Factory Premises.

ORDER, DATED THE 30TH DAY OF SEPTEMBER, 1939, MADE BY THE MINISTRY OF HOME AFFAIRS UNDER SECTION 11 OF THE CIVIL DEFENCE ACT (NORTHERN IRELAND), 1939.

1939. No. 140.

WHEREAS a Code for the guidance of occupiers and owners of factories, commercial buildings, and other persons concerned in providing air-raid shelter, was issued before the commencement of the Civil Defence Act (Northern Ireland), 1939, and published by His Majesty's Stationery Office under the title " Air-raid Shelters for Persons Working in Factories and Commercial Buildings."

AND WHEREAS it is expedient that the requirements prescribed in the said code should have effect in relation to shelter provided before the date of this Order :

NOW, THEREFORE, the Ministry of Home Affairs for Northern Ireland, in pursuance of the powers vested in it by section eleven of the Civil Defence Act (Northern Ireland), 1939, hereby by this Order approves the said Code for the purposes of the said Act :

AND WHEREAS it is expedient that the said Code should be revised :

NOW, THEREFORE, the Ministry of Home Affairs, in pursuance of the powers vested in it by the said section, hereby further orders and directs as follows :—

1.—That the said Code be revised by such revocation and variation of and addition to its provisions as are necessary to bring the said Code into conformity with the Revised Code set out in the Schedule hereto.

2.—The Interpretation Act, 1889, as applied to Northern Ireland by the Interpretation Act, 1921, shall apply for the purpose of the interpretation of this Order as it applies for the purpose of the interpretation of an Act of Parliament.

3.—This Order may be cited as " The Civil Defence (Approval and Revision of Code) Order (Northern Ireland), 1939."

Sealed with the Official Seal of the Ministry of Home Affairs for Northern Ireland this 30th day of September, One thousand nine hundred and thirty-nine, in the presence of

(L.S.)

A. Robinson,
Secretary

SCHEDULE.

REVISED CODE (SECTION 11 OF THE CIVIL DEFENCE ACT (N.I.), 1939) FOR THE GUIDANCE OF OCCUPIERS AND OWNERS OF FACTORY PREMISES, FACTORIES AND COMMERCIAL BUILDINGS, AND OTHER PERSONS CONCERNED.

PART I.

REQUIREMENTS WITH WHICH SHELTER MUST COMPLY.

1. *Definitions.*—For the purposes of this Code the following expressions shall have the meanings hereby respectively assigned to them:—

"Air Raid Shelter" means protection otherwise than by war-like means or by any article of apparel, from hostile attack from the air, and "an air raid shelter" means any premises, structure or excavation used or intended to be used to provide air raid shelter.

"Trench shelter" means an air raid shelter in the form of a covered trench or tunnel which, where above or partly above ground level, is covered with earth to a thickness of at least 12 inches at every part.

"Accommodation" relates to the number of persons to be accommodated in an air raid shelter or in any section or compartment thereof.

"Prescribed stresses" shall mean the maximum permissible working stresses specified,

(*a*) in respect of reinforced concrete, in the "Recommendations for a Code of Practice for the use of Reinforced Concrete in Buildings" of the Reinforced Concrete Structures Committee of the Building Research Board,

(*b*) in respect of steel, in British Standard Specification No. 449-1937 ("The Use of Structural Steelwork in Buildings"),

(*c*) in respect of pressures on load-bearing concrete and masonry (brick and stone), in "Notes on the Use of Materials and Construction in Connection with Steel Structures" appended to B.S.S. 449-1937,

(*d*) in respect of timber, in "By-laws for the Use of Timber" made by the London County Council on the 30th November, 1937.

"Sound brickwork" means brickwork consisting of sound, well-fired clay bricks, sand-lime bricks complying with the requirements of British Standard Specification 187-1934 for building bricks Class A, or cement concrete bricks having a crushing strength of not less than 1,500 lb. per sq. in. when tested in accordance with the methods laid down in the second schedule of Ministry of Health, Model Byelaws, Series IV, Buildings 1937, properly bonded and jointed in mortar which is properly set and hardened.

"Brickwork in cement mortar" means brickwork consisting of bricks as described above for sound brickwork, properly bonded and jointed in cement mortar not weaker than one volume of cement to three volumes of sand, or in cement lime mortar not weaker than two volumes of cement, to one of lime to nine of sand.

"Sound stonework" means coursed natural or cast stone masonry in sound condition.

"Ordinary concrete" means concrete mixed in the proportion of not less than 112 lb. of cement complying with the requirements of British Standard Specification No. 12-1931 or of British Standard Specification No. 146-1932 to 12 cubic feet of suitable coarse and fine aggregate measured as combined.

" Structural concrete " means concrete of a quality permissible under the recommended Code of Practice for the use of Reinforced Concrete in Buildings of the Reinforced Concrete Structures Committee of the Building Research Board, consisting of not less than 112 lb. of cement, complying with the requirements of British Standard Specification No. 12-1931 or of British Standard Specification No. 146-1932, to 2½ cubic feet of suitable fine aggregate and 5 cubic feet of suitable coarse aggregate.

"Reinforced concrete" means structural concrete as described above, reinforced in accordance with the Code of Practice, such reinforcement amounting in each cubic foot of concrete to not less than 2 lb. of steel total (exclusive of laps and hooks), suitably distributed in the concrete, of which total at least 0.7 lb. is distribution steel at right angles to the main steel.

2. *Lateral and overhead protection.*—An air raid shelter must be of such construction as to give

(*a*) Lateral protection by means of not less than :—

(i) 1½ in. thickness of mild steel plate or plates,
(ii) 12 in. thickness of reinforced concrete,
(iii) 13½ in. thickness of sound brickwork or sound stonework,
(iv) 15 in. thickness of ordinary or structural concrete, unreinforced,
(v) 2 ft. thickness of ballast or broken stone,
(vi) 2 ft. 6 in. thickness of earth or sand, or
(vii) a corresponding aggregate thickness of a proportionate combination of such materials ; and

(*b*) Overhead protection, subject to the requirements of paragraph 3 for protection from falling debris, by means of not less than :—

(i) ¼ in. thickness of mild steel plate,
(ii) 4 in. thickness of structural concrete reinforced if and as necessary or otherwise suitably strengthened or effectively supported,
(iii) 6 in. thickness of ordinary concrete, reinforced if and as necessary or otherwise suitably strengthened or effectively supported,
(iv) concrete in hollow type construction conforming with the requirements set out in the Appendix to Part I of this code,
(v) 8½ in. thickness of arching in sound brickwork or sound stonework,
(vi) 1 ft. 6 in. thickness of ballast, broken stone or earth,
(vii) a corresponding aggregate thickness of a proportionate combination of such materials, or
(viii) a substantial building overhead consisting of a roof and not less than two floors (including that covering the shelter) where such structure is enclosed with walls of brick, stone or concrete.

Provided that, subject to the approval of the Ministry, other materials, of such thickness as it may prescribe, may be used to give protection.

In the case of an external air raid shelter wholly or partly above ground, the material affording overhead protection must be such as to be a dead weight of not less than 60 lb. per sq. ft. of horizontal area or must be so fastened down as to resist an upward force of 300 lb. per sq. ft. of horizontal internal surface.

The lateral protection must extend throughout the height of the air raid shelter and similarly the overhead protection must extend over the whole area of the air raid shelter.

Provided that in the case of an air raid shelter wholly above ground where the aggregate area of door and window openings in any one wall of a shelter compartment does not exceed one-quarter the surface area of such wall and the total width of such openings does not exceed one-third the total length of such wall, it shall suffice if the protection in such openings extend to a height of 6 feet above the floor of the air raid shelter, subject to movable protection being provided to the space above, such protection consisting of timber shutters not less than 2 inches thick or mild steel shutters not less than ⅛ inch thick or other approved material or it shall

suffice if the openings are protected by a screen wall or walls giving the lateral protection required under section (2) above, situated not more than 12 feet from the face of the wall of the shelter and extending beyond such openings for a distance sufficient to prevent the entrance of splinters. This requirement will be deemed to be complied with where the extent of such screen beyond the opening is not less than its distance from the opening.

3. *Protection from falling debris.*—Adequate provision must be made to afford protection from falling loads due to the collapse of any structure over an air raid shelter or within a distance from such air raid shelter equal to one-half the height of such structure, by the provision of a floor or by the strengthening of the existing floor where necessary or by a suitable roof or other construction based on an estimated static loading as representing the effect of impact, to the satisfaction of the Ministry.

Provided that where such falling loads would not include heavy machinery, materials and goods of abnormal weight nor such constructions as chimney-shafts, towers, heavy colonnades, pediments or cornices, but would comprise only the loads of a normal structure and superimposed loading of ordinary goods or light plant and equipment, it shall suffice if, for purposes of calculation, the falling loads be deemed to be static loads in accordance with the following requirements :—

(*a*) For buildings wherein the loads are carried on load-bearing brickwork or stonework :—

Number of Storeys at a Higher Level than the Top of the Shelter.	Minimum Static Load (in addition to the Floor Load) to be assumed to represent the effect of the Debris. lb. per square foot of Floor Area.
1 or 2	200
3 or 4	300
over 4	400

(*b*) For buildings wherein the whole of the loads are carried on steel or reinforced concrete framing, the effect of the debris load may be assumed to be a static load of 200 lb. per sq. ft. of floor area (in addition to the floor load) irrespective of the number of storeys at a higher level than the top of the shelter.

For the purpose of this clause, the expression "floor load" means the combined dead and superimposed floor load calculated in accordance with the Ministry of Health Model Byelaws, Series IV—Buildings, 1939.

4. *Stability.*—All new constructions, extensions, additions and alterations in connection with air raid shelter must be so executed that all loading occasioned thereby shall be safely sustained and transmitted to the ground without exceeding the limitations of the prescribed stresses except as herein provided for in respect of linings to trench shelters.

Except where executed in hard rock or other self-retaining materials, trench shelters must be provided with linings consisting of concrete, brickwork, steel (suitably protected from corrosion), or any other suitable material. Such linings must be designed and constructed in accordance with normal engineering principles in such manner as safely to retain the earth without exceeding the limitations of the prescribed stresses in the materials employed, or (in the case of any other material) such limitation of stresses as may be approved by the Ministry.

Provided that where such trench shelter is at a distance from any building or structure of not less than one-half the height of such building or structure, the stresses in the materials employed in a lining of reinforced concrete or steel may exceed the prescribed stresses by not more than 25 per cent.

5. *Gas-proofing.*—Every air raid shelter providing accommodation for more than twelve persons must be so constructed as to permit of its being rendered gas-proof without structural alteration should the need arise.

6. *Space required in shelters.*—The accommodation of an air raid shelter must, subject to the ultimate limitations specified in paragraph 7, be determined in accordance with the following rules, that is to say :—

(1) (*a*) in the case of a shelter accommodating not more than twelve persons, or (*b*) in the case of a trench shelter having openings at both ends into the open air, it must have for every person accommodated a floor area of not less than 3¾ square feet.

(2) In the case of a shelter other than as described in rule (1) above, not intended to be permanently sealed against gas, and ventilated by the entrance and exit or otherwise efficiently ventilated by natural means, or by mechanical means at a rate of not less than 150 cu. ft. of air per hour, per person, it must have, for every person accommodated,

not less than 6 square feet of floor area,
not less than 50 cubic feet capacity,
not less than 25 square feet of surface area of walls, floor and ceiling or roof, excluding from this calculation the surface area of partition walls less than 8½ in. thick.

Provided that the floor area, capacity or internal surface area of any such shelter may be of less extent subject to the following conditions :—

(*a*) That the shelter is ventilated mechanically at a substantially higher rate than the normal (exceeding 450 cubic feet of air per hour for every person in the shelter) and provided that satisfactory arrangements are made for emergency operation of the ventilating plant, when it will be sufficient if there is a floor area of 3¾ sq. ft. for every person in the shelter, or

(*b*) that the shelter being entirely below ground level has abnormally massive construction with dividing walls not less than three feet thick and heavy slabs or vaulting over not less than three feet in thickness at any part inclusive of any solid filling, subject to authorisation of the Ministry.

(3) In the case of an unventilated shelter accommodating more than twelve persons intended to be permanently sealed against gas during the whole period of occupation, it must have, for every person accommodated,

not less than 6 square feet of floor area,
not less than 50 cubic feet capacity,
not less than 75 square feet of surface area of walls, floor and ceiling or roof, excluding from this calculation the surface area of partition walls less than 8½ in. thick.

For the purpose of computing the floor area, when there are seats beneath which the floor does not extend (as in a shelter in the form of a horizontal tube), the area of such seats may be deemed to be floor area.

Every trench shelter shall have a horizontal floor and a clear head-room, measured therefrom, of not less than 6 feet extending throughout the length of such shelter or of as much of its length as is intended to provide accommodation.

7. *Limits of accommodation.*—In order to minimise the number of casualties likely to result from a direct hit every shelter should, wherever the circumstances of the case make it possible, be divided into sections or compartments for the accommodation of not more than 50 persons.

Every trench shelter intended to accommodate more than 50 persons must be divided into sections. In the case of a continuous trench shelter such divisions must be effected by a change in direction through an angle of 80 to 100 degrees and extending in the new direction a distance of not less than 5 feet (measured clear of the width of the trench shelter) subject to such distance being not less than 25 feet in the case of a second change of direction involving a return parallel to and opposite the first section.

