it, and a recent official publication* from Barcelona recommends that one should keep from 10 to 13 feet distant to avoid setting the clothes or shoes on fire. The same publication goes on to state that fragments of thermite are thrown about by the bomb and these fragments often continue burning without flame, and if neglected may start a fresh fire.

In most air raids on Barcelona a relatively small number of incendiary bombs have been dropped and have done very little damage. Most of the buildings there are of robust masonry construction, with floors of steel filler joists and brick arches, which give good protection against the penetration of the smaller incendiary bombs. Probably for this reason " Kilo " bombs which have been used considerably on Madrid, have been used hardly at all on Barcelona. The incendiary bombs used on the latter city have been heavy ones of 35 lbs., some fitted with armoured noses to increase their penetrative power have been employed.

On the whole the use of incendiary bombs in Spain has not produced the widespread devastation that might have been expected, a fact which has caused the attacking aircraft to rely more and more on high explosive bombs. Professor Haldane, however, has expressed the opinion that incendiary bombs might be much more effective in England than in Spain, due to the greater amount of timber used in our domestic buildings.†

*Protection Necessary against Incendiary Bombs*

In considering the protection necessary against incendiary bombs two aspects must be dealt with—preventing penetration of the bomb, and localizing the effects of the bomb after ignition.

It is stated by the Home Office that an ordinary reinforced concrete roof 5 ins. thick may be expected to keep out a 22 lb. incendiary bomb.

The Swiss handbook states that protection against the penetration of two kilograms (4½ lbs.) incendiary bombs is ensured by the following floor slabs :—

(*a*) Reinforced concrete hollow tile floor having at least 2½ ins. cover of concrete over the hollow tiles. In addition to the normal reinforcement, the top layer is to be reinforced both

* Iniciacion en la Defensa Pasiva. Barcelona, March, 1938.

† *Reynolds News*, January 16, 1938.

*Unexploded incendiary bomb in roof of Prado at Madrid.*

ways with quarter inch rods at 3 in. centres.

(*b*) Normal reinforced concrete hollow block roof slab with screeding and asphalt. The concrete cover over the hollow block together with the screeding should be not less than $4\frac{3}{4}$ ins.

(*c*) Monolithic reinforced concrete at least 3 ins. thick.

The thicknesses can be diminished slightly if the roof slopes at 45° or more to the horizontal. In densely built-up urban areas, however, the sloping roof designed to deflect the bomb is definitely a disadvantage, since there is a danger that the bomb will glance off and penetrate the lower storeys of a neighbouring building, whereas a flat roof will arrest the bomb and allow it to burn out relatively harmlessly.

An ordinary timber-framed roof with a covering of slates or tiles is useless to resist even small incendiary bombs. The likelihood is that these, after penetrating the roof, would come to rest on the attic floor. It is necessary therefore to protect the existing attic floor with an incombustible covering. The Home Office states that a two-inch layer of sand or dry earth spread on the attic floor will help to localize the effect of the burning bomb. A $1\frac{1}{2}$–2 in. layer of concrete, reinforced with expanded metal, and supported by a layer of sand, is recommended by a German authority.* The capacity of the existing joists to bear the additional load should be considered, and it might be necessary to have recourse to shoring. The same writer suggests that rafters and purlins can best be protected by a fireproof covering of lime and cement mortar on expanded metal, care being taken to ensure that no voids are left between the timbers and the protective covering.

Included in structural precautions against incendiary bombs is the general question of fire-resisting construction and of the prevention of the spread of fire from one building to another. The continuation of party walls to a height of at least 1 ft. 8 ins. above the roof is recommended by the above-quoted author.

## GAS BOMBS

GAS may be dropped in bombs or it may be sprayed directly from aircraft. Gas bombs weigh from as little as 20 lbs. up to 600 lbs. They contain more than half their weight of gas.

Two types of gas are used,† "non-persistent" such as chlorine and phosgene, and "persistent" such as mustard gas.

### *Effects of Gas*

Non-persistent gases begin to diffuse from the moment they are released; persistent gases, on the other hand, may be a source of danger for a considerable time. Mustard gas, for example, which is released in liquid form and vaporizes slowly under the influence of warmth is absorbed by porous materials, including brick and concrete, which remain sources of danger until decontaminated.

So far poison gas has not been used in Spain and it is not possible to say what its effects on urban populations would be under modern war conditions.

### *Protection against Gas*

Protection against gas falls under two heads: protection of people and protection of buildings. The protection of people (in so far as it is the concern of the architect) involves the rendering of buildings gas-proof and the provision of facilities for the anti-gas treatment of casualties.

Two courses may be adopted with the object of making buildings or shelters gas proof—hermetically sealing up the room or refuge, or by maintaining a slight positive pressure of air in the room, so that any leakage is from the inside outwards. This is achieved by the installation in the refuge of an air filtration plant, which delivers sufficient pure air to maintain a continuous over-pressure.

The method of sealing a room to make it gas proof by stopping all holes and cracks with adhesive paper, plastic materials, etc., has been described by the Home Office A.R.P. Department.‡ Although this procedure will prevent the entry of gas through crevices, etc., it seems unlikely it will prevent the normal movement of air through the external walls of buildings. Indeed, after a series of experiments§ carried out on a gamekeeper's cottage, the A.R.P. Department does not claim more for its recommendations than that they will "reduce very considerably the amount of gas penetrating into the room."

On the other hand, a ventilating plant with suitable filters and maintaining a positive pressure in the room will ensure complete protection.

Unfortunately, however, the difficulties of protection against gas are multiplied a hundred-fold by the likelihood that any gas attack would be preceded by a bombardment of high explosives, which to say the least would have serious consequences for sealed rooms and their occupants. Protection against high explosives must take priority over protection against gas. The problem of defence against chemical attack becomes therefore one of providing bomb-proof refuges with proper safeguards against the entry of gas.

The other aspect of protection of people against gas—the provision of facilities for anti-gas treatment—is dealt with in the section on "Planning and Equipment of Shelters."

The protection of buildings from the effects of gas requires a knowledge of the action of war gas on various building materials. Liquid mustard gas, for example, is fairly readily absorbed by porous materials like brick and concrete, and the work of decontamination would be greatly facilitated by the use of vitrified materials, such as faience, for external facings. Mustard gas has also a particular affinity for bitumen, with which it forms a toxic paste which is difficult to decontaminate. A cement finish would be preferable to asphalte from the point of view of gas precautions.

* Kohsan, "Bautenschutz," No. 5, 1936.

† "Gas" is here used in the popular sense. Chemical attack includes also such forms as liquids and smokes.

‡ A.R.P. Handbooks, Nos. 1 and 6. Home Office, 1937.

§ Experiments in the Anti-Gas Protection of Houses. Home Office, 1937.

# SURFACE SHELTERS

## PLANNING AND EQUIPMENT

THE primary function of a shelter is to safeguard its occupants from death or injury from aerial attack. In all types of shelter, whatever its specialised functions, certain basic factors influence the design. These are protection and accessibility. The first steps must be to decide what degree of protection (i.e., against gas, blast, splinters, direct hits) and what degree of accessibility are necessary. The degree of protection will depend on the proximity of the refuge to important military objectives. Shelters near to armament factories would expect to be bombarded by heavier bombs than would shelters in sparsely populated residential areas. It should be understood, however, that while this is true as a general principle, no hard and fast line can be drawn around " military objectives," nor can it be said that heavy bombs will never be dropped on residential areas.*

The degree of accessibility will depend on the duration of the warning period. The time needed by the enemy raiders, after the warning has been sounded, to reach their objective, will determine the maximum distance which any person ought to have to walk to a shelter—and therefore the maximum distance between any two public shelters.

From these two basic factors several conclusions can be drawn. The degree of protection afforded will determine the number of people that can occupy a single shelter; the higher the degree of protection the less is the risk in concentrating a large number of people in one spot. The need for greater or less accessibility will determine the location of shelters in relation to concentrations of population. In London, for example, the warning time may be as little as seven minutes, and shelters should be accessible therefore in less than this time. From the point of view of accessibility, shelters in or adjacent to buildings are preferable to independent shelters (and have an additional advantage that people do not have to go into the open to reach them). Where public shelters have to be erected independently of buildings it would be necessary to utilise open spaces such as parks, gardens and squares.†

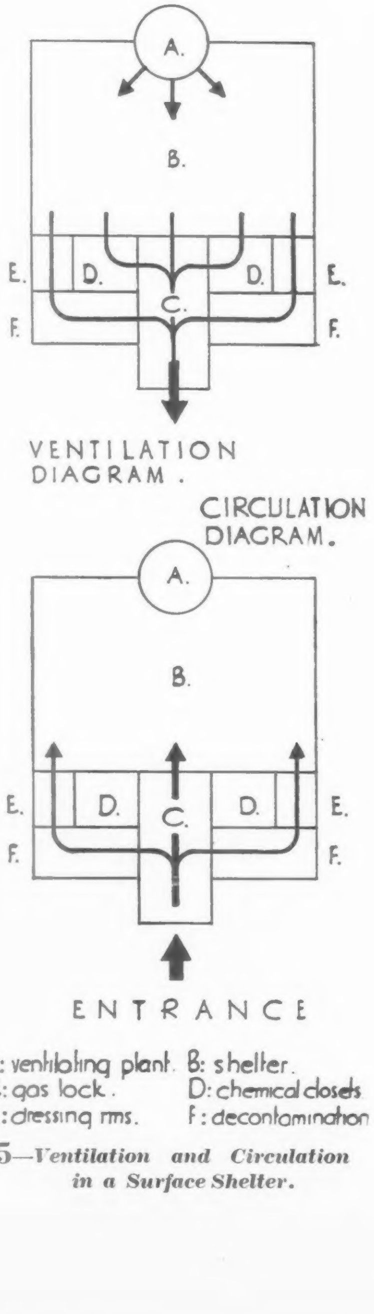
Having decided which buildings, etc., are important military objectives, it is still largely a matter of conjecture what weight and type of bombs will be used. The trend of the current wars in Spain and China indicates that whole cities are regarded as military objectives, a trend which is reflected in the present policy of the Spanish government of building refuges in the important cities proof against direct hits from heavy bombs.

Side by side with their general function of providing protection, every shelter has its own specialised function which depends on the particular requirements of the occupants The people sheltered may be members of the public caught unawares in the street, they may be the inhabitants of a block of flats, they may be the key workers in an important factory or they may be people wounded before being able to reach safety. Each case presents its particular problems. In presenting the requirements set out below, we had in mind a public refuge or a refuge for the occupants of a large building, because these types appear to embody most of the requirements of shelters in general. Shelters should, if possible, be so designed that they can be adapted for peace time uses. Public shelters might serve also as street subways or underground car parks. Shelters in factories, etc., might do duty as store rooms or cycle sheds in time of peace.

### ACCOMMODATION

In addition to the refuge room proper which gives protection against high explosives and the infiltration of gas, there must be some means of enabling people to enter the shelter, without the gas-laden external atmosphere entering at the same time. This is accomplished by a gas lock—a small chamber sealed from the external air, and from the refuge room by gas tight doors, and only one of these doors is opened at a time.

The possibility must also be reckoned with that late-comers will reach the shelter contaminated with gas. Facilities would have to be provided for anti-gas treatment and the decontamination of clothing. This would have to be arranged so that under no circumstances do contaminated people enter the refuge room before receiving treatment. The plan sequence is therefore: gas lock—decontamination and anti-gas treatment—refuge room. In addition to these main elements of the plan there must be at least one emergency exit, lavatories, accommodation for ventilating plant, food storage, etc. (Fig. 5).




5—*Ventilation and Circulation in a Surface Shelter.*

* In Spain heavy bombs have certainly not been reserved exclusively for military objectives. Many 6-cwt. bombs have fallen on residential areas.

† The total areas of open spaces in various London boroughs appear at first sight to be sufficient for any number of shelters. More careful analysis will show that often a large proportion of the total open space is comprised in a single big park and too far distant from the densely populated areas to be of much use. Small squares, gardens and school playgrounds, distributed fairly evenly throughout built-up areas would appear to be the best sites for underground shelters.

● *Feet are a most likely point of contact with persistent gas, and it is therefore important to arrange for them to be decontaminated.*

### GAS LOCK

The size of the gas lock determines the rate at which people can pass through it. In a public shelter it should be at least 70 sq. ft. The minimum size of a gas lock should be determined by the space required for a stretcher and two bearers. If the doors are at right angles allowance should be made for turning the stretcher.

The possibility of a splinter penetrating both the gas tight doors should be guarded against by staggering the doors.

### DECONTAMINATION

Decontamination is of the utmost importance, particularly in shelters which have to be approached externally. The person who has been in contact with persistent gas is not only liable to injury himself, but would, if not given anti-gas treatment and clean clothing, constitute a grave danger to the other occupants of the shelter. Feet are a most likely point of contact with persistent gas, and it is therefore important to arrange for them to be decontaminated. This can be done by forming a sinking outside the entrance to the gas lock about three feet square and a few inches deep, filled with a mixture of chloride of lime and sand, and so arranged that everyone has to shuffle his feet in it before entering. Inside the shelter there should be decontamination accommodation entered from the gas lock. In shelters holding 25 people an ordinary basin is sufficient but if there are more, a shower is necessary. In large shelters there should be (*a*) an undressing room, (*b*) a shower and (*c*) a dressing-room. Separate accommodation for each sex is desirable. It is unlikely, however, that all the occupants would enter contaminated, and it is necessary to provide for short-circuiting the decontaminating accommodation by arranging an entrance to the refuge room direct from the gas lock.

(*a*) *Undressing Room.*—Should be entered direct off the gas lock and equipped with gas-tight bins for contaminated clothing. There should also be receptacles for chemicals for decontamination.

(*b*) *The Shower Room.*—Should be at least large enough to accommodate two people—one washing and one in attendance. A hand shower is preferable, and a supply of hot water is necessary for decontamination of people affected by persistent gases. The floor should be laid to falls, and the waste water led to a trapped gulley.

Since liquid mustard gas penetrates easily into brick and concrete, it is preferable to finish the walls of the undressing and shower rooms with glazed tiles.

(*c*) *Dressing Room.*—Should immediately follow the shower, and be arranged so that water cannot splash in. Shelves or bins should be provided for the storage of clean clothes.

*Refuge Room.*—The size of the refuge room is dependent on three principal factors : (*a*) the number of people accommodated, (*b*) the air volume per person, (*c*) the floor area per person.

(*a*) *Number of Occupants.*—It is a general principle that the greater the degree of protection afforded, the larger the number of people which can be accommodated in safety in one refuge room. The determination, however, of the actual number that can be sheltered in a refuge room affording a specified degree of protection must be to some extent arbitrary. It is widely accepted, however, that where protection is limited to safety from medium weight bombs, not more than 50 people should be accommodated in one room. If larger numbers have to be sheltered then the space would have to be sub-divided into more or less self-contained units of 50. The recommended maximum number of people which may safely occupy a blast-proof shelter varies in different countries. In Lithuania it is 12, in Switzerland 25, and in Germany 50. At the other end of the scale, however, a single station on the Paris Metro—where relatively complete protection is afforded—accommodates several thousands.

***Entrance to surface shelter near London (Messrs. Trollope & Colls).***

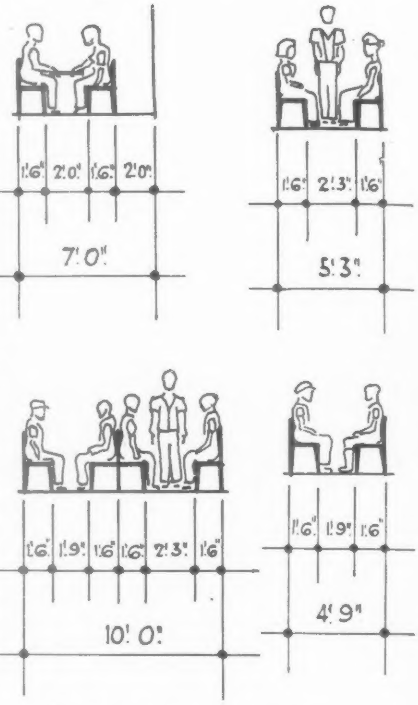
● ***In Spain people in shelters shun a cul-de-sac. . . . From this it appears that psychologically, as well as from the practical point of view, it is best to have the doors at the opposite extremities of the refuge room.***

(*b*) *Air Volume per Person.*—This will depend on whether the shelter is artificially ventilated or not. In the case of an unventilated shelter, which contains within its walls the whole air supply for the occupants, the volume per person would greatly exceed that in a ventilated shelter which depends on purified air drawn in from outside.

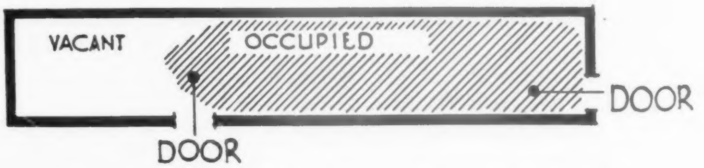
(*c*) *Floor Area per Person.*—This must be sufficient to permit the occupants to be comfortably seated. In an unventilated shelter of normal height the volume required would ensure ample floor space in any case, but in an artificially ventilated shelter where it is possible to allow less volume per person, floor space becomes a determining factor. A minimum requirement for ventilated shelters is 6 square feet per person, although the Home Office* permits as little as 3½ square feet under "emergency conditions."

Seating accommodation should be provided for all occupants. Minimum requirements are shown in Fig. 6. For sick people and children, beds ought to be provided.

Besides being proportioned to provide sufficient air space and floor space for the physical comfort of the occupants, the refuge room should not be designed so as to ignore completely their psychological needs. As far as possible the room should be designed to avoid creating an oppressive sensation. For this reason the ceiling should be 8 ft. high if possible, with a minimum of 7 ft. In Spain it has been the experience that people in shelters tend to shun a cul-de-sac, preferring to occupy the space between two means of exit (Fig. 7). From this it appears that psychologically, as well as from the practical point of view, it is best to have the doors at the opposite extremities of the refuge room.




**6**—*Spacing for seating accommodation in shelters.*




**7**—*Diagram showing why doors should be at ends of refuge rooms.*

ENTRANCES

The shelter should be planned with a minimum of two means of exit—that is, an entrance and at least one emergency exit, arranged in such a way that they are not likely both to be buried under debris at one time. The entrance door should itself be protected. To construct a door capable of giving protection from bombs falling at close range would be extremely expensive, if not impracticable. It is therefore better to use a relatively light door and protect it by a wall which affords the same degree of protection as the rest of the shelter.

Owing to the force of blast, which might easily destroy the close fit of gas-tight doors, it would be better to have an outer blast-proof door to protect the gas-tight door.

Gas-tight doors should, however, be designed so that a slight deformation does not destroy the seal. This can be achieved by making the seal of some elastic material such as rubber tubing. A method of sealing gas-tight doors with a rubber gasket of this type is shown in Fig. 8. The doors should be equipped with a glazed spy-hole so that people about to enter can satisfy themselves that the inner door of the gas lock is closed before opening the outside one.

CLOSETS

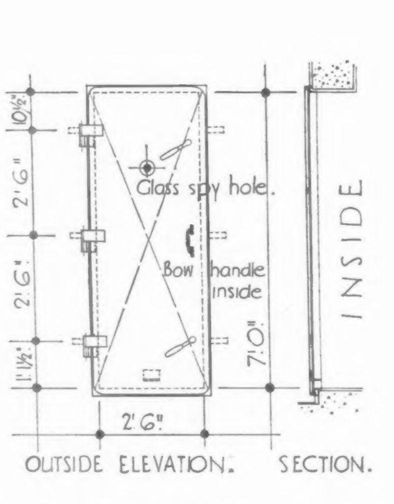
There should be one W.C. for 20 to 25 people, but in shelters for 100 or more the number can be reduced. Chemical closets overcome the difficulty of connection with the sewer.

