# AIR RAIDS AND CIVIL DEFENCE

By

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"The measures for safeguarding the civil population against the effects of air attack . . . have become a necessary part of the defensive organisation of any country which is open to air attack. The need for them is not related to any belief that war is imminent. It arises from the fact that the risk of attack from the air, however remote it may be, is a risk that cannot be ignored, and because preparations to minimise the consequences of attack from the air cannot be improvised on the spur of the moment, but must be made, if they are to be effective, in time of peace."

*General Preface, the Home Office*
*A.R.P. Handbooks.*

## ABBREVIATIONS USED

| | |
|---|---|
| A.R.P. | Air Raid Precautions. |
| A.R.P.H. | Home Office A.R.P. Handbook. |
| A.R.P.M. | Home Office A.R.P. Memoranda. |
| I.C.J. | The Indian Concrete Journal. |
| J.A.R.P.I. | Journal of the Air Raid Protection Institute. |
| J.I.C.E. | Journal of the Institute of Civil Engineers. |
| J.R.I.B.A. | Journal of the Royal Institute of British Architects. |
| J.T.P.I. | Journal of the Town Planning Institute. |
| R.A.F. | Royal Air Force. |


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L. M. CHITALE.

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# INTRODUCTION

The darkening European horizon has given a new significance to the arguments advanced on social and aesthetic grounds against the uncontrolled expansion of cities.[1] Overcrowding and congestion of people and buildings, thoughtless association of different kinds of activities, inadequacy of water, air and ventilation and scope for movement, the dominant features of modern urban communities have made cities, danger spots of national security. This is the lesson which recent events in Western Europe teach. Men and women are fleeing from the great city in search of safety to country villages. It is now evident that the normal pattern of our existence in peace time is such that it is not merely useless in time of war, but a positive menace to life and limb. Urban surveys and statistics have demonstrated their unfitness even in times of peace. "Never go to cities" said the Upanishads, although with a different object. In the huge agglomerations of men and buildings breed the danger "beating down the will to live" and intelligent citizens are already leaving the hearts of cities to their outskirts, as the American movement of depopulation and blighted areas show.

Are great cities a menace? The weapons of air attack leave no room for doubt. It needs £360,000 a day for A.R.P. and evacuation alone for a tiny country like England just to reduce the quantity of destruction. As long as the threat of war remains so long will the Exchequer be drained. In addition there is the expenditure on coastal patrol and other services organised to deal with the risk. Inconvenience to the people and the strain upon the nerves of citizens should also be added.

1. W. A. Robson, "Evacuation, Town Planning and the War." The Political Quarterly—Volume, XI No. I Jan.March, 1940, pp. 45—58.

The price we pay for city life in times of peace is serious if not spectacular. The loss of efficiency, the harm to health, the waste of resources and energy are hard to evaluate. Careful investigation alone will open our eyes to this appalling waste in our civic organism. If municipal finance spent upon ameliorative measures, urban sanitation and the like are an index to the inadequacy of our civic organism to meet the needs of peace, expenditure upon A.R.P. might be taken as the index to the unsuitability of cities in times of war.

In spite of immense sacrifices and expense the feeling is prevalent that the risk can not be avoided. France where the need for A.R.P. was visualised ten years ago—in fact a scheme for evacuation was prepared in 1930—paid heavily for the first mass air attack of the Nazis. 250 people lost their lives and 650 were injured in the heart of Paris claimed to have been equipped with all the anti-aircraft devices.

This is because the root of the problem remains unaffected. "Hitlerism will never be defeated by counter Hitlerism. It can only breed superior Hitlerism raised to the Nth degree."[1] Air attacks carefully planned to destroy cities as they are, can be successfully counteracted only by measures which change its form, its plan and pattern. The logic of this argument will become apparent when we study carefully the kinds and capacity of the weapons used in air attacks.

Defence is no longer the repelling of invasion but the protection of the home and the soil.[2] And considered opinion is therefore gathering round the view that proper planning of civic communities, careful selection of centres of population and industry and thoughtful balance between the built up and open areas are necessary to meet the air menace.

This danger is three dimensional and hence the need? What a shield could do when bows and arrows

1. Mahatma Gandhi: The "Harijan," 22nd June, 1940.
2. Robson.

were weapons of the war; the fortress, the rampart and the moat had to do, when infantry and cavalry marched against the enemy. Against aerial bombs they offer no safeguard; in planning alone lies chances of survival.

Planning is a necessity to readjust our urban communities and to provide us towns fit to live-in, and cities to be proud of, where our people can dwell in comparative security. How will these prevent air raids? As Chapter VI would show properly planned cities and towns would render air raids uneconomic and not worthwhile. Herein lies the safety for cities and civilization without the aid of Le Corbusier and his deep underground cities or Commodore Charlton and his human hives overground. This ideal towards the very best, will give us the correct basis of development. Even if the weapons are made more powerful such a plan would render possible, protective measures.

Absolute security is possible only if the world forgets the aeroplane or submits to the Gandhian ideal of non-violence in matters international or internal. Mere conventions and agreements or Leagues and Covenants do not help. The Geneva Gas Protocol of 1925 prohibited the use of poison gas in war but in Abyssinia barrels of liquid mustard gas were used.[1] And it is only in the name of 'civilization' that women and children are machine-gunned and killed by champions of 'civilization' in Europe. In a world with such leaders, limiting wars to warfields is unworkable. When women and children and non-combatants form the targets of attack by bombs and blockades what can the Kshatria ideal of zoning warfields do?

Until human nature improves and man gets humanised there is little hope as Sir Clement Hindley points out of obtaining peace for mankind from the threat of air raids.[2] When will it change? Centuries of

1. A. A. Spaight: Air power in the next war.

2. Presidential address. Institution of Civil Engineers. J.I.C.E., Nov., 1939, p. 4.

'progress' has left man where he was in the days of Cain. If it is idle to hope for improvement there is no alternative but to plan and plant the communities in such a way as to infuse strength into them to resist and recover from air attacks.

Will readjustment of our cities, towns and villages to meet the needs of war injure the needs of peace, the requirements for health and comfort of those who should dwell in them? Fortunately the measures necessary for air resistance are eminently helpful to enhance civic comfort. This is a silver lining to the threat of air attack gathering in the sky and screening the dawn of hope and survival. Town planners therefore view this new threat as a blessing in disguise. For the reforms which eminent authorities in public health, sociology, civic economy dietetics, traffic control etc., have been recommending these many years are essential since they are eminently helpful to face the high explosive, the incendiary bomb and liquid poison gas. The open pattern required for safety is ideal for efficiency.

Details of researches in sciences directly affecting human welfare that call for change in our mode of life are discussed in their relevant places. Emphasis should however be laid upon the most vital factor in human welfare, namely the maintenance of the proper balance between, organism, function and environment (men, occupation and land) on which alone a stable civilisation could be built. The lessons which human ecology has to teach us, has immense bearing upon the problem of safety. The Royal Commission on the Geographical Distribution of the Industrial Population and the recent cry of 'grow your own food' in Great Britain, the 'back to village' movement in other countries are but feeble manifestations of the unconscious recognition of the vital need to restore the lost balance between these fundamental constituents of society. And this can be solved as sociologists have pointed out only by a correct proportion between agriculture and industry, land and labour, cities and towns, work and wealth. If air raids compel us to realise and adopt this as our goal, they would not have been in vain.

To this lack of balance and proper spacial distribution of population and industry is due the difficulty of securing safety for the citizens and civilisation in Europe, inspite of the enormous expense and discomfort. In the words of Mahatma Gandhi "it is not unreasonable to presume from the state of Europe that its cities, its monster factories and huge armaments are so intimately interrelated that one cannot exist without the other." For "a society which anticipates and provides for meeting violence with violence will either lead a precarious life or create big cities and magazines for defence purposes."[1] The legacy of the industrial revolution was one-sided, and the consequences we are witnessing to-day; bread without butter and diet without nutriments; homes without housewives, schools without children, children without schools, lamps without light and strain without war!

If India neglects these valuable lessons the same difficulties are bound to be in store for her. The situation is not beyond reform if attempted at present. We are yet to discover the optimum spacial distribution of population and sooner an effort is made the better. Industrialisation awaits India and its evil consequences can be avoided only by careful planning in advance.

A.R.P. in India is rapidly gathering momentum. Long before the declaration of hostilities in Europe steps were taken to prepare schemes for India, although the September crisis gave a fillip to A.R.P. activities and to public interest in the matter. Information available indicates that A.R.P. in our country covers such items as black-out, wardens, sandbagging, sirens, first-aid parties, etc. Attempts at air raid shelters have also been made; and A.R.P. organisations are being built up in

1. The "Harijan," Jan. 13, 1940.

important cities. Medical aspect of A.R.P. has drawn wide attention.

However necessary these may be, events in Europe indicate that they cannot assure protection, even if our finances permitted their adoption on the British scale, to 30 million people inhabiting more than 1,000 centres.

If we should succeed in obtaining air security for our country every effort must be made to discover and apply measures that would be both economical and efficient. Is this possible when the threat of attack is at our doors? "So long as the possibility of attack exists, it is necessary to create organisations to minimise the consequences of attack and as it would not be possible to improvise effective measures on the spur of the moment in time of emergency, preparation must be made in time of peace.

"It is of essence of any such preparation that the civil population should be informed of the present and future possibilities of air attack and instructed in the precautions designed to meet it."[1] This warning of the Home Office of Great Britain has special significance to India. A correct perspective is essential to make our plans efficient. Effective public opinion is needed to launch comprehensive schemes.

In the following pages an attempt has been made to deal with the problem of air raids and how best we could face this danger. The weapons used in air raids, their terrible potentialities and the destruction caused by them are first dealt with since a correct appreciation of the position is essential for formulating measures to combat them. Prevention is the most desirable solution, and the measures generally adopted, are described next. Since total prevention is impracticable the following three Chapters deal with the question how best the people could be protected, city structures could be made resistant to air raids and the supply of essential services immunised from the risk of dislocation and destruction.

1. Home Office A. R. P. Circular dated 9th July 1935 p. 2.

The plan and pattern of urban communities that would resist and recover from air raids are given next. In the three chapters that follow are indicated emergency measures and precautions for immediate adoption; decentralisation and dispersal; air raid shelters; precautions to structures and services. A.R.P. organisation and education to make these reforms possible are outlined in the concluding chapter.

The literature on A.R.P. is rapidly growing. Government departments, expert bodies and manufacturers have published valuable books and pamphlets. Research work is being carried on under their auspices. The experiments of the Home Office of Great Britain and the A.R.P. Handbooks and Memoranda constitute a mine of valuable information to which the reader must turn for further details. The aim of the author however has been to present the different aspects of the problem in their true perspective, concisely over a comprehensive canvas without which the approach to the remedy is impossible. He would consider his labours amply rewarded if the following pages succeed in stimulating a healthy public interest on this vital question before the peril comes too close to make this impossible.

# CHAPTER I

## AIR ATTACK: MEANS AND METHODS

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Air attacks are intended to destroy the morale, property and lives of the inhabitants of the enemy country in the shortest possible time. The means and methods of achieving this, are therefore carefully planned. Thickly peopled zones, and closely built-up areas and strategic centres are selected. Squads of bombers drop different kinds of bombs in quick succession. Their aims are accomplished by demolishing railway stations, harbours, power houses, telephone exchanges, bridges, and other key positions; by destroying factories, industries, godowns and warehouses; by spreading fire; by poisoning men, their food, clothes, roads and buildings; and by harassing people by machine-gunning.