In the case of any other shelter intended to accommodate more than 200 persons, compartments must be formed by the erection of dividing walls extending the full height of the shelter. If such compartments accommodate not more than 50 persons each of the dividing walls must be of reinforced concrete not less than 12 inches thick or of sound brickwork or sound stonework not less than 13½ inches thick. New dividing walls must be constructed in brickwork in cement mortar.

If such compartments accommodate more than 50 persons the dividing walls must consist of either :—

(*a*) a wall of reinforced concrete not less than 24 inches thick, or

(*b*) two walls, each consisting of reinforced concrete not less than 12 inches thick or of sound brickwork or sound stonework not less than 13½ inches thick, with a space between them not used as an air raid shelter.

No compartment of a shelter may be used to accommodate more than 200 persons.

8. *Accessibility of air raid shelter.*—Every air raid shelter must be boldly marked and so situated and accessible by day and by night that the persons for whose protection it is intended may pass from the place they work into their shelter within 7 minutes.

In the case of A.R.P. personnel, including persons occupied with essential duties which may not be entirely discontinued during the whole period of a raid (such as boiler-house and switchgear attendants and men in charge of machinery which cannot be shut down at short notice), special provision must be made for the necessary air raid shelter at, or adjacent to, their working positions.

9. *Entrances and exits.*—Every air raid shelter and every compartment of an air raid shelter must be provided with an entrance which (except in the case of an air raid shelter intended to accommodate not more than 12 persons), shall have a width of not less than 2 ft. 6 in.

Every air raid shelter intended to accommodate more than 12 persons must have at least two exits as remote as may be practicable from each other, one of which may be the normal entrance if suitable. One at least of such exits must, wherever practicable, give access to the open air and when possible be so situated as to be free from the danger of falling debris. Where the emergency exit gives access to another air raid shelter or to another compartment of an air raid shelter, the opening must not exceed 3 ft. 6 in. in height nor 2 ft. 9 in. in width.

Where the entrances to, or exits from an air raid shelter are in the wall of a building or are situated at a distance from any building or structure, not exceeding one-half the height of such building or structure, all reasonable measures must be taken to afford one of such entrances or exits proper protection from falling debris.

If an entrance or exit of an air raid shelter be from or to the open air and be above the ground level, such entrance or exit must be protected by a door or screen affording a degree of lateral protection not inferior to that specified in paragraph 2 of this code and of such extent as to prevent the entrance of splinters.

10. *Drainage.*—Where necessary, adequate arrangement must be made to keep every air raid shelter free from water.

11. *Sanitary facilities.*—Every air raid shelter must have proper closet facilities at the rate of not less than one seat per 25 persons accommodated, and also such subsidiary buckets and urinals as may be necessary. Such conveniences must, where practicable, be contiguous with the shelter and divided therefrom by a partition or partitions extending the whole height of the shelter.

Provided that where adequate sanitary facilities are afforded (by an existing building or otherwise) in close proximity to the shelter and within

ready and easy access, this requirement may be deemed to be complied with.

12. *Lighting.*—Every air raid shelter must be adequately lighted, and a system of independent lighting must be installed sufficient to afford such light as may be necessary in the event of the failure of the normal lighting service. Where generators or large storage batteries are employed for such purpose, they must be isolated and have separate ventilation.

Where electric torches or electric battery hand lamps are employed for such purpose, a sufficient supply must be permanently kept in the shelters.

13. *Dangerous pipes, etc.*—Pipes, tanks or containers which might prove a source of danger (such as pipes or containers conveying or holding steam, gas, compressed air, refrigerants or noxious chemicals) must not be permitted in any air raid shelter, and water pipes connected direct to the mains or to large supply tanks, and gas pipes, must be provided with such valves as may be necessary to permit of their being isolated where they pass through any shelter.

Where water mains or sewers are of such size or in such proximity to an air raid shelter as to be hazardous, such provision must be made as may be necessary to exclude their contents from the shelter in the event of damage.

APPENDIX TO PART I.

Rules for Hollow Types of Floor Construction which may be deemed to conform with the requirements of Standard Overhead Protection.

Hollow type construction which has been designed for its normal structural purpose in accordance with the Code of Practice for the use of Reinforced Concrete in Buildings prepared by the Reinforced Concrete Structures Committee of the Building Research Board, or in accordance with the various building regulations at present in force, and which is composed of

(*a*) a system of hollow tiles or hollow concrete blocks of good standard quality and of a maximum width of 12 in., embedded between reinforced concrete ribs of width not less than 2 in. or one-quarter of the width of the tiles or blocks, whichever is the greater, or

(*b*) a system of precast reinforced concrete structural units of a maximum width of 12 in., with or without supplementary ribs of reinforced concrete deposited in situ or supplementary steel in the joints between the units,

and which in each case (*a*) and (*b*) has, above the system of tiles, blocks or precast units not less than 3 in. of reinforced concrete, or alernatively not less than 2½ in. of reinforced concrete, together with a superimposed screeding not less than 1 in. thick.

PART II.

Advice as to Incidental Matters and as to Methods to be followed in providing Shelters.

General—Layout of Shelters—Notes on the Ventilation of Shelters—Methods of Providing Shelters—Notes on Construction of Trench or Tunnel Shelters outside Buildings—Notes on the Construction of Shelters within Buildings—Construction of Emergency Exits from Shelters in Buildings—Provision of Shelters in a Typical Mill Building—Provision of Shelters in a Multi-storey Warehouse Building—Provision of Shelters in a Building with Basement and Area, such as an Office Block—Provision of Shelters in a Shop, on Corner Site, with Basement extending under the Pavement and with Pavement Lights.

General.

No two factories or commercial buildings are alike ; they differ in location, in structural design, in layout and equipment ; it is not possible, therefore, to specify any one scheme of protection which would be best or even applicable to all cases. The fact that certain hypothetical problems, illustrating a few basic principles, are presented in these notes must not be taken as an indication that this work can be undertaken by persons without expert knowledge, but it should rather be assumed that each case must be treated individually, and advice on the best method of treatment should be sought from engineers or architects qualified for such work. When firms have no engineers or architects in their employ, the name of suitable experts may be obtained from the well-known professional institutions.

Layout of Shelters.

Wherever possible, shelters should be spaced at least 25 feet apart, measured in the clear. With trench shelters situated outside buildings this rule should only be departed from in exceptional circumstances where space is very restricted. In water-logged ground or in cases where it is not feasible to erect trench or tunnel type shelters completely below ground the minimum distance between shelters stated above should be increased in proportion to the height of the shelter above ground. In the extreme case of shelters erected completely above ground this minimum distance should be at least 50 feet except in exceptional circumstances where space is very restricted. With shelters situated within buildings a clear space of 25 feet between shelters should be maintained wherever possible, but it is realised that there will be many cases where it will not be practicable, and it then becomes necessary to divide shelters into compartments with dividing walls of the kind required in paragraph 7, Part I.

Where shelters are situated within buildings they should wherever practicable be placed below ground level or at ground floor level. There may be cases when it is necessary to provide shelters on upper floors of buildings, but this should only be done under expert advice.

In siting shelters, due regard should be given to the nature of existing structures on the site.

Fig. 4 illustrates some characteristic sources of danger to be avoided in the layout of shelters in industrial buildings.

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

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

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

Area D would require special protection of pavement and stall-board lights on account of the possibility of collapse of the heavy cornice and parapet, which again would make the problem of emergency exits particularly difficult.

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

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

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

Notes on the Ventilation of Shelters.

Rules are given in Part I for the number of persons who may be accommodated in various kinds of shelter with various conditions of ventilation.

The comfort of the occupants of a shelter depends to a certain extent on the degree of ventilation, i.e., the rate at which the air is removed and replenished, but to a much more important extent on the rate at which the bodily heat of the occupants is removed. Thus a greater degree of discomfort results from a rapid rise in the temperature of the shelter than from the vitiation of the air.

The dissipation of the body heat emanating from the occupants may take place mainly in two ways ; by its absorption by the structure of the shelter, and by the removal of the heated air by ventilation.

Where there is not an efficient system of natural or mechanical ventilation (and it must be remembered that when a shelter is "gas-proofed" the natural system is put out of action) conduction must be relied upon to rid the shelter of superfluous heat. For this reason the heat absorption capacity of the walls, floor and roof of a shelter is an important factor in the determination of the permissible accommodation. The trench shelter—with its sides and floor in intimate contact with the earth and with an adequate earth cover—is good in this respect, provided the floor and lining of the trench shelter be constructed of a material which is a good heat conductor such as metal or dense concrete in direct contact with the earth. In the absence of sufficient ventilation, the necessity for the conduction of the internal heat to the earth cannot be over-emphasised and it is rarely advisable to cover the lining and floor with heat-insulating materials. If wood flooring is to be used, it should be in the form of open moveable grids so that the atmosphere can come into direct contact with the cold surface of the concrete below.

There are two main conditions of ventilation for shelters to be considered. The shelters may be entirely sealed for the duration of an air raid against the possible entry of gas, by air-tight doors and with air-locks at the entrances. In such cases it may be useful to provide mechanical ventilation, with some form of manual or pedal operation as an alternative to the normal power supply which might fail in an emergency. With gas-tight, mechanically ventilated shelters, it is important that the incoming air should pass through a filtration unit capable of removing war gases and, as an additional safeguard, the air inlet may be situated at a high level. With sealed shelters, not mechanically ventilated, it is necessary to limit the number of occupants.

In the second condition shelters will not normally be sealed against gas and their entrances and exits will be left open whilst they are occupied. Should gas be released in their vicinity the openings would be temporarily closed by blankets or similar devices, and the shelters would be evacuated when the attack was past. When normal entrances and exits of shelters are left open the bodily heat of the occupants will set up air convection currents which will normally suffice to ventilate the shelters when continuously occupied.

Methods of Providing Shelters.

There are two general methods available for the protection of personnel :—

(1) by the provision of isolated shelters above or below ground, or trench shelters outside the buildings, see Figs 2 and 3 ; or

(2) by providing shelters within the building, for which there are the following alternatives :—

(*a*) Trenches or tunnels may be constructed beneath the lowest floor of the building ; or

(*b*) Existing basements may be adapted to provide shelters. The floors over them must be strengthened to support the debris of the structure above in the event of a collapse ; or

(*c*) Existing rooms on the ground or other floor may be adapted to provide shelters. The walls must be made to afford the standards of lateral protection indicated in Part I, and the floors or roofs over them where necessary must be strengthened to support the debris of the structure above in the event of collapse ; or

(*d*) Shelters may be specially built within the buildings or "lean-to's" may be erected against a wall of the building or against a boundary wall.

Notes on the Construction of Trench Shelters Outside Buildings.

The choice of the type and position of shelters will nearly always be governed by site conditions.

The required protection may often be obtained by placing shelters on any vacant land adjoining the premises. The land need not necessarily be rendered unsuitable for future building extensions if the shelters are sited with the possibility of such extensions in view. Trench shelters may be so arranged that they come between the rows of stanchion bases or footings of possbile building extensions and, by keeping the tops of the trench linings at a suitable depth below the proposed floor level, the shelters need not interfere with the floor layout, or shelters may be so arranged as to form a part of the basement of a future extension. Emergency exits from the shelters would be arranged in the form of manholes or trap-doors set at the level proposed for the new buildings. A scheme where this arrangement has been carried out is shown diagrammatically in Fig 1.

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

It is an advantage to construct shelters close to the premises, for in that way they can be occupied more quickly and there will be less disturbance of production. There is very little likelihood of the shelters being more vulnerable on account of their proximity to buildings, provided they are sufficiently far removed to avoid risk of being buried under debris in the event of collapse, and the advantage of ease of access outweighs any possible disadvantage of greater vulnerability. The shelters should, however, be kept at a safe distance (preferably at least half the height of the structure) from high buildings, chimney-stacks, water-towers, etc., so that in the event of a collapse of any part of these structures the shelters will not be damaged.

Drainage is an important matter, and wherever possible shelters should be constructed on the higher part of the site, or on a slope so that they can be drained naturally.

For trench or tunnel shelters there should be a clear space between shelters of not less than 25 feet in any direction, but 40 to 50 feet clear space, or as much more as may be possible, is to be preferred where the site permits.

Where space is very restricted as many as 1,200 persons can be accommodated on an acre of ground as shown in the block system illustrated in Fig. 2.

General Notes on the Construction of Shelters within Buildings.

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

(*a*) in covered trenches constructed under the ground floor of the factory ;

(*b*) in existing basements ;

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

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

(a) Trenches beneath Floors.

The system of constructing trenches beneath the floors provides good protection, and is suitable for adoption in some buildings where there is no unoccupied ground available or where, owing to the vital character of the work on which the employees are engaged, it is imperative, in order to avoid serious dislocation, that they should have shelter accommodation as near the scene of their normal activities as possible. It offers the advantage that alterations to the structure of the bulidings are reduced to a minimum. Cases occur, particularly where buildings are situated on a sloping site and when floor levels vary, where it would be possible to tunnel on one level beneath the concrete floor on a higher level, entrances being formed at either end, one giving access to the floor of the building and the other to the open. The tunnels normally would be kept well clear of stanchion bases, etc. The external openings could be protected in an emergency by earth or other form of screen wall. In peace time, such tunnels could be used as store rooms or cycle-sheds.