In trench systems, the Home Office recommends that closets should be situated so that no-one will have to travel more than 50 yards.

VENTILATION

Shelters may be either designed so that the refuge room is hermetically sealed and of such dimensions as to ensure adequate breathing conditions for the occupants, or else equipped with a system of artificial ventilation.

(*a*) *Unventilated Shelters.*—Continental authorities are mostly agreed on a standard of 1 cubic metre (35 cubic feet) per person per hour.




**8**—*A gas-proof door (from information supplied by the Crittall Manufacturing Co., Ltd.)*

* A.R.P. Handbook, No. 6. Home Office, 1937.

● *The Home Office* states that "under English summer conditions closed rooms may be safely occupied for a period up to 12 hours if the surface area of the walls, floor and ceiling is equivalent to an allowance of 100 sq. ft. per person."*

*Gas Proof Door (Messrs. Trollope & Colls & Hobbs, Hart & Co.)*

Swiss regulations, on the basis of a four-hour stay, prescribe 4 cubic metres per person (140 cubic feet). German regulations are satisfied with 3 cubic metres (105 cubic feet) per person. In Spain, 4 cubic metres for a three-hour stay is required. The Home Office* states that "under English summer conditions closed rooms may be safely occupied for a period up to 12 hours if the surface area of the walls, floor and ceiling is equivalent to an allowance of 100 sq. ft. per person." This recommendation is based on the argument that before the air became unbreathable as a result of the increasing proportion of exhaled carbon dioxide, conditions in the room would have become intolerable due to the humidity of the atmosphere. The wall surface is calculated to ensure the condensation of atmospheric moisture and thereby to reduce the humidity.

As an example, a room 10 ft. square and 8 ft. high has a total wall, floor and ceiling area of 520 square feet, and will therefore on the Home Office basis accommodate 5 people for 12 hours. This works out at 160 cubic ft. per person, and compares favourably with the continental figures; although spread over 12 hours it gives only 14 cubic ft. per hour. An alternative figure of 75 ft. super of wall, floor and ceiling space for a stay of 6 hours is given in Handbook No. 6. The entrances to an unventilated refuge room ought to be arranged so that a complete and rapid air change can be ensured after a period of occupation.

(*b*) *Artificially Ventilated Shelters.*—For ventilated shelters a far smaller cubical content is required for each person. In Germany, if artificial ventilation is used, the volume per person may be reduced to 1 cubic metre (35 cubic ft.) instead of 3 cubic metres (105 cubic ft.) for unventilated shelters.

There are two methods of providing a supply of pure air, by regeneration and by filtration.

Regeneration consists in purifying the vitiated air by absorbing the carbon dioxide produced by the respiration of the occupants, and releasing a proportion of fresh oxygen from cylinders. In this system no air is taken from outside, the air contained within the shelter being used over and over again. The disadvantage with this system is that unless the room is absolutely gas-tight there is no guarantee that gas-laden air will not leak in.

The filtration system, on the other hand, draws in air from outside and by passing it through a series of filters delivers a supply of fresh purified air. The Home Office requires that a ventilation plant shall deliver 150 cubic ft. of air per person per hour. Continental regulations vary from 3 cubic metres (105 cubic ft.) to 5 cubic metres (175 cubic ft.) per person per hour. The plant can be operated by an electric motor running off the mains, but it should always be possible to go over to manual operation in the event of a failure of the supply. Filtration plants are designed to produce a slight excess of pressure inside the shelter, over the external atmosphere, so that any leakage through the walls, etc., of the shelter will be outwards, and not from the gas-laden air inwards. There should be at least two air intakes, and they should be arranged so as to avoid as far as possible the risk of being blocked with debris. From the point of view of prolonging the life of the filter, it is an advantage to have the intake sufficiently high above the ground level to ensure that it will not draw air from an area where heavy concentrations are likely to accumulate. At the same time the vulnerability of a lofty intake must be taken into account. A good filter can cope with any practical concentration of gas, but would require earlier renewal if it had always to work with a high concentration of gas.

The ventilation plant should be so located in the shelter that the flow of air is outwards, as in Fig. 5. Gas collects in the entrance and gas lock, and to some extent in the decontaminating room. It is important, therefore, that the air should flow through the refuge room and out through the decontamination room and gas lock. The air should be finally expelled via a special non-return valve suitably located either in the outer door or the external wall of the gas lock. Care must be taken also to see that offensive smells from the closets are not carried into the shelter proper. This can be ensured by arranging them adjacent to the decontamination room (Fig. 5).

It will be obvious that a system of artificial ventilation makes possible a very large reduction in the cube of the shelter. An unventilated refuge 6 ft. 6 in. high, after being equipped with a ventilating plant, was found to be adequate for about three times the number of people previously accommodated.†

* A.R.P. Handbook, No. 1. Home Office, 1937.
† F. Roedler. V.D.I., 1937. No. 15.

● ***It would appear, therefore, that the relatively small additional cost incurred in installing artificial ventilation is more than offset by the big saving in excavation and reinforced concrete construction.***

It would appear, therefore, that the relatively small additional cost incurred in installing artificial ventilation is more than offset by the big saving in excavation and reinforced concrete construction.

### SERVICES

Gas and water pipes should not pass through the shelter as they may be ruptured by an explosion.

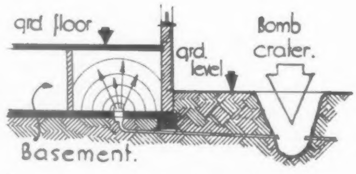
Where a pipe unavoidably passes through the shelter wall, the junction must as far as possible be made gas-tight. In the case of pipes subject to temperature variations, the junction must be made with some elastic material.

Untrapped gullies are a source of danger since, if the drain is broken, gas may enter the shelter (Fig. 9).

Water supply can be from the main, but provision must be made for a failure of supply. Swiss regulations recommend an emergency supply of 15 litres (about $3\frac{1}{2}$ gallons) per person.

Power and light may be from the mains but, again, the possible failure of these must be reckoned with. Ventilation plants suitable for 50 persons can easily be operated manually, but for larger installations an emergency source of power is desirable. For a very large plant it is desirable to have a motor generating set, which will also provide a completely independent source of lighting. A generating set must be installed in a separate room entirely cut off from the shelter, and with its exhaust carried out into the open air. Storage batteries can be used for emergency lighting, although in a shelter with ventilating plant it would, of course, be possible to use oil lamps and candles without vitiating the atmosphere. Luminous paint can also be used, especially for defining the position of exits and for notices.

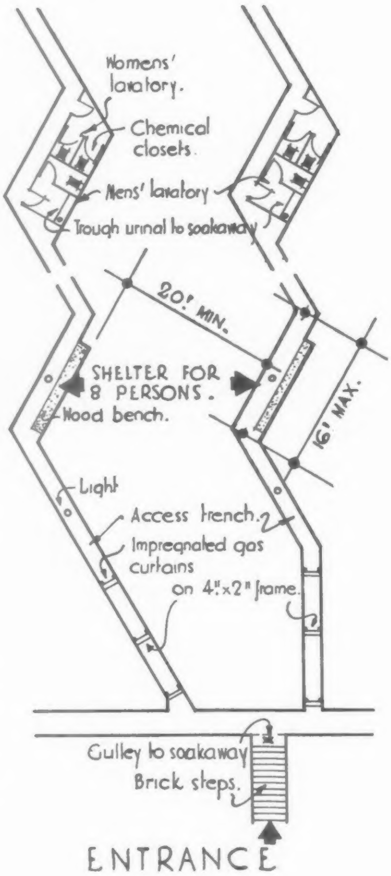
Owing to the heat generated by the bodies of the occupants a heating system is quite unnecessary. The problem is rather one of keeping the temperature down. An exception occurs in the case of first-aid shelters, where casualties would need to be kept warm.




**9**—***Gas collecting in the bomb crater may be forced into the shelter through a broken drain, by the blast of a nearby explosion.***

### MISCELLANEOUS EQUIPMENT

Separate storage space should be provided for first-aid materials, food and tools. Food should be kept in gas-tight containers. The tools are necessary so that the occupants can release themselves should all the exits be blocked with debris, and should include crowbars, picks, saws, spades and axes.




## THE CONSTRUCTION OF SHELTERS

It is not possible to consider every type of shelter, but certain general categories can be established. Shelters can be classified according to degree of safety afforded—which may be anything from protection against splinters to protection against direct hits from heavy bombs.

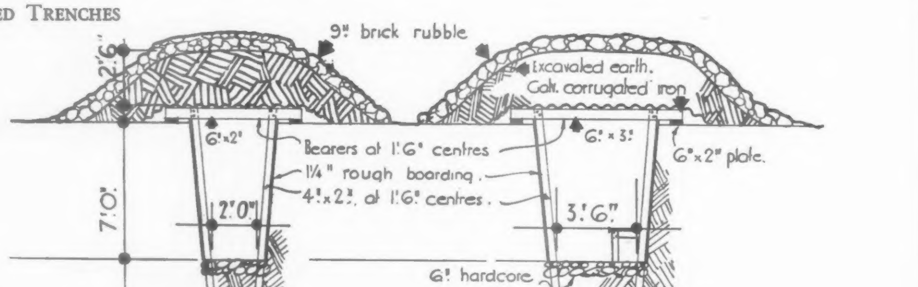
The shelter may be independent or it may be built in a new or existing building. We have considered surface shelters (as distinct from tunnels) under the following classification: first, independent surface shelters, including covered trenches, blast-proof shelters and bomb-proof shelters; and second, shelters in buildings.

## INDEPENDENT SURFACE SHELTERS

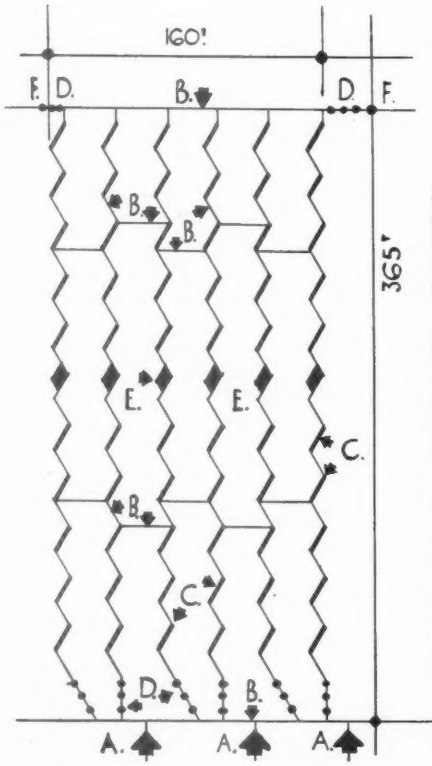
### COVERED TRENCHES

Covered trenches provide good protection against blast and splinters. A typical trench section is shown in Fig. 10. The excavated earth is used to form a roof, which is supported on some form of permanent shuttering. The Home Office* recommends that trenches should be a minimum of 7 ft. deep and 2 ft. wide at the bottom and with recesses 1 ft. 6 in. deep at intervals, long enough to seat 10 people. The roof is recommended to be of a minimum of

* A.R.P. Handbook, No. 6. Home Office, 1937.



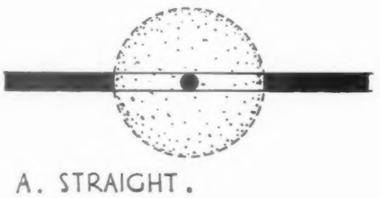

**10b**—***Plan and details of a system of covered trenches.***



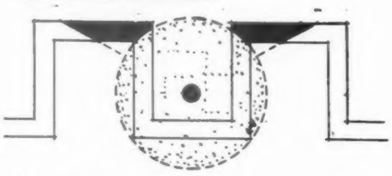

PLAN OF
UNVENTILATED TRENCHES
for 480 persons : 370 per acre

A • entrances, stairs down. B • access trench.
C • shelters D • gas curtains.
E • lavatories. F • emergency exit

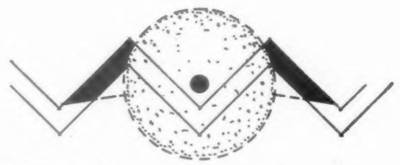
**10 C**



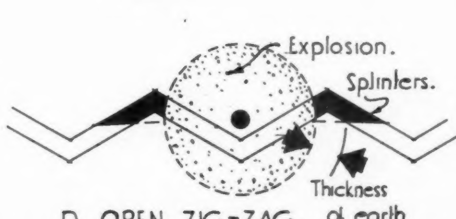
A. STRAIGHT.



B. CRENELLATED.



C. CLOSE ZIG-ZAG.




D. OPEN ZIG-ZAG.

**11**—***Effects of bombs on different trench plans. (Information from the Defensa Passiva de Catalunya.)***

● *It has been found in practice in Spain that the zig-zag type (of trench) provides greater safety than the crenellated type.*

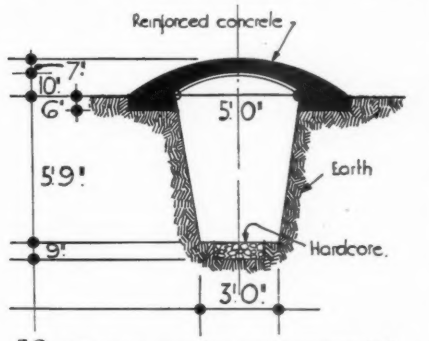
2 ft. 6 in. of earth supported on sheets of corrugated iron on wood joists at intervals. The protection can be further increased by a layer of hardcore 9 in. thick on top of the earth. Trenches should be not less than 20 ft. apart. The walls should be lined with creosoted boards or corrugated iron and held in position by 4 in. by 2 in. uprights driven 1 ft. 6 in. into the ground.

A recent Spanish Government publication* recommends trenches for places where the existing buildings have no basements. Where the trenches are excavated near buildings they should at least be as far away as the height of the building. In order to localize the effects of explosion trenches, should be excavated zig-zag on plan. It has been found in practice that the zig-zag type provides greater safety than the crenellated type. The effects of blast and splinters from bombs falling on trenches varying in plan is shown diagrammatically in Fig. 11.† The trenches should not run more than 5 metres (16 feet) without changing direction. Where space is limited, the trenches should be excavated 4 ft. wide at the bottom to accommodate two files of people. Where sufficient space is available, it is better to excavate a narrower trench, 2 ft. 7 in. wide at the bottom, accommodating a single file of people spaced at 1 ft. 8 in. centres. In order to keep the trench free from water, a soakaway is recommended at the foot of each flight of steps. A layer of rammed hardcore is an advantage in keeping the floor of the trench in good condition. In cases where there is subsoil water, the regulations give 8 in. as the minimum distance from the floor of the trench to the subsoil water level. In such a case the side of the trench might have to be partly formed of earth walls above the normal ground level.

In Spain, where protection has had to be contrived while a war is in progress, great emphasis is placed on the advantages of rough-and-ready shelters which can be provided quickly and improved at a later date. With this idea in mind, many open trenches have been excavated, providing partial protection from splinters, but which can be rendered safer by the addition of an earth or reinforced concrete roof when the exigencies of war permit. Fig. 12 illustrates a trench section recommended by the Defensa Passiva de Catalunya. When putting a concrete slab over a trench it is important to give it ample bearing on each side as it was found in the first covered trenches of this type in Spain that the wet came in under the edges of the slab.

Although trenches give good protection against blast and splinters, they are difficult to make gas-proof. They can only be excavated in dry soil, and are difficult to drain.

In order to arrive at an estimate of the cost of providing earth-covered trenches, we produced the scheme illustrated in Fig. 10. The trench sections conform generally to the recommendations of the Home Office, but the planning has to some extent been influenced by experience gained in Spain. The trenches in Spain are not as a rule adapted to give protection against gas, and therefore the entrances are open to the external air. This permits more people to occupy the trench than would be the case if it were sealed with gas locks. In the scheme which we have prepared it was found that to comply with the Home Office requirements relating to wall surface per person, it was necessary to arrange the occupants in groups at intervals. There is accommodation for 480 people seated in recesses off the main trench. Gas locks are provided at the entrances, and chemical closets at the rate of 1 to 25. Lighting is by electrical storage batteries, there being one light point to each length of trench.




**12**—***Trench section recommended in Spain***

*Costs.*—The total cost of the trench shelters as shown in Fig. 10, including the carting away of surplus earth, £4,603; cost per head, £9 12s. 0d.

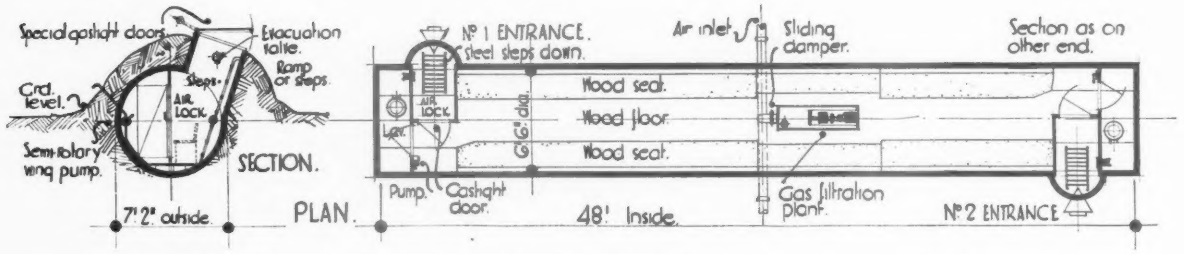
### BLAST-PROOF SHELTERS

By a "blast-proof shelter" is meant a shelter affording its occupants protection not against blast alone but, in the words of the German Bomb Proof

* Iniciacion en la Defensa Passiva. Issued by the Junta de Defensa Passiva de Catalunya. Barcelona, March, 1938.

† Information from the Defensa Passiva de Catalunya.

● *Generally speaking blast- and splinter-proof shelters depend, like trenches, on a covering of earth to ensure protection, although other materials such as concrete, coal, slag, etc., might be used.*

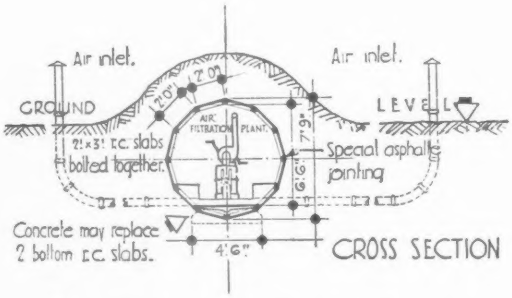



**13**—*Blast-proof shelter for 50 people (Carrier Engineering Co., Ltd.).*

Shelter Regulations,* "against air concussion, air suction, bomb splinters and debris of building materials (where the shelter is in or adjoining a building) as well as against chemicals employed for offensive purposes. No security is afforded against direct hits."

The Home Office recommends that blast-proof shelters should be proof against direct hits from incendiary bombs up to 25 lbs. in weight and against blast and splinters from a 500 lb. high explosive bomb bursting not nearer than 50 ft.

Generally speaking, blast- and splinter-proof shelters depend, like trenches, on a covering of earth to ensure protection, although other materials such as concrete, coal, slag, etc., might be used. They usually consist of a thin shell of reinforced concrete or steel sheets which, while itself giving a certain degree of protection, functions primarily as a permanent shuttering for a covering of earth or other material. Being enclosed in steel or concrete they can fairly easily be made gas-proof, making possible the installation of a ventilating plant and a consequent considerable reduction in the dimensions of the shelter.