Three kinds of weapons are designed for this purpose; the high explosive bomb, the incendiary bomb and liquid poison gas. The bombs are released from aircraft and liquid gas is also directly sprayed from the plane.

An aircraft bomb is a container holding high explosive, or incendiary mixture or gas, with means of detonating, burning, or discharging the filling. A bomb is simply released from an aircraft and is shaped to minimise the resistance offered, by the air. They are cylindrical or streamlined, the length of the body being about 4 to 6 times that of the diameter.

### THE HIGH EXPLOSIVE BOMB[1]

The deadliest and the most irresistible is the high explosive bomb. One variety of this bomb called the armour piercing, is designed for deep penetration and

1. This section is based on the Home Office A.R.P.H.5 "Structural Defence."

is used for demolishing factories and other protected centres. Another variety known as the general purpose bomb is designed for maximum destruction in built-up areas by blast and splinter effect.

High explosive bomb used in Spanish raids.

High Explosive bombs are classified according to the weight of their case or containers into heavy, medium and light case. Heavy case bombs, are also classified as armour piercing and semi-armour piercing, medium case, as general purpose, and small bombs as fragmentation or anti-personnel. A special class of light case bomb is classified as anti-submarine.

High explosive bomb used by the R.A.F.

The weight range of H.E. Bombs is given below:—

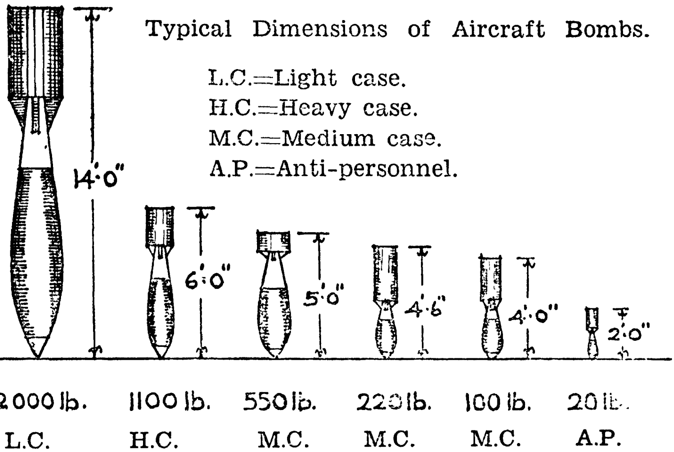
| Type of bomb. | Charge\|weight. Percentage. | Gross weight. Lb. |
|---|---|---|
| Anti-personnel .. | 15 to 20 | 20 |
| Light-case .. | 50 to 60 | |
| Medium-case .. | Small | 50 to 4,000 |
| Heavy-case .. | 25 to 40 | |

• In the following table is given typical dimensions for a few bombs. In practice they vary considerably. The figures in brackets in the second column give the length of bomb carcass that is, the part enclosing the charge.

| Bombs. | Length. Ft. | | Diameter. Ins. | Sectional Density. Lb. sq. in. |
|---|---|---|---|---|
| 2,000 lb. light case .. | 14 | (9) | 24 | 4.4 |
| 1,100 lb. heavy case .. | 6 | (4) | 12 | 9.7 |
| 550 lb. medium case | 5 | (4) | 15 | 3.1 |

| Bombs. | Length. Ft. | Diameter. Ins. | Sectional Density[1] Lb. sq. in. |
|---|---|---|---|
| 220 lb. medium case | 4½ (2) | 10 | 2.8 |
| 100 lb. ,, .. | 4 (2) | 9 | 1.6 |
| 20 lb. anti-personnel .. | 2 (1) | 5 | 1.0 |

[1]Mass|Maximum Cross-sectional area.



Typical Dimensions of Aircraft Bombs.

A heavy case bomb is designed to withstand the shock of impact and to penetrate into or through the object struck, before detonation, and a delayed fuse is inserted. Its potentiality will be developed only when it hits specially protected targets and it is hoped that the armour piercing bomb is likely to be restricted only to that purpose. Heavy case bombs vary from 250 to 2,000 lbs. in weight and their frequent use is unlikely as heavier bombs alone are effective and fewer only can be carried.

In the medium case bomb, the explosive content ranges from 25 to 40 per cent. of the weight; and it is less strong to withstand the shock of impact. Still with a delay fuse it can penetrate some distance and would ordinarily be strong enough to perforate several concrete floors of the thickness usual in multi-storeyed buildings.

Medium case bombs range from 50 to 1,000 lbs. and they may be designed to produce intense blast as well as fragmentation. Heavier ones are possible, but tactical considerations would make them vary between 110 to 660 lbs. as the most practical against civil buildings.

Light case bombs contain 50 to 60 per cent. or more of explosives and are used for maximum blast effect and will be used where blast is the decisive factor. If used for underwater attack for docks, reservoirs etc., they would be fused for delay. Such bombs may be of any size.

The fragmentation or anti-personnel bomb usually weighs about 20 lbs. and is designed for use in large quantities to cause fragmentation, to cause injury to persons in the open and is fused to fire on impact.

Explosives used as fillings for bombs are, Gun-cotton (dry), Tri-nitro-toluene (T.N.T.), Dynamite No. 1, Amatol 80|20. A high explosive bomb has a filling of high explosives with devices for detonating the filling. The impact causes a needle to fire a cartridge cap contained in the head of a detonator, which in turn detonates another intermediary filling which initiates the detonation of the main filling.

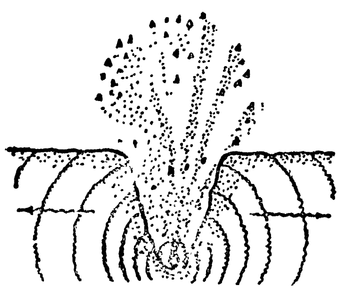
The means of detonating the filling, or fuse may be (1) instantaneous, causing the bomb to burst on impact with the target or (2) delay, introducing a time interval between impact (which starts the fuse mechanism working) and the detonation of the bomb. This gives the bomb time to penetrate the target before bursting. The former is usually fitted to the nose of the bomb while the latter is attached to the tail. Some bombs carry both types.

The high pressure generated by the conversion of the solid explosive into gas, causes the metal case to swell until it reaches about 1½ times its original diameter, when it bursts into fragments or splinters. The time taken for the detonation of the main filling of a typical 500 lb. bomb may be assumed to be of the order of one ten-thousandth of a second.

On explosion, the explosive inside is suddenly converted into gas at a very high temperature and pressure. The effect is that of a sudden blow on immediate surroundings, the violence of which depends on the velocity of detonation and the pressure produced. When the bomb bursts on a flat surface the gas expands to a radius of 20 to 25 feet.

In the air which surrounds the explosion itself, is created the blast pressure. This air borne shock wave, is analogous to an ordinary sound wave except that its amplitude and velocity are higher. It is propagated by wave motion through the air without bodily movement of the air and persists for considerable distances.

Apart from the shock-wave, generated in the air, analogous waves are also generated in the earth or other target in or on which the bomb explodes. If the bomb penetrates to a sufficient depth in the earth the earth waves are created which may prove very dangerous at close distances.



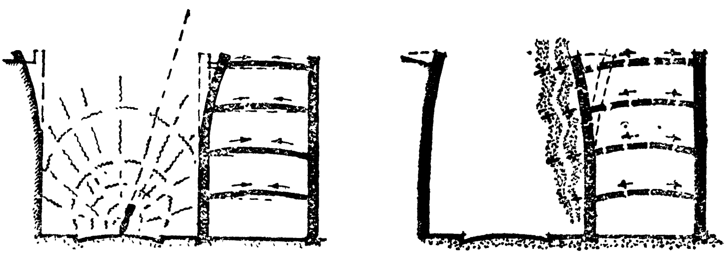
The effect of a high explosive bomb bursting in the ground.

Detonation is followed by the effects of blast, earth movement and earth waves, fragmentation, disruption and cratering. In sequence the effects of a bomb are, penetration, impact, fragmentation, rupture and cratering. Home Office authorities recognize the difficulty of accurately stating the effects of these, produced by a bomb. Artificial experiments, they rightly feel, cannot give correct results but a fair degree of reliance could be placed on proper calculation.

When a bomb bursts the hot compressed gases escape and deliver an instantaneous but localised blow on the surrounding air, and their pressure on detonation has been variously estimated at between 100 and 650 tons per square inch. The maximum distance of the outward movement is stated to be of the order of 25 feet when the bomb bursts on a flat surface in the open air. Experiments indicate that blast from such an explosion sends a shock wave of an initial positive pressure phase followed by a negative (suction) phase which is probably followed by a small decaying oscillation. At 50 feet from a 500 lb. bomb the maximum pressure in the wave is of the order of 6 lb.|sq. inch. and that the durations of the positive and negative phases are respectively, 5 milli-seconds and 25 milli-seconds.

The total duration of the combined positive and negative phases is about 1|30 of a second whether the distance is 50 to 200 feet from the bomb, but the duration of the negative phase varies from three to six times that of the positive phase. The wavelength of the initial phases is about 30 feet.

The pressures in the subsequent decaying oscillation are much less than those in the initial phases, and it appears that any structural damage occasioned by the blast will be due to the initial phases.



Effects of the positive and negative phases of blast upon the walls of a building.

Much has been written about the suction effect produced by detonating bombs for they are contrary to anticipation, since debris etc., is thrown towards the bomb site. This is due to the true suction effect of the negative component of the shock wave, that is to the wave of rarefaction following immediately on the wave of compression.

A bomb explosion particularly in a confined space such as a street or building, will always tend to give chaotic and apparently freakish effects, which are probably attributable to reflections of the pressure from a multitude of surfaces.

In the case of bombs, penetration is not an end in itself but is primarily a means to an end, which may be destruction by explosion, or fire or the distribution of war-gas. Various formulae are met with in literature and are assembled together and the following table gives the penetration into various media, based on published results, for a 500 lb. bomb of the assumed sectional-density M/A=5 lb. sq. inch. Depths are given in feet, and the striking velocity is assumed to be 820 f.s.