The trench shelters should be distributed throughout the building, and should be placed between the lines of stanchions so that they do not interfere with the footings and foundations. They can be placed conveniently between the rows of machines, and may be constructed to have a cover giving the standard overhead protection laid down in Part I (as at E in Fig. 5), and strong enough to withstand debris from the superstructure. Like trench or tunnel shelters outside buildings they should, wherever possible, be spaced at least 25 feet apart. In places where depth of excavation is not of importance the shelters may be constructed so as to have a cover of earth not exceeding 2 feet in thickness in addition to the normal thickness of floor (as at D in Figs 5 and 6). They can be lined permanently with brickwork, concrete, or other suitable material. Access to them should be from the workshop floor, and an emergency exit should be provided clear of the building. As this exit is only for emergency use, it need not be of large dimensions, and a pipe 2 ft. 9 in. in diameter, as a "crawl away," and leading to a manhole, would serve the purpose (see Figs. 5 and 6). The emergency exit would also assist in ventilating the trench.

(b) *Basements.**

If a convenient basement exists it may be used for conversion to a shelter, as at C, Fig. 5. Where it is proposed to make a shelter within a building, either in a basement or above ground level, it is necessary to ensure that the floor over the shelter is adequate to support the fall of debris consequent on the demolition of the superstructure ; but where there is not a substantial building structure above the shelter, it is also necessary to ensure that the floor provides the minimum overhead protection indicated in Part I. There may be cases where existing floors are sufficiently strong to support the debris loading, but in the majority of buildings it may be expected that some strengthening of floors will be required. The strengthening required should be investigated in each case, but must at least be based on the rules for estimation of debris loads laid down in Part I of this Code, realising that the rules are arbitrary and that buildings must be treated as special cases where any abnormal features exist.

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

Rules for the number of persons who may be accommodated in basement shelters are given in paragraph 7 of Part I.

Where a basement which complies with the requirements given in Part I is not intended to accommodate more than 200 persons it may be treated as one compartment and in such a case dividing walls are not required.

*Further information may be found in Air Raid Precaution Memorandum No. 10—"Provision of Air Raid Shelters in Basements."

(c) *Shelters constructed within buildings by adaptation of existing accommodation above ground.*

Where there is no basement but where there is a substantially built section of the building as, for instance, a section of an office block adjacent to a single storey block with roof lighting, it may be possible to select a room or rooms in this section for conversion to shelters. These rooms should be on the ground floor wherever possible, but in certain cases it may be preferable to provide shelter accommodation on upper storeys, though this should only be done under expert advice. If the ground floor has large window openings, such as showrooms or shop fronts, the shelters should be made in inner rooms or corridors protected by adequate walls (as at A in Fig. 5). As the enclosing walls of the shelters should be not less than 13½ inches of solid brickwork or not less than 12 inches of reinforced concrete, as indicated in Part I, some thickening of the existing walls and protection of doors and window openings may be necessary. The floor or roof over the shelter must be strengthened as for basement shelters, and all loading occasioned thereby safely transmitted to the ground as required in paragraph 4 of Part I.

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

In some cases it may be found convenient to erect an independent shelter room within the building (as shown in B in Figs. 5 and 6).

Lean-to shelters may be constructed having walls and roof affording the standard lateral and overhead protection laid down in Part I of this Code (as shown at F in Fig. 5). A lean-to against a single-storey building would not require a roof of heavier construction than that required to give the standard overhead protection, but against multi-storey buildings it is obvious that the structure would need to be sufficiently strong to withstand the debris load consequent on collapse of the wall of the main building. Lean-to shelters can serve in peace time as cycle or store sheds. An entrance can be made to give access dirctly from the main building in an emergency. See Fig. 5.

Entrances to and Exits from Shelters.

It is required in paragraph 8 of Part I that all persons shall be able to reach their places in shelters within a period of 7 minutes. Entrances, and passages giving access to them, should be constructed with a view to ease of access.

Investigation has shown that a safe horizontal space to allow for the passage of a person is 22 inches. Taking this dimension as a unit, openings should be designed on the basis that a crowd of persons will pass through an opening at the rate of 40 per minute per 22 in. unit width of opening. In the case of a well-disciplined body of people the rate of passing may be greater up to, say, twice that number. The minimum width of 2 feet 6 inches which is laid down for the entrance to shelters in paragraph 9, Part I, is required for the convenient passage of a stretcher.

Rules for the provision of emergency exits are laid down in paragraph 9, Part I. The principle which should be observed is that the entrances and exits of shelters should be so constructed as to diminish the likelihood of all being blocked by debris in the event of the collapse of building structures above the shelter. Where it is not practicable to provide emergency exits clear of the area which might be covered by debris it may in some cases be expedient to provide alternative exits in excess of the minimum required in paragraph 9, Part I, and as widely separated as possible. In basement shelters in closely built-up neighbourhoods it will often be desirable to form emergency exits into adjacent basements. The openings should be made only in an emergency, when the basements on either side of the opening have been cleared of combustible materials. If such openings are made in party walls, or fire division walls, they should be protected by self-closing fire-resisting doors to the requirements of the local authority normally controlling building in any locality. Alternatively such openings

can be made without any danger of spread of fire between adjoining buildings by forming the openings, inserting suitable lintels over and blocking the opening with brickwork or masonry in lime mortar with straight joints to the jambs. The closure need not be more than 9 inches in thickness and openings closed in this way can be broken through quickly in an emergency.

Provision of Shelters in a Typical Mill Building.

A typical example is shown diagrammatically in Fig. 7. Very often buildings of this kind are to be found situated in congested areas with no vacant ground available. It then becomes necessary to provide shelters for the personnel inside the building. The buildings are often constructed with masonry walls much cut away by window openings, with cast iron columns, and with beams housed tightly into cast iron caps on the columns. This form of construction is ill adapted to withstand the shock from a near-by explosion, and there is the possibility to be faced that debris loads on shelters in the lower part of the building may be abnormally heavy. The best form of shelter in such a case would be a tunnel under the ground floor of the building, provided the soil conditions would permit of excavation without risk of disturbance of heavily loaded foundations (see D, Fig. 7). Where the soil conditions are unfavourable, it will probably be necessary to provide shelter on the ground floor by erecting strong walls and a heavy roof slab over, independent of the existing floors (as at B in Fig. 7), and using the most suitable part of the building for the purpose. Generally speaking, the most suitable part would be the corners of the building, as providing ease of access and exit and a degree of dispersal of personnel. It may sometimes be found that bales of textile materials, rolls of printing paper and similar goods can be so arranged as to augment the resistance of the shelter walls.

Provision of Shelters in a multi-storey Warehouse Building.

An example is shown in Fig. 8. The building has a reinforced concrete or encased steel frame, with floors designed for heavy loads, and external walls would be of panel construction supported by the frame. Any part of the centre of the building at basement or ground floor level would be very suitable for the provision of a shelter, and it will be necessary only to fill in walls up to the standard of lateral protection laid down in Part I and, possibly, to provide some additional support to the ceiling over.

Provision of Shelters in a Building with Basement and Area, such as an Office Block.

A building of this kind is shown diagrammatically in Fig. 9. These buildings will usually consist of load-bearing masonry or brickwork with heavy timber floors, or in later examples with filler joist and concrete slab floors.

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

This basement is already considerably sub-divided by substantial walls. Assuming that the whole area is required for shelter accommodation, the most economical allocation of the space available will be to keep to the existing sub-divisions, treating each compartment as a shelter for a group not exceeding 50 persons in number.

Some of the existing walls will need to be strengthened up to the thickness of 13½ inches required in paragraph 7 of Part I, as shown in Fig. 9.

Access for the occupants of the building will normally be by way of the central staircase at the rear of the building and emergency exits should be provided to the area in front of the building and to basements of adjoining buildings.

Provision of Shelters in a Shop, on Corner Site, with Basement Extending under the Pavement and with Pavement Lights.

The building is shown diagrammatically in Fig. 10. The external walls and central tower would often be in load-bearing masonry, the floors consisting of reinforced concrete or filler joist construction with cased steel beams.

The basement would normally be chosen for the shelter area, but it is somewhat vulnerable on the sides fronting on the streets owing to the pavement lights and large openings below first floor level.

As examples of the application of the rules for limits of accommodation set out in paragraph 7 of Part I, four arrangements of shelters in this basement are considered :—

Case I.

There may be only a limited number of employees to be accommodated, in which case a part only of the basement need be set apart for shelter accommodation. Referring to Fig. 10, it will be seen that there is a range of small rooms, in the area EGHA at the back of the basement which, with some strengthening of existing walls, are well suited for the provision of 50-person compartments.

The dividing walls between these compartments and the wall AH would require strengthening up to 13½ inches of brickwork or masonry and the area under the pavement lights might be blocked off by the 13½ inch wall on the side GH.

The normal entrance to the shelter compartments would be by way of the staircase from ground floor level and the entrance from the basement in the front wall of the shelter group. The front wall of shelter No. 3 might be strengthened up to 13½ inches in thickness to provide protection against splinters coming through the entrance to the shelter group, thus obviating the need of a screen wall to this entrance.

Emergency exits might be formed at E into the adjoining basement, and at G into the area under the pavement, with an access ladder, manhole in the pavement and a hood to cover the manhole.

Case II.

Assuming that the part of the basement delimited by the area ABCD is occupied as stock-room accommodation, this could also be sub-divided as shown into 50-person compartments to an extent sufficient to provide for any personnel for whom there is insufficient accommodation in the small rooms EGHA. This need not seriously interfere with the use of the space in time of peace.

The dividing walls between shelters 6, 7, 8, 9 and 10 will need to be in 13½ inch brickwork or 12 inches of reinforced concrete. The front walls might be in 9 inch brickwork with a 13½ inch corridor wall against the open basement to cover the entrances against penetration of splinters.

The area under the pavement lights on the side CD might be blocked off by 13½ inch walls as shown in Fig. 10. There is an existing 9 inch wall to the staircase in shelter No. 8 and this is sufficient to arrest debris falling down the stair well.

An emergency exit might be formed to the area under the pavement lights at CD with an access ladder and manhole in the pavement, the latter being covered with a hood.

Case III.

The small rooms EGHA are insufficient to accommodate all persons for whom shelter is required, but for normal use it is necessary to preserve the maximum of clear space in the basement.

The rooms in the area EGHA are used as shelters as in Class I and an additional shelter is made in the area DKLM for approximately 200 persons.

Walls of 13½ inch brickwork or 12 inches of reinforced concrete are provided at KL and LM. The area under the pavement lights on the side DM is blocked off with 13½ inches of brickwork.

Large openings are indicated for circulation in time of peace. One of these should be closed in war time and the other should be reduced in size. A screen wall would be required to protect the entrance at L. Emergency exits should be formed in the adjoining basement and under the pavement light at M with an access ladder, manhole and hood over.

Case IV.

It is required to provide shelter for the maximum possible number of persons and to use the space available to the best advantage.

The area AHPD is divided into four large compartments, Nos. 4, 5, 6 and 7, each for approximately 200 persons. The small rooms in the area EFJA are retained as set out in Case I but compartments Nos. 4 and 5 of the original layout are eliminated. They might be used, however, if a strong dividing wall, 2 feet thick, were to be provided along BH.

The walls dividing compartments 4 and 5 and 1, 2, 3 and 7 must be 2 feet thick in reinforced concrete as required in paragraph 7 of Part I. The space between shelters 6 and 7, if not taken as shelter accommodation, obviates the necessity for a very thick wall.

Access to the larger shelters is by a central corridor which would be useful in time of peace but which should not be used for shelter. Since the corridor provides an unoccupied space separating the shelters, the walls need only be of 13½ inch brickwork or 12 inches of reinforced concrete.

Emergency exits are arranged on the same general plan as those previously shown in Cases I, II and III. By staggering the entrances from the corridor the need for screening is obviated.