**14**—*Blast-proof shelter for 50 people (Stent Precast Concrete, Ltd.).*

The most economical method of construction would be to bury the shelter partly below ground level so that the excavated earth is sufficient to provide the necessary top cover. The Home Office requires 2 ft. 6 in. of earth or 12 in. of normally reinforced concrete to stop splinters—reinforced concrete being therefore 2½ times as resistant to splinters as earth. If the shelter lining is of reinforced concrete 5 in. thick it would be necessary, on this basis, to provide an additional cover of 1 ft. 6 in. of earth in order that the total should be equivalent to 12 in. of reinforced concrete or 2 ft. 6 in. of earth.

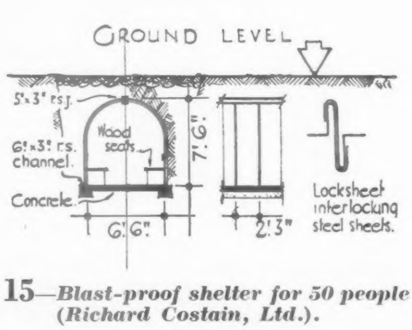
Reinforced concrete shelters of this type may be either monolithic or of precast units or spun pipes. The two latter have the advantages that they lend themselves readily to mass production and reduce the time of erection to a minimum.

A shelter for 50 persons constructed of 6 ft. 6 in. diameter spun concrete pipes is illustrated in Fig. 13. Standard units are used except for the ends and entrances which are purpose made. It may be said in passing that the transport costs of large pipe sections is likely to be quite a big item if the site is very far from the works. This shelter is partly underground, the excavated earth being used to provide the necessary protective layer. Equipment includes an air filtration plant situated midway from the ends and delivering purified air which passes out at the ends via the gas locks through non-return valves. Two chemical closets and electric lighting are provided. A similar shelter illustrated in section in Fig. 14 is constructed of precast reinforced concrete segments which are bolted together on the site.

Shelters of rectangular sections may be built up with precast reinforced concrete beams held at the angles with grooved corner posts of the same material.

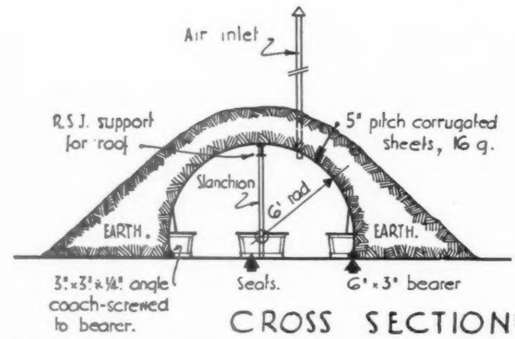
Steel shuttering for shelters varies from corrugated iron sheets to sheet piling, the latter being largely used in Germany. Fig. 15 illustrates in section a form of interlocking copper alloy steel sheets which have been designed for air-raid shelters. The shelter is constructed by erecting the sections on a bed of concrete which forms the floor of the shelter, and filling in the ends with brickwork. A cover of earth or concrete is necessary to ensure protection.

According to information received from the manufacturers, the shelters so far described, accommodating 50 persons, can be built for from £7–£9 per head. It should be understood that transport costs and local conditions inevitably influence the price.

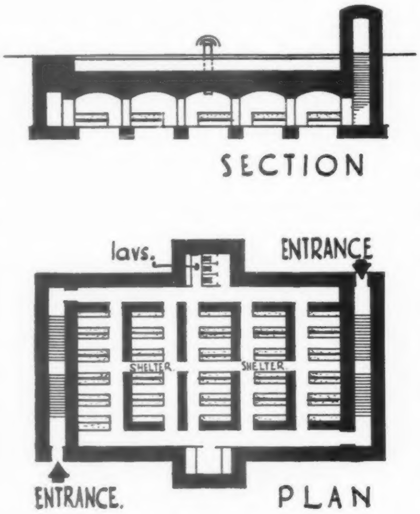



**15**—*Blast-proof shelter for 50 people (Richard Costain, Ltd.).*

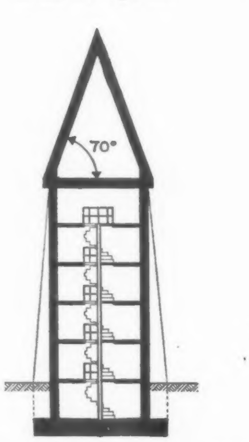
* First administrative provisions under Article I of the 2nd Decree for the application of Air Raid Precautions Law. 4th May, 1937.



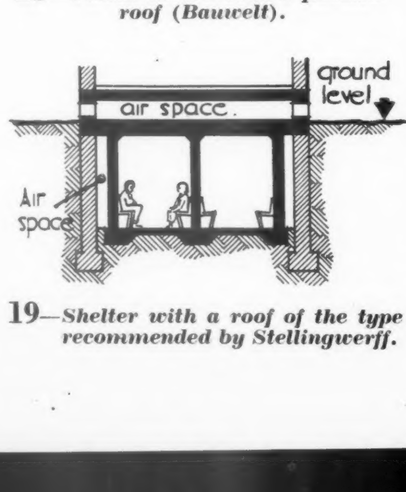

**16**—*Blast-proof shelter for 50 people (Nissen Buildings, Ltd.).*




**17**—*Type of surface shelter being built in Spain.*




**18**—*Tower shelter with a pointed roof (Bauwelt).*




**19**—*Shelter with a roof of the type recommended by Stellingwerff.*

● *These (working class residential) areas will certainly suffer far more than thinly populated residential areas, and it seems logical to provide a higher degree of protection for those of the population who have to remain in such danger zones.*

A shelter utilizing light curved corrugated iron sheets of the " Nissen hut " type is shown in section in Fig. 16. With a 2 ft. 6 in. cover of earth and with accommodation and equipment similar to those previously described, we are given to understand by the manufacturers that the cost would be up to £5 12s. per head.

It should be said that the types of shuttering or lining referred to here for the construction of blast-proof shelters can be equally well used for bomb-proof shelters, in which the earth cover would be replaced by several feet of reinforced concrete.

### BOMB-PROOF SHELTERS

The degree of protection to be provided must be determined by the location of the shelter in relation to military objectives. Not only industrial areas, but densely populated working class districts are to be regarded as objectives if one judges by the trend of events in Spain and China. Areas such as these will certainly suffer far more than thinly-populated residential areas, and it seems logical to provide a higher degree of protection for those of the population who have to remain in such danger zones.

In Spain, after experiencing the effects of high explosive bombs, the policy of the Government is to provide bomb-proof shelters for as many as possible of the population in the important towns. Shelters are designed to withstand bombs of the order of 6 cwts.

French regulations recommend that shelters should be proof against hits from at least 2 cwt. bombs.

In Lithuania the regulations require that " medium " shelters (which are considered to be a minimum for public refuges, railway stations and power station employees, etc.) are to be proof against 1 cwt. bombs. It is further recommended that public shelters should give protection against 6 cwt. bombs.

Stellingwerff* considers that in densely populated areas protection should be given against 2-cwt. bombs. With open planning and relatively low density of population, protection against splinters, blast and debris is considered sufficient. In the case of large public shelters—such as converted subways and underground stations—he regards protection against 6-cwt. bombs a minimum. The efficacy of the Spanish bomb-proof shelters was illustrated recently in a series of air raids on Barcelona. During the course of five bombing raids only six people were injured and no one was reported killed. Three of those injured were occupants of a shelter on which a direct hit was scored. A second bomb fell alongside. " The bombs weighed 220 lb. each. One exploded directly on top of the refuge, the other about 10 ft. to one side. No shrapnel from either reached the people sheltering inside, and the three who were injured were struck by chunks of concrete falling from cracks in the ceiling. The refuge itself is all above ground. It is built of reinforced concrete, with buttresses along the sides and sand boxes on top. The space inside is divided into a maze of narrow corridors." (*Daily Telegraph*, May 31, 1938.)

In the design of a refuge two courses may be adopted to ensure protection from direct hits. The roof may be horizontal and of sufficient strength to withstand the full effects of the bomb, or a sharply sloping roof may be employed which would serve to deflect the bomb so that it would explode beside the refuge and not on top of it (Fig. 18). Although a sloping roof need be of less thickness than a flat roof, its use in an urban area is of doubtful advantage, since the deflected bomb might cause greater damage to surrounding buildings.

Data is not available respecting the comparative merits of solid slabs of concrete or reinforced concrete as against the " sandwich " type of roof composed of two or more separate slabs of reinforced concrete (Fig. 19). It is interesting to note that in Barcelona shelters claimed to be capable of resisting 6-cwt. bombs have been built under squares and gardens, with roofs of two independent slabs with an air space in between, on the lines recommended by Stellingwerff (Fig. 20). A type of shelter now being built in Barcelona, and claimed to give protection against heavy bombs, has three separate superimposed slabs of reinforced concrete. The upper void (between the top and middle slab) is filled with sand, and the lower void (between the middle and bottom slab) with stones.

It is a basic principle in designing a bomb-proof shelter that there should be the same degree of protection in all directions. It is obviously uneconomical to design a shelter, the roof of which will resist a bomb of a given weight, but having walls which would be destroyed by the same bomb falling beside them. The floors and walls must be considered equally with the roof.

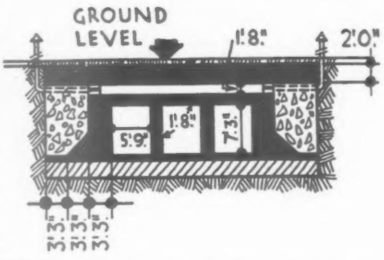
* Protezione dei Fabbricati dagli Attacchi. Aerei. Milan, 1936.

The roof has to withstand both the penetrative and explosive effects of the bomb falling on it, while the walls will have to resist only the explosive effects of bombs bursting alongside. An important factor influencing the design of the walls is the tamping effect of the earth surrounding them (Fig. 4).

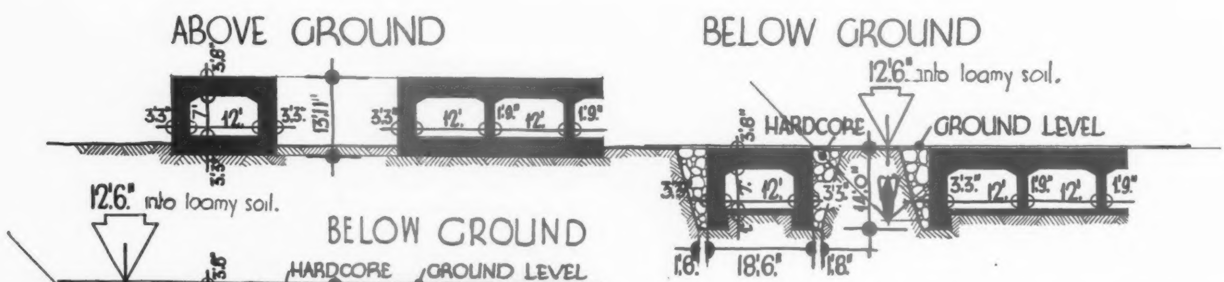
The floor of the shelter is subject to destruction by bombs penetrating deeper than the foundation of the shelter. In designing a shelter to resist a given weight of bomb, therefore, the theoretical depth of penetration of such a bomb into the surrounding soil must first of all be ascertained. By taking the walls and foundation down to a level slightly below the maximum depth of penetration of the given bomb, the floor is protected from the bursting of the bomb and can be of normal thickness (Figs. 21 and 22). It may be found in the case of very loose earth, however, that in order to protect the floor in this manner the foundations would have to be carried down to an uneconomical depth. This would certainly be the case with a shelter built above ground level. It would then be better to design the floor the same thickness as the walls, giving in effect a straightforward concrete box (Figs. 21 and 22).

The internal division walls within the shelter can be considerably thinner than the external walls. They should be sufficient to support the roof, which may be subjected to the impact of a bomb, and should be at least splinter proof.

An obvious economy in construction is to reduce external walls as far as possible by grouping people in large shelters with relatively thin division walls between the units, instead of a large number of small shelters. The same principle can be adopted vertically, by making the shelter in two storeys, with relatively thin floors (Figs. 21 and 22). The indefinite extension of refuges in this way is limited by the greater risk incurred by concentrating very large numbers of people together in one spot.

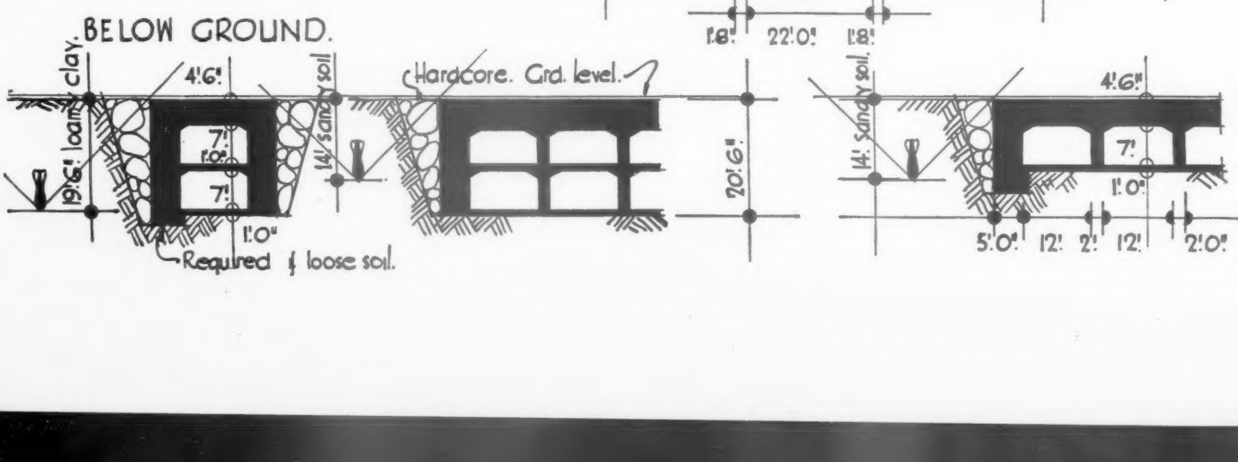


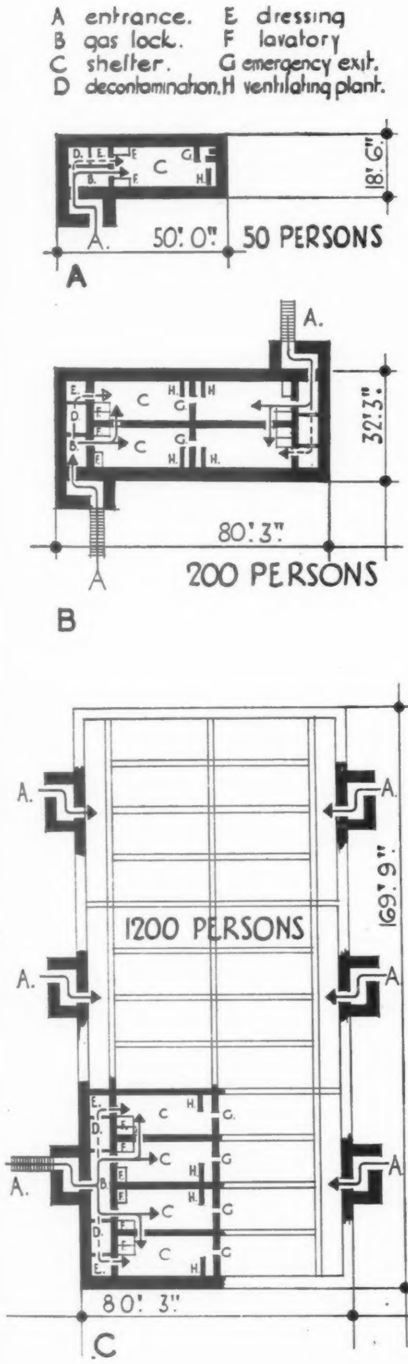

**20**—*A type of shelter built in Barcelona ("Refugios," Barcelona, 1937).*




**21**—*Sections of reinforced concrete shelters proof against 2-cwt. bombs. (Based on information from "Technische Richtlinien fur den Baulichen Luftschutz.")*

**22**—*Sections of reinforced concrete shelters proof against 6-cwt. bombs. (Based on information from "Technische Richtlinien fur den Baulichen Luftschutz.")*






**23 A, B and C**—*Plans of shelters for 50, 200 and 1,200 persons.*

In an attempt to arrive at the probable cost of providing protection of this character, we have designed a series of bomb-proof refuges of various capacities.

It is not claimed that either in planning or construction these projects are the last word in shelter design. They are primarily to form the basis of an approximate estimate of the cost of bomb-proof protection, and are designed according to figures of the Swiss Federal Commission on A.R.P.* Shelters were designed to give protection against 2-cwt. bombs and 6-cwt. bombs.

In all cases a unit accommodating a maximum of 50 persons has been adhered to as the basis of the designs Each unit has two entrances and is equipped with an air-filtration plant. The floor area per person, excluding lavatories, gas locks and decontamination accommodation, is 6·25 sq. ft., and the volume per person is 43 cu. ft.

Accommodation for anti-gas treatment is provided between the gas lock and the shelter proper. The entrance to the shelter is protected by a baffle formed of walls the same thickness as the main external walls of the shelter.

The application of this unit to a single shelter is given in Fig. 23A. It is obvious from this plan that the external walls occupy a very large proportion of the total area.

A shelter for 200 people is illustrated in Fig. 23B. Two gas locks are provided with two units entered from each lock.

The application of the same basic unit to a shelter accommodating 1,200 people is illustrated in Fig. 23C. Fig. 24 shows the detailed arrangement of a portion of this shelter.