Penetrations (in ft.) for 500 lb. bomb; M/A=5 lb. sq. in:

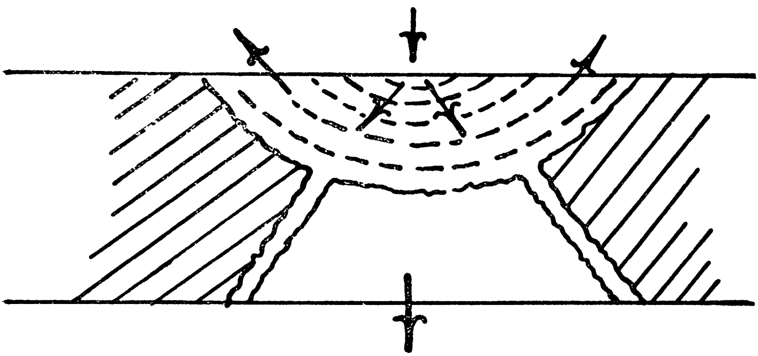
S. V. =820. f.s. Normal incidence.

| Material as described by the authors. | Metz Committee (Poncelet) | Petry. | Vieser. | Peres. |
|---|---|---|---|---|
| Limestone .. | 3.0 | 2.5 | — | — |
| Ferro-concrete .. | — | 2.1 | 1.5 | 1.7 |
| Ordinary concrete .. | — | — | 2.1 | 3.2 |
| Stone masonry .. | — | 5.4 | — | — |
| Brick masonry .. | 10 | 9.3 | 4.3 | — |
| Sandy soil .. | 20 | 17 | 10 | — |
| Soil with vegetation .. | — | 22 | 12 | — |
| Ground of average firmness .. | — | — | — | 17 |
| Soft soil .. | — | 34 | 19.5 | — |
| Loose earth .. | 25 | — | — | 26 |

Penetration depth will decrease if departure from normal incidence occurs and as the angle of impact measured from the normal to the target, increases, until at a certain angle of impact the bomb will merely ricochet without penetrating appreciably. Moreover, for angles between zero degree to the normal and the angle of ricochet, that is, for all practical impact çonditions the bomb, after penetrating a certain distance into the ground, usually deviates from its course, generally in an upward direction.

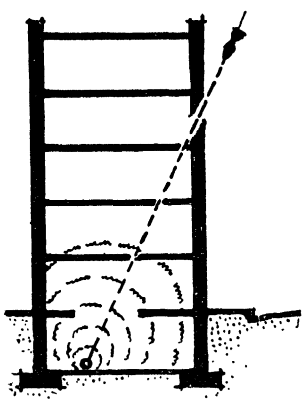
The effect on the target varies considerably with its physical properties. The path followed by a bomb when penetrating natural rock or soil is rarely a straight line from point of entry to its final position; variation in the resistance of the soil is liable to cause the bomb to deviate considerably from its original direction. The longer the path the greater is the tendency to deviate.

A direct hit causes scabbing. Scabbing consists in flinging off from the rear of the target, of a piece of the target opposite the part struck, and may occur whether the target is perforated or not. The scab or plug is usually of the shape shown below.



DIAGRAMMATIC REPRESENTATION OF SCABBING

When a typical 500 lb. medium case bomb with a delay fuse falls, at a steep angle, on a multi-storeyed building having a roof and floors of reinforced concrete each six inches thick, it can perforate the roof and five floors before exploding, provided it does not break up and is not deflected from its path by obstructions such as steel girders. The total thickness penetrated by the bomb is thus about 36 inches. But the corresponding depth of penetration into a single thick, reinforced concrete block would be less, other things being equal, because the penetration is not helped by the scabbing.



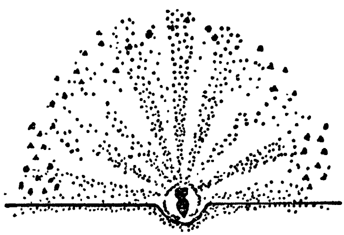
Delayed action high explosive bomb penetrating a multi-storeyed building.

A heavy case bomb being designed for penetration prior to explosion, its capacity for penetration is comparatively definite; but the penetration of delay action medium-case bomb into resistant material, such as concrete, or even into semi-resistant rock such as chalk, is doubtful. Not being designed specifically for penetration the case is liable to deformation on impact with resistant material to an extent which is scarcely predictable.

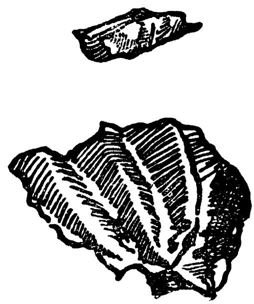
When heavy case bombs fall on soil, gravel, shingle, and chalk, they tend to diverge from their original direction after penetrating some distance, and to follow an erratic path influenced by local obstruction. Sometimes the path is a fairly uniform curve, often concave to the ground surface and turning upwards towards the last stage. If a bomb meets clay at an early stage the total penetration is increased.

A typical heavy case 500 lb. bomb falling from a considerable height could penetrate to a vertical depth of 25 feet of chalk or dry sand. 1 2|3 times in loam, ordinary soil; 2 2|3 times in clay; 3|5 times in gravel; Hence the maximum vertical penetration of a typical 500 lb. heavy case bomb in ordinary soil would be 42 feet.

Fragmentation is equally dangerous and difficult to judge. It is not easy to discover the direction, number, shape, weight and velocity of all the fragments which are shot out when the casing of the bomb bursts. The total number of fragments from any ordinary bomb runs to thousands, and although by far the greater percentage may weigh less than an ounce they may nevertheless be lethal to human beings and animals. The number of fragments range between 2,000 and 6,000 for all sizes of bombs from 25 lb. and the average size of the fragments tends to increase with the size of the bomb.



Fragments of a bomb exploding on impact.



Bomb fragments taken out from an injured person in Spain; actual size.

The maximum velocities attained by fragments probably lie within the limits of 4,000 to 7,000 ft. per second for most bombs and are reached within less than 10 ft. from the bomb. Thereafter the fragment velocity drops owing to air resistance. At about 50 ft. from the bomb the velocities probably lie between 2,500 and 5,000 ft. per second, the higher velocities being associated with the larger bombs.

The effective range of fragments is about 500 ft. but the gross range, if the bomb is fired above ground in the open is from 300 to 1,200 yds. depending on the kind and size of bomb, and its charge-weight percentage. If the bomb bursts below ground the gross range might be halved.

In a given bomb the fragment velocity depends on the explosive used. But the depth to which a bomb fragment can penetrate structural materials depend on the weight, size and shape of the fragment, its velocity, the angle of strike and the material attacked.

An idea of the penetrating power of fragments could be had from the adjoining table giving the thickness of various materials, recommended for protection by the Home Office of Great Britain.

| Material. | Thickness. |
|---|---|
| | Inches. |
| Mild steel plate or plates of an aggregate thickness, not less than .. .. | 1½ |
| Solid brickwork or masonry, not less than .. | 13½* |
| Reinforced concrete, not less than .. | 12** |
| Ordinary concrete, not less than .. .. | 15*** |
| Earth or sand, not less than .. .. | 30 |
| Ballast, or broken stone, not less than .. | 24 |

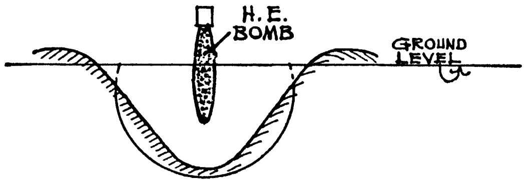
* This thickness is suitable for sound brickwork in cement mortar, hydraulic lime mortar, or cement-lime mortar, or for coursed masonry in sound condition. For old brickwork, where the mortar is found on inspection to be weak and friable and for rubble masonry, the thickness should be increased upto double that given in the table, according to condition.

A cavity wall of brickwork with outer leaf 4½ ins. cavity 2 ins., and inner leaf 9 ins. thick offers resistance similar to that of a solid wall 13½ ins. thick.

** This thickness is suitable for concrete containing not less than 112 lb. of cement to 2½ cub. ft. of fine aggregate and 5 cub. ft. of course aggregate, with not less than 0.2 per cent. of reinforcement in each direction (total 0.4 per cent.) properly distributed.

*** Ordinary concrete should contain not less than 112 lb. of cement to 12 cub. ft. of fine and course aggregate in combination.

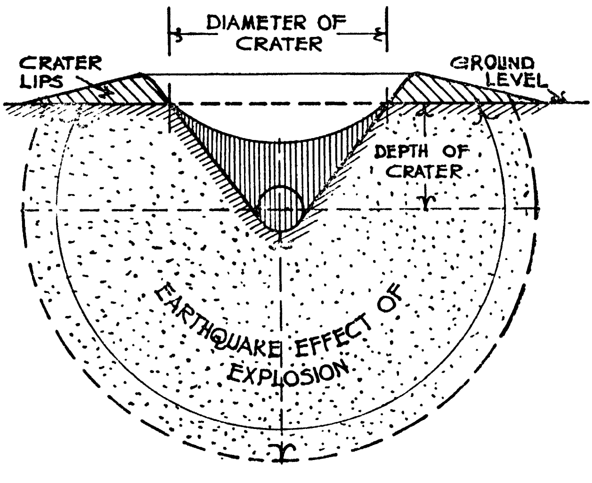
Cratering is another destructive consequence when the H.E. bomb bursts in the ground. The material is




Formation of crater.

broken up and form a cone-shaped pit called a crater. The size of the crater formed will depend on the kind of earth, the depth to which the bomb penetrates before bursting, the weight and characteristics of the high-explosive filling, and the amount of energy taken up in the bursting of the case of the bomb.

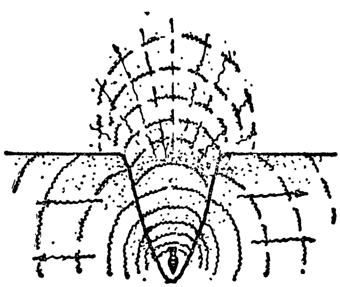
Immediately outside the circumference of the crater are formed the crater lips and in addition, the ground near the crater will be cracked and shaken. The zone in which this happens will be bounded by a circle concentric with the crater but of larger diameter.




SHAPE OF A TYPICAL CRATER

The volume of material thrown out by the explosion will approximate in shape to a blunt inverted cone with apex below the centre of the charge. The amount of earth displaced by a bomb may be considerable and American figures for 300 lb. bombs and 2,200 lb. bombs amount to 90 tons and 1,000 tons respectively, the bombs having about 50 per cent. charge|weight ratio.

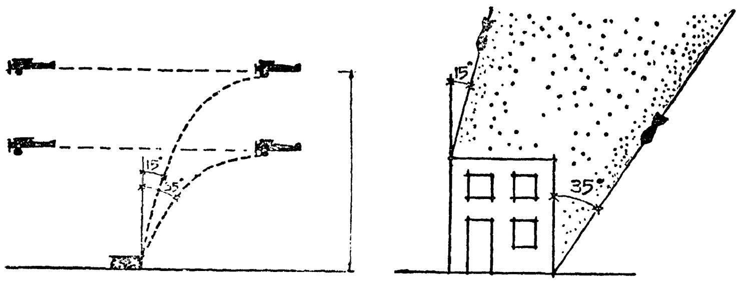
Apart from the damage resulting from the crater formation, a bomb bursting within a solid target transmits pressures through the target in the form of waves, with or without translational movement of the material of the target. The physical movement of the earth and pressure waves may damage underground structures and services such as water and gas mains, sewers, electric power and telephone cables. Reports from war areas state that medium case bombs penetrate road ways to a depth of about 2 ft. and their effect on the road was greater than that of similar bombs bursting on contact. A one ton High Explosive Bomb removed from St. Paul's Cathedral compound and made to detonate produced a crater 100 ft. wide.



Pressure waves created when the high explosive bomb explodes within the target.

A trial experiment conducted by the Home Office showed the great potential danger to underground services by bombs; water and gas mains, telephone cables, were severely damaged and shattered. A deep underground sewer escaped but with a heavier bomb it would have been destroyed. Another experiment made showed that when a heavy case bomb was detonated with the nose buried 2 ft. down in a slab of reinforced concrete 15 ft. by 20 ft. and 3 ft. thick, the concrete was completely disintegrated over a diameter of about 12 ft. and the slab was split open. Another trial showed that 15 ft. of first-class rock above an unlined underground chamber with a cross section of 4 ft. by 2 ft. 6 ins. would give full structural protection against a heavy case bomb weighing about 250 lb. while against a similar bomb of about 500 lb. about 20 ft. rock cover would be required.