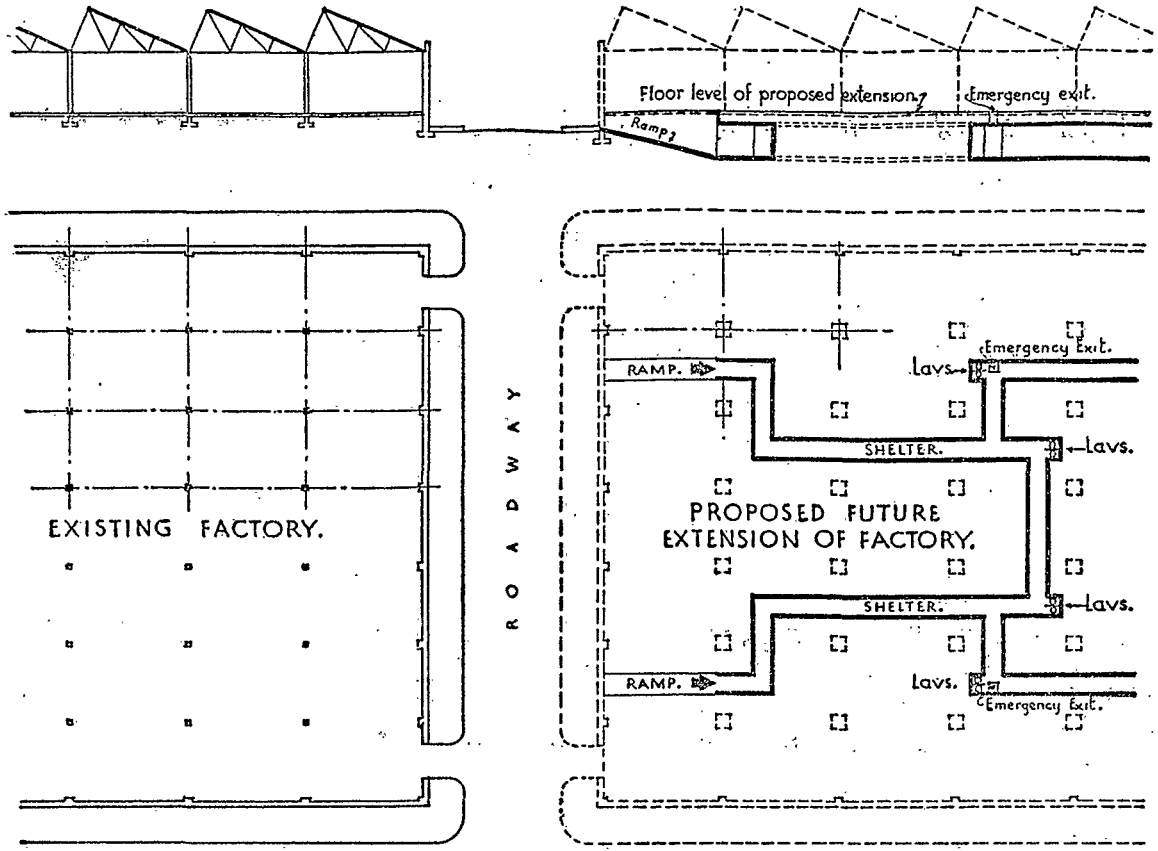
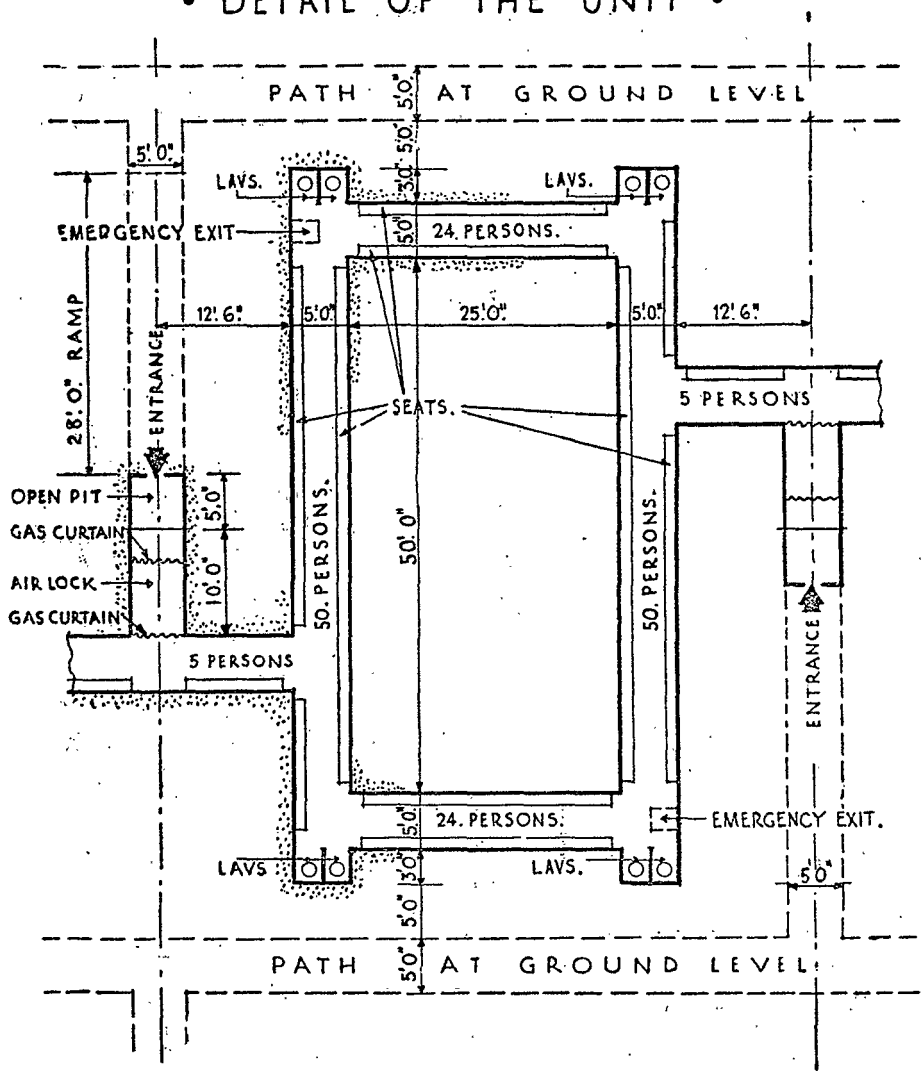


FIG. 1.—Suggested Layout of Trench-Shelters to Accord with Future Factory Extensions.



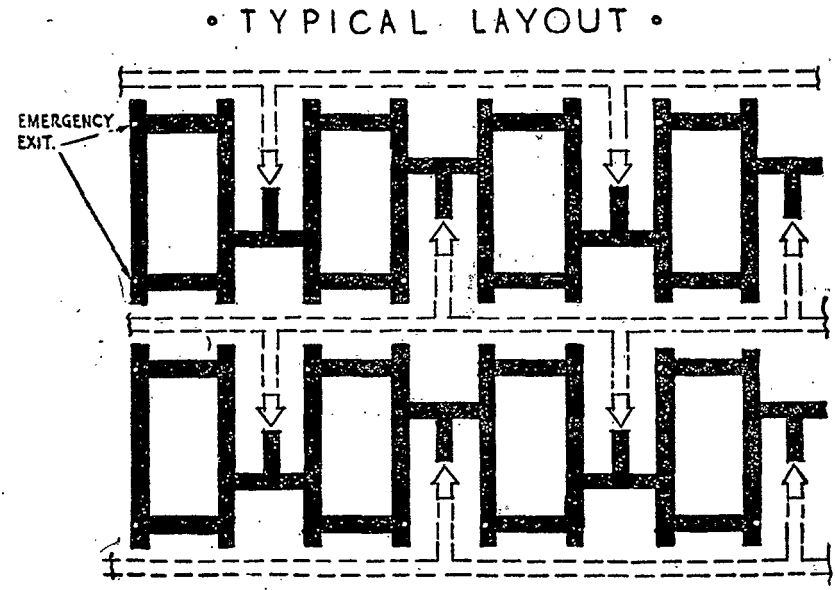
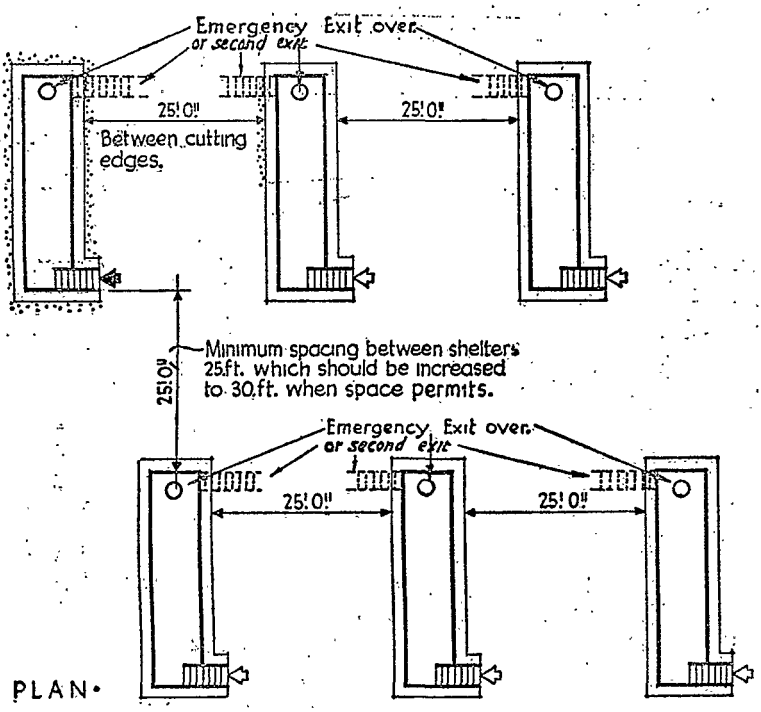
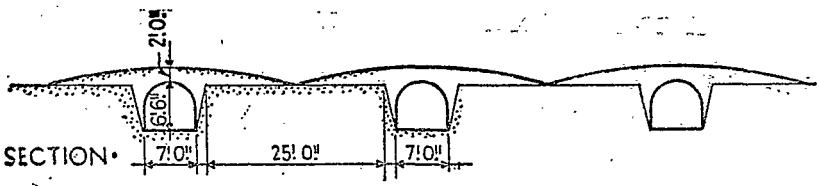


FIG. 2.—Block System of Trench Shelters.



MINIMUM SIZE OF SHELTERS AT 18.IN. SPACING PER PERSON INCLUSIVE OF ENTRANCE

7 Ft. wide shelter 30.ft. long 6.ft. 6.in. high.
5.Ft. " " 42.ft " 6.ft. 6.in. "



Depth of shelters should be deep as conditions of soil will allow up to 6.ft.. Overhead earth cover 1.ft. 6in. to 2.ft. but not more.

FIG. 3.—Layout of independent shelters each accommodating not more than 50 persons.

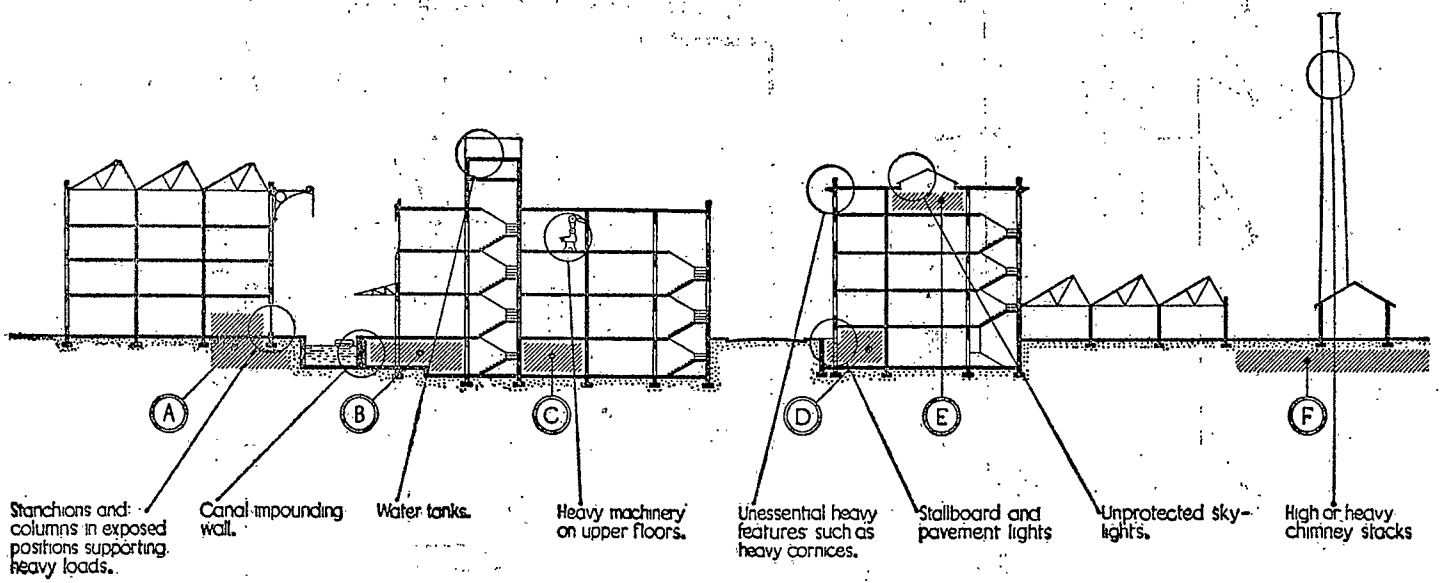


FIG. 4.—Some Features of Buildings in an Industrial Area requiring particular attention when Surveying for Provision of Shelters.