COSTS

**SHELTER PROOF AGAINST 2-cwt. BOMBS**

| Above ground | Total cost | Per head |
|---|---|---|
| | £ | £ s. |
| For 50 people ... ... ... ... ... | 1,401 | 28 0 |
| For 200 people ... ... ... ... ... | 3,637 | 18 4 |
| For 1,200 people ... ... ... ... | 18,304 | 15 5 |
| **Below ground** | | |
| For 50 people ... ... ... ... ... | 1,818 | 36 7 |
| For 200 people ... ... ... ... ... | 4,275 | 21 8 |
| For 1,200 people ... ... ... ... | 19,705 | 16 8 |

**SHELTER PROOF AGAINST 6-cwt. BOMBS**

**(The thickness of walls, floors, and roofs are shown in Fig. 22.)**

| Below ground | Total | Per head |
|---|---|---|
| | £ | £ s. |
| For 200 people ... ... ... ... ... | 6,189 | 30 19 |

The following is an analysis of the cost of the shelter below ground for 200 people proof against 2-cwt. bombs :—

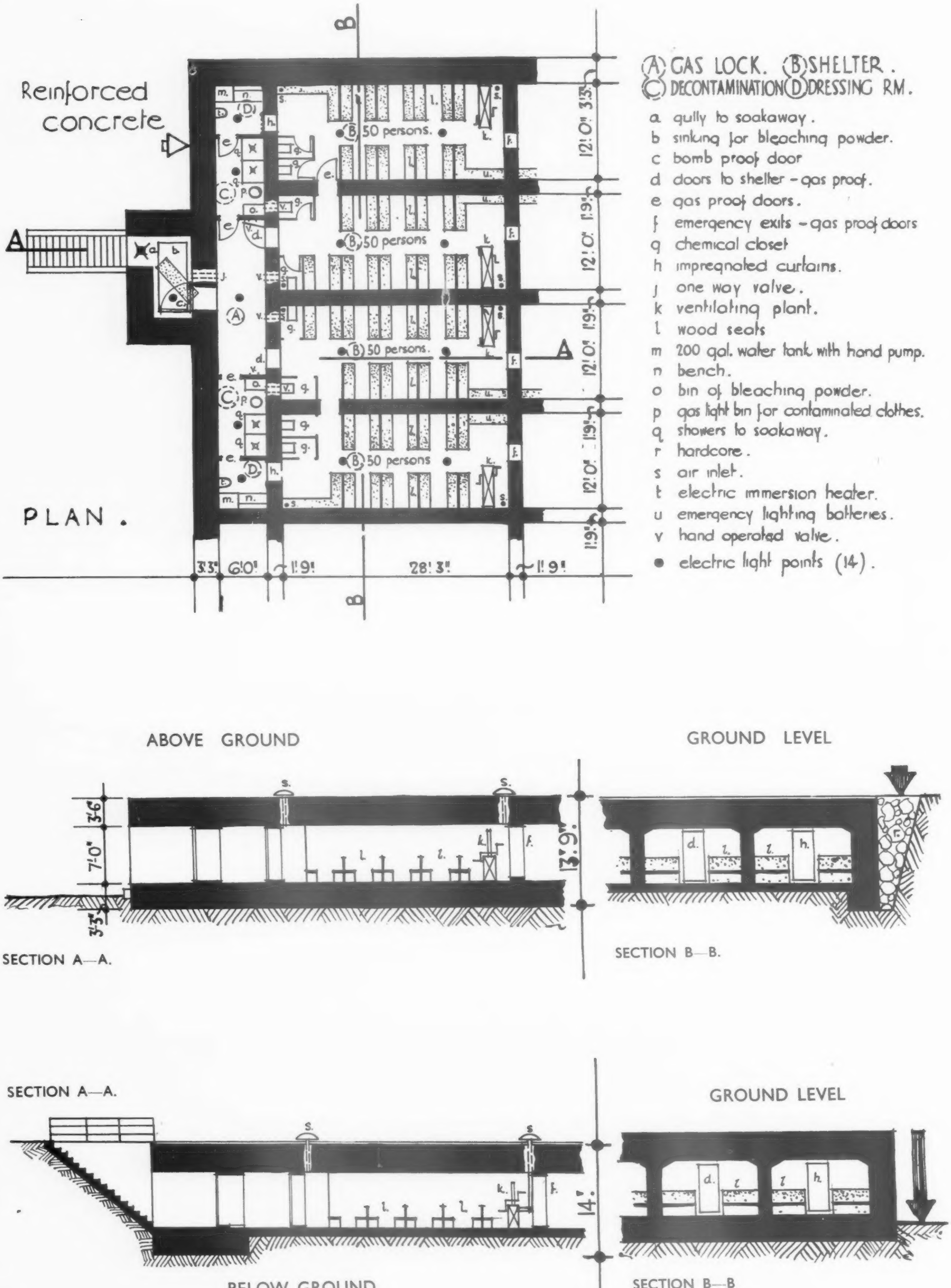
| | £ |
|---|---|
| Excavation and disposal of earth... ... ... ... | 871 |
| Concrete ... ... ... ... ... ... ... ... | 1,032 |
| Reinforcement ... ... ... ... ... ... ... | 1,331 |
| Air filtration plant... ... ... ... ... ... | 324 |
| Gas proof and splinter proof doors ... ... ... | 184 |

In the item for excavation and disposal of earth the sum of £455 has been included for carting away. Approximately two-thirds of this could be saved if this earth were deposited close to excavation.

Although there are few examples of bomb-proof shelters in mass concrete, it is, however, important to consider the use of this material, since in some respects it has certain advantages over reinforced concrete ; viz. (1) that construction is quicker, the concrete being poured into position, instead of having to be tamped round reinforcement. (2) Mass concrete shelters require less skilled labour for their construction. (3) That the price of steel is liable to fluctuate and would certainly be high in case of an emergency.

It will be seen from the above analysis that the cost of reinforcement forms a considerable proportion of the total. We have therefore worked out a mass concrete shelter, proof against 2-cwt. bombs based on figures given in the Swiss handbook, and have found that the price is almost exactly the same as the corresponding shelter in reinforced concrete.

* Technische Richtlinien für den Baulichen Luftschutz. Berne, 1936.




**24**—*Details of Shelter for 1,200 persons.*

# SHELTERS IN BUILDINGS

## BLAST-PROOF SHELTERS

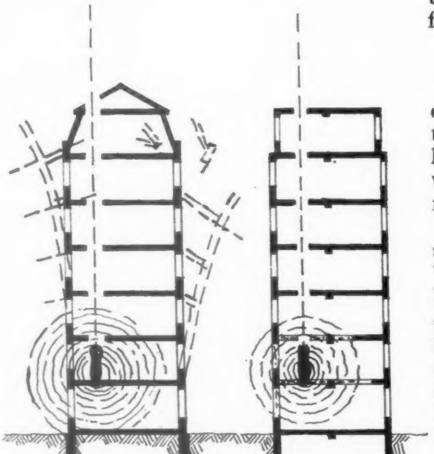
THE advantages to be gained from constructing shelters in buildings, rather than as isolated structures, are first that the shelters are easily accessible to the occupants, and second that the structure of the building itself can to some extent be used for protection. The facility with which a refuge can be contrived in a building depends very largely on the type of building—whether steel-framed or with weight-bearing walls, number of storeys, construction of floors, thickness of walls and so forth.

### BLAST-PROOF SHELTERS IN BUILDINGS

Broadly speaking, buildings may be classified as framed and unframed. The blast of a bomb falling nearby is likely to demolish a building of traditional construction, that is with weight-bearing walls. A framed building will suffer much less. The likelihood is that some of the walls and panels would be destroyed, but that the framework and floors would remain intact. A framed building, therefore, either of steel or reinforced concrete is much preferable to the traditional type of structure. (Fig. 25.)

Splinters ejected from the bomb crater will damage the walls of several of the lower storeys of nearby buildings, the ground floor walls being particularly vulnerable. The best protected part of the building, therefore, from the point of view of both blast and splinters is the basement, which has the advantage of a solid wall and is encircled by a natural protection of earth. In a high building, of course, the upper floors might be made reasonably safe from splinters, but the danger of blast and the collapse of the building would always be present. Where (owing, for example, to the absence of a basement) it becomes necessary to locate the shelter on an upper floor, it should not be situated below the second floor and should have at least two storeys above it to provide overhead protection.*

The German regulations† which require blast-proof shelters to be provided in every building, make the use of the cellar compulsory in all but exceptional circumstances. To provide the same degree of protection in a building without a basement would be, relatively, a difficult and costly process.




25—*Effects of a direct hit on an unframed building and a framed one.*

* E. F. J. Hill. Inst. Mun. Co. Eng. J. 1937. No. 24.
† First Administrative Provisions under Article I of the Second Decree for the application of the Air Protection Law.

● *In large buildings it is desirable to have a number of small shelters evenly distributed over the plan rather than one large central shelter.*

● *Experience gained from explosions has shown that it takes at least three hours to remove debris from exits.*

The location of the shelter or shelters will depend considerably on the layout and size of the building. In large buildings it is desirable to have a number of small shelters evenly distributed over the plan rather than one large central shelter. Three important considerations must always be borne in mind: accessibility, means of escape, and protection against the collapse of the building. The shelter should not be situated under large water tanks or under floors bearing heavy machinery, which might be dislodged and fall on to the shelter. Boiler-rooms should never be adapted as refuges. Rooms under warehouses, particularly those where combustible goods are stored, are also to be avoided. Experience gained from explosions has shown* that it takes at least three hours to remove debris from exits. A fire, raging above the shelter would, to say the least, be very distressing for the imprisoned occupants. In some cases the risk of flooding, due, for example, to the proximity of water mains or sewers, renders the adaptation of the basement very difficult. To ensure protection it would be necessary to tank the refuge room with asphalt and provide means of access above the flood level. In a building with a sub-basement this danger might be met by locating the shelter in the basement rather than the sub-basement, which would function as a sump for the flood water. (Under different conditions one might be influenced to use the sub-basement as a refuge in order to take advantage of the greater overhead protection afforded.)

The planning of the shelter conforms generally to the principles previously indicated. In an existing building it is often possible to provide the required accommodation with very little structural alteration. The main entrance to the shelter should be inside the building and easily accessible to the occupants. Other things being equal the entrance would be best situated at the foot of a main staircase. As, in the event of the building collapsing, this entrance would be blocked with debris, it is essential to have one, or preferably two, emergency exits which should have direct access to the street. The emergency exit might conveniently take the form of a manhole cover in the pavement (Fig. 26). This form of emergency exit could be fairly easily contrived where the basement extends partly under the pavement. A better form of emergency exit, but difficult to arrange in urban buildings, would be a tunnel with an exit well away from the building. The provision of an emergency exit will largely influence the location of the shelter. From this point of view, refuges adjacent to the street are preferable to those with access to internal courts, or in sub-basements.

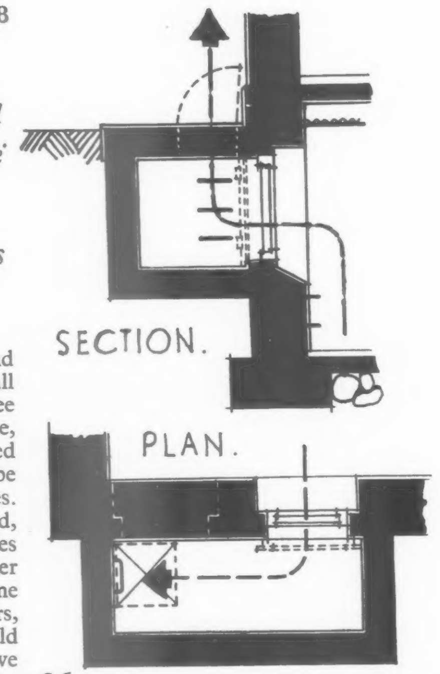
Pipes are always an undesirable feature in a refuge, and difficulty in avoiding them is generally encountered when adapting existing basements. Nevertheless, every effort should be made to ensure that they do not pass through the walls of the refuge.

However high the degree of lateral protection which is afforded by a basement, its occupants are in danger of being smothered under debris unless adequate safeguards are provided against the collapse of the building above. In an existing building some method of strengthening the basement ceiling is essential, if it is to support the debris of the collapsed building. A new floor of reinforced concrete can be built, or the span of the existing floor reduced by shoring. Shoring can be either of wood (Fig. 27) or steel, and it is possible to use brick piers. Steel has the advantage of occupying less space (Fig. 28). Considerable care is required in shoring floors, particularly those of reinforced concrete, since incorrectly placed shoring may actually be a source of weakness.† It may be necessary to provide concrete foundations to the shores. In a new building, of course, it is possible to design the ground floor to withstand the potential debris load.

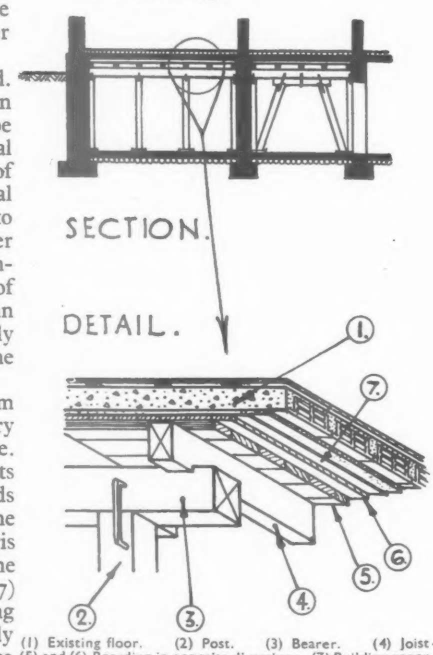
Basement walls where surrounded with earth can be regarded as blast and splinter proof, but where the basement is surrounded by an area, or is actually a semi-basement, additional precautions would have to be taken. Fig. 29 shows a method of protecting a window-opening in an area. Windows which are not essential for light or ventilation might well be bricked up. The German regulations previously referred to make the following recommendations with respect to the thickness of walls of blast-proof shelters in buildings: Where the shelter extends not more than 3 ft. 3 ins. above ground level the thickness of the wall shall be 16 ins. in brickwork, 15 ins. in concrete or 12 ins. in reinforced concrete. In cases where the wall extends more than 3 ft. 3 ins.

* Zenner. Bauwelt. 1937. No. 17.

† The following instance is given by K. Thier in *Deutsche Bauzeitung*, 1935, No. 12. By placing a shore or pier under a freely supported reinforced concrete floor, the part of the slab over the pier becomes virtually a continuous beam, with resulting negative bending movement over the point of support. The slab, not being reinforced to withstand it, would fail.

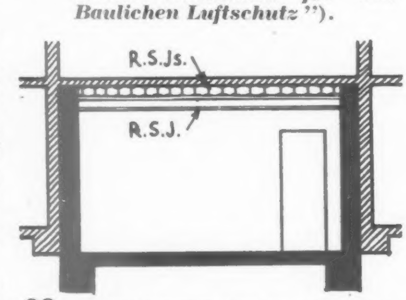



**26**—*Emergency exit from a shelter in a building.*



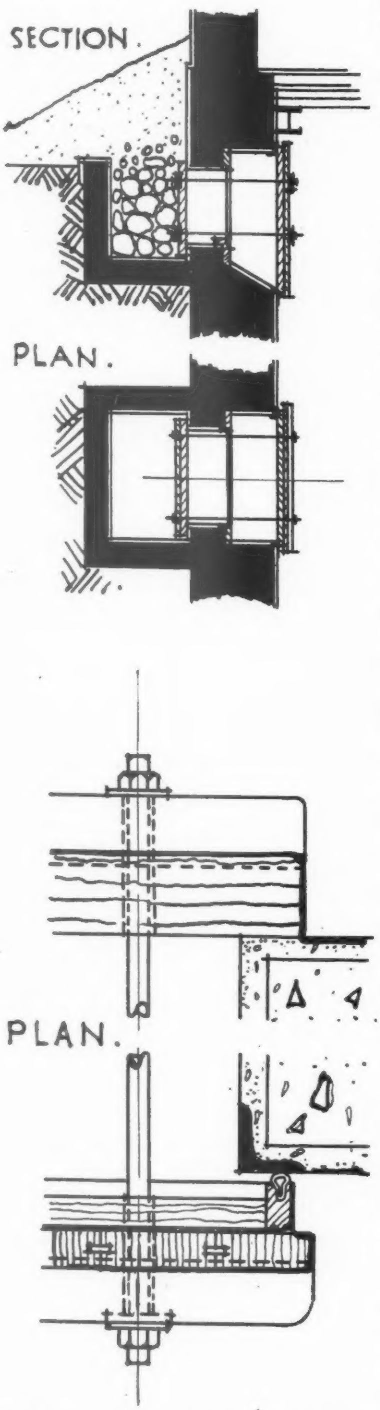

(1) Existing floor. (2) Post. (3) Bearer. (4) Joist. (5) and (6) Boarding in opposite directions. (7) Building paper.

**27**—*Timber shoring (from "Technische Richtlinien fur den Baulichen Luftschutz").*




**28**—*Showing method of shoring a basement roof with R.S.J.s.*

● *It seems sometimes to be assumed that the protection offered by a building is determined only by the number and construction of the floors. It would appear that the angle of impact of the bomb and the construction of the external walls are at least as important.*




**29**—*Details of protection of a basement window.*

above ground the thicknesses have to be increased to 20 ins., 19½ ins., and 15½ ins., respectively.

In an independent blast-proof refuge it is undoubtedly an economy to instal an air-filtration plant to reduce the size of the refuge room. In the case of an adapted basement, on the other hand, there may be sufficient space available to make a hermetically sealed refuge economically preferable to one with artificial ventilation.

## BOMB-PROOF SHELTERS IN BUILDINGS

Much of what has been said in the foregoing section applies with equal force to bomb-proof shelters. However, the adaptation of an existing building, or the incorporation of a refuge in a new building, is relatively easy when nothing more than protection against blast and splinters is required ; but it becomes a much more difficult task to provide a bomb-proof shelter, particularly in the case of an existing building. That the difficulties are by no means insuperable is shown by the requirement of the French regulations that " only premises which in their present state, or with slight alterations, could protect their occupants against medium-sized bombs (2 cwt. max.) and at least three hours in a toxic atmosphere should be classed as shelters."

The same general principles apply to shelters in buildings as in the construction of independent shelters. In a building, however, it becomes possible to reduce the thickness of the refuge roof, by reason of the effect of the superimposed floors in absorbing the penetrative force of the bomb. For example, as will be seen from the foregoing tables, the Swiss regulations permit a reduction of 2⅜ ins. in the thickness of the shelter roof of reinforced concrete in respect of each 6-in. reinforced concrete floor above. French regulations similarly allow 1¼ in. per floor or, if reinforced concrete floors are used, 3 in. for a 4-in. floor and 4¾ in. for a 6-in. floor, which allowance can be made in respect of a maximum of three floors.

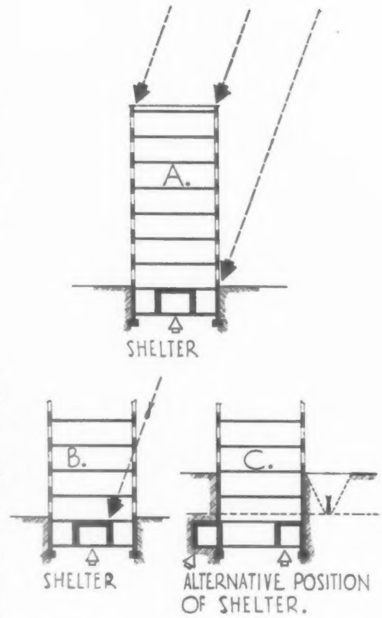
It seems sometimes to be assumed that the protection offered by a building is determined only by the number and construction of the floors—i.e. the higher the building the greater protection afforded by the basement. It would appear that the angle of impact of the bomb and the construction of the external walls are at least as important factors* as the number of floors in determining the degree of protection which can be afforded in the basement. The diagram on the next page (Fig. 30) makes the point clear. The section is of a typical office building with seven floors and a basement. A bomb is assumed to be falling at an angle of 20 deg., in which case it will be seen that chances of the bomb striking the wall or the roof are about the same. It will be seen that the chance of a bomb passing through all nine slabs before reaching the shelter is extremely small. The thin panel wall with up to 50 per cent. glass area will certainly not cause the bomb to ricochet, so that the possibility arises (Fig. 30B) of the bomb penetrating only two floors before it strikes the roof of the refuge. It should be noted that the refuge is located centrally in the building—had it been against an external wall still less protection would have been afforded by the upper floors. It must be admitted that the worst case has been taken; a similar consideration of the longitudinal section would lead to quite different results. However, " the chain is as strong as its weakest link," and in designing a shelter the worst possibilities ought to be considered.

From the foregoing it appears that a reduction in the refuge roof made in respect of the upper floors should only be permitted after a study of the section of the building in question. Generally speaking, it can be said that the upper floors provide more protection for a refuge centrally placed on the section than for one adjoining an external wall. Also in the majority of multi-storey buildings only a limited number of floors may be assumed to give protection to the refuge. This would apply particularly to buildings like flats and offices (requiring ample daylight and therefore narrow on section), but to a less degree to buildings like warehouses and department stores (wide on section).

As an example, take a multi-storey building with normally reinforced concrete upper floors 6 ins. thick and with a basement (9 ft.) clear which is to be used as a refuge, giving protection against a direct hit from a 2-cwt. bomb. The Swiss tables give a required thickness of 3 ft. 8 ins. of " specially reinforced concrete." Assume that after studying the section the conclusion is arrived at that two floors only can be taken into account in reducing the thickness of the refuge roof. According to the Swiss figures this would give a resulting thickness of 3 ft. 3 ins.