In aerial bombing there is danger not merely to the roof but to walls and sides of buildings. For the angle of approach of the bomb when it hits the target is between 15 to 35 degrees from the vertical.




The angle of impact of high explosive bomb.

The approximate striking velocity and the angle of arrival for a bomb released from an aircraft flying horizontally at 200 miles an hour is given below.

| Height of Release. | Angle of Impact. | Striking Velocity. |
|---|---|---|
| Feet. | Degrees. | Feet per second. |
| 1,000 | 46 | 390 |
| 3,000 | 33 | 520 |
| 5,000 | 26 | 610 |
| 7,500 | 22 | 710 |
| 10,000 | 19 | 800 |
| 12,500 | 17.5 | 880 |
| 15,000 | 16 | 950 |

## INCENDIARY BOMBS[1]

To set fire to a city and destroy it is easier and cheaper. The incendiary bombs are used for this purpose. They burn with intense heat and spread an effective fire

1. The following account is based on A.R.P.H.9 "Incendiary Bombs and Fire Precautions."

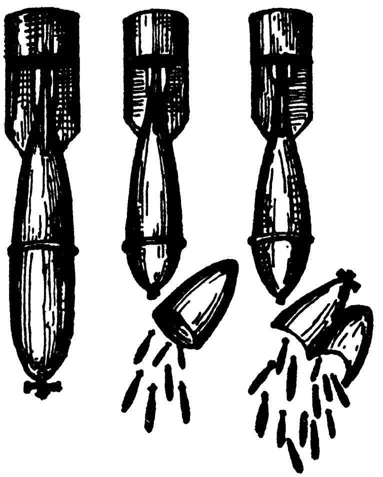
and so many fires are started as to make the task of dealing with them by the fire brigades impracticable. A large bomber can carry between 1,000 to 2,000 small incendiary bombs which if scattered over built up areas, and not dealt with within two or three minutes after falling might start so many fires that no fire fighting organisation could be expected to deal with them all. The water mains may be damaged or drained dry for fire fighting elsewhere, with the result that there might not be enough water nearby for a fire engine to use; or again, roads might be damaged by high explosive bombs and so prevent a fire engine from reaching the site of the fire. It should be remembered that sufficient appliances may not be available to deal with the fires caused by incendiary bombs; and as each fire left unattended in a building is a potential "burn out" of that and possibly neighbouring buildings, it is obvious that this weapon will prove most disastrous to property.

There are several types and sizes of incendiary bombs. The well-known is the Light Magnesium (Electron) bomb weighing 1 kilo. Two, twelve and twenty-five kilo bombs are known but are likely to be aimed at special targets. It is however considered possible that 2-kilo bombs might be used in indiscriminate bombing.

Multiple effect bombs have been designed for use against store yards, large factory buildings and ammunition dumps etc. They contain a number of separate incendiary units of magnesium or phosphorus which are expelled from the bomb and scattered over a wide area. The incendiary units are small and have little penetrating power but the main bomb weighs over 12 kilos and its steel nose can perforate strong roofs. Magnesium could be dealt with as in the case of the 1 kilo bomb but phosphorous is more difficult to deal, for it re-ignites after drying, when extinguished with sand or water. Until all the material is removed, the surrounding must be kept wet and the process of removing it may poison and burn the skin if it comes in contact with it. Thermite bombs in which the entire incendiary charge consisted of the material, were used in the last war. Though its heat is intense it burns rapidly and incendiary effect is smaller than that of magnesium.

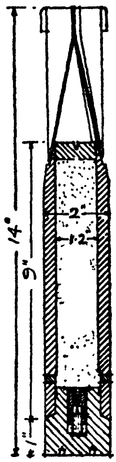
Petrol bombs are not considered likely because the five and 10 kilo types used in the Great War were not found very effective. Sodium and Sodium pottassium alloys are difficult to deal with water, but can be easily extinguished by dry sand, and are poor incendiary agents. They are also not considered likely.

A combination of the high explosive and incendiary bombs has been made in Russia. Over Finland were used this weapon with deadly effect. A large high explosive bomb halfway down to the target breaks and releases a number of incendiary bombs which scatter all round. The high explosive bomb contained in the other half of the missile hits the target and explodes.



Molotov's breadbasket. The Nazis have used this over England recently. It is about eight feet long and three feet in diameter. Many incendiary bombs are packed in a hollow cylinder which detaches midway and scatters them over the target.

Since the main objective of an attack by incendiary bomb is the starting of more fires than can be dealt with by the available fire brigade services, authorities are certain that the one kilo magnesium electron bomb will be largely used. It consists of a thick walled tube 9 in. long and 2 in. in diameter, made of an alloy of magnesium with a small proportion of aluminium. On one end of this tube there is a tail 5 in. long to steady the bomb in flight. The tube is filled with a priming composition, thermite type. The bomb is fitted with an igniter which may be situated either in the nose or in the rear end of the tube.



Typical Kilo Magnesium (Electron) Incendiary Bomb: section.

The bomb weighs about 2 lb. 2 oz. and with the exception of a few ounces in the tail and igniter, there is no dead weight, the whole being incendiary material. The bomb functions on impact. It does not explode but burns fiercely, the priming composition for 40|50 seconds at a temperature of 2,500 degrees centigrade. This ignites the magnesium tube and the molten magnesium burns for 10 to 15 minutes at a temperature of about 1,300 degrees centigrade and will set fire to anything inflammable within a few feet.

Pieces of molten magnesium may be thrown as far as even 50 feet during the first minute when the priming composition burns violently. The thermite composition contains its own oxygen, and cannot be extinguished by smothering while the magnesium depends for its oxygen, upon the air or surrounding materials, in order to burn. One large bomber could carry between 1,000 and 2,000 of these very light bombs, which would probably be dropped from a considerable height, so as to increase their velocity. They would not be dropped singly but would be released from containers each holding 10 or 20 bombs. Several may be released simultaneously. The bomb has very poor ballistics and cannot be aimed accurately. They spread out as they fall, and a group of bombs dropped simultaneously from 5,000 ft. would cover an area of about 100 yds. square.

Unlike the high explosive, incendiary bombs will not strike the target at an angle. Owing to air resistance they come down perpendicularly and hit the roofs of the buildings.[1] A bomb dropped from a height of about

1. Vide Felix Samuely. "Protective measures against Incendiary Bombs." The Builder, Dec. 1 1939 p. 755—757.

15,000 ft. would hit the target at a velocity of 400 ft. per second if it is of the one kilo variety. An idea of the penetrative capacity of incendiary bombs of various weights can be had from the following table giving the minimum thickness required for protection against penetration by impact.

| Bomb. | Reinforced concrete. | Sand* | Earth* | Shingle* | Mild steel plate. |
|---|---|---|---|---|---|
| 1 Kilo .. | 3½"—4" | 6" | 6" | 6" | ¼" |
| 2 " .. | 5" —6" | 3' 6" | 5' | — | ⅜" |
| 5½ " .. | — | 4' 9" | 7' | — | — |
| 10 " .. | — | 6' | 9' | — | 1" |

*Approximate. 1 Kilo=2⅛ lbs.

The incidence of fires depends upon the speed at which the bomber is flying, the quickness at which the bombs are released and the height from which they are dropped. For instance, flying in a straight line, at 200 m.p.h. at a height of 5,000 ft. or over, and releasing 20 bombs per second, the bomber would drop its 1,000 bombs in a little under 3 miles and would start one fire every 60 or 70 yds. The number of fires would be very large since attacks would be made by formations. Assuming that the built up area is about 15 per cent. of the open space, as it is the case in Great Britain, one out of every 6 bombs dropped might hit a building and the others might fall in gardens, streets, yards, etc. A bomber carrying 1,000 bombs can secure 166 hits. Half of them might either glance off sloping roof, and not penetrate or penetrating might fail to function. The remaining 83 would probably cause fires that is approximately 8 per cent. of the bombs dropped. Assuming the bomber flies in a straight line as noted above there might be one fire for every 60 or 70 yds.

In the absence of persons to deal with them immediately and effectively the fire brigades cannot cope with them. It will penetrate any ordinary roof (including tiles, slates, corrugated iron, and patent roofing materials, even though on close wood backing). But as it is not designed for great penetration it is likely to remain in an upper storey, and start a roof fire which is probably more difficult to deal with, than one on lower floor, since attics and roof spaces are usually less accessible and not so easy to move about in.

Molten magnesium may run through the cracks in the boarded flooring if any, immediately below the roof. The bomb will burn through into the ceiling below and roof timbers 2 or 3 feet above the bomb, may also easily catch fire by its radiated heat. Floor boards 7|8 inch thick, may be burnt through in four or five minutes and lead would be melted almost at once. Corrugated iron (20 gauge) is proof against burning, but if during the burning of the composition a vent-hole of the bomb is against the sheet, the blow pipe effect may cause a hole. Also the sheet will get red hot and if in contact with the floor boards may set them on fire.

It is difficult to deal with this bomb. Sand does not extinguish the bomb, but by cutting off the supply of free air would cause the bomb to burn less fiercely and the glare and radiated heat are reduced. But the metal would still be burning underneath the sand and, if left, may burn through floor boards in a few minutes.

Pouring water from a bucket or can, does not help. In fact it is dangerous and should in no circumstances be attempted because the effect is not to extinguish the burning magnesium, but to cause an accelerated combustion, so that the magnesium, instead of burning in the ordinary way by combining with the oxygen from the air, obtains an increased supply of oxygen from the water. The hydrogen of the water is set free, and burns in the air.

But if a jet of water is turned on to the bomb, the effect will be to scatter the burning magnesium, a piece of which might hit the operator. The intense heat when the thermite burns makes it difficult to approach the bomb and it is advised that we must be not less than twelve feet away to minimise the risk to person while using the spray pump recommended to bring down the effect of the bomb and to avoid scattering and help the magnesium to be consumed in one or two minutes.

To prevent conflagration, the situation should be tackled as soon as possible, after the bomb has functioned. To deal with a bomb three people may be required; "one to take the nozzle, the two others to work the pump and keep up the water supply; but two persons can manage quite well and even one might be successful if the situation were tackled very promptly."

For every bomber carrying 1,000 bombs it may require 83 x 3 or 249 persons and for a squad of 20 such bombers we may perhaps require about 5,000 persons! If there is mass attack with incendiary bombs a large proportion of the city population would be needed to deal with them and they must be in their homes and not in shelters fearing the high explosive !

Half kilo bombs are also considered likely for they are as good incendiary agents as the kilo variety and since the bombers can carry double the number. The spread of conflagration will be quicker and more serious. In fact this is even believed to be the secret weapon which Hitler announced to the world.

To congested cities incendiary bomb attack is extremely dangerous and towns in the tropics are particularly vulnerable. If broadcast over a city after driving the people into shelters by high explosives the consequences will be disastrous.