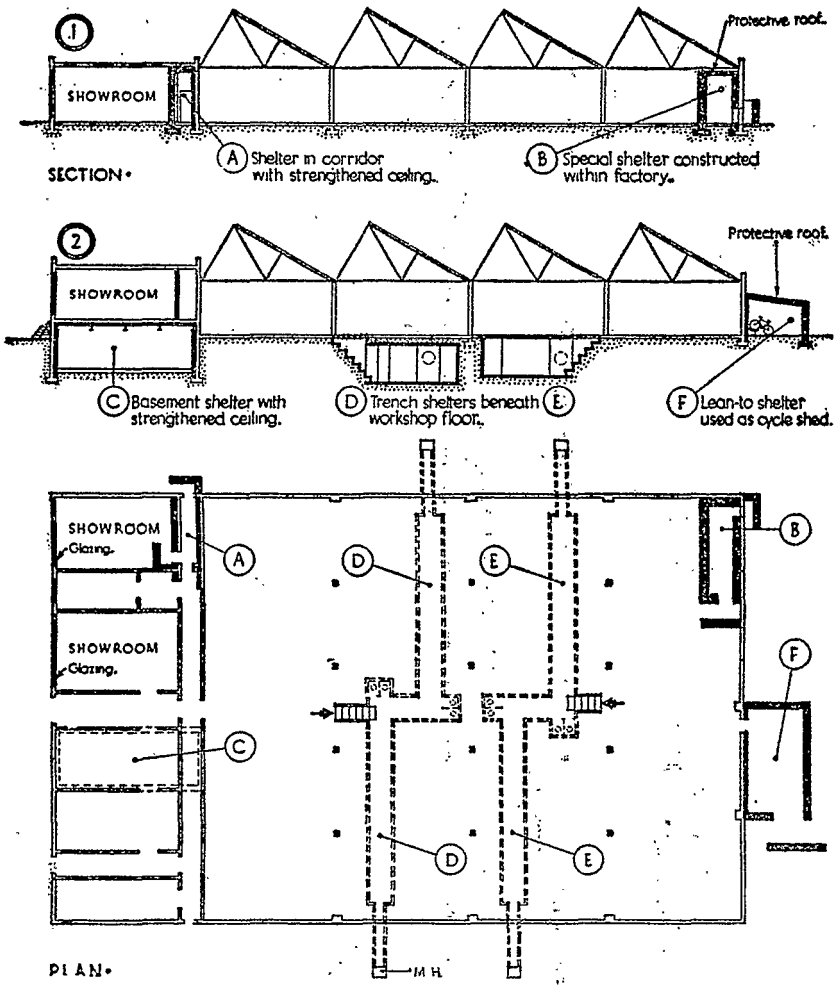
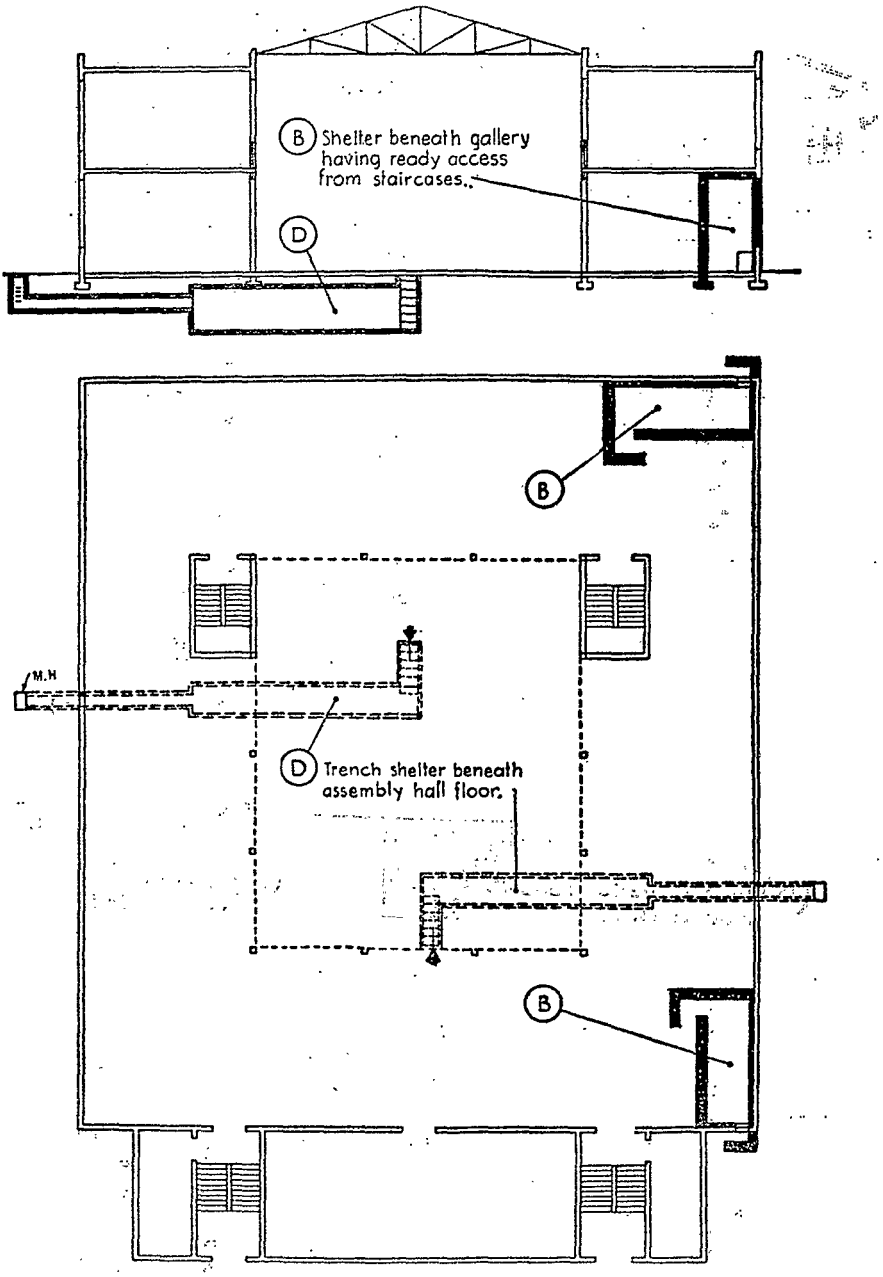
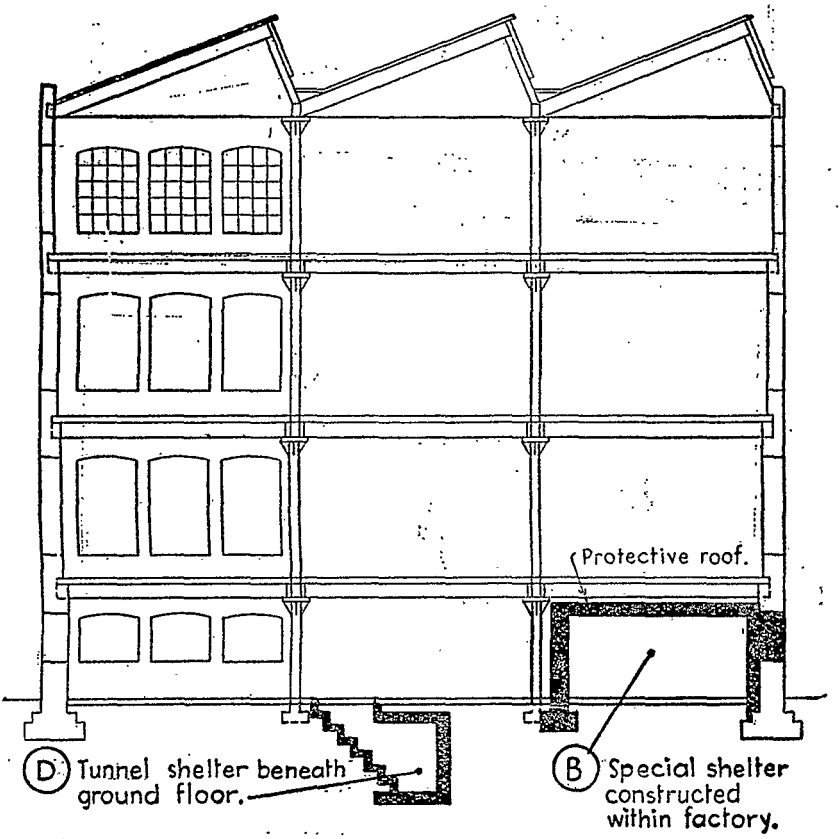


FIG. 5.—Suggestons for the Provision of Shelters in Single storey Buildings with light roofs.



The types of shelters suggested for Single storey Buildings with light roofs are applicable also to this type of structure.

FIG. 6.—Suggestions for the Provision of Shelters in Factories with Large Assembly Hall.

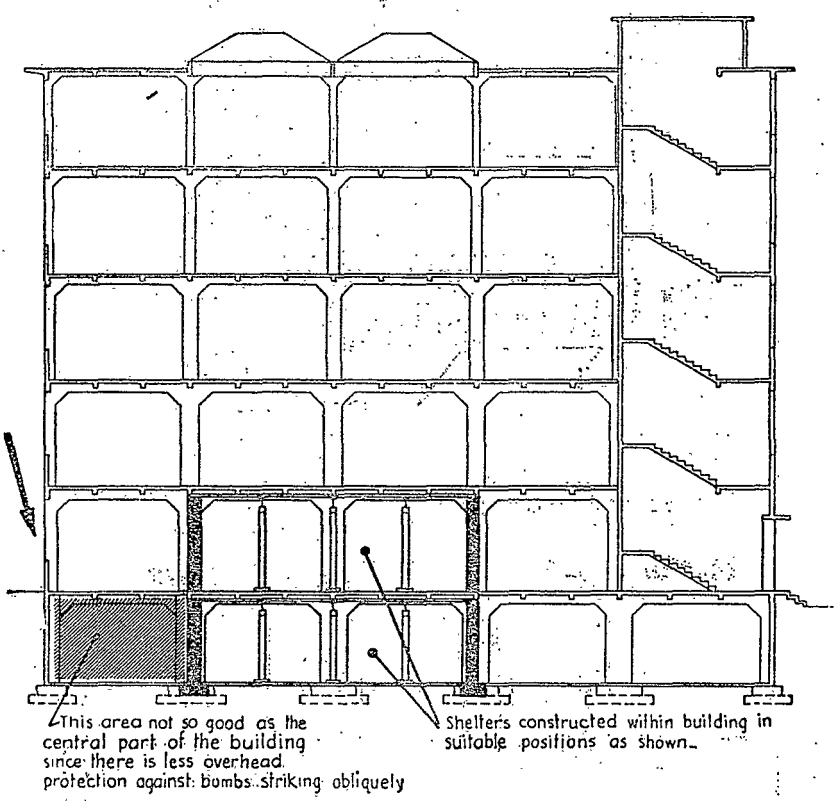


Unlike a framed building or a reinforced concrete building a typical mill building would be unable to withstand serious shock and would be in danger of complete collapse if hit by a bomb.

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

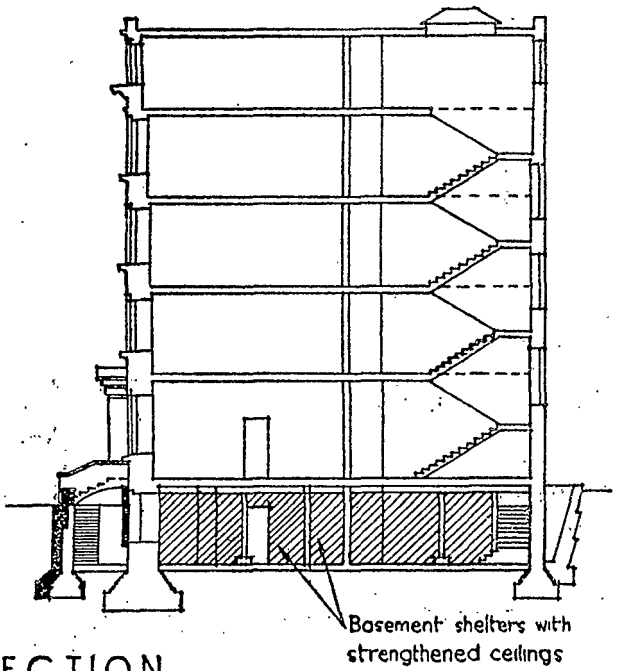
The best form of shelter within such a building, where soil and foundation conditions permit, would probably be one in the form of a tunnel (Type D) beneath the bottom floor continuous throughout the width of the mill with exits at both ends.

FIG. 7.—Suggestions for the Location of Shelters in Mill Type Buildings.

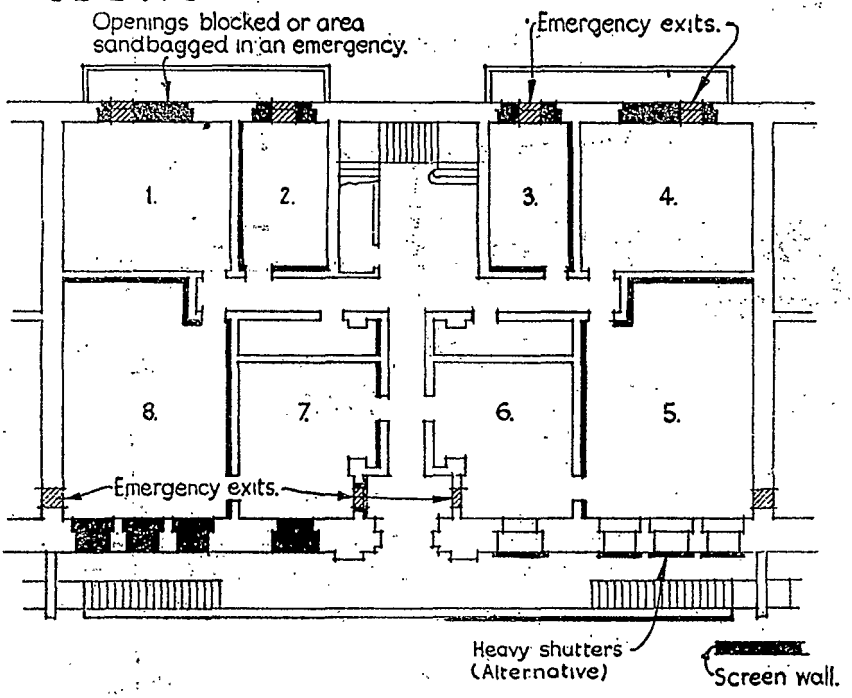


A monolithic concrete or steel-framed multi-storied building would offer considerable resistance to shock or to a direct hit, and with some additional strutting of the ceiling, and partitions to give lateral protection, both the inner rooms on the ground floor and those in the basement would offer suitable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

FIG. 8.—Suggestion for the Provision of Shelters in a Framed Warehouse Building.