* These factors seem to have been ignored by Stellingwerff in certain examples he has worked out. P. 113 *et seq.* Protezione dei Fabbricati dagli Attacchi Aerei.

● *Since a confined explosion is more damaging than one in the open, the only advantages that can be claimed for locating a refuge in the basement is that here it interferes less with the planning, and that its quite considerable weight is transferred direct to the foundations.*



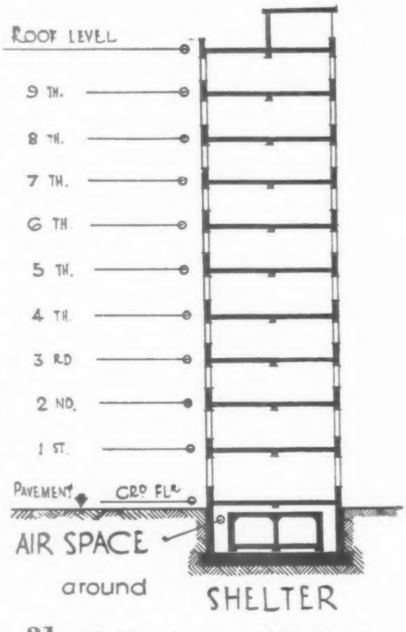

**30**—*Various positions for bomb-proof shelters in buildings.*

In an existing building the lack of headroom in the basement might be an insuperable obstacle to the construction of the refuge roof. In the example given in the preceding paragraph, however, the shelter roof would (after taking into account the thickness of the ground floor, say 8 in. of reinforced concrete) reduce the height of the basement from 9 ft. to 6 ft. 6 in., or barely sufficient headroom for a refuge. In an existing building the height of the basement will to a large extent limit the degree of protection, unless of course one has recourse to excavation to lower the existing floor level. In Barcelona, the problem of building heavy bomb-proof shelters under buildings has been considerably simplified by the existence of very lofty basements—usually at least 15 ft. high. On the other hand, in Paris, when it was required to build a shelter with a roof 6 ft. thick to protect the administrative staff of the Hôtel de Ville it was found to be easier and more economical to build it under the courtyard rather than to attempt the difficult and costly task of excavating under the existing building.

Stellingwerff takes the view that a shelter under a building with more than 10–12 floors is uneconomical owing to the great weight of debris. A 9-storey building of reinforced concrete is, according to him, the best type of building in which to incorporate a refuge, giving protection against 2-cwt. bombs (Fig. 31). This conclusion, as has been suggested, appears to be based on an over-estimation of the value of superimposed floors in giving protection.

If the existing basement walls are utilized to form one or more sides of the refuge it will probably be necessary to strengthen them to ensure that the degree of lateral protection is as high as that overhead. As has previously been pointed out, the confining effect of the earth around a basement concentrates the force of the explosion against the basement wall, which has in consequence to be thicker than would be the case if it were above ground.

Two methods of overcoming this difficulty suggest themselves: either the bomb could be prevented from penetrating the earth adjacent to the basement wall, or the confining earth could be removed altogether. The first could be achieved by the use of a suitably designed detonating slab placed at ground level, and the second by surrounding the walls with a filling of dry hardcore, the interstices of which would help liberate the gases generated by the explosion. If the foundations under the basement walls do not extend down sufficiently far to protect the refuge against the effect of bombs penetrating to below the level of its floor it would become necessary to increase the floor thickness accordingly.

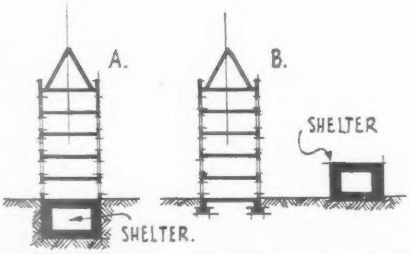



**31**—*Shelter in a multi-storey building (Stellingwerff).*

It appears that since only a limited number of immediately superimposed floors can be relied upon to contribute to the safety of the refuge, and that since a confined explosion is more damaging than one in the open, that the only advantages that can be claimed for locating a refuge in the basement are that here it interferes less with the planning, and that its quite considerable weight is transferred direct to the foundations. From the point of view of protection only, it would appear that the ground floor is a more suitable location than the basement.

Where, however, deep sub-basements exist a new factor emerges. Here it might be found that the lowest basement is so far below ground level that the surrounding earth alone offers sufficient protection against bombs up to a given weight. In such circumstances the external walls, being well below the radius of destruction of the bombs, would not require reinforcing. Also the possibility arises of extending the sub-basement laterally to utilize the superimposed earth for overhead protection (Fig. 30c).

In the case of new buildings which would not normally have basements (e.g. blocks of working class flats) it might be more economical to build independent shelters where these can be placed above the ground. The saving in the cost of excavating must be balanced against the cost of the foundations for the flats, and of a slight additional thickness of the shelter roof (Fig. 32).




**32**—*Shelters for working-class flats.*

Where shelters are placed in the basements of buildings it is generally found that there is ample room to accommodate all the occupants of the buildings. In an example which we worked out it was found that the area covered by a 5-storey block of working class flats was sufficient for refuges for twice the number of occupants of the flats. In other words a basement occupying half the total area would be sufficient to provide refuge accommodation. It might be feasible, therefore, to allocate certain refuges under buildings for the use of the public.

*Designed as a surface shelter, this layout and lining is equally suitable for tunnel shelters. (Messrs. Trollope & Colls.)*

# TUNNEL SHELTERS

AN alternative to the surface type of shelter is the tunnelled shelter which makes use of the earth itself to give protection to the occupants. As far as we are aware, no complete study has been made of tunnelled shelters giving protection against high explosive bombs. Such shelters are, however, being constructed on a large scale in Barcelona, and we have made full use of the information we have obtained about these. There are also some examples of the adaptation of existing tunnels as shelters, for example some stations of the Paris Metro.

It is apparent, therefore, that the conclusions we have arrived at must be regarded as tentative and liable to be revised in the light of events. We feel most strongly that it is imperative that official information should be published on the subject, based, if necessary, on experiments. An example of the information required is the depth of the various strata found in different parts of England to give protection against different weights of bombs.

It is obvious that before adapting existing tunnels or constructing new tunnelled shelters it is necessary to have geological details of the area.

## NEW TUNNELLED SHELTERS

The main advantages of tunnelled shelters, compared with surface shelters, are :—

(*a*) That it is comparatively economical to give protection against the heaviest bomb, owing to the fact that protection is afforded by the earth itself. In order to give complete protection, it is only necessary to have the tunnel the required depth under the ground.

(*b*) That tunnels, provided they are of sufficient depth, can be constructed irrespective of the buildings or the amount of open space on the surface (which would limit the number of surface shelters). This is of the greatest importance when considering shelters for the crowded parts of towns.

(*c*) Our research has shown that, under favourable conditions, tunnelled shelters, giving almost complete protection, are cheaper per head than surface shelters proof against medium weight bombs.

A disadvantage is the long staircase approach to the tunnel, especially when the time of warning of a raid is short. Another point to be considered is the possibility, in certain strata, of water finding its way into the tunnel.

Two other advantages have been found in Barcelona for tunnelled shelters : first, the tunnels can be used as shelters during the course of construction, and even, owing to the favourable nature of the soil, before they have been lined. Secondly, there is great freedom in planning. Not being affected by buildings on the surface, branch tunnels are driven in all directions and connected with each other, with entrances at suitable points.

● *Underlying the whole of the London area is a strata of London Blue Clay varying from 60 ft. to 430 ft. thick. This is eminently suitable for tunnelling.*

NATURE OF SOIL

There are many soils in Great Britain ideal for economical tunnelling. The methods which would need to be used would vary with the different types of soil. Thus, for instance, in hard rock blasting would be necessary, while at the other extreme, in silt or waterlogged soil, compressed air might have to be used.

It is not possible here to go into this matter in any detail, which in any case is a problem for the tunnel engineer. There are, however, some general observations that can be profitably made on the geological structure of the London region in relation to tunnelling.

Underlying the whole of the London area is a strata of London blue clay varying from 60 ft. to 430 ft. thick. This is eminently suitable for tunnelling, and in fact, the " tube " railways are almost wholly constructed in it.

Over a large area of London this clay reaches the surface, while elsewhere, mainly along the Thames, it is covered with sandy beds, gravel, other river deposits and made-up ground.

The clay itself is impervious to water, and therefore when it does not extend to the surface, there are liable to be underground streams and water lying on top of the clay. This underground water should be avoided wherever practicable when sinking shafts. In any case the water can be dealt with by simple pumping arrangements, or in the case of tunnels near the Thames, by water-tight doors.

It is of interest to note that a great deal of tunnelling has been carried out in the London clay, apart from the Underground Railway. For instance, it is often found economical to tunnel for large sewers instead of to excavate. In the West Middlesex Main Drainage Scheme 54 miles of sewer varying in diameter from 4 ft. to 10 ft. 6 in. were tunnelled, largely in London clay, but sometimes even through waterlogged ballast, a special shield being used for this purpose. It is of interest to note that the cost of a lineal yard of a 6 ft. 6 in. diameter sewer on this scheme, constructed with three rings of special bricks, was £24.

*Precast R.C. units suitable for lining either surface or tunnel shelters (Messrs. Costain).*

DEPTH FOR PROTECTION

Even though it is comparatively inexpensive to assure complete protection in a tunnelled shelter, there is a limit to the length of staircase that the occupants can be expected to walk up and down. This is not only because of exertion, but also that the time of warning may not be sufficient to ensure that they have reached the shelter proper before the raid begins.

The recent tendency in Barcelona has been to cover a series of tunnels with slabs of concrete so as to reduce the depth of the tunnel. It must be remembered, however, that there is very short, and sometimes no warning of a raid in Barcelona. The depth of earth above the tunnels where there is no slab at the surface is normally 30 to 45 feet.

The French Government Handbook, " Instruction Pratique sur la Defense Passive," 1936, gives 26 ft. for 2-cwt., 39 ft. for 6-cwt., and 65 ft. for one-ton bombs in " Normal Earth."

Table III, from the Swiss Handbook, gives the order of different soils as soft rock, ballast or gravel, dry earth or sand (p. 19).

Pini, an Italian expert on air raid protection, writing in " Abali de Lavoir Publici " (May, 1935) and considering underground railways as shelters, states a depth of 8 feet of rock or concrete to 46 ft. of loose soil would give protection against a 550-lb. bomb, and also that experiments were being conducted to arrive at figures between these two materials. The depth of earth above Maison Blanche, one of the stations on the Paris Metro that has been converted into an air raid shelter, is about 54 ft.

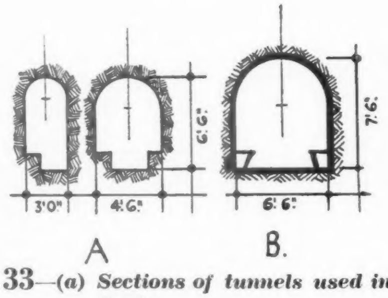
Mr. Eric L. Bird, one of the R.I.B.A. representatives advising the Home Office on Air Raid Precautions, stated* " that complete protection is feasible in mined or tunnelled galleries with a thickness of 60 feet of earth above."

As we have already stated, there are no official figures for the depth required in London blue clay.

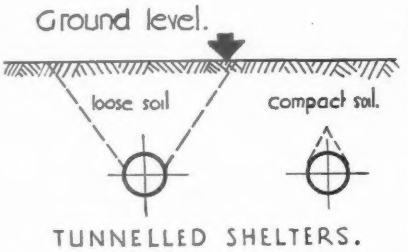
We realize that the penetration of a bomb into London blue clay might be considerable, more for instance than into ballast. For the purpose of the scheme which we have drawn up as a basis for estimating, we have, in the absence of accurate data, worked on the assumption that 50 feet of London clay would give virtually complete protection. It should be understood that in this scheme the occupants are segregated into groups of 150, and in a scheme where a larger number of people would be congregated together the greater risk might make it desirable to increase the cover.

* A paper read before the Architectural Association. 8.6.37.

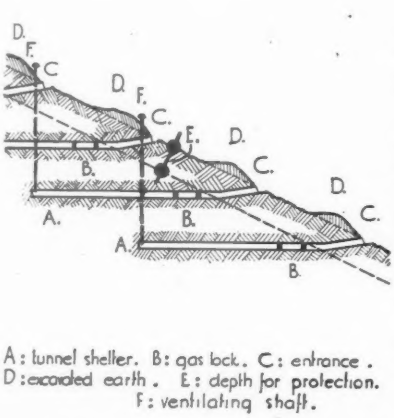
● *After taking into account the fact that the staircase must not be too long, . . . we consider that 50 ft. (depth) should give virtually complete protection.*




**33**—**(a)** ***Sections of tunnels used in Spain.***
**(b)** ***Section of steel lined tunnel.***




**34**—***Tunnels in loose and compact soils, showing superimposed loads to be considered.***




**35**—***Tunnels in a hillside.***

CONSTRUCTION

The method of construction will depend largely on the nature of the soil. Tunnels in hard ground might require blasting, and no timbering would be needed. Tunnels in soft ground are usually excavated by hand, with or without a shield.

In constructing tunnels in very loose soils, the lining to the tunnel has to be sufficiently strong to support the soil above the angle of repose as shown in Fig. 34A. In the case of tunnels in compact soils (sandstone, chalk, limestone, London clay) the lining has only to carry the triangle of soil contained within the angles the soil would overhang without support as shown in Fig. 34B.

There are various methods of lining tunnels. Timber, brick, cast iron segments, precast concrete units or steel sheets can be used.

(*a*) *Timber.*—It is easy and economical to line a small tunnel with timber, but has the disadvantage that the wood is liable to deteriorate under damp conditions.

(*b*) *Brick.*—The usual lining to the tunnels in Barcelona is one 9-in. brick ring. This, however, compared with cast iron segments or steel sheets, is very slow, requires centering and strutting and skilled labour to carry it out.

(*c*) *Cast Iron Segments.*—The most usual form of lining for large tunnels and incidentally the method for London's "tube" railways. This method has the advantage of simplicity of erection and can easily be rendered watertight.

(*d*) *Precast Concrete Units.*—Some of the tunnels of the new extensions to London's Underground Railway are being lined with precast concrete units bolted together, the joints being filled with bitumen. These units should be suitable for lining tunnelled shelters, except for the fact that when constructing a small tunnel a circular section is not suitable owing to the fact that full use cannot be made of the whole of the sectional area of the tunnel. It should be possible, however, to produce precast concrete units with a section suitable for small tunnels.

(*e*) *Steel.*—Sheet steel lining has the advantage of ease of erection, and can be produced by mass production. It is important that provision should be made against corrosion.

An example of steel lining is "Locksheet" sections. This consists of interlocking sections of 14 gauge, rust-resisting copper steel. These are fixed into a rolled steel joist at the head, and rolled steel channels at the floor as shown in Fig. 39. This type of lining is recommended in A.R.P. Handbook No. 6, where it is stated that under average conditions a narrow gallery 3 feet wide, with three men working, can be tunnelled at the rate of 4 ft. in an 8-hour shift, or a tunnel 9 ft. wide with six men working, 1 ft. 6in. can be tunnelled in 8 hours.

The tunnel linings described above are all applicable to tunnels excavated in dry soil, but where water is likely to be encountered it would be necessary to use cast iron or precast concrete segments.

PLANNING AND EQUIPMENT

In many respects the planning and equipment of tunnelled shelters is similar to surface shelters, already described. The main differences are due to the fact that there is a higher degree of protection, and therefore the occupants are not split up into separate cells.

*Entrances.*—To protect the entrances to a tunnel to the same degree as the tunnel itself would obviously be most expensive. The tunnel being protected against heavy bombs, the entrance would have to be surrounded with a great thickness of reinforced concrete to obtain the same degree of protection. The alternative is to recognize that the entrance and stairs down to the tunnel are not protected, to cut off the stairs from the tunnel itself and to provide interconnection with other entrances so that, in the case of one entrance being damaged, another can be used.

When tunnels are constructed in the side of a hill, the entrances are relatively simple, as there is no need for staircases, as shown in Fig. 35.

Staircases are the best approach to tunnels constructed under level ground. Ramps are out of the question owing to the depth of the tunnel, and the consequent length of the ramp.

The staircases can be of two kinds ; either specially excavated in straight flights, as in the Spanish examples, or use can be made of a shaft sunk in connection with the construction, which can accommodate a spiral staircase. This latter is only possible if the diameter of the shaft is fairly large.

● *To protect the entrances to a tunnel to the same degree as the tunnel itself would obviously be most expensive.*

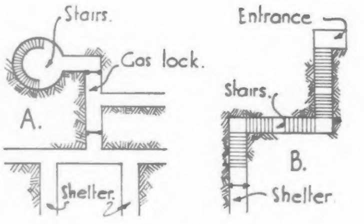
In either case the tunnel must be cut off from the staircase to prevent explosions affecting the shelter as in Fig 36. Fig. 36B shows the usual practice in Barcelona. Blast and splinter proof doors must be provided at the bottom of the staircase as indicated in the diagrams.

If the shaft or staircase has been driven through a waterlogged strata it is essential that, at the bottom of the shaft or staircase, watertight steel doors are provided, for use in the event of the staircase walls being ruptured in an explosion. In any case, the shafts and entrances should be kept away from sewers and water mains.

It is necessary to provide gas-tight doors at the top of the staircase to prevent heavy concentrations of gas sinking down to the shelter.

The number of entrances is determined by the number of people that can use one staircase and the fact that every tunnel shelter should have at least two entrances with emergency connection to the next tunnel shelter giving alternative means of escape. Normally the tunnelled shelters in Barcelona have one narrow staircase to 200 occupants.

It seems reasonable to say that the maximum number that should use any one staircase should be 500. This would be a staircase 5 ft. 6 ins. wide with a central handrail. A shelter for 1,000 people would have two such staircases (apart from access to adjoining shelters).




36—*Alternative staircases to tunnels.*

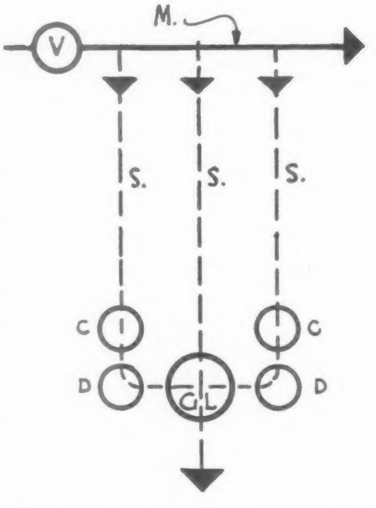
*Gas Locks and Decontamination Rooms*

It is necessary to provide gas locks and decontamination rooms, on the same general lines as those for surface shelters. As, however, tunnel shelters are not divided into cells the decontamination rooms and chemical closets must be grouped round the gas lock, serving the whole shelter. The position of these is largely determined by the position of the ventilating plant and the direction of the current of the purified air. Examples are shown under the section on "Planning."

*Closets.*—There should be one to about 30 people. A.R.P. Handbook No. 6 recommends 50 yards as the maximum distance which the occupants of trenches should have to travel to a closet, and it seems reasonable to adopt the same standard for tunnels.

*Ventilation.*—Owing to the fact that tunnel shelters have virtually complete protection and the shelter is not divided into units, the ventilating plant can deal with as large a number of people as required. For instance, in the Paris Underground stations, plants have been installed for up to 8,000 people.