## POISON GAS[1]

Poison gas is another weapon used in air raids. Italy used mustard gas extensively in Abyssinia and her

1. Vide A.R.P.H.1 "Personal Protection Against Gas."
A.R.P.H.4, "Decontamination of Materials."
A.R.P.H.12 "Air Raid Precautions for Animals."
"The Protection of Foodstuffs Against Poison Gas." Home Office Pamphlet.
A.R.P.M.3 "Organisation of Decontamination Services."

victory at Ashangi is attributed to the spraying of the shores of the lake with mustard gas. So very distressing is this form of attack that the use of poison gas in war was forbidden by the Geneva Gas Protocol of 1925. All the most important countries of Western Europe were parties. But no one doubts the possibility of its use to-day. Every one in vulnerable areas has been supplied with a respirator free by the Government of Great Britain and the extensive anti-gas precautions taken in that country, indicate the danger.

By the term "gas" in warfare is meant any chemical substance, whether solid, liquid or vapour, which is used because it produces poisonous or irritant effects on the human body.

They are liberated in the air as vapours or irritant smokes, and mix in the air and produce their harmful effect upon unprotected persons who are exposed to this atmosphere. Mustard gas and like substances cause serious effect either by direct contact or with objects which have become contaminated by the liquid.

Some of them form clouds of gas or smoke which drift along the wind, for instance, cholorine, phosgene and arsenic compound smokes. Mustard gas or other blister gases are usually liquids which evaporate slowly giving off dangerous vapour until all evaporate, and the contaminated objects will give rise to skin burns until decontaminated. While the latter persists the former do not and are less dangerous. In congested areas persistent gases do greater injury.

The more important war gases likely to be used are:

1. Tear Gases.
   - (*a*) Chlor-aceto-phenone (C. A. P.) (non-persistent).
   - (*b*) Ethyl-ido-acetate (K. S. K.) (persistent).
   - (*c*) Bromo-benzyl-cyanide (B. B. C.) (persistent).

2. Nose irritant gases.
   (*a*) Di-phenyl-chlor-arsine (D. A.) (non-persistent).
   (*b*) And similar compounds such as di-phenyl-amine-chlor-arsine (D. M.) and Di-phenyl-cyano-arsine (D. C.) (non-persistent).

3. Lung irritant gases.
   (*a*) Chlorine (non-persistent).
   (*b*) Phosgene (non-persistent).

4. Blister gases.
   (*a*) Mustard gas. (BB'-di-chloro-di-ethyl sulphide) (persistent).
   (*b*) Lewisite (B-chloro-vinyl-di-chlor-arsine) (persistent).

The tear gas has immediate effect upon the eyes causing intense smarting, a profuse flow of tears and spasm of the eyelids which generally make it very difficult for the person to see. The liquid gas may cause permanent injury to the eye but generally in pure air the effects of the vapour soon pass off. Chlor-aceto-phenone (C.A.P.) (non-persistent) has an irritating effect upon the exposed skin in high concentrations while Ethyl-ido-acetate (K.S.K.) (persistent) is a respiratory irritant also.

Nose irritant gases produce intense pain in the nose, throat and breathing passages during the exposure to the gas but these painful effects soon pass off in fresh air. They are non-persistent and no permanent injury results when the patient is removed into pure air after an attack.

Lung irritant gases otherwise called choking gas attack the breathing passages and the lungs. Chlorine and phosgene will produce death if breathed in sufficiently large quantities. They are non-persistent and a good wind can dilute them and blow them away.

Blister gases cause intense irritation or burning of the skin according to the amount of gas which has come into contact with the affected part. Deep and extensive blisters may be caused in severe cases. No immediate pain is felt on contact with the mustard gas in the solid, liquid or vapour form, but the effects become apparent a few hours later. It also affects eyes and lungs but symptoms appear after sufficient attack. It is this absence of immediate effect which constitutes one of the greatest dangers of the mustard gas. The need for protection is not appreciated until too late.

Mustard gas is an oily liquid probably dark brown in colour and the substance is readily soluble in certain liquids such as oils, benzene and methylated spirit, and also in tar and fat. Owing to its solubility in fat, it is quickly absorbed by the skin. It is also readily absorbed in the tar surfaces of roads. It evaporates slowly at ordinary temperature and is very persistent. The liquid is more dangerous than the vapour when it contacts the body. Mustard gas is dangerous in a number of ways as shown below.

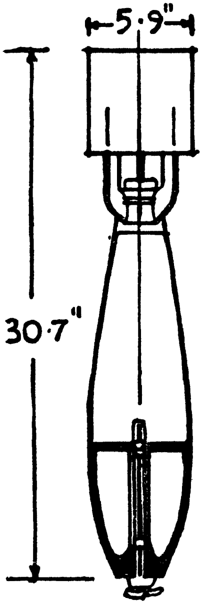
Its vapour given off by the ground or other objects splashed with the liquid, may injure the eyes, the lungs or exposed parts of the body. Clothing may absorb the vapour which will penetrate the skin and cause burns. Touching the contaminated ground or splashed object by the hand or other parts of the body will cause burns unless immediate precautions are taken. Contaminated persons or clothes are dangerous, for the vapour arising from them will affect others. Persons may also be contaminated by mustard gas spray directly.

As already noted neither liquid nor vapour produces any immediate recognisable sensation or effect. "The symptoms do not become apparent for from two to eight hours afterwards by which time it is too late to prevent injury."

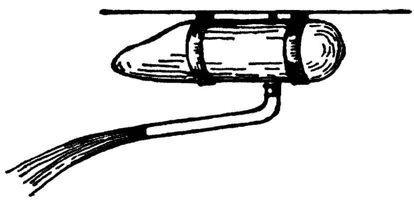
It will also affect the eye seriously even if present in small quantities in the atmosphere. Liquid contamination of the skin needs immediate treatment for the effect will be serious. Even the vapour will burn the skin and if the concentration is high will blister it. Lewisite contains arsenic, has a strong smell, acts more rapidly than mustard gas and is noticed at once. Otherwise its characteristics and effects are generally similar to those of mustard gas.

The effects produced by any war gas depend on the amount of the gas and the length of time a person is exposed to it. The stronger the gas the greater will be the injury produced in a given time. Lung irritants need a certain amount of breathing before their effect becomes dangerous.

There are two methods of using poison liquid gas; by bombs from aircraft, by sprays from aircraft. Air

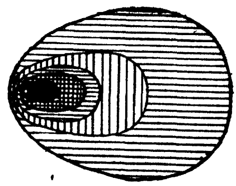


The combined high explosive and liquid gas bomb.


Container attached to the plane for spraying liquid gas.

bombs are particularly suitable for charging with gas because they do not have to withstand the shock of discharge from a gun. Gas bombs range up to 500 lb. in weight and the quantity of gas which a bomb will hold is somewhere about half of the total weight of the bomb. They explode over the surface and not deep underground and liberate the gas. If it is non-persistent gas a cloud will form at the site of explosion and will drift with the wind becoming more and more diluted ultimately becoming harmless. A high wind may blow them away but also into places where it would not be, otherwise. Generally speaking, however, the danger to be anticipated from a non-persistent gas will be very much reduced by high wind.

If there should be no wind at all, only a slight drift, the worst situation will arise, though the effects will be more local. A dense cloud of gas will form at the point of burst and will remain in that particular area until it is gradually dispersed. It will find its way by diffusion and ventilation current into areas, cellars, tunnels, etc., and once there, it is not so readily cleared as the gas in the open streets. Once the gas has penetrated into a confined space it is not subject to the influence of the wind and air currents prevailing outside, and may continue to be dangerous when the outside air has become clear of gas.


The spreading of poison gas.

Production of gas from a generator contained in the bomb is also anticipated which will produce greater concentration over larger area.

Bombs containing mustard gas and other persistent gases, make a large splash of liquid at the place where the bomb is dropped and will also cover a considerable area with fine droplets. The size and type of bombs as well as the nature of the ground and the strength of the wind, determine the degree of contamination and the size of the area affected. The liquid drops or splashes will cause serious injury to the body of men unless immediately attended to. Persons walking over gas contaminated ground will be liable to contaminate their boots by stepping in the liquid or picking up mud containing mustard gas. This danger will persist for a long period (usually some days) unless the area is decontaminated.

Unless the weather is very cold the contaminated area will continue to give off vapour until it has been decontaminated. Tear gas bomb will act similarly. Evaporation of the liquid on the ground will render a large area intolerable, and the vapour effect will continue for a number of days until decontamination is effected.

Small bombs will contaminate a large number of centres and are more difficult to locate and clear, while large ones may produce heavy concentration but in few areas only.

Mustard or other persistent gas can be sprayed from aircraft. The liquid falls in fine drops over a fairly wide area. The drops may indeed be so small as not to be noticed by persons upon whom they may fall. Such a spray may be a source of very great danger, because it may fall on the face, neck, and any exposed parts of the body, in addition to the clothing, without being noticed. Although there are difficulties in these methods the risk to persons in the open cannot be ignored but the danger may be avoided by remaining under cover.

The horrible nature of gas attack to personnel would become apparent when we realise that a respirator cannot protect men, for, it can be effective for about 4 hours only in contaminated atmosphere, and even during that time it can protect only the eyes, nose, mouth and lungs leaving other parts exposed to the dangers of mustard gas liquid and vapour. Even a full decontamination dress cannot help because " the protection against blister gas vapour afforded by the heavy anti-gas suit is of limited duration, owing to the suction effect produced by movement."[1]

Poison gas also affects food and clothing, buildings and structures, roads and public utility services, rendering them dangerous and unfit for use until proper measures are adopted. The danger to these mainly arises from the persistent gases, and is caused by splashes of the liquid or windborne spray. Temporary contamination may also be present in the disturbed earth of the crater of a bomb containing a non-persistent gas.

Food stored in the ordinary way is liable to be contaminated, and must be thrown away. Otherwise gas-proof packing will have to be resorted to for the entire area liable to be attacked. Clothing contaminated by

1. T. J. Muirhead, "Air Attacks on Cities."

liquid gas cannot be used unless boiled in water for one hour minimum, keeping the garments fully immersed. If they are greasy they should be boiled for two hours. Cotton and linen fabrics need half this time by this process. Anti-gas clothing and oil skin needs boiling for half an hour, gum boots for 2 hours. The civilian respirator cannot be made serviceable after liquid contamination.

To buildings and structures contamination may happen in three ways.

1. Fine spray from aircraft.
2. Gross spray from low-flying aircraft.
3. Heavy local contamination from gas bombs.

The degree of contamination depends upon the surfaces on which they fall. In an absorbent surface, they will penetrate it and take correspondingly longer to evaporate naturally or to be removed or neutralised artificially. The blister gases are of oily nature and are readily absorbed by other oils, by fats (in the human skin) and by tar products (road surfaces). Bricks, stone and concrete also absorb the liquid.

All our buildings and structures are therefore liable to be contaminated and rendered unfit for use. Decontamination is not easy for not merely ample water supply is needed, a suitable way of draining away the washed water is necessary. If it is allowed in the underground drain, the walls of the mains and crevices may get affected and remain so for a long time. Weathering may take unduly long time in congested areas.

Probably the greatest risk is from the use of a persistent gas such as mustard gas in conjunction with high explosive bombs. Material damage will be produced by the high explosive; and the mustard gas, whether used as spray or in bombs, will render the task of rescuing and treating casualties more difficult and hazardous.