SECTION



BASEMENT PLAN

FIG. 8.—Suggestions for the provision of Shelters in Buildings with Basement having open area fronting on to street.
(Heavy Masonry Construction with Timber Floors)

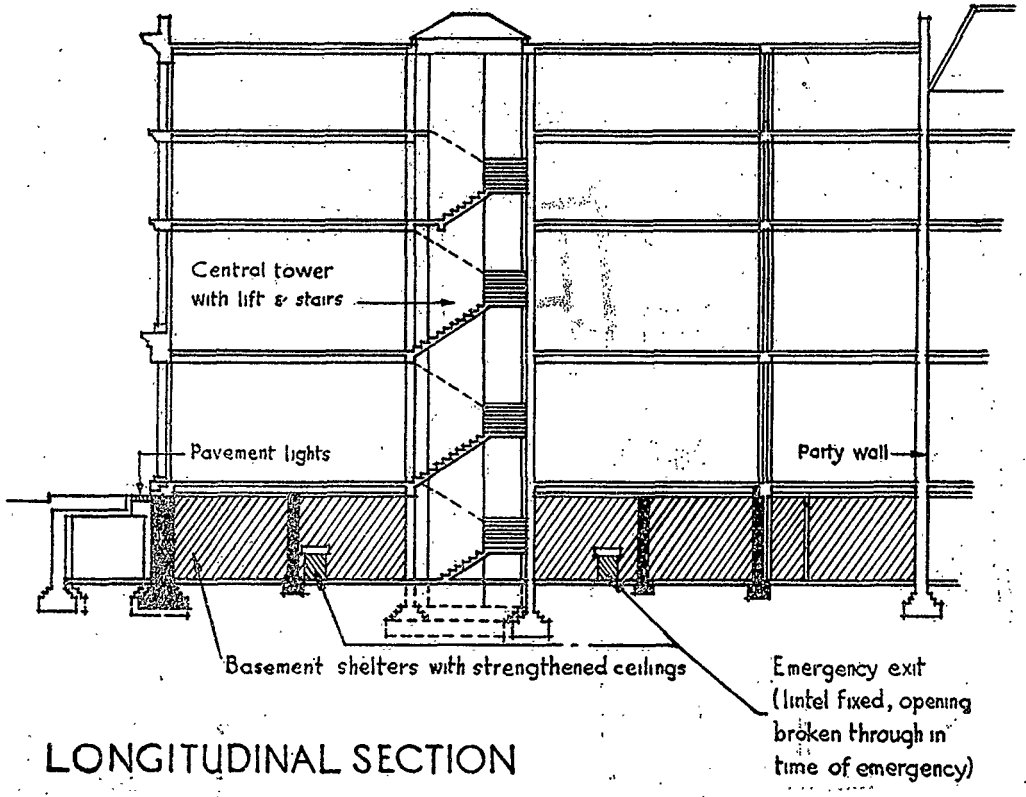


FIG. 10.—Suggestions for the provision of Shelter in a large shop with Basement (Floors and Basement not subdivided. Central tower with stairs and lift) Fronting on to two streets

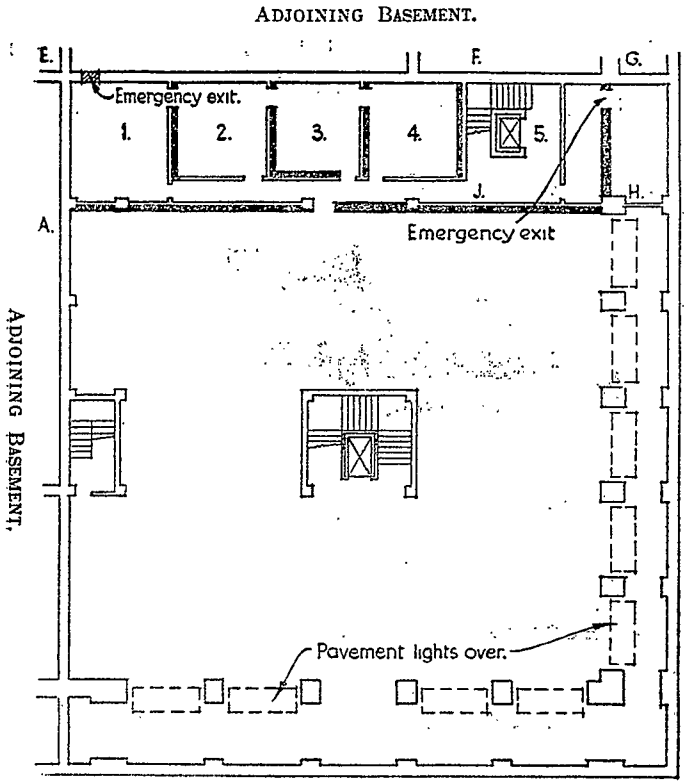


FIG. 10.—Case 1.

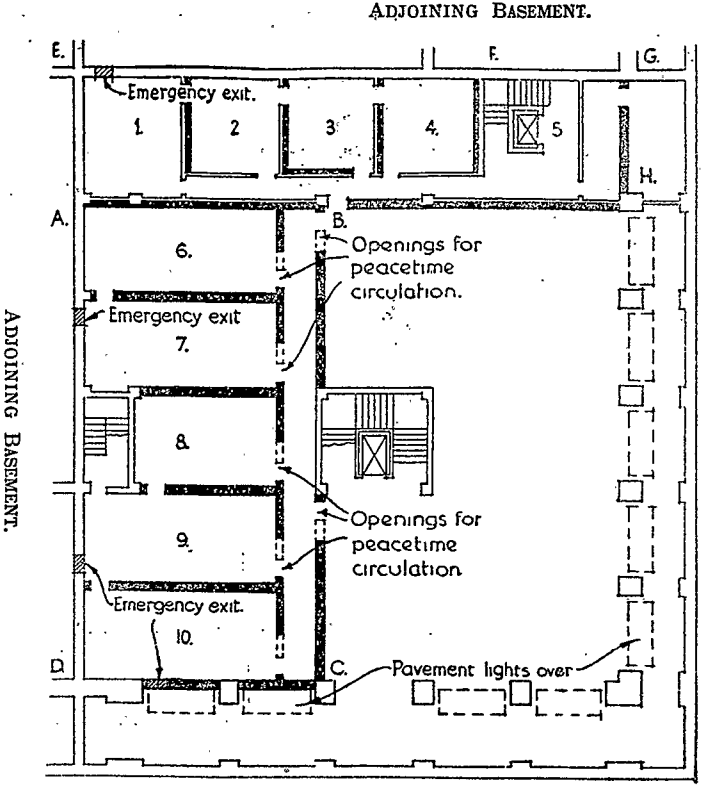
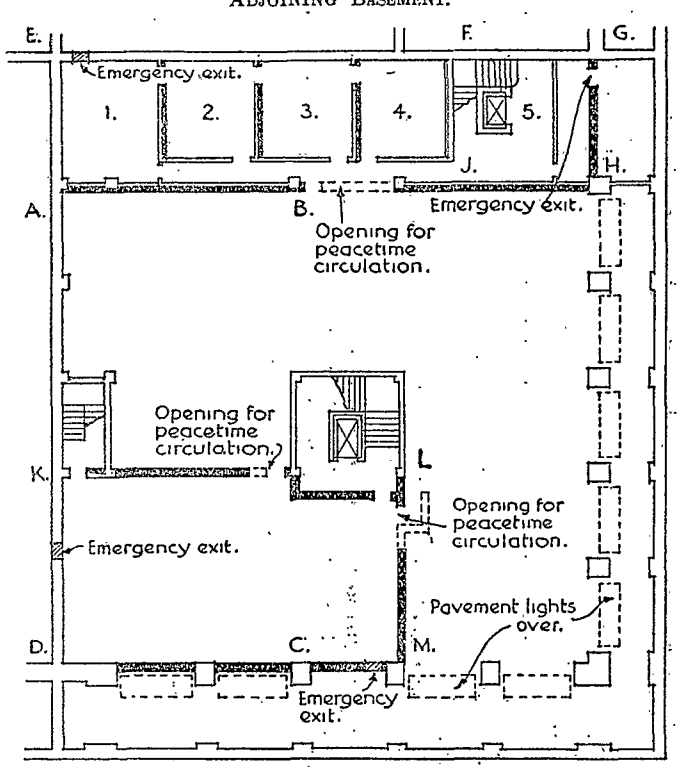
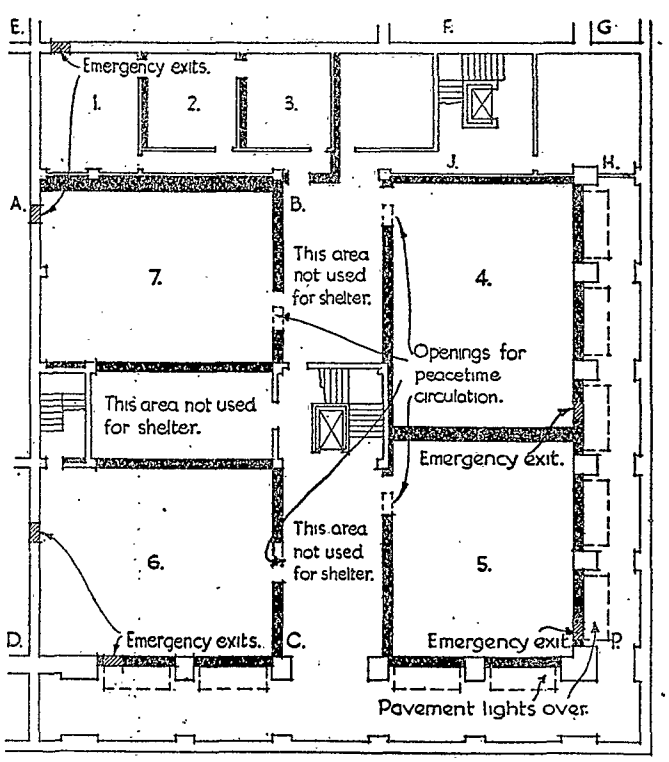


FIG. 10.—Case 2.



BASEMENT PLAN.

FIG. 10.—Case 3.



BASEMENT PLAN.

FIG. 10.—Case 4.

APPENDICES TO PART II.

APPENDIX I.—NOTES ON THE STRENGTHENING OF EXISTING FLOORS FORMING THE CEILINGS OF AIR RAID SHELTERS.

The following tables suggest the sizes of timber or rolled steel joists necessary to strengthen existing floors so as to afford protection from falling debris, but it must be clearly understood that these are type examples issued for general guidance only and that each particular case of strengthening must be treated on its merits using expert advice.

A Tables give details of timber strutting necessary for the strengthening of normal types of timber floors. Close heavy timber sheeting is indicated in the drawings accompanying these tables as it may be found necessary, in some cases at least, to include this sheeting, owing to the weakness of the existing floor. On the other hand where the existing floor is soundly constructed it may be found possible to provide adequate strengthening by means of beams and struts alone.

B Tables refer more particularly to strengthening by means of steel joists, girders and stanchions. In these cases heavy timber sheeting has not been indicated, because in the cases of sound timber floors, solid reinforced concrete floors formed with a hard stone aggregate, and not less than 4 in. thick, or filler joist floors of similar concrete where the spacing of the filler joists does not exceed $4\frac{1}{2}$ times the thickness of the solid constructural concrete, this heavy timber sheeting will not normally be required.

In cases of reinforced concrete or filler joist floors not conforming with the above conditions heavy timber sheeting should be used but in these cases the spacing of the sheeting may be up to 3 times the thickness of the constructural concrete forming the slab.

In cases of breeze concrete, hollow tile or hollow concrete floors, closely spaced heavy timber sheeting will generally be found necessary.

Attention is directed to the fact that whilst this appendix deals with strengthening of floors to resist debris loading, overhead protection in accordance with the Code standards is also required for all Air Raid Shelters.

TABLE A.1.

9 in. × 3 in. Plank Sheeting, Laid Flat and Closely Spaced.

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

NOTE.—f = working fibre stress of timber.

Slippers. Hardwood (oak, beech, birch, rock maple) slippers 6 in. × 18 in. × 2 in. to distribute loads from struts to beams and sole pieces.

Sole pieces. 6 in. × 2 in.

Cross Bracing. 3 in. × 2 in. cut to fit and joined at intersection.

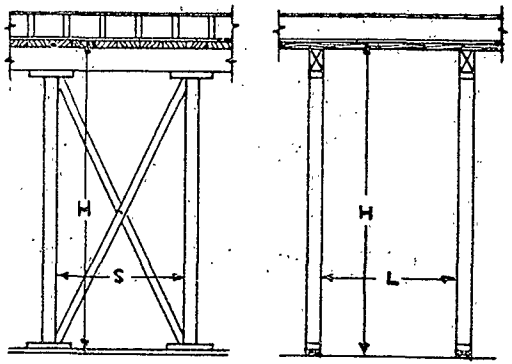


TABLE A.2.

9 in. × 4 in. Plank Sheeting. Laid Flat and Closely Spaced.

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

NOTE.—f = working fibre stress of timber.

Slippers. Hardwood (oak, beech, birch, rock maple) slippers 6 in. × 18 in. × 2 in. to distribute loads from struts to beams and sole pieces.

Sole Pieces.—6 in. × 2 in.

Cross bracing. 3 in. × 2 in. cut to fit and joined at intersection.