The ventilating plant can be run from the electric mains but in the event of failure alternative supply must be arranged. A diesel engine properly ventilated is probably the most economical way of dealing with this. There should be three alternative inlet ducts as far apart as possible.




37—*Ventilation diagram for a tunnelled shelter.*

*Planning*

The layout of a tunnelled shelter is determined by :—

(*a*) The position and number of entrances and relation to buildings above ;

(*b*) The position of the ventilating plant, the direction of the flow of purified air in relation to chemical closets, decontamination rooms, gas locks, etc. ;

(*c*) The arrangement of tunnels in relation to the method of construction ;

(*d*) Whether the tunnel is sunk below level ground or whether driven into a hillside.

Fig. 37 shows diagrammatically the relation of ventilation plant, decontamination rooms, entrance, etc. The purified air flows from the main duct through the shelter proper past the chemical closets, and out through the gas lock with a non-return valve.

Fig. 35 shows diagrammatically the construction of tunnels in a hillside. The entrances are slightly ramped to shorten the length of unprotected tunnel, while still enabling the excavated earth to be brought out of the entrance. The cost of staircases, which are necessary in a tunnelled shelter in level ground, is thus saved. Part of the excavated earth can be used to give additional protection to the entrances.

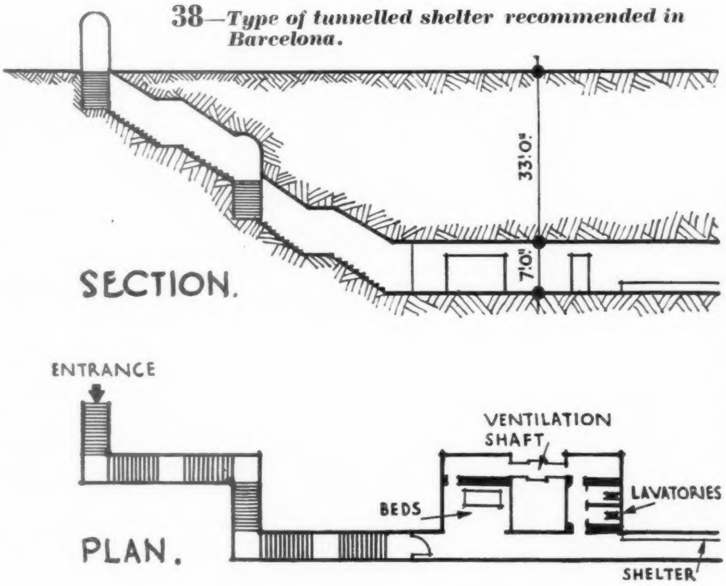
In order to arrive at the cost, we have prepared a scheme for a tunnelled shelter (Fig. 39). It has been assumed the ground is level and that the tunnel is constructed in London Blue Clay which reaches the surface.

The scheme has accommodation for 4,000 people, with one ventilating plant. The duct from the plant is on the ceiling of the main tunnel, with outlets discharging purified air into the shelters. A circular constructional shaft is sunk over the main central tunnel.

A portion of the scheme is shown in detail. All of the tunnels, except the chamber for the ventilating plant, but including the staircase, gas locks, decontamination rooms, are lined with " Locksheet " steel sheets, as already described. The ventilating plant is enclosed in a room with reinforced concrete walls and roof. Electric lighting with storage batteries in case of failure of the main is provided.

COST

| | |
|---|---|
| The total price of the scheme shown in Fig. 39, including disposal of excavated earth ... ... ... ... ... ... ... | £43,841 0 0 |
| Total cost per head ... ... ... ... ... ... ... | £10 19 0 |




**38**—*Type of tunnelled shelter recommended in Barcelona.*

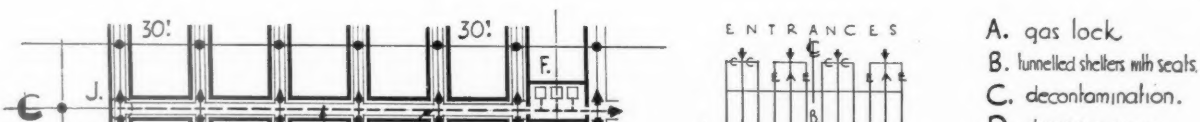
## THE ADAPTATION OF EXISTING TUNNELS AS SHELTERS

There are many existing tunnels which appear to be suitable as air-raid shelters. Indeed, a real danger is that people would rush to use underground shelters such as " tube " railways whether they are safe or not.

Mr. Duncan Sandys, M.P.,* writing of Barcelona, said " The tubes are by far the most popular places of refuge. . . . For the most part, the underground railway is sufficiently deep to afford a high degree of protection. There are, however, a number of stations which are too near the surface to offer more than very superficial security. In these cases large notices have been put up warning the public of this fact." (*Daily Telegraph*, April 9, 1938.)

London's underground railways were used spontaneously by the public during the Great War.

* Chairman of the Parliamentary A.R.P. Committee.

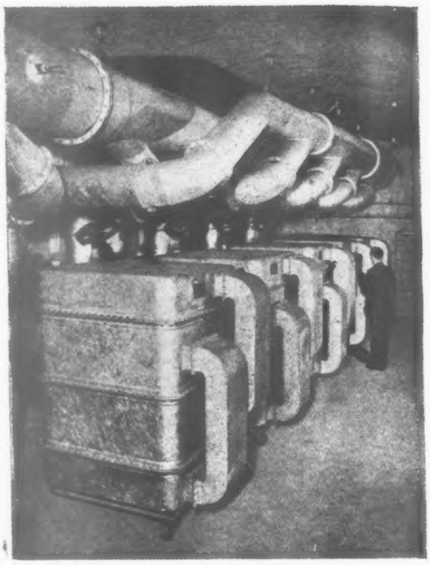



**39**—*Scheme for a tunnelled shelter for 4,000 people.*

● ***Only those portions of the tunnel which are of a sufficient depth to give protection must be used. It is not possible to give a definite figure for the depth required over the London Underground Railways as the soil is not always homogeneous. Each section must be studied separately.***

A Police† Report of a visit to Old Street station in September, 1917, estimated that there were 3,000 people on the platforms and not less than 10,000 in the station.

It is planned to convert several stations of the underground railway in Paris into air raid shelters and two, (Maison Blanche and Place des Fêtes) have already been converted.



***Battery of three filters having an output of 350,000 cubic feet per hour. (Carrier Engineering Co.)***

FACTORS DETERMINING WHETHER EXISTING TUNNELS CAN BE ADAPTED AS SHELTERS

(*a*) *Depth for Protection.*—Only those portions of the tunnel which are of a sufficient depth to give protection should be used. It is not possible to give a definite figure for the depth required over the London Underground Railways as there is no data regarding London clay and also the soil is not always homogeneous. Each section must be studied separately.

The distance from the ground to the top of a tunnel in one Paris station converted into a shelter is 54 ft. (Place des Fêtes). In Barcelona the Metro is considered safe from 300 kg. bombs (6 cwt.) if there is 23 ft. of earth above the tunnel.

(*b*) *Flooding.*—If parts of London's underground railway were used there would be no danger of the tunnel itself being ruptured and admitting water, as the portions used would in any case be out of reach of the heaviest bomb. There is a possibility, however, that the escalator or lift shafts would be damaged by a bomb. Even in this eventuality it is unlikely that there would be any danger from flooding in cases where the London Clay reaches the surface.

The danger may exist, however, where there are other strata, sand, gravel, or other river deposits, and made up ground above the clay.

There is the further danger of the tunnels being flooded from the Thames. The tunnel may be damaged under the river itself, or, in stations near the river, there may be subsoil water level with the river.

The danger from water mains and sewers is not so serious. The volume of water discharged could be held back by doors at the bottom of the shaft, allowing the occupants to walk through the tunnel to the next station or shaft.

Our conclusions are that :—

(*a*) Where the London Clay reaches the surface, there are rarely dangers from flooding and, provided the tunnel is at a sufficient depth, it should be suitable for conversion into a shelter.

(*b*) Where the London Clay is covered with other strata, it should be ascertained whether there is water on top of the clay. If so, watertight doors should be provided at the bottom of the shafts.

(*c*) Tunnels adjoining the Thames should receive full consideration before it is decided whether they are suitable as shelters.

A further important point to consider is that the underground railway would probably be required to be used during hostilities. The tubes will probably be the one safe means of transport and would be required for evacuation, movement of hospital cases, food, etc., but this does not mean that the stations might not at the same time be utilized as shelters as is the intention in Paris. Dr. Haden Guest, M.P., describing the Paris scheme, says " I saw extraordinary arrangements for stopping trains on the Underground. At times of danger every train would be brought to a standstill at the nearest convenient station."*

It would always be necessary to stop the trains during air raids, owing to the risk of gas being drawn into the tunnels at the open ends. It should be remembered that even if the stations are not adapted as shelters it would not be safe to run the trains unless precautions were taken against gas and flooding.

ADAPTATION AS SHELTERS

In considering the use of underground railway stations as shelters, we have studied the measures taken in the two stations of the Paris underground that have already been converted into shelters.

† Quoted in " Air Defence and the Civil Population," by H. M. Hyde and G. R. Falkiner-Nuttal. In the same book, the authors also state " the utmost use should be made of . . . underground railways, etc."

* *Daily Herald.* March 16, 1938.

The measures necessary for the adaptation of Underground stations as shelters are :

(*a*) Doors must be provided in the tunnel itself which are normally folded back, but which, in an emergency, can be used to close the tunnel and isolate the station.

(*b*) An air filtration plant must be provided in a fully protected position.

(*c*) A series of gas locks (in the Paris stations there are seven sets of doors) must be provided at the entrance to the station, which in normal times are folded back.

(*d*) Provision of blast proof doors at the bottom of any shafts entering the station. Where there is danger of flooding, these doors would have to withstand water pressure.

(*e*) Provision of decontamination rooms, chemical closets, first aid stations, etc.

A further utilisation of existing tunnels can be made by driving new tunnels from the existing tunnels. Thus, for example, tunnels might be driven from underground stations. This has the advantage that good entrances are already available. It would be necessary to provide an additional exit at the end of the series of new tunnels driven from the station. In the same way, tunnels might be constructed at a lower level from stations which are not deep enough to give protection.

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# P R I C E S

On the following pages appear *(a)* Prices for Measured Work, Part II; *(b)* Prices for Approximate Estimates.

★ ***ANSWERS TO QUESTIONS***

*While the* JOURNAL, *naturally, cannot presume to undertake the responsibilities of a quantity surveyor, it has arranged with the authors of this Supplement to answer readers' questions regarding any matter that arises over their use of the Prices Supplement in regard to their work, without any fee. Questions should be addressed to the Editor of the* JOURNAL, *and will be answered personally by Messrs. Davis and Belfield. As is the normal custom, publication in the* JOURNAL *will omit the name and address of the enquirer so that it is unnecessary to write under a pseudonym.*

The complete series of prices consists of four sections, one section being published each week in the following order :—

1. Current Market Prices of Materials, Part I.
2. Current Market Prices of Materials, Part II.
3. Current Prices for Measured Work, Part I.
4. A.— Current Prices for Measured Work, Part II.
   B.—Prices for Approximate Estimates.

● ***Prices are for work executed complete and are for an average job in the London Area, all prices include for overhead charges and profit for the general contractor.***

# PART 4

## CURRENT PRICES FOR MEASURED WORK—II

***BY DAVIS AND BELFIELD,*** *P.A.S.I.*

### JOINER

*Deal Flooring*

| | | 1″ | 1¼″ |
|---|---|---|---|
| Plain edge flooring in batten widths | per square | 39/2 | 48/– |
| Ditto tongued and grooved ditto .. | per square | 42/10 | 52/1 |
| T. & G. B.C. Pine rift flooring in narrow widths .. .. .. | per square | 50/– | — |

*Wood Block Flooring, laid herringbone,* 100 *yards and up*

D.G. and T.G. kiln dried, 2 block border, laid in hot mastic composition on cement screed, including 2 feet run of straight cutting per yard super, and wax polishing at time of laying.

| | | 1″ nominal | 1¼″ nominal |
|---|---|---|---|
| Burma teak .. .. .. | per yard super | 13/11 | 18/4½ |
| Canadian Maple .. .. | per yard super | 11/6 | 13/8 |
| 25–30 per cent. quart Austrian Oak .. .. .. | per yard super | 12/10 | 16/– |
| Plain American Oak (no selection made for sap) .. | per yard super | 11/8 | — |
| Gurjun .. .. .. | per yard super | 12/7 | 14/9 |
| Pitch Pine (50% rift sawn) | per yard super | 11/10 | 13/8 |
| Ditto (100% ditto) | per yard super | 13/1½ | 15/6 |
| British Columbian Pine .. | per yard super | 10/– | 11/6 |
| Kara Sea Deal, 100 per cent. rift sawn .. .. .. | per yard super | 9/9 | 10/6 |
| Jarrah .. .. .. | per yard super | 13/2 | 15/9 |
| Additional straight cutting | 5¼d. per foot run | | |

### JOINER—*(continued)*

*Secret Nailed Tongued and Grooved Strip Flooring, fully Desiccated, including Polishing*

| | | 1″ nominal | | | 1¼″ nominal | | |
|---|---|---|---|---|---|---|---|
| | | £ | s. | d. | £ | s. | d. |
| Austrian Wainscot Oak .. | per square | 8 | 18 | 6 | 10 | 12 | 7 |
| Plain Japanese Oak .. | per square | 7 | 10 | 8 | 9 | 2 | 2 |
| Plain American Oak .. | per square | 7 | 7 | 0 | 9 | 3 | 9 |
| Pitch Pine .. .. | per square | 7 | 0 | 6 | 8 | 15 | 7 |
| British Columbian Pine .. | per square | 4 | 14 | 6 | 5 | 7 | 7 |
| Canadian Maple .. .. | per square | 6 | 19 | 1 | 8 | 10 | 7 |
| Burma Teak .. .. | per square | 8 | 18 | 6 | 10 | 17 | 4 |
| English Oak .. .. | per square | 10 | 4 | 9 | 12 | 15 | 11 |
| Gurjun .. .. .. | per square | 6 | 19 | 1 | 8 | 10 | 7 |
| Jarrah .. .. .. | per square | 6 | 13 | 10 | 8 | 6 | 5 |

*Wall Linings*

| | | |
|---|---|---|
| ⅝″ Deal tongued and grooved V-jointed Matching in narrow widths .. .. .. .. .. | per square | 33/4 |
| ¼″ (6 mm.) Birch (A) Plywood and fixing to walls | per square | 46/6 |
| 3/16″ Asbestos cement sheets butt jointed | per foot super | –/3¾ |
| ½″ Fibre board and fixing to walls .. | per yard super | 2/11 |
| Deal battens as ground plugged to brickwork | per foot super | –/1½ |
| 1½″ × ⅜″ wrot and chamfered fillets .. .. | per foot run | –/1¼ |
| 2″ × ½″ wrot and moulded ditto .. .. | per foot run | –/1¾ |

# CURRENT PRICES

*BY DAVIS AND BELFIELD, P.A.S.I.*

## JOINER, IRONMONGER AND STEEL AND IRONWORKER

### JOINER—(*continued*)

*Skirtings*

| | | Deal | Austrian Oak |
|---|---|---|---|
| 1" chamfered or moulded 4" high, fixed to and including grounds and backings planted on | per foot run | -/3½ | -/7¾ |
| Add for plugging to brickwork | per foot run | -/0½ | -/0¾ |

Fitted ends on hardwood price as 4" of skirtings, mitres as 6".
Fitted ends, etc., on deal skirting included in price per foot run.

*Casements and Fanlights*

| | | 1½" | 2" |
|---|---|---|---|
| Deal moulded sashes divided into squares with glazing bars | per foot super | 1/4½ | 1/5½ |
| Add for hanging casements (butts measured separately) | each | 1/9 | 2/- |

*Cased Frames and Sashes*

| | | |
|---|---|---|
| Deal cased sashed frame, including 2" double hung sashes, with 6"×3" Oak cill and brass axle pulleys, sash line and weights, average 15 feet super | per foot super | 3/9 |

*Doors in Deal*

| | | ¾" | 1" | 1¼" |
|---|---|---|---|---|
| Matchboarded, ledged and braced door | per foot super | 1/- | 1/2 | 1/4 |
| | | 1½" | 1¾" | 2" |
| Framed, ledged and braced door, filled in with matchboarding | per foot super | 1/5 | 1/9 | 1/10 |
| Ditto garage doors | per foot super | | | 1/7 |
| | | | | 4-panel |
| 1½" square framed, both sides | per foot super | | | 1/7 |
| 2" ditto | per foot super | | | 1/9 |
| 1½" ditto bead butt panels one side, but square the other | per foot super | | | 1/9 |
| 2" ditto, ditto | per foot super | | | 1/11 |
| 1½" moulded both sides | per foot super | | | 1/10 |
| 2" ditto | per foot super | | | 2/- |
| For fixing only p.c. doors allow | per foot super | | | -/2½ |

Hardwood doors two-and-a-half times as much as deal.

| | | |
|---|---|---|
| Deal glazing beads, mitred and bradded | per foot run | -/1½ |
| Ditto and fixed with brass cups and screws | per foot run | -/3 |

*Window and Door Linings*

| | | 1" | 1¼" | 1½" |
|---|---|---|---|---|
| Deal linings, 6" wide, tongued at angles and planted on including backings | per foot run | -/6¼ | -/7 | -/8 |
| Add for plugging to wall | per foot run | -/0½ | -/0½ | -/0½ |
| Add for rebating | per foot run | -/0½ | -/0½ | -/0½ |
| Add for ½" × 2" Deal stop planted on | per foot run | -/1½ | -/1½ | -/1½ |
| Deal window board 9" wide, with rounded nosing, tongued at back and on and including bearers plugged to brickwork | per foot run | -/10 | -/11 | 1/1 |
| ¾" Deal scotia mould | per foot run | | -/1½ | |
| Oak linings 6" wide tongued at angles and planted on including backings | per foot run | 1/2½ | 1/4½ | 1/7½ |
| Add for plugging to brickwork | per foot run | -/1 | -/1 | -/1 |
| Add for rebating | per foot run | -/1 | -/1 | -/1 |
| Add for ½" × 2" Oak stop planted on | per foot run | -/3½ | -/3½ | -/3½ |
| Oak window board 9" wide, with rounded nosing tongued at back and on and including bearers plugged to brickwork | per foot run | 1/10 | 2/1 | |
| ¾" Oak scotia mould | per foot run | | -/3½ | |

*Window and Door Frames*

| | | Deal | Austrian Oak |
|---|---|---|---|
| 4" × 3" door frames | per foot run | -/10 | 2/0½ |
| 4" × 3" window frames | per foot run | 1/- | 2/4½ |
| 4" × 3" transomes and mullions | per foot run | 1/3½ | 2/11½ |
| 6" × 3" door cill, sunk weathered twice throated and grooved for water bar (measured separately) | per foot run | — | 3/9 |
| 6" × 3" window ditto | per foot run | — | 3/1 |
| Add or deduct for variation in sectional area per square inch | per foot run | -/0½ | -/1½ |
| Add for each labour, for chamfer, bead or rebate, etc. | per foot run | -/0½ | -/1 |
| Add for each moulding | per foot run | -/0¾ | -/1½ |

*Architraves*

| | | Deal | Oak |
|---|---|---|---|
| 1"×3" chamfered or moulded architraves, including mitres on softwood, planted on | per foot run | -/3 | -/7¼ |
| Mitred angles on oak price as 6" of architrave. | | | |
| Add for plugging to brickwork | per foot run | -/0½ | -/0¾ |
| Add for narrow splayed grounds | per foot run | -/1½ | -/1½ |