Road surfaces, and vehicles readily absorb mustard gas, and transport services could easily be dislocated.

Overhead telephone wires are affected by gross contamination of mustard gas. To underground systems too a gas attack is dangerous, especially when a high explosive bomb containing mustard gas penetrates the road surface and shatters the mains. Immediately attending to it would be almost impossible because of liquid gas splashes and the supply could be dislocated. Gas contamination might also be carried along the mains by water.

Particularly in the tropics gas attack will be most distressing because of congestion and heat which will vapourise the liquid rapidly resulting in very heavy concentration of poison in the atmosphere.

Liquid gas affects animals as well, and cows and bullocks and horses and other transport animals are liable to be affected particularly by blister gases, whose injury would require weeks to heal.

Animals are affected by mustard gas and lewisite, by choking gases like phosgene, but nose gases are not fatal to them and fresh air will cure the sneezing. They are not affected by tear gas. Even fodder exposed to the true gases, arsenical smoke or the vapour of blister gas may become unpalatable. No satisfactory animal gas mask has been yet produced.[1]

Liquid mustard gas causes deep ulceration after sometime and healing takes 8 to 10 weeks. When animals walk over contaminated ground, their legs are injured. Mustard gas liquid falling in the eye may injure it and it may take some months to heal but heavy contamination may blind them. Grazing contaminated pasture will ulcerate the digestive tract. Mustard gas vapour unless in very high concentration or prolonged exposure will not injure the skin of the larger animals but mustard gas vapour will affect the eyes for weeks as well as the respiratory tract which may prove fatal.

A gas attack is therefore considered most distressing and efforts to prohibit the use of gas were made, with

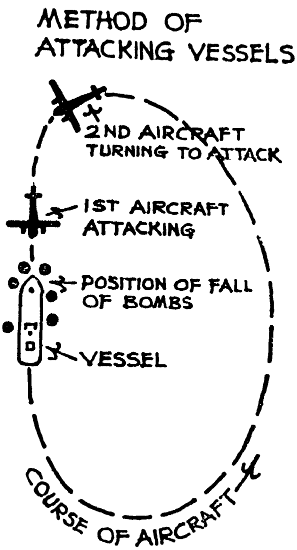
1. A.R.P.H.12.

results, well known. Its use in Poland and Finland is suspected and the British Government expects it any day, indicating unmistakably the need to get prepared to meet this danger whenever national security is threatened by the air arm.

## Machine Guns

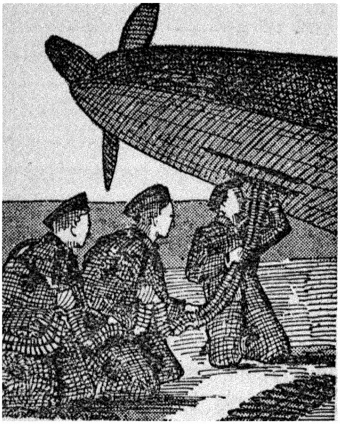
Machine-gunning is another method of harassing the enemy from the plane. It is resorted to especially upon defenceless people on land and sea and sometimes upon the navy and armed forces. Russian bombers machine-gunned peasants and farm servants in the villages of Finland, and in many cities 'the raiders machine-gunned the civilians.' Solitary pedestrians and vehicles on roads were machine-gunned. Moving trains laden with passengers have been mercilessly machine-gunned in Poland and China.

Machine-gunning of trawlers and fisher folk in the North Sea by Nazi raiders was almost a daily occurrence. Harrowing tales have been recounted by lucky folk who escaped machine-gunning. The planes swoop down from the clouds and machine-gun the deck and the crew. In one of the most murderous attacks ever made, (over a Trinity House vessel) the German planes intermittently machine-gunned the deck for half an hour injuring 32 men, some seriously and one fatally. Women and children are now being machine-gunned in the streets of London.

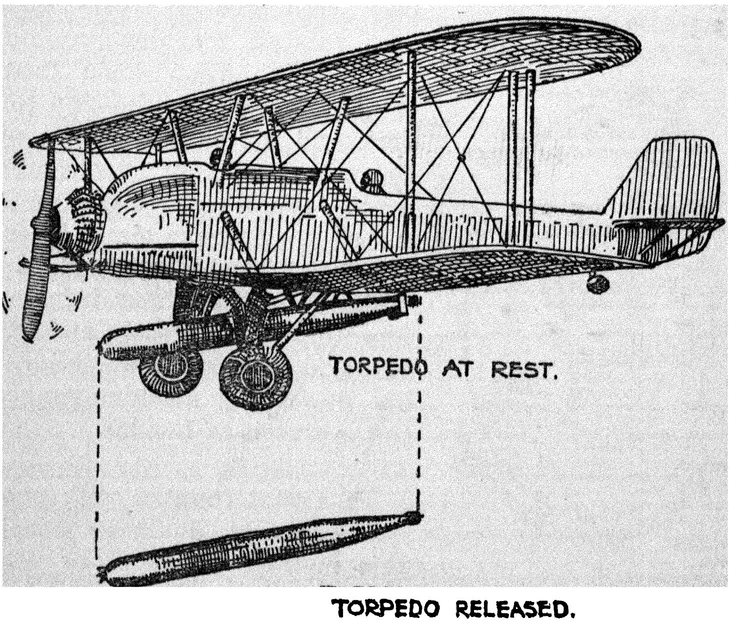



To a vast country with poor defences and unarmed people this method would prove very effective to break the morale of the nation. It is less expensive, but at the same time equally frightful.

Torpedo attacks from the air are carried out by a special type of torpedo carrying aircraft. The torpedo, similar to that used by submarines and surface craft but of a smaller (18-inch) type, is slung beneath the fuselage of the aircraft, with the nose between the landing wheels. Approaching the ship at a great height to avoid detection, the torpedo bomber dives throws his torpedo into the sea from a height of less than 100 feet, and within a thousand yards of the enemy ship. As the torpedo is released a trigger starts the motor that drives it.



Machine Gun bullets being loaded into an aeroplane.




Aerial Torpedo.

Abundant evidence has accumulated in recent years proving the destructive capacity of these weapons and the disastrous consequences of air raids.[1]

## AIR RAID DESTRUCTION

The large scale use of gas in recent times comes from Abyssinia.[2] Italy used mustard gas on a great scale. It was first dropped in drums and there is some evidence that, so used, it had no considerable effect. Gas was much more effective when sprays were substituted for drums later on, and one eye-witness attributes Italy's victory at Lake Ashangi to spraying the shores of the Lake with mustard gas. Aircraft and explosive bombs also materially contributed to the success.

During the six months for which the war lasted nearly 2,000 tons of bombs were dropped. 74 tons were dropped on one day, the quantity German aeroplanes dropped upon Britain in the Great War. Its capacity for harrying a beaten foe was enormous. 396 tons of bombs were dropped within 4 days resulting in 3,000 casualties at the ford of the River Takkazewas.

The raids on Barcelona during one day succeeded in killing 875 persons (including 245 women and 118 children) and wounding 1,500; 48 buildings were completely destroyed and 75 severely damaged. About 200 persons were killed and 500 injured, most of them being women and children in a Catalan town of 10,000 inhabitants, in one day.

1. The following approximate figures indicate the relative first-line strengths with possible reserves, of the stronger air forces of the world:

| | | First-line aircraft. | Reserve per cent. |
|---|---|---|---|
| U. S. S. R. | .. | 4,000 | 50 |
| Germany | .. | 3,000 | 50 |
| Britain | .. | 2,200 | 25 |
| Italy | .. | 2,100 | 25 |
| U. S. A. | .. | 2,100 | 30 |
| France | .. | 1,900 | 20 |
| Japan | .. | 1,300 | 50 |
| Czecho-Slovakia | .. | 500 | 25 |
| Poland | .. | 500 | 20 |

(Encyclopaedia Brittanica: Book of the Year 1939 p. 34).

2. See A. A. Spaight.

In China too, as in Spain, we see terrible manifestations of the destructiveness of bombardments from the air, cities grievously damaged, men, women and children slain and mutilated.

In the series of raids which began in the end of May, 1938 and continued for a week, the number of killed and wounded among the civil population ran into thousands, although apparently the Pearl River Bridge, the power station, waterworks, railway stations and factories were targets of attack.

Even in towns equipped with anti-aircraft defences and fighter squadron, the risk to life is very grave as recent raids over Malta indicate. Twenty three civilians were killed and several wounded in one of the raids on June 26, 1940. About 70 bombs were dropped. One bomb hit a bus, full of passengers most of whom were killed. The previous day 12 civilians were killed and several wounded. The bombers were driven off by British fighters and anti-aircraft fire. Destruction would have been far greater if bombers had their way.

Ramsgate in England has been almost razed to the ground. Over 800 houses have been destroyed and the entire town rendered uninhabitable. More than 8 churches in London have been damaged including St. Paul's. The famous Cathedral at Canterbury has not escaped.

The destruction of Warsaw is so complete that it is doubtful whether the city will ever be rebuilt to its former size and even if attempted reconstruction will take years. Thousands of inhabitants have been rendered homeless, and many beautiful churches and palaces lie in ruins.

Many of the most prominent buildings and thoroughfares were totally destroyed. It is estimated that one-third of Madrid's houses have been completely ruined and that half of its houses were damaged. The same is true of many towns in the fighting area of Spain. One can see buildings destroyed everywhere. The railways are in the same condition as the railways of Central Europe after the war. The seats are missing, wood has been torn away for fuel, leather taken for shoes and slippers, the windows have been removed, and there were no lights in the carriages, owing to the large number of engines, trucks and wagons destroyed by gunfire, air-raids, and over-use.

Chinese towns subjected to air raids are not different. Canton Port was destroyed as well as parts of Shanghai and Chunking. During a day's raid on Chunking whole blocks were levelled to the ground.

Hango, Abo, Viipuri and other towns of Finland also reveal the destructive power of air raids, the high explosive bomb and the incendiary. Abo suffered 30 raids during 2 months of war. Russian raiders dropped some twelve hundred bombs and eight hundred buildings were made uninhabitable. Further, air raids and the threat of attack by aircraft, forced the people of Abo to reverse their mode of life. For over 5 weeks they worked by night and spent the days taking shelter.

In fact this is the most distressing feature of air attack and its possibility. The strain of the people, the psychological effect of fear constantly harrowing the mind of the old and the young, the women and even animals are far more serious than what is indicated by statistics of deaths and injuries and damages to buildings. We cannot overlook the " far and wide terrorisation of the populace, women and children, sick and old, especially. The ill-health of vast numbers must be counted in, and the misery caused. The constant obsession of mind with a dead weight of fear to the exclusion of everything else must be reckoned."[1] And above all we must remember that all this happen to people who dwell at home far from the fighting-fronts; who are powerless to do more than suffer passively the tragedy and the grief. This is evident from the condition of the people of England during the great war when the threat of air attack hung over them for four years, although air raids were very much less deadly than what they are to-day. In fact more bombs have been dropped in one week recently

1. L. E. O. Charlton, "War over England." For the following account see Part I.

than the total number that was dropped during the entire period of four years in the last war.