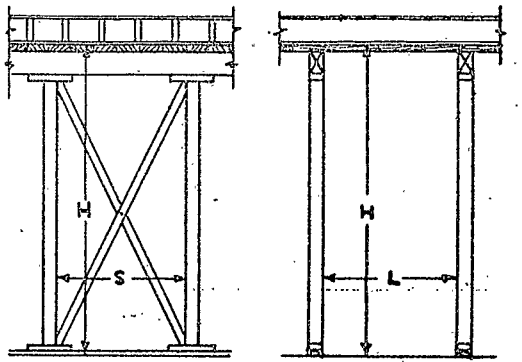
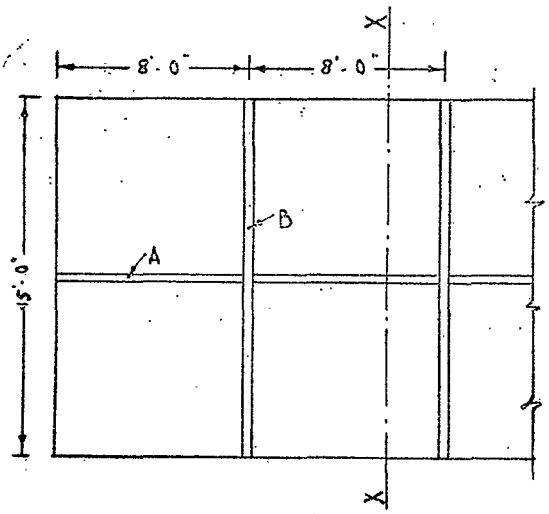
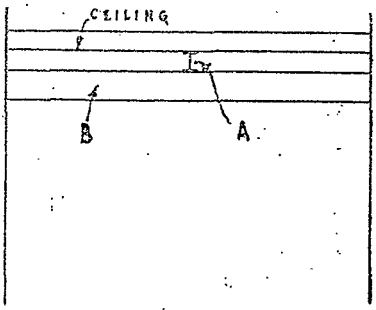


TABLE B.1.—For rooms not more than 15′ 0″ wide with 11″ × 2″ or 11″ × 1½″ floor joists, or concrete floor spanning from wall to wall without intermediate beams.

For Rooms not less than 8′ 0″ high.



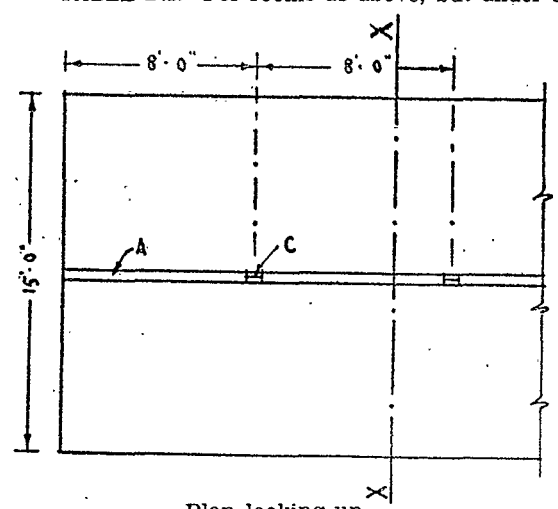
Plan looking up.



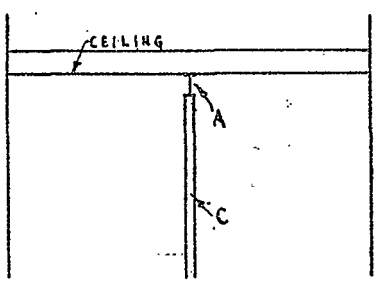
Section X X

Superimposed loading *in addition to normal*	A		B		Length of padstones	
					Under A.	Under B.
400 lbs.	10″ × 4½″	25 lbs.	18″ × 6″	55 lbs.	3′ 0″	3′ 0″
300 ,,	8″ × 5″	28 ,,	16″ × 6″	50 ,,	2′ 9″	2′ 9
200 ,,	9″ × 4″	21 ,,	14″ × 6″	46 ,,	2′ 6″	2′ 6

TABLE B.1.—For rooms as above, but under 8′ 0″ high.



Plan looking up.

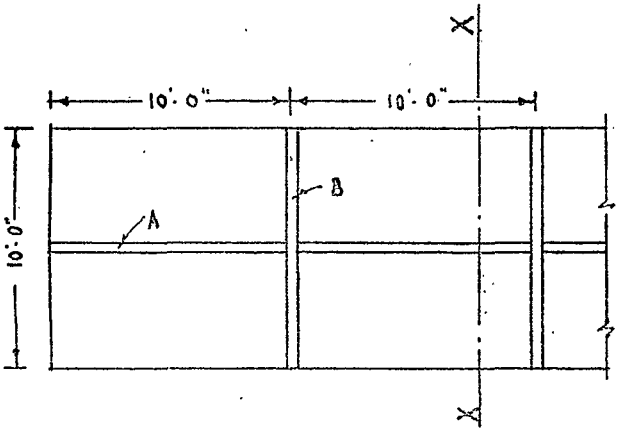


Section X X

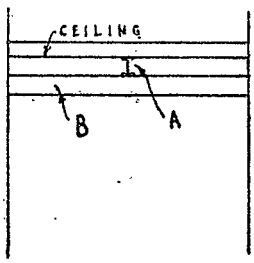
Superimposed loading *in addition to normal loading*	A		C		Length of Padstone under A.
400 lbs.	10″ × 4½″	25 lbs.	7″ × 4″	16 lbs.	3′ 0″
300 ,,	8″ × 5″	28 ,,	7″ × 4″	16 ,,	2′ 5″
200 ,,	9″ × 4″	21 ,,	5″ × 3″	11 ,,	2′ 6″

TABLE B.2.—For rooms not more than 10′ 0″ wide with 9″ × 2″ or 9″ × 1½″ floor joists or concrete floor spanning from wall to wall without intermediate beams.

For rooms not less than 8′ 0″ high.



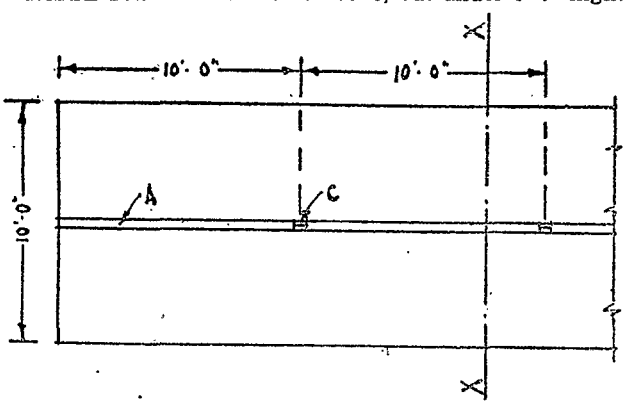
Plan looking up.



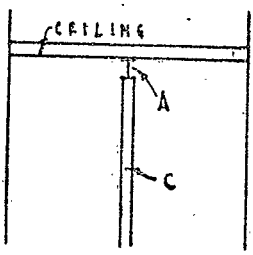
Section X X

Superimposed loading *in addition to normal loading*	A		B		Length of padstones	
					Under A	Under B
400 lbs.	10″ × 5″	30 lbs.	12″ × 6″	44 lbs.	3′ 0″	3′ 0″
300 ,,	10″ × 4½″	25 ,,	10″ × 6″	42 lbs.	2′ 9″	2′ 9″
200 ,,	8″ × 4″	18 ,,	10″ × 5″	30 lbs.	2′ 6″	2′ 6″

TABLE B.2.—For rooms as above, but under 8′ 0″ high.



Plan looking up.

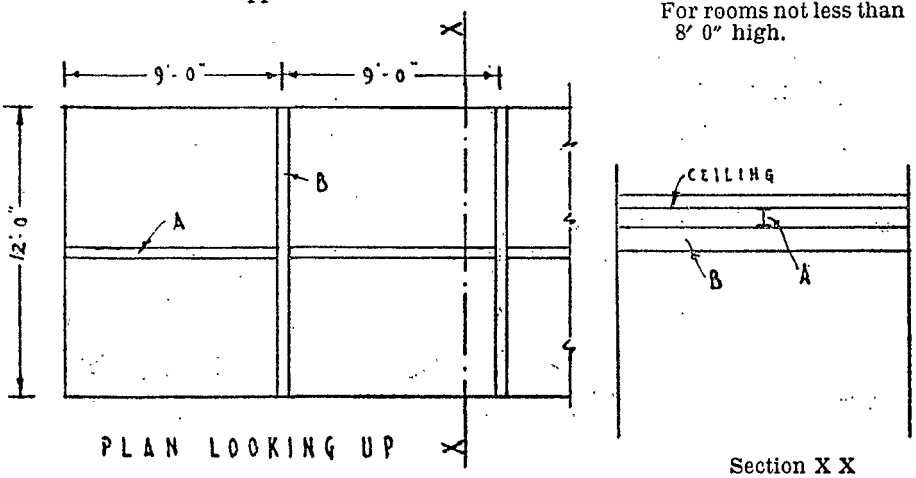


Section X X

Superimposed loading *in addition to normal loading*	A		C		Length of padstone under A
400 lbs.	10″ × 5″	30 lbs.	7″ × 4″	16 lbs.	3′ 0″
300 ,,	10″ × 4½″	25 ,,	7″ × 4″	16 ,,	2′ 9″
200 ,,	8″ × 4″	18 ,,	4″ × 3″	9½ ,,	2′ 0″

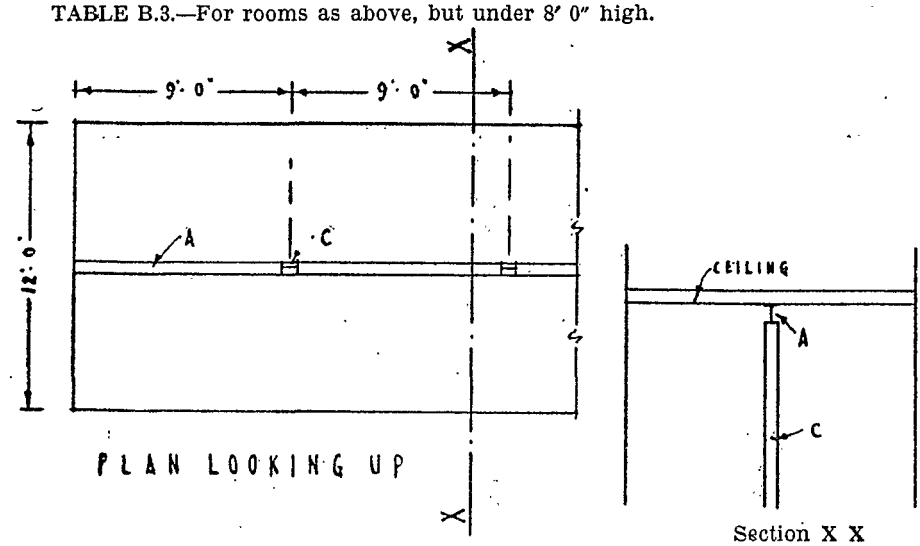
TABLE B.3.—For rooms not more than 12′ 0″ wide with 11″ × 2″ or 11″ × 1½″ floor joists, or concrete floor spanning from wall to wall without intermediate supports.

For rooms not less than 8′ 0″ high.



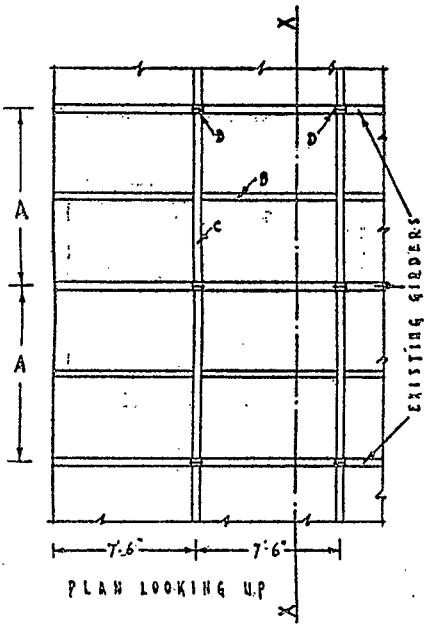
Superimposed loading *in addition to normal*	A		B		Length of Padstones	
					Under A	Under B
400 lbs.	10″ × 5″	30 lbs.	15″ × 6″	45 lbs	3′ 0″	3′ 0″
300 ,,	10″ × 4½″	25 lbs.	15″ × 5″	42 ,,	2′ 9″	2′ 9″
200 ,,	9″ × 4″	21 lbs.	13″ × 5″	35 ,,	2′ 6″	2′ 6″

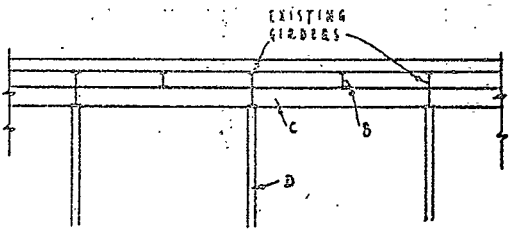
TABLE B.3.—For rooms as above, but under 8′ 0″ high.