### JOINER—(*continued*)

*Shelving*

| | | Deal | Oak |
|---|---|---|---|
| Slat shelving of 1" × 2" spaced ¾" apart | per foot super | -/9 | — |
| 1" shelving | per foot super | -/10 | 2/2 |
| 1¼" ditto | per foot super | -/11½ | 2/6 |
| 1" cross-tongued shelving | per foot super | 1/- | 2/6 |
| 1¼" ditto | per foot super | 1/1½ | 2/10 |
| 1" × 2" chamfered bearers planted on | per foot run | -/2¼ | -/5½ |
| Add if bearers plugged to brickwork | per foot run | -/0½ | -/0¾ |

*Teak Draining Boards and Twice Oiling*

| | | |
|---|---|---|
| 1¼" Moulmein cross-tongued fluted draining board fixed to slight falls | per foot super | 3/9 |
| ½" × 2" rounded rim bedded in white lead and screwed to edge of draining board | per foot run | -/5 |
| ½" × 4" rounded skirting fillet ditto | per foot run | -/9 |

*Staircases*

| | | Deal | Oak |
|---|---|---|---|
| 1¼" treads and 1" risers | per foot super | 2/- | 5/- |
| 2" strings, fixed | per foot run | 1/10 | 4/7 |
| Housing treads and risers to strings | each | -/9 | 1/6 |
| 3" × 2½" French polished moulded handrail | per foot run | — | 2/6 |
| 1¼" × 1¼" square balusters 2' 6" long | each | -/10 | 2/- |
| 4" × 4" Newels with chamfered edges and fixing | per foot run | 1/4 | 3/4 |

### IRONMONGER

*Fixing only*

| | | |
|---|---|---|
| 4" Butt hinges to softwood | per pair | 1/- |
| 4" ditto to hardwood | per pair | 1/4 |
| 16" T. hinges to softwood | per pair | 1/6 |
| 48" Collinges patent gate hinges to softwood | per pair | 7/6 |

| | | Softwood | Hardwood |
|---|---|---|---|
| 6" Cabin hooks | each | -/7½ | -/10 |
| Hat and coat hooks | each | -/3 | -/4 |
| Cupboard knobs | each | -/3 | -/4 |
| Night latches | each | 1/6 | 2/- |
| Thumb latches | each | 1/6 | 2/- |
| Letter plate and knocker, including perforation in door | each | 2/6 | 3/4 |
| Barrel or tower bolts | each | -/10 | 1/1 |
| Flush bolts | each | 1/6 | 2/- |
| Rim locks and furniture | each | 2/- | 2/8 |
| Mortice ditto | each | 3/- | 4/- |
| Rebated ditto | each | 3/6 | 4/8 |
| Grip handles | each | -/6 | -/8 |
| Cupboard locks | each | 1/- | 1/4 |
| Spring catches | each | -/10½ | 1/1½ |
| Casement fastener | each | 1/- | 1/4 |
| Ditto stays | each | -/10 | 1/1 |
| Sash fastener | each | -/8 | -/11 |

### STEEL AND IRONWORKER

(For Rainwater Goods—*see* "Plumber.")

*Steelwork*

| | | £ | s. | d. |
|---|---|---|---|---|
| Basis for plain rolled steel joists | per ton | 17 | 7 | 6 |

*Fabricated Steelwork*

| | | £ | s. | d. |
|---|---|---|---|---|
| Joists cut and fitted | per ton | 21 | 11 | 6 |
| Stanchions, ordinary sections with riveted caps and bases | per ton | 25 | 12 | 6 |
| Stanchions, compound | per ton | 27 | 3 | 0 |
| Plate girders | per ton | 31 | 12 | 6 |
| Framed roof trusses, 25' 0" span | per ton | 32 | 17 | 0 |
| Ditto ditto 60' 0" span | per ton | 30 | 7 | 0 |

The above prices are ex mills ordered well in advance of delivery. Prices ex London stocks are considerably higher, and definite quotations should be obtained.

*Wrot Iron Work*

| | | |
|---|---|---|
| Simple balusters and handrail fixed (excluding mortices, etc.) | per cwt. | 56/- |
| Bolts and nuts fitted | per cwt. | 45/- |

*Galvanized Corrugated Sheeting*

| | | 20 B.G. | 22 B.G. |
|---|---|---|---|
| Sheeting in 3" corrugations and fixing on wood framing with screws and galvanized embossed curved washers including laps | per square | 56/- | 49/- |
| Ditto fixed to steel framing | per square | 63/4 | 56/8 |

# CURRENT PRICES

BY DAVIS AND BELFIELD, P.A.S.I.

# PLASTERER, EXTERNAL AND INTERNAL PLUMBER

## PLASTERER

*Lime and Sirapite Plastering*

| | Per yard super | In narrow widths per foot super |
|---|---|---|
| Expanded metal lathing .. .. .. .. | 1/8 | -/3 |
| 1" × 3/16" sawn laths .. .. .. .. | -/9 | -/1½ |
| Render and set in lime and hair .. .. | 1/8 | -/3½ |
| Render, float and set in lime and hair .. .. | 2/- | -/3¾ |
| Plaster, float and set ditto on lathing (measured separately) .. .. .. .. .. .. | 2/1½ | -/4 |
| Render and set with Sirapite .. .. .. .. | 1/9½ | -/3½ |
| Plaster, float and set ditto on lathing (measured separately) .. .. .. .. .. .. | 2/3 | -/4 |
| Skimming coat Sirapite .. .. .. .. .. | 1/5½ | |
| ⅜" thick plaster board fixed including covering joints with scrim cloth .. .. .. .. | 2/- | |

*Keenes*

| | Per yard super | In narrow widths per foot super |
|---|---|---|
| Cement plain face on and including a backing of Portland cement and sand .. .. .. .. | 2/6 | -/5 |

*Mouldings and Labours*

| | | Lime and Sirapite | Keenes |
|---|---|---|---|
| Plain cornices and mouldings 6" girth | per foot run | -/9½ | -/11 |
| Labour arris, quirk or throat .. | per foot run | -/1½ | -/1½ |
| Ditto rounded angle .. .. | per foot run | -/2 | -/2 |
| Ditto staff bead .. .. .. | per foot run | — | -/7½ |

Mitres price as 12" of moulding, stopped ends as 6", and rounded angles as 18".

*Portland Cement and Sand* (1 : 3)

| | | ½" | ¾" |
|---|---|---|---|
| Screeds to floors for wood or tiles | per yard super | 1/2½ | 1/4 |
| Screeds for tiling, etc., on walls | per yard super | 1/4 | 1/6 |
| Renderings to walls—one coat float finish | per yard super | 1/6 | 1/8 |
| Plainface .. .. .. | per yard super | 1/10 | 2/- |

*Coloured Cement Plainface*

| | | |
|---|---|---|
| Cullamix No. 2 or 3 cream, on and including water repellent cement and sand backing .. .. | per yard super | 3/10 |
| Snowcrete mixture on and including ditto | per yard super | 3/10 |
| Snowcrete and white silica sand on and including ditto | per yard super | 3/6 |

For raking out joints of brickwork, keyed bricks or hacking face of concrete, to form key for plastering, see "Bricklayer."

*Wall Tiles, Commercial Quality*

| | | |
|---|---|---|
| 6" × 6" × ⅜" ivory or white .. .. | per yard super | 16/- |
| Extra for rounded edge tiles.. .. .. | per yard run | 1/5 |
| 6" × 6" × ⅜" coloured enamel bright glazed | per yard super | 21/3 |
| Extra for rounded edge tiles .. .. | per yard run | -/7¾ |
| 6" × 6" × ⅜" eggshell gloss enamelled | per yard super | 22/1 |
| Extra for rounded edge tiles .. .. | per yard run | -/6¾ |

## EXTERNAL PLUMBER

*Lead*

| | Flats | Gutters, Flashings, etc. | Stepped Flashings | Soakers cut to size |
|---|---|---|---|---|
| Milled sheet lead and labour .. per cwt. | 39/6 | 40/7 | 41/8½ | 34/4 |

| | | |
|---|---|---|
| Bedding edges in white lead .. .. .. | per foot run | -/2 |
| Lead wedgings to flashings .. .. .. | per foot run | -/1½ |
| Ditto to stepped flashings .. .. .. | per foot run | -/2 |
| Dressing 6-lb. lead over glass and glazing bars | per foot run | -/3½ |
| Copper nailing .. .. .. .. .. | per foot run | -/1½ |
| Close ditto .. .. .. .. .. | per foot run | -/2 |
| Bossed ends to rolls .. .. .. .. .. | each | -/7½ |
| Extra labour dressing through shoots and into rainwater heads .. .. .. .. .. .. .. | each | 3/- |
| Ditto to cesspools, including extra solder .. .. | each | 5/3 |

*Cast Iron Rainwater Goods*

*Rainwater Pipes fixed to brickwork.*

| | | 3" | 4" |
|---|---|---|---|
| Round pipes .. .. .. | per foot run | 1/5½ | 1/9 |
| Extra for bends .. .. .. .. | each | 2/2 | 2/10 |
| Ditto 6" offset .. .. .. .. | each | 2/4 | 2/10 |
| Ditto single branches .. .. .. | each | 2/7 | 3/1 |
| Ditto shoes .. .. .. .. .. | each | 1/7 | 2/2 |
| | | 3½" × 3½" | 4" × 3" |
| Square and rectangular pipes .. | per foot run | 3/2 | 2/10 |
| Extra for elbows .. .. .. .. | each | 4/11 | 3/6 |
| Ditto single branches .. .. .. | each | 5/9 | 5/4 |
| Ditto shoes .. .. .. .. .. | each | 4/8 | 4/3 |

## EXTERNAL PLUMBER—(*continued*)

*Gutters fixed to fascia.*

| | | 4" | 5" | 6" |
|---|---|---|---|---|
| Half-round gutters .. | per foot run | 1/- | 1/2½ | 1/8½ |
| Extra for angles .. .. .. | each | 1/9 | 2/- | 2/3 |
| Ditto nozzles .. .. .. | each | 1/7 | 1/10 | 2/5 |
| Ditto stop ends .. .. .. | each | 1/- | 1/3 | 1/4½ |
| Ogee gutters .. .. | per foot run | 1/1½ | 1/4 | 1/9½ |
| Extra for angles .. .. .. | each | 1/9½ | 2/3 | 2/4 |
| Ditto nozzles .. .. .. | each | 1/8 | 2/3 | 2/8 |
| Ditto stop ends .. .. .. | each | 1/1½ | 1/4½ | 1/7½ |

## INTERNAL PLUMBER

*Lead Pipes*

*Service.*

| | | ½" | ¾" | 1" | 1¼" |
|---|---|---|---|---|---|
| Pipes laid in trenches .. | per foot run | -/10¾ | 1/2½ | 1/8¾ | 2/4½ |
| Add if fixed on walls .. | per foot run | -/2 | -/3 | -/4 | -/5 |
| Ditto if in short lengths .. | per foot run | -/1 | -/1 | -/1½ | -/2 |
| | | 1½" | 2" | 2½" | 3" |
| Pipes laid in trenches .. | per foot run | 3/- | 4/- | — | — |
| Add if fixed on walls .. | per foot run | -/6 | -/8 | — | — |
| Ditto if in short lengths .. | per foot run | -/3 | -/4 | — | — |

*Distributing.*

| | | ½" | ¾" | 1" | 1¼" |
|---|---|---|---|---|---|
| Cold water pipes fixed to walls | per foot run | -/10¾ | 1/2¾ | 1/8½ | 2/3 |
| Add if in short lengths .. | per foot run | -/1 | -/1 | -/1½ | -/2 |
| | | 1½" | 2" | 2½" | 3" |
| Cold water pipes fixed to walls | per foot run | 2/9½ | 3/7¼ | — | — |
| Add if in short lengths .. | per foot run | -/3 | -/4 | — | — |

*Flushing and Warning.*

| | | ½" | ¾" | 1" | 1¼" |
|---|---|---|---|---|---|
| Waste and overflow pipes fixed in short lengths .. .. .. | per foot run | -/8¾ | -/11 | 1/2 | 1/5 |
| | | 1½" | 2" | 2½" | 3" |
| Waste and overflow pipes fixed in short lengths .. .. .. | per foot run | 1/10 | 2/5½ | — | — |

*Soil and Ventilating.*

| | | 3½" | 4" | 4½" |
|---|---|---|---|---|
| Pipes fixed, including lead tacks | per foot run | 5/3 | 5/10 | 6/8½ |

| | 1½" | 2" | 2½" | 3" | 3½" | 4" | 4½" |
|---|---|---|---|---|---|---|---|
| Bends .. each | 1/6 | 2/- | 2/9 | 3/9 | 4/3 | 4/6 | 5/6 |

| | ½" | ¾" | 1" | 1¼" | 1½" | 2" |
|---|---|---|---|---|---|---|
| Soldered joints to fittings each | 2/1½ | 2/4 | 2/7 | 2/9 | 3/- | 3/5 |
| Soldered branch joints (price as largest branch) .. each | 2/3½ | 2/6 | 2/9 | 3/- | 3/8 | |

| | 2" | 2½" | 3" | 4" | 4½" |
|---|---|---|---|---|---|
| Soldered branch joints (price as largest branch) .. each | 3/8 | 4/- | 4/6 | 5/- | 6/6 |

Soldered branch joints in the table above: the sizes are ½", ¾", 1", 1¼", 1½".

Wrap small pipes with hair felt.. .. .. per foot run -/6

*Drawn Lead Traps*

| | 1¼" | 1¼" 3" deep seal | 1½" | 1½" 3" deep seal | 2" | 2" 3" deep seal |
|---|---|---|---|---|---|---|
| P. Traps 6 lb. with cleaning eye and two soldered joints .. .. each | 7/1 | 7/7½ | 8/3 | 8/9½ | 9/8 | 10/2½ |
| S. ditto .. .. each | 7/6 | 8/0½ | 8/8 | 9/2½ | 10/4 | 10/10½ |

*Brasswork (Best Quality)*

| | | ½" | ¾" | 1" |
|---|---|---|---|---|
| Brass screwdown stop cocks including two soldered joints .. .. .. .. | each | 7/6 | 9/9 | 13/1 |
| Ditto, including two red lead joints for iron | each | 5/8 | 7/10 | 11/- |
| Ditto, including one soldered and one red lead joint .. .. .. .. .. | each | 6/1 | 8/1 | 11/2 |
| High pressure Portsmouth pattern ball valve with flynut and union and one soldered joint | each | 8/5 | 11/7 | 17/2 |
| Ditto, including red lead joint for iron.. | each | 6/5 | 9/2 | 16/8 |

| | | 2" | 4" |
|---|---|---|---|
| Brass thimble and soldered and cement joints | each | 5/- | 9/5 |
| Ditto, with solder and caulked lead joints | each | 6/- | 11/2 |

*Fixing Only (Connections to Pipes measured separately)*

| | | |
|---|---|---|
| 24" × 18" × 6" sinks including taps, etc., and pair of brackets cut and pinned to brickwork .. .. | each | 6/- |
| 24" × 18" lavatory basins ditto .. .. .. | each | 6/6 |
| W.C. suite comprising pan and trap, seat, W.W.P. and brackets.. .. .. .. .. .. .. | each | 10/6 |
| Baths, including taps, etc., and setting in position .. | each | 10/6 |

# CURRENT PRICES

*BY DAVIS AND BELFIELD, P.A.S.I.*

# INTERNAL PLUMBER, GLAZIER AND PAINTER

## INTERNAL PLUMBER—(*continued*)

*Screwed and Socketed Galvanized Steam Quality Steel Tubes and Fittings*

Pipes up to and including 1½″ include short running lengths, sockets, connectors, elbows, bends, fire bends; Tees and Diminishing Pieces enumerated.

***Distributing.***

| | | ½″ | ¾″ | 1″ | 1¼″ | 1½″ | 2″ |
|---|---|---|---|---|---|---|---|
| **Pipes fixed to walls** | per foot run | –/10 | 1/– | 1/4 | 1/10 | 2/4 | 3/– |
| **Ditto in short lengths, fittings, etc., measured separately** | per foot run | –/10 | 1/– | 1/4 | 1/10 | 2/4 | 3/– |
| ***Extra for*** | | | | | | | |
| **Firebends** .. .. .. | each | –/4 | –/6 | –/9 | 1/3 | 1/6 | 2/– |
| **Bends** .. .. .. | each | 1/2 | 1/5 | 1/9 | 2/6 | 3/1 | 4/9 |
| **Round elbows** .. .. | each | 1/5 | 1/8 | 2/– | 2/4 | 2/10 | 4/4 |
| **Square ditto** .. .. | each | 1/5 | 1/8 | 1/11 | 2/3 | 2/8 | 4/1 |
| **Tees** .. .. .. | each | 1/6 | 1/10 | 2/1 | 2/9 | 3/1 | 4/8 |
| **Crosses** .. .. .. | each | 2/9 | 3/2 | 3/10 | 5/– | 6/– | 9/1 |
| **Diminishing pieces** .. | each | –/10 | –/11 | 1/2 | 1/6 | 1/11 | 2/8 |
| **Caps** .. .. .. | each | –/7 | –/8 | –/10 | 1/– | 1/5 | 1/9 |
| **Plugs** .. .. .. | each | –/6 | –/6 | –/8 | –/11 | 1/4 | 1/8 |

*Cast Iron Waste, Soil and Vent Pipes*

| | | 2″ | 3″ | 4″ | 5″ | 6″ |
|---|---|---|---|---|---|---|
| **L.C.C. pipes in 6′ 0″ lengths fixed to brickwork** .. | per foot run | 1/10 | 2/– | 2/5 | 4/5 | 5/4 |
| **Extra for bends** .. .. | each | 5/3 | 6/1 | 7/10 | 11/– | 14/9 |
| **Ditto single branches** .. | each | 6/5 | 8/2 | 11/– | 17/6 | 23/6 |
| **Ditto swannecks 6″ projection** | each | 6/1 | 8/9 | 11/1 | 16/1 | 22/– |
| **Extra for access door or any fitting** .. .. .. | each | 6/9 | 6/9 | 7/3 | 8/6 | 8/6 |

*Zincworker*

| | | 13 G. | 14 G. | 15 G. | 16 G. |
|---|---|---|---|---|---|
| **Rolled sheet zinc on flats** | per foot super | –/7½ | –/8 | –/9 | –/9½ |
| **Ditto in gutters, cover flashings, etc.** | per foot super | –/8¼ | –/8½ | –/9½ | –/10¼ |
| **Ditto in stepped flashings** | per foot super | –/10½ | –/11 | 1/– | 1/0½ |
| **Labour and risk dressing over glass** | per foot run | –/4¼ | –/4¼ | –/4¼ | –/4¼ |
| **Capped ends to rolls** .. .. | each | –/2¼ | –/2¼ | –/2¼ | –/2¼ |
| **Extra labour to cesspools** .. | each | 2/7½ | 2/7½ | 3/2 | 3/2 |