The estimated total damage during last war by air raids in England was; 1,414 killed, 3,416 wounded. The material damage just under three million pounds. About 270 tons in deadweight of bombs fell in British soil throughout the war in the course of 103 raids, airship and aeroplane combined. In all some 8,500 bombs were let fall small and great, from the light-weight incendiaries to the high-explosives upto a ton weight. Within two days in January 1940, some 3,000 bombs fell in Finland and within a month, 234 were killed, 264 seriously wounded and 210 slightly wounded by air raids.

Yet the threat of raids made the life of people intolerable. "It was a strange England: strange in city and town and strange over the country side." For the better part of the two whole years until the airship ceased to raid, the whole country lived and suffered under a Zeppelin psychosis.

Full moon days were special nights of terror to the teeming masses of the Metropolis, and dark nights were dreaded when Zeppelins continued to raid. Panic was particularly severe among the foreign folk in the crowded East End. In the shelter of the tube stations the distress of Jewish mothers and children was very difficult to soothe. They would scream loudly, tearing their clothes and beating their breasts, while old men amongst them would pluck the hair from their beards in the fashion of the Scriptures. Too often, bands of young aliens belonging to neutral or allied countries, shedding every vestige of manhood, would behave like animals of the wild, sometimes brutally trampling people to death in a mad, insensate rush for safety.

Nightly, except when weather conditions obviously prevented raiding, hordes of people would slowly progress towards the tube station nearest to their homes and there take up quarters for the night. They would throng the staircases, passages and platforms, occupying every square inch of available space. As many as a quarter of a million would find accommodation in this manner, the able-bodied accompanied by the sick and the halt. In such circumstances babies were born and those at the last gasp died. Sanitation there was none. Food litter lay around, and worse still, to add to the squalor of the scene, passengers on the system were sometimes unable either to take train or to alight at their destination, so densely packed was the multitude.

People left London to suburban terminus to camp in the fields till dawn. Groups of people belonging to this super added local population would behave distractedly, praying for deliverance in camp-meeting style and cursing loudly, with arms extended, the brilliant autumnal moon.

This refers to London the Mecca of the raiders. The same things though in lesser measure happened over half the rest of the country. The eastern coastal fringe was particularly affected, and especially places such as Hull, Tyneside, Edinburgh and Harwich, important objectives and clearly demarcated by their situation at the head of estuaries. In those places also similar scenes of death, and destruction resulted from the raids, and there as well, murder of the mind conjointly with murder of the body was committed.

In the provincial hospital wards, likewise, babies were born deaf, deformed and blind owing to the terrorization of the expectant mothers. The case of the children was sad indeed and those of tender age suffered cruelly from nerve shock.

At school, the day after a raid the children would be encouraged by their teachers to sleep through the lesson hours so as to restore the nervous strength which the night of terror had dispersed.

False alarm, and numerous were the occasions, had as much force as actual attack in the sense of fear awakened. The harassing effect on old and young alike, of the nightly migrations from the towns to the shelter of mine workings and colliery drifts in the Midlands and North; to the open fields, caves, subterranean passages, and disused chalk pits by the dread of a raid, "is beyond computation."

Black-out had dangers and depressions. Pedestrians could only grope their way home by the light of hand-held electric torches fitfully switched on. Mill-working lasses in the Lancashire cotton factories were in jeopardy for darkness provides an opportunity for the violator. Here and there prosecution resulted for striking matches in the open. The motorist's plight was deplorable if his car headlights were on.

Even the very birds and animals developed air raid nerves. It was for them their war-time malady. Dogs would howl piteously. Cats sought the darkest recesses. In open country cows lowed uneasily and the horses in the fields stampeded up and down. Sheep lamented in the fold. In the coverts and amongst the stubble the birds chattered when they should have slept and noises of alarm came from the pheasant and the partridge. Their alert, animal sense of hearing could detect the hum of engines in the air long before the sound reached the ear of man.

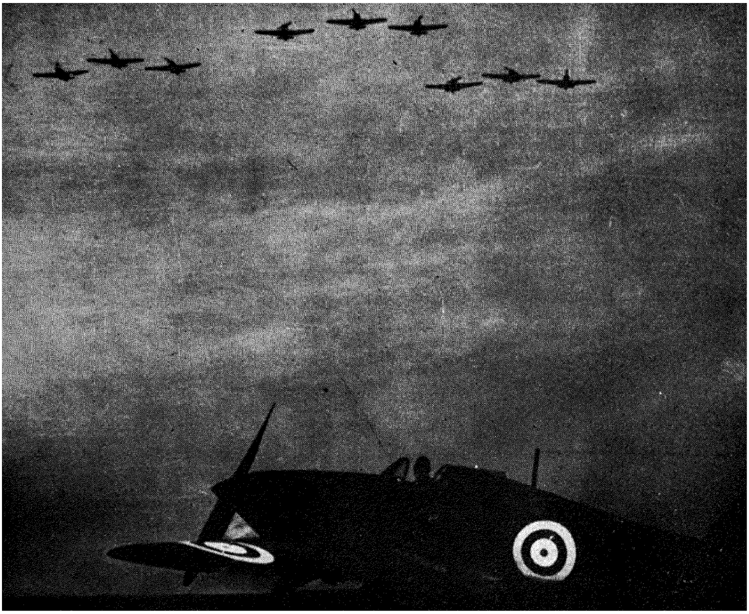
The people "were like patients in a hospital ward. They were reliant on the treatment and the medicines and felt certain they would get well if they did what the doctors told them to, refusing to say "die." They were as helpless and as passive."

This grave consequence is not accidental but deliberate. For demoralising the civil population and destroying the morale of the nation is one of the objects of air attack, and raids are planned accordingly. Therefore it is that in addition to aerodromes, aeroplane manufacturing centres, seaplane bases, naval bases, harbours, bridges, railways and other military objectives and nerve centres and sources of production of essential supplies such as electric power houses, telephone and telegraph centres, reservoirs and dams, hospitals, hospital ships and trains, educational institutions, historic memorials, even frightened civilians fleeing for life are attacked. In addition to towns and villages isolated farms and peasants' homes were ruthlessly attacked in Finland by the Russians. Not a single place which the British Labour Delegation saw which had been hit in Hango was a military objective but in many places workers' houses were destroyed completely. The Russian bombers "primarily concentrated on demoralising the civilian population." No more evidence is needed to make this apparent than the machine-gunning of civilian population and unarmed fishermen.

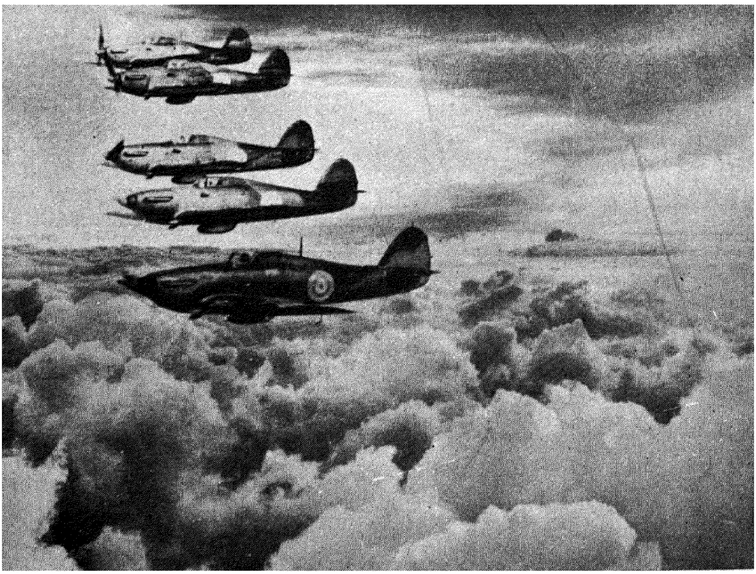
The destruction of property and the dislocation in the supply of services necessary for the normal functioning of the community have also become evident from recent raids. To achieve these aims crowded and congested cities are extremely well suited as experience proves. The three basic constituents of the civic organism namely, the citizen, the city structures and the supply of essential services, are vitally affected by weapons used in air raids. If poison gas affects men by contaminating the atmosphere and buildings and roads, the high explosive bomb is dangerous because its blast and splinters and the indirect damage through flying and falling masonry, and the incendiary bomb because of its power for effective conflagration. Liquid gas (persistent) incendiary and H.E. bombs are all dangerous to structures of all kinds normally found. Underground systems, particularly if they are not laid very deep are liable to be blown up by the high explosive if it strikes the road and incendiary bombs can set fire to buses and transport systems as it happened in Finland. The High Explosive can dislocate transport services by destroying railways and roads, electric power houses, and telephone exchanges, etc. A combined high explosive and liquid gas bomb is particularly dangerous to underground mains, and Lewisite gas used in adequate quantities can poison city water supply sources and render the normal functioning of the community impossible.

# CHAPTER II

## PREVENTION AND ESCAPE



The British Hawker Hurricane fighters.



Hurricanes on patrol.

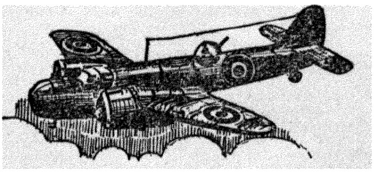
## CHAPTER II

## PREVENTION AND ESCAPE

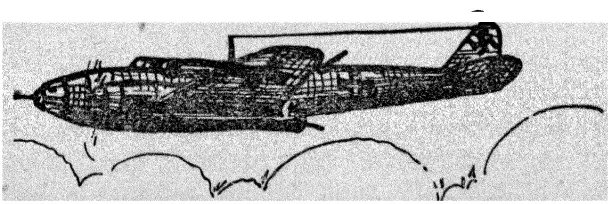
The terrible destruction and the horrible consequences of air raids can be avoided if we could prevent the bomber getting through and discharging his deadly weapons upon the desired targets. Every effort is therefore made to prevent bombers getting over important centres and cities as well as to conceal the targets and make the task of recognising them as difficult as possible, if they should succeed.

### FIGHTER AIRCRAFT

Fighter aircraft are lighter and very much faster than bombers. These form the first line of defence for they are intended to drive the bombers away or shoot them down. The Defiant, Spitfires and Hawker Hurricanes of Great Britain are credited with incredible speed. Such planes could chase the bombers, but although speed is essential to chase the bomber, success depends on other factors as

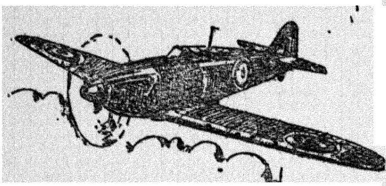


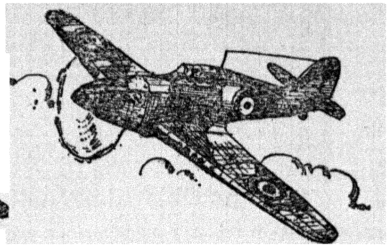
The celebrated Bristol "Blenheim" long range bomber. Capable of cruising at 200 m.p.h. for 5½ hours and with a maximum speed of 285 m.p.h. these machines are of all-metal-stressed-skin construction and have a total wing span of 56 feet 4 inches.



The Heinkel bomber "III K."

well, such as the number of aircraft engaged and the mode of attack, the capacity of the pilots and climatic condition.