Superimposed loading *in addition to normal*	A		C		Length of Padstone under A
400 lbs.	10″ × 5″	30 lbs	7″ × 4″	16 lbs	3′ 0″
300 ,,	10″ × 4½″	25 ,,	7″ × 4″	16 ,,	2′ 9″
200 ,,	9″ × 4″	21 ,,	5″ × 3″	11 ,,	2′ 6″

TABLE B.4.—For reinforced concrete or wood floors of any width or length divided into bays with rolled steel joists not less than 18″ deep. Stanchions D. and girders C. spaced 7′ 6″ apart, where actual height of stanchion does not exceed 12′





Section X X

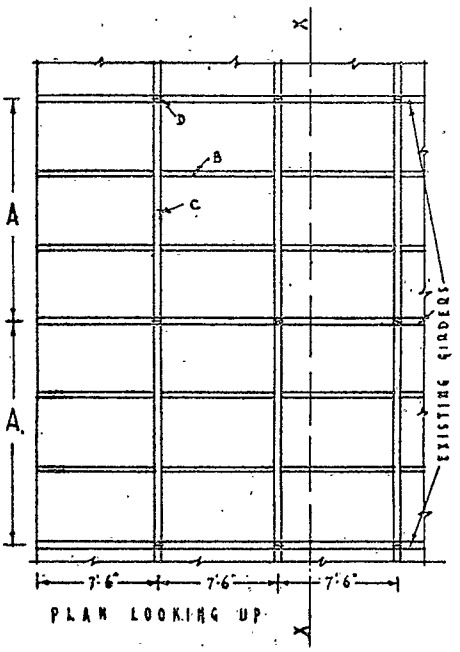
Superimposed loads *in addition to normal*	A Ft.	B	lbs.	C	lbs.	D	lbs.	Length of padstone under B & C.	Size of Stanchion Foundation
400 lbs	10	6″ × 5″	25	10″ × 6″	42	5″ × 4½″	18	2′ 0″	3′ 3″ × 3′ 3″ × 1′ 3″
300 ,	10	6″ × 4½″	20	10″ × 5″	30	5″ × 4½″	18	2′ 0″	2′ 9″ × 2′ 9″ × 1′
200 ,	10	7″ × 4″	16	10″ × 4½″	25	7″ × 4″	16	1′ 6″	2′ 6″ × 2′ 6″ × 1′
400 ,,	12	8″ × 5″	28	10″ × 6″	40	6″ × 5″	25	2′ 9″	3′ 6″ × 3′ 6″ × 1′ 3″
300 ,,	12	8″ × 4″	18	10″ × 6″	40	5″ × 4½″	18	2′ 3″	3′ 0″ × 3′ 0″ × 1′
200 ,,	12	7″ × 4″	16	10″ × 6″	40	7″ × 4″	16	1′ 9″	2′ 9″ × 2′ 9″ × 1′

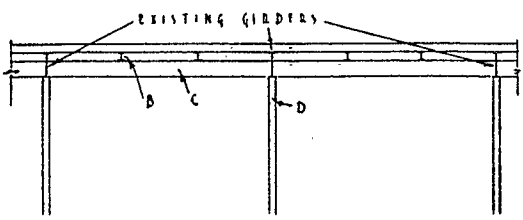
TABLE B.5.—For floors similar to preceding but constructed in hollow tiles. There should be two girders B, instead of one, spaced equidistant in the bay A.

Superimposed loads *in addition to normal*	A Ft.	B	lbs.	C	lbs.	D	lbs.	Length of padstone under B & C.	Size of Stanchion Foundation
400 lbs	10	2/7″ × 4″	16	10″ × 6″	40	5″ × 4½″	18	1′ 6″	3′ 3″ × 3′ 3″ × 1′ 3″
300 ,,	10	2/7″ × 4″	16	10′ × 5″	30	5″ × 4½″	18	1′ 3″	2′ 9″ × 2′ 9″ × 1′
200 ,,	10	2/6″ × 3″	12	10′ × 4½″	25	7″ × 4″	16	1′ 0″	2′ 6″ × 2′ 6″ × 1′
400 ,,	12	2/6″ × 4½″	20	12″ × 6″	44	6″ × 5″	25	1′ 9″	3′ 6″ × 3′ 6″ × 1′ 3″
300 ,,	12	2/7″ × 4″	16	10″ × 6″	40	5″ × 4½″	18	1′ 6″	3′ 0″ × 3′ 0″ × 1′
200 ,,	12	2/6″ × 3″	12	12″ × 5″	30	5″ × 4½″	18	1′ 3″	2′ 9″ × 2′ 9″ × 1′

TABLE B.6.—For reinforced concrete, hollow tile or wood floor of any width or length, divided into bays with rolled steel joists not less than 18″ deep.
Stanchions D. and girders C. spaced 7′ 6″ apart.

Where actual height of stanchion does not exceed 12′ 0″.





Section X X

Superimposed loads *in addition to normal*	A Ft.	B	lbs.	C	lbs.	D	lbs.	Length of padstone under B & C
400 lbs.	14	3/6″ × 4½″	20	12″ × 6″	44	6″ × 5″	25	1′ 6″
300 ,,	14	3/5″ × 4½″	18	13″ × 5″	35	6″ × 5″	25	1′ 6″
200 ,,	14	3/6″ × 3″	12	12″ × 5″	32	5″ × 4½″	18	1′ 3″

APPENDIX II.—REPRINT OF PORTIONS OF THE SCHEDULES IN THE MINISTRY OF HEALTH MODEL BYELAWS, SERIES IV, BUILDINGS, 1939.

PART OF FIRST SCHEDULE.

1.—*Dead Loading.*

For the purpose of calculating the dead loading of a building or any part of a building, the weights of the materials shall be assumed to be those set out in British Standard Specification No. 648—1935 (Schedule of Unit Weights of Building Materials), or if not set out in that Specification shall be determined by test.

2.—*Superimposed Loading.*

For the purpose of calculating the superimposed loading on beams, pillars, piers and walls, the minimum superimposed load on each floor and on the roof of a building shall be estimated as equivalent to the dead load specified in the following table for the appropriate type of building, floor or roof:—

Type No.	Description of building, floor or roof.	*Pounds per square foot* of floor area.
1	Rooms of dwelling-houses, flats, hotel buildings and similar residential buildings; hospital rooms and wards; corridors, staircases and landings of dwelling-houses and flats.	40
2	Offices—floors above entrance floor.	50
3	Offices—entrance floor and floors below entrance floor.	80
4	Churches, schools, reading rooms, art galleries and similar buildings.	70
5	Retail shops and garages for cars of not more than *two tons* dead weight.	80
6	Assembly halls; drill halls; dance halls; gymnasia; light workshops; public spaces in hotels and hospitals; corridors, staircases and landings for the buildings mentioned in this table other than those described in Type No. 1 above; cinemas; restaurants and grand stands.	100
7	Warehouses, book stores, stationery stores and buildings similarly used, and garages for motor vehicles exceeding *two tons* dead weight. Actual load to be calculated but not less than	200
8	Flat roofs and roofs inclined at an angle with the horizontal of not more than *twenty degrees*.	30 (*per square foot* of covered area).
9	Roofs inclined at an angle with the horizontal of more than *twenty degrees*.	10 (*per square foot* of covered area).

3.—*Partitions.*

Where the position of a partition in a building is definitely located in the design, the actual weight of the partition shall be included in the dead floor load.

Where the position of a partition is not definitely located in the design, a uniformly distributed load sufficient to allow for it shall be added to the dead floor load, and for all such floors used for offices the minimum total allowance for partitions shall be at the rate of *twenty pounds per square foot* of floor area.

PART OF SECOND SCHEDULE.

In determining the maximum permissible pressures on walls constructed of bricks or blocks, the crushing strength of the individual brick or block shall be determined in the following manner:—

Twelve whole bricks or blocks with sides not less than *three inches* long shall be taken. The materials shall be soaked for *twenty-four hours* in water at a temperature between *fifteen degrees* and *twenty degrees* Centigrade The frogs in bricks shall then be filled with mortar and the top and bottom surfaces of hollow bricks or blocks shall be made plane and parallel with mortar. The mortar shall consist of *one part* (by weight) of cement and *three parts* (by weight) of dry and clean Leighton pit sand, the cement used being either normal Portland cement or rapid-hardening Portland cement. After the application of the mortar to the bricks or blocks, the specimens shall be covered with damp cloths for *six hours*, then immersed in water at a temperature between *fifteen degrees* and *twenty degrees* Centigrade for *twenty-seven days* in the case of normal

Portland cement mortar, and for *six days* in the case of rapid-hardening Portland cement mortar, or for such period, being not less than *two days*, at which the mean crushing strength of three cubes each with sides *three inches* long made from the batch of mortar used in the preparation of the bricks or blocks and stored under similar conditions will be between *two thousand* and *four thousand pounds per square inch.*

The test pieces shall finally be crushed between three-ply wood sheets *one-eighth-of-an-inch* thick, the load being applied at a uniform rate of approximately *two thousand pounds per square inch per minute.* The average value of the crushing stress thus obtained for the twelve test pieces, calculated over the gross area of the test pieces, shall be taken as the crushing strength of the individual brick or block.

APPENDIX III.—REPRINT OF EXTRACTS FROM "BYELAWS FOR THE USE OF TIMBER" MADE BY THE LONDON COUNTY COUNCIL ON 30TH NOVEMBER, 1937.

8. The stresses in timber shall not exceed those set out in Tables II and III following:—

TABLE II.

Nature of stress.	*Maximum stress in lbs. per square inch.* Non-graded.	Grade 1200 *lbs. f.*
Extreme fibre stress in bending ...	800	1,200
Shear stress in the direction of the grain	90	100
Compression perpendicular to the grain	165	325
Compression in the direction of the grain in posts and struts having a slenderness ratio not exceeding 10	800	1,000
Tension in the direction of the grain ...	800	1,200
Modulus of elasticity	1,200,000	1,600,000

When a post or strut has a slenderness ratio exceeding 10, the compressive stress in the direction of the grain shall not exceed the maximum pressure set out opposite the slenderness ratio in Table III following:—

TABLE III.

Slenderness ratio.	*Maximum pressure in lbs. per square inch.* Non-graded.	Grade 1200 *lbs. f.*
Exceeding 10 but not exceeding 12 ...	785	985
,, 12 ,, ,, ,, 14 ...	775	970
,, 14 ,, ,, ,, 16 ...	755	950
,, 16 ,, ,, ,, 18 ...	725	920
,, 18 ,, ,, ,, 20 ...	690	875
,, 20 ,, ,, ,, 22 ...	635	820
,, 22 ,, ,, ,, 24 ...	565	745
,, 24 ,, ,, ,, 26 ...	485	650
,, 26 ,, ,, ,, 28 ...	420	600
,, 28 ,, ,, ,, 30 ...	365	485
,, 30 ,, ,, ,, 32 ...	320	430
,, 32 ,, ,, ,, 34 ...	285	380
,, 34 ,, ,, ,, 36 ...	255	340
,, 36 ,, ,, ,, 38 ...	225	300
,, 38 ,, ,, ,, 40 ...	205	275

9. The slenderness ratio of any post or strut shall not exceed forty.

10.—When a post or strut is subject to bending action in addition to axial loading, such post or strut shall be of a section sufficient to withstand such bending action in addition to the axial load.

NOTE.—"Slenderness ratio" in relation to a post or strut means the ratio of length to thickness.

APPENDIX IV.—SANDBAG WALLING.

The Army pattern sandbag measures 33 ins. by 14 ins. empty. Each sandbag weighs about 6 ozs.

Sandbags should be three-quarters filled with earth or sand, so that when beaten with a shovel to a rectangular shape they measure about 20 ins. by 10 ins. by 5 ins. Hard Ground, gravel, bricks, etc., must be broken small, so that when the sandbag is filled with this material it can be shaken into a compact pliant mass. In this case, the sandbags must not, of course, be beaten.

It is not necessary to tie up a sandbag if the mouth is carefully folded under it when it is being placed in position, as the weight of the bag will prevent loss of filling material.

A sandbag is said to be a "stretcher" when it is laid with its longer side parallel to the face of the wall, and a "header" when at right angles to the face.

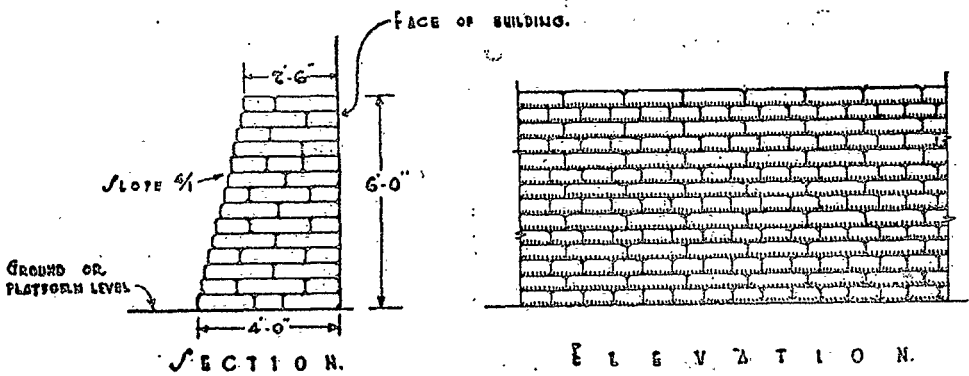
The bond used in sandbagging is known as English bond, i.e., alternate courses of "headers" and "stretchers;" the first course should be "headers." "Headers" should be laid with chokes (folded ends) inside. If the bag has only one seam, this should also be turned towards the inside when laying "stretchers."

In building a sandbag wall care should be taken to break vertical joints. The wall should be built in all cases with a batter of 1 to 4 on the sides remote from the wall of shelter, and the sandbag wall should overlap the opening to be protected by a minimum of 12" on each side. If the opening exceeds 5 ft. wide the vertical face of sandbag wall should be built against strong horizontal planking placed across the opening to be protected.

Where a sandbag wall is built independently to form a traverse or screen for, say, an emergency exit, it should have a batter of 1 to 4 on all faces.

The sandbag when filled contains a little over 1/2 cu. ft. of earth.

A filling party should consist of three men—two holding and tying (if necessary for transport) and one shovelling. Building parties should work in pairs. The size of the carrying party connecting the filling and building parties depends, of course, on the distance bags have to be carried. Three men should fill and two men should lay 60 bags in one hour, so that the carrying party should be sufficient to deal with this number of bags.



SANDBAG WALLING.