*Copperworker*

***Distributing.***

| | | ½″ | ¾″ | 1″ | 1¼″ | 1½″ | 2″ |
|---|---|---|---|---|---|---|---|
| **Solid drawn copper tube fixed to walls** .. .. | per foot run | –/9 | 1/– | 1/5½ | 1/10 | 2/3 | 3/3 |
| **Add if in short lengths** | per foot run | –/0¾ | –/0¾ | –/1 | –/1½ | –/2 | –/2¼ |
| Fittings for copper tubes | | | | | | | |
| Compression type | | | | | | | |
| **Straight couplings** .. | each | 1/10 | 2/2 | 3/– | 3/9 | 5/1 | 7/3 |
| **Obtuse elbows** .. .. | ,, | 2/8 | 3/2 | 4/5 | 5/6 | 8/10 | 12/7 |
| **Tees** .. .. .. | ,, | 3/1 | 3/6½ | 5/4 | 7/4½ | 11/3 | 15/7 |
| **Crosses** .. .. .. | ,, | 4/1½ | 4/8 | 5/8½ | 8/– | 13/2 | 18/– |
| **Reducing coupling** .. | ,, | — | 2/2 | 3/– | 3/9 | 5/1 | 7/3 |
| **Bends** .. .. .. | ,, | 2/5 | 2/10½ | 3/1 | 5/– | 8/3 | 11/11 |
| **Brass stopcocks** .. .. | ,, | 5/6 | 7/10 | 11/– | 19/3 | 26/6 | 43/6 |
| Capillary type | | | | | | | |
| **Straight coupling** .. | each | 1/6 | 1/11 | 2/7 | 3/3 | 4/1 | 5/4½ |
| **45° Elbow** .. .. | ,, | 2/4 | 2/11½ | 3/10½ | 4/11 | 6/10 | 9/7 |
| **Tees** .. .. .. | ,, | 2/7 | 3/– | 4/3 | 5/10 | 7/10 | 11/– |
| **Crosses** .. .. .. | ,, | 3/1 | 3/6 | 5/1½ | 6/10 | 9/8 | 13/5 |
| **Reducing coupling** .. | ,, | — | 1/7 | 2/– | 2/6 | 3/3 | 4/8 |
| **Bends** .. .. .. | ,, | 2/8 | 3/2 | 4/3 | 5/7 | 8/1 | 10/11 |
| **Pillar tap connections** .. | ,, | 1/11 | 2/6 | | | | |

| | | 24 G. | 23 G. |
|---|---|---|---|
| ***Rolled sheet copper on flats** | ..per foot super | 1/5 | 1/7 |
| **Ditto in gutters, cover flashings, etc.** | per foot super | 1/7 | 1/9 |
| **Ditto in stepped flashings** .. | ..per foot super | 2/1½ | 2/4½ |
| **Labour and risk dressing over glass** | per foot run | –/4¼ | –/4¼ |
| **Capped ends to rolls** .. .. .. | each | –/3¼ | –/3¼ |
| **Extra labour to cesspools** .. .. .. | each | 3/8 | 3/8 |

## GLAZIER

*Sheet Glass (Ordinary Glazing Quality)*

| | | |
|---|---|---|
| **18 oz. clear sheet and glazing to wood, sprigged and with back and front putties, to all normal sizes not exceeding 60″ in length or 40″ wide** .. .. | ..per foot super | –/6¼ |
| **24 oz. ditto** .. .. .. .. | ..per foot super | –/7¾ |
| ***32 oz. ditto** .. .. .. .. | ..per foot super | –/11½ |

## GLAZIER—(*continued*)

| | | |
|---|---|---|
| Obscured ground sheet glass, net extra to above prices | per foot super | –/1¾ |
| ⅛″ figured rolled white glass and glazing to wood with beads (measured separately) .. | ..per foot super | –/10½ |
| Ditto, normal tints, ditto .. .. | ..per foot super | 1/2¾ |
| Hammered double rolled cathedral white ditto | per foot super | –/10 |
| Ditto, normal tints, ditto .. .. | ..per foot super | 1/1¾ |
| Add for glazing into metal frames (ordinary rebates) | per foot super | –/1⅛ |
| Ditto, metal sashes with ferroput .. | ..per foot super | –/2¼ |
| Ditto, solid metal casements and screw beads | per foot super | –/2¼ |
| Wash leather strip or similar material and bedding edge of glass .. .. .. .. .. .. | per foot run | –/3¼ |

*Glazing only* thick drawn sheet glass, polished plate or wire polished plate for all normal sizes. (For prices of glass see materials section and add profit, say 10 per cent.) per foot super 6½d.

## PAINTER

*Painting, Whitening and Distempering (on new Plastered Walls)*

| | | |
|---|---|---|
| Twice distempering white .. .. | per yard super | –/5 |
| Ditto, in common colours .. .. | per yard super | –/7 |
| Add for stippling .. .. .. | per yard super | –/2 |
| Preparing and painting three coats of paint | per yard super | 1/9 |

*Preparing and Painting Two Coats of Oil Colour on Ironwork after fixing*

| | | |
|---|---|---|
| General surfaces .. .. .. | per yard super | 1/1½ |
| Perforated landings and staircases both sides (one side measured) .. .. .. .. | per yard super | 2/6 |
| Pipes, bars, balusters, etc., not exceeding 3″ girth | per yard run | –/1¾ |
| Metal Window Frames .. .. .. | per yard run | –/2¾ |
| Eaves gutters .. .. .. .. .. | per yard run | –/7½ |
| 2″ Rainwater pipes .. .. .. .. | per yard run | –/3 |
| 4″ ditto .. .. .. .. .. .. | per yard run | –/6 |
| Squares one side .. .. .. .. | per dozen | 1/9 |
| Large ditto .. .. .. .. .. | per dozen | 2/3 |
| Extra large ditto .. .. .. .. | per dozen | 3/– |
| Edges of casements .. .. .. .. .. | each | –/3 |

*Painting on New Woodwork*

| | | Knot, prime, stop and paint three coats oil colour | Add or deduct for each coat more or less |
|---|---|---|---|
| General surfaces .. | per yard super | 2/– | –/6 |
| Fascias and soffites .. | per yard super | 2/6 | –/7½ |
| Fillets, skirtings, etc., not exceeding 3″ girth .. .. | per yard run | –/8 | –/0¾ |
| Ditto, not exceeding 6″ | ,, ,, ,, | –/5½ | –/1¼ |
| Ditto, not exceeding 9″ | ,, ,, ,, | –/7 | –/1¾ |
| Ditto, not exceeding 12″ | ,, ,, ,, | –/9 | –/2 |
| Squares one side .. .. | per dozen | 3/6 | –/9 |
| Large ditto .. .. | ,, ,, | 4/6 | 1/– |
| Extra large ditto .. .. | ,, ,, | 6/– | 1/4 |
| Edges of casements .. | each | –/6 | –/1½ |

*Sundries*

| | | |
|---|---|---|
| Twice creosoting woodwork .. .. | per yard super | –/6 |
| Twice limewhiting brickwork .. | per yard super | –/4 |

| | | Sizing | Staining | Once Varnish |
|---|---|---|---|---|
| General surfaces .. | per yard super | –/2 | –/4½ | –/6 |

| | | |
|---|---|---|
| Wax polishing .. .. .. .. | per foot super | –/4½ |
| Body in and French polish on hardwood surfaces | per foot super | 1/– |

*Writing*

| | | |
|---|---|---|
| Plain letters or figures, two coats, 2″ to 12″ letters | per dozen inches in height | 1/10½ |
| Ditto, shaded .. .. .. | ,, ,, ,, ,, ,, | 2/6 |
| Plain gold, 2″ to 12″ letters .. | ,, ,, ,, ,, ,, | 2/6 |
| Ditto, 12″ to 24″ .. .. | ,, ,, ,, ,, ,, | 3/9 |

*Gilding*

| | | Single Gold | Double Gold |
|---|---|---|---|
| Preparing and gilding in best oil gold | per foot super | 5/3 | 8/4 |
| Ditto in matt or burnished gold | per foot super | 7/4 | 11/6 |

*Paperhanging*

*Pasting and hanging only.*

| | | On walls | On ceilings |
|---|---|---|---|
| Preparing new plastered walls for papering | per piece (60 feet super) | 1/4 | 1/5½ |
| Plain lining paper .. | ,, ,, ,, ,, | 1/4 | 1/8 |
| Common printed papers | ,, ,, ,, ,, | 2/– | 2/6 |

*** Items marked thus have fallen in price since June 9th.**

# APPROXIMATE ESTIMATES

★ON this and the three following pages the JOURNAL's section of Approximate Estimates is published for the sixth time.

There is nothing revolutionary about the idea—its usefulness lies in its efficiency as a time-saver in calculating the approximate price of work to which the cubing system cannot be applied.

In brief, an Approximate Estimate in considering a roof, converts the several units of pricing involved into a common unit of price per square yard, and then adjusts the price to cover sundry labours. By this means several stages of calculation are saved by the estimator in a hurry.

• ***The following composite prices are for work executed complete and should be used for the preparation of Approximate Estimates only.***

## *FOUNDATIONS*

| | | Thickness of walls | | |
|---|---|---|---|---|
| | | 9″ | 11″ Hollow | 13½″ |
| • Excavation in clay soil for foundations 2′ 6″ deep to walls, including stock brickwork in second stocks cement mortar 1 : 3 up to 6″ above ground and horizontal double slate damp-proof course with external facings p.c. 100/– and pointing ... ... | *per yard run* | 25/1 | 28/3 | 35/4 |
| • Ditto, in ordinary soil ditto ... ... ... ... | *per yard run* | 23/10 | 27/1 | 33/9 |

## *EXTERNAL WALLS*

| | | | | |
|---|---|---|---|---|
| • External walls in Fletton brickwork in cement mortar 1 : 3 including three coat lime plaster and twice distempering one side and facings p.c. 100/– in Flemish bond, joints raked out and pointed with a neat struck weathered joint, the other ... ... | *per yard super* | 19/4 | 19/1 | 24/9 |
| • Ditto, including Keenes cement plain-face and three coats oil colour one side and ditto ... ... | *per yard super* | 21/– | 20/9 | 26/5 |
| • Ditto, including internal fair face, flush jointed one side and ditto ... ... ... ... ... | *per yard super* | 17/7½ | 17/4½ | 23/0½ |
| • For variation of 10/– per m. in p.c. of facings in Flemish bond (stretcher in cavity work) ... ... | *per yard super* | –/9 | –/6¾ | –/9 |

# APPROXIMATE ESTIMATES—(*continued*)

## *INTERNAL WALLS AND PARTITIONS*

| | | 2″ | 3″ | 4½″ | 9″ |
|---|---|---|---|---|---|
| • Breeze partitions set in cement mortar or Fletton brick walls and including three coat lime plaster and twice distempering both sides ... ... ... | ...*per yard super* | 9/11 | 11/1 | 11/1 | 16/7 |
| • Ditto, built fair and flush jointed both sides | ...*per yard super* | — | — | 7/8½ | 13/2 |
| • Ditto, including Keenes cement plain-face and three coats oil colour both sides | ...*per yard super* | 13/3 | 14/5 | 14/6 | 19/11 |

## *GROUND FLOORS*

| | | |
|---|---|---|
| • Solid ground floor construction including 9″ excavation, 4″ bed of hardcore, 6″ concrete 6 : 1 surface bed, finished with 1½″ granolithic paving trowelled smooth ... ... ... ... ... ... | *per yard super* | 9/10 |
| • Ditto, finished with ¾″ cement and sand 1 : 3 screed and wood block flooring or paving p.c. 10/– yard ... ... ... ... ... | *per yard super* | 18/2 |
| • Ditto, finished with 2″ × 2″ sawn floor fillets and floor clips and 1″ deal tongued and grooved flooring, batten widths ... ... ... | *per yard super* | 12/11½ |
| • Ditto, finished with floor fillets as before and 1″ (nominal) oak tongued and grooved narrow widths strip flooring polished at time of laying | *per yard super* | 25/2½ |
| • Sleeper wall ground floor construction, including 15″ excavation, 4″ bed of hardcore, 6″ concrete 6 : 1 surface bed, sleeper walls 12″ high, built honeycomb, 4½″ slate damp-proof course 4½″ × 3″ fir plate, and 4″ × 2″ sleeper joists and 1″ deal tongued and grooved flooring in batten widths ... ... ... ... ... ... | *per yard super* | 15/3 |
| • Ditto, with 1″ nominal oak tongued and grooved narrow widths strip flooring polished at time of laying ... ... ... ... ... | *per yard super* | 27/6 |

## *UPPER FLOORS*

| | | With 7″ Joists | With 9″ Joists | With 11″ Joists |
|---|---|---|---|---|
| • Wood construction including 2″ fir joists on 4″ × 3″ fir plates and herring-bone strutting with three coat lime plaster and twice distempering white to soffite and 1″ deal tongued and grooved flooring in batten widths ... ... ... ... | *per yard super* | 12/– | 13/2 | 14/3 |
| • Ditto, with 1″ nominal oak tongued and grooved narrow widths strip flooring polished at time of laying ... ... ... ... ... ... | *per yard super* | 24/3 | 25/5 | 26/6 |

| | | |
|---|---|---|
| • 5″ thick concrete 4 : 2 : 1 reinforced with fabric suitable at 13′ 0″ spans for carrying ¾ cwt. per ft. super, with two coat lime plaster and twice distempering white to soffite and 1″ Kara Sea deal 100 per cent. rift sawn block flooring wax polished at time of laying ... | *per yard super* | 25/7 |
| • Ditto, with 1″ nominal 25/30 per cent. quartered Austrian oak block flooring polished at time of laying ... ... ... ... ... | *per yard super* | 28/8 |

# APPROXIMATE ESTIMATES—(*continued*)

## *FLAT ROOFS*

| | | Using 7" Joists | Using 9" Joists | Using 11" Joists |
|---|---|---|---|---|
| • Wood construction including 2" fir joists on 4" × 3" fir plates and herring-bone strutting with three coat lime plaster and twice distempering white to soffite and best natural rock asphalt roof finish ... | *per yard super* | *18/5* | *19/5* | *20/6* |

| | | |
|---|---|---|
| • 5" Thick concrete 4 : 2 : 1 reinforced with fabric (suitable at 13' 0" span for carrying 40 lbs. per ft. super) with two coat lime plaster and twice distempering white ditto ... ... ... ... ... | *per yard super* | *22/7* |

## *PITCHED ROOFS*

| | | |
|---|---|---|
| • Bangor Countess 20" × 10" slating, laid to 3" lap fixed with zinc nails, including 2" × 1" battens, ⅞" roof boarding and 4" × 2" rafters (measured on slope) ... ... ... ... ... ... ... | *per yard super* | *13/1* |
| • Westmorland Random green slates No. 1 best 24" to 12" long proportionate widths ditto ... ... ... ... ... ... ... | *per yard super* | *17/2* |
| • Machine-made tiles 10½" × 6½" laid to a 4" gauge, fourth course nailed with galvanized nails ditto ... ... ... ... ... ... | *per yard super* | *11/6* |
| • Hand-made sand faced tiles ditto ditto ... ... ... ... | *per yard super* | *12/3* |
| • Slate ridges, including cuttings and 1½" × 9" deal ridge ... ... | *per yard run* | *9/10½* |
| • Half-round ridge tile ditto ... ... ... ... ... ... | *per yard run* | *7/7* |
| • Slate hips, including cuttings, lead soakers, and 1½" × 11" deal hips | *per yard run* | *12/5½* |
| • Hip tiles, including cuttings and 1½" × 11" deal hips ... ... .. | *per yard run* | *14/-* |
| • Lead valley gutter to slated roof, including cuttings and 1½" × 11" deal hips ... ... ... ... ... ... ... ... ... | *per yard run* | *18/5* |
| • Purpose-made valley tiles, including cuttings and 1½" × 11" deal hips | *per yard run* | *13/7* |

## *DOORS*

| | | Partitions or Walls | | | | |
|---|---|---|---|---|---|---|
| | | 2" | 3" | 4½" | 9" | 13½" |
| • 2" flush door p.c. 29/- 2' 6" × 6' 6", including deal frames or linings, ironmongery p.c. 15/- and simple architraves both sides, all painted ... ... ... ... ... | each | *100/-* | *101/5* | *96/3* | *100/10½* | *106/10½* |

## *WINDOWS*

Prices are for normal size, including suitable ironmongery, glazing with clear sheet glass and painting.

| | | |
|---|---|---|
| • Standard metal casements with fixed lights ... ... ... ... | *per foot super* | *2/5* |
| • Ditto, with average proportion of opening lights ... ... ... | *per foot super* | *3/10* |
| • Standard metal casements in wood frames with fixed lights ... ... | *per foot super* | *4/-* |
| • Ditto, with average proportion of opening lights ... ... ... | *per foot super* | *4/11* |
| • Standard industrial type sashes with fixed lights ... ... ... | *per foot super* | *2/2* |
| • Ditto, with average proportion of opening lights ... ... ... | *per foot super* | *3/6* |
| • Solid deal frames and 2" casements ... ... ... ... ... | *per foot super* | *5/0½* |
| • Deal cased frames and double hung sashes ... ... ... ... | *per foot super* | *4/10½* |

NOTE.—Standard wood surrounds to metal windows can be obtained at a cheaper price than that given for wood frames above.

# APPROXIMATE ESTIMATES—*(continued)*

## *STAIRCASES*

| | | | | |
|---|---|---|---|---|
| • Deal 9′ 0″ high, including half space landing, newels, balusters and handrail | *each* | *£23* | *10* | *0* |
| • Austrian oak ditto | *each* | *£44* | *5* | *0* |
| • Precast concrete ditto | *each* | *£32* | *15* | *0* |

## *DRAINS*

| | | Ordinary Soil | Clay Soil |
|---|---|---|---|
| • Manhole, 2′ 3″ × 1′ 6″ × 2′ 0″ deep, including excavation, 6″ (6 : 1) concrete bottom, one brick sides 3rd stocks in cement mortar with brown glazed half-round straight main channel and one brown glazed branch channel, including benching, sides rendered in cement and sand (1 : 3) and a 24″ × 18″ black single seal cast iron manhole cover and frame, weight 0 cwts. 3 qrs. 0 lbs. | *each* | *£3 12 6* | *£3 15 6* |
| • Manhole 2′ 3″ × 3′ 9″ × 4′ 0″ deep ditto including six branches | *each* | *£7 2 0* | *£7 6 6* |

| | | Clay Soil 4″ | Clay Soil 6″ | Ordinary Soil 4″ | Ordinary Soil 6″ |
|---|---|---|---|---|---|
| • British standard quality stoneware drain pipes laid on and including 6″ thick concrete bed flaunched up both sides of pipe and excavating average 2′ 6″ deep | *per foot run* | *2/5* | *3/0½* | *2/3* | *2/10½* |
| • Ditto, but excavating 4′ 0″ deep | *per foot run* | *4/1½* | *4/9* | *3/7½* | *4/3* |
| • Cast iron drain pipes in 9′ lengths and laying in trench including 6″ concrete bed and excavating average 2′ 6″ deep | *per foot run* | *4/8* | *6/6½* | *4/6* | *6/4½* |
| • Ditto, average 4′ 0″ deep | *per foot run* | *6/4½* | *8/3* | *5/10½* | *7/9* |

## *PATHS AND DRIVES*

| | | |
|---|---|---|
| • 2″ finished gravel paths, including 6″ excavation and 4″ bed of hardcore and edging boards | *per yard super* | *5/3* |
| • 7½″ finished gravel drive, including 6″ excavation, 6″ bed of hardcore and edging boards | *per yard super* | *6/9* |
| • 2½″ Tarmacadam drive including ditto | *per yard super* | *7/10* |

## *FENCES*

| | | |
|---|---|---|
| • Cleft chestnut pale fence 4′ 0″ high | *per foot run* | *-/10* |
| • Deal weather boards, including posts, arris rails and gravel boards creosoted, 5′ 0″ high | *per foot run* | *2/9½* |
| • Ditto, in English oak throughout | *per foot run* | *3/10½* |

***The four sections on PRICES published in the issues of June 16, 23, 30 and this week, together complete the PRICES SUPPLEMENT. Next week the FIRST SECTION—PRICES OF MATERIALS, PART 1—will be repeated with items revised according to market quotations.***