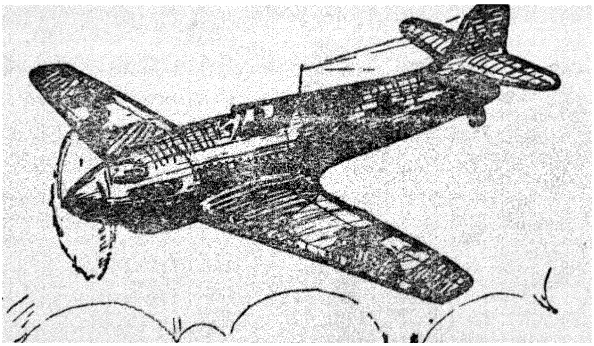


Fighter aircraft

(*a*) The Supermarine "Spitfire" has eight machine guns mounted at the wings and can develop a maximum speed of 367 m.p.h.

(*b*) The Hawker "Hurricane" single seater fighter has eight machine guns and can develop a speed of over 330 m.p.h.

Expert opinion asserted years ago that an air attack, cannot be repulsed and met by the air arm alone. In his



(*c*) The Messerschmitt "Me 109" fighter, considered the fastest air craft in the world; has a speed of 354 m.p.h. It carries two machine guns in the wings, two synchronised machine guns above the engine and a 23 mm. cannon firing through the boss of the air screw.

book, "Behind the Smoke Screen,"[1] General Groves sets forth his conclusions thus:—

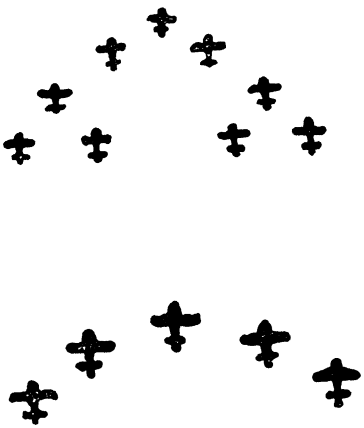
1. Air attack upon cities cannot as a rule be met and defeated in the air;
2. Anti-aircraft guns cannot as a rule be relied upon to bring down aeroplanes;

1. Quoted in, "The Menace of our National Defence," by Sir Norman Angel, pp. 67—68.

3. Local defence can only, in favourable circumstances afford partial protection against aerial bombardment, and then only if it is proportional to the scale of attack;

4. Under weather conditions such as are quite normal in England, local defence may be greatly discounted or entirely useless.

This is because aerial warfare involves action in three dimensions. The vast scale upon which it may be carried on greatly reduces even the chance of air forces meeting and engaging each other. According to Air Marshal Brooke Popham,[1] late Commandant of the R.A.F. Staff College, "Fighting in the Air on a large scale only takes place by accident or by mutual consent."



Bombers flying in formation.

Major Oliver Stewart, the Air Correspondent of the *Morning Post* and distinguished fighting pilot in the last War supports the view and emphasises the difficulty of locating enemy planes. "In order to pick up aeroplanes from an aeroplane with certainty, it would be necessary to be able to look everywhere at once."[2]

The air defence of a city does not imply merely the protection of the perimeter of the town, it necessitates the guarding of that area to a height of 25,000 feet. For large cities this would mean the guarding of many cubic miles of air. To find the enemy in this immensity, in any but the clearest weather, may be as difficult as finding a needle in a haystack.[3]

1. *Ibid.*
2. Vide Norman Angel, p. 70.
3. Major-General Ashmore; quoted, *Ibid.* p. 72.

Recent events in Europe have shown that intercepting bombers is extremely difficult. The problem of intercepting enemy aircraft moving at speeds of four miles a minute and upwards at any height up to 20,000 feet and taking advantage of cloud and haze conditions is obviously one of great difficulty.[1] It can never be claimed however thorough the defence system that enemy aircraft "would not on occasion penetrate it."

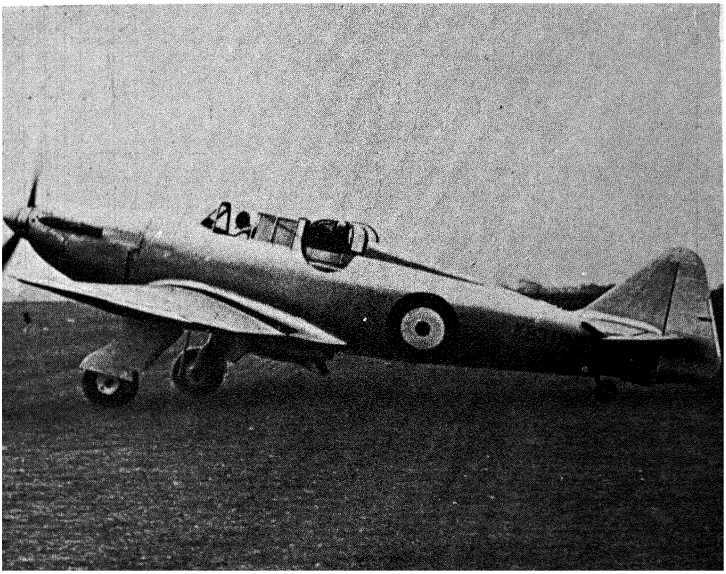
For instance in the North Sea air battle fought in the beginning of January the "twin-engined multi-gun Messer-Schmidts, latest of Germany's fastest fighters diving with the advantage of the sun behind them, were unable to shake the formation of the British planes. .... Even the heaviest close range attacks were successfully beaten off by the British planes, keeping 'shoulder to shoulder' in tight formation."[2]

When the R. A. F. aircraft in the last week of February attacked warships near Heligoland with bombs "anti-aircraft fire was encountered from ships and shore batteries. One British aircraft was attacked by three enemy fighters without success and it is believed one enemy fighter was forced down. No casualties or damage was suffered by any British aircraft during the opposition."

In another reconnaisance flight over the same territory "one of the British aircraft was attacked by five Messer-Schmidts. Having repulsed the five separate attacks, British aircraft returned home safely after completing their task."

An authoritative description of the air battle states that a British bomber was attacked from above, from the left and from astern by five Messer-Schmidt fighters of 109 type. Despite the enemy's superior speed, and the fact that it was hit six times by machine-gun fire and one of the British machine guns was virtually out of action, the bomber succeeded in evading its pursuers and

1. Sir Kingsley Wood. Reply in House of Commons.
2. The succeeding account is based on Official *Communiques* and *Reuter's* News published in the "Hindu" Madras during Sept., 1939 to June, 1940.



The British fighter "Defiant."

Loading ammunition into the machine-guns of fighters.

returned safely to its base with valuable photographs previously obtained over enemy territory. All members of the crew escaped injury.

Many German raids on the East coast of Great Britain have been carried out during daytime when fighters failed to make contact. May be it is due to mist and bad visibility, the better ability of enemy pilots and the suddenness with which the attack was made; but these factors cannot be ignored. When aircraft under cover of mist attacked with bombs and machine-gun fire merchant ships on the East coast of Scotland on the 10th January, and dropped a number of bombs "fighter aircraft was sent up, but owing to bad visibility no contact was made." British planes arrived shortly after two large German bombers attacked a steamer off east coast but the Air Ministry does not know "whether they made contact with enemy."

"British fighters ascended but failed to make contact" a fortnight later when three planes flew over the Shetlands. The planes dodged behind the clouds and spent nearly two hours flying backwards and forwards across the island. A few days later a Heinkel which attacked an armed British trawler at Great Yarmouth "escaped into the clouds off the Scottish coast after being intercepted by fighters."

"Two German planes bombed and machine-gunned the *City of Bath* off the Firth of Tay. The liner replied with anti-aircraft guns and the planes flew away just before the arrival of three British fighters. After a game of hide and seek in the clouds the planes made a second attack on the *City of Bath.*"

Two enemy bombers were observed off the East Coast of Scotland on one morning, during the close of January, at less than 600 feet high with a British plane in close pursuit. The Heinkel bomber swooped down on a patrol vessel dropped two bombs and made off. "The plane appeared playing hide and seek in the cloud with R.A.F. planes which had earlier driven off another big grey plane. After they had chased the first one out to the sea, the other appeared further south; the "enemy aircraft . . . . was pursued by fighter and coastal patrol aircraft with results not yet known."

Ships batteries, shore defences and fighter aircraft combined to drive off the enemy, says an Admiralty *Communique* which however admits that "German aircraft made a raid on the Fleet Anchorage at Scapa Flow. About fourteen enemy aircraft reached their objective. A considerable number of bombs were dropped, one hitting a warship . . . . "

More than 50 high explosive bombs as well as many scores of smaller incendiary bombs fell in West Orkneys; "despite strong fighter and anti-aircraft defence the German planes carried out their orders successfully."

German fighters claimed to be incredibly fast, seem to be no more successful. In the course of a day-light reconnaissance of Heligoland Bight on March 16th, British machines bombed a number of German Naval Patrol vessels between Borkum and Heligoland. The next day one British aircraft swooped from 6,000 to a few hundred feet and dropped a salvo of bombs on vessels. The bomber came under concentrated fire of the patrol vessels but was not hit. Other machines encountered anti-aircraft fire and fighter attacks but all returned safely. Why did the British bombers succeed against the faster and heavily armed Messer-Schmitts in the battle in the North Sea in the second week of January? Well judged leadership, fighting discipline and steady formation of flying are considered responsible. The bombers were nine Blenheims, flying in formation, at a height of 5,000 feet. When the leader sighted the Messer-Schmitts he closed up the formation and turned off his course in order to lead the Germans further from their bases and dived to sea level in order to reduce the number of directions from which an attack could be made.

The Messer-Schmidt's top speed is reported to be about 365 miles an hour and they are heavily armed with machine-guns and cannons. "The fight lasted twenty minutes during which the Messer-Schmidts delivered attacks with great rapidity both from ahead, from on the beam and from astern. Despite the simultaneous attack from different directions, the Messer-Schmidts failed to make any appreciable impression on the steadiness of the British formation."

A careful review of the war in the air during the first four months of the struggle, September to December 1939, makes it clear that bombers have successfully escaped fighters. In the words of a well-known authority on matters aerial, "the single-seat and two-seat fighters—interceptors as we call them, pursuit ships in America, *appareils de chasse* in France, and *Jagdflugzeugen* in Germany—have had plenty of practice in all belligerent countries. The comparatively few bombers on each side which have flown over enemy territory have been intercepted and chased by so many defensive fighters that the wonder is that any of them returned.

In some of the bomber versus fighter affairs we have discovered that a four-gun power-driven turret in the tail of a bomber is well able to tackle a four-gun chaser."

## ANTI-AIRCRAFT GUNS

The anti-aircraft gun can fire its shells to a height of over 20,000 feet. It is aided in its attempt by searchlights and sound locators and constitute a potential danger to bombers. Mounted in strategic positions or near important targets they are intended to keep bombers away. It is now part of the defence organisation in most European countries. The anti-aircraft army which was 6,000 strong three years ago, is to-day one hundred and twelve thousand strong in Great Britain. British anti-aircraft guns and searchlights are spread in a white chequer board over the land, by lonely copses, alongside farm buildings, in hills, and in fen country keeping increasing watch over the country day and night.

The anti-aircraft shell fragments and explosion can shatter the aeroplane, and even a nearby bursting of the shell is dangerous, but the fact is that even a nearby explosion is difficult to obtain.[1] For as the British Ministry of Munitions pointed during the last war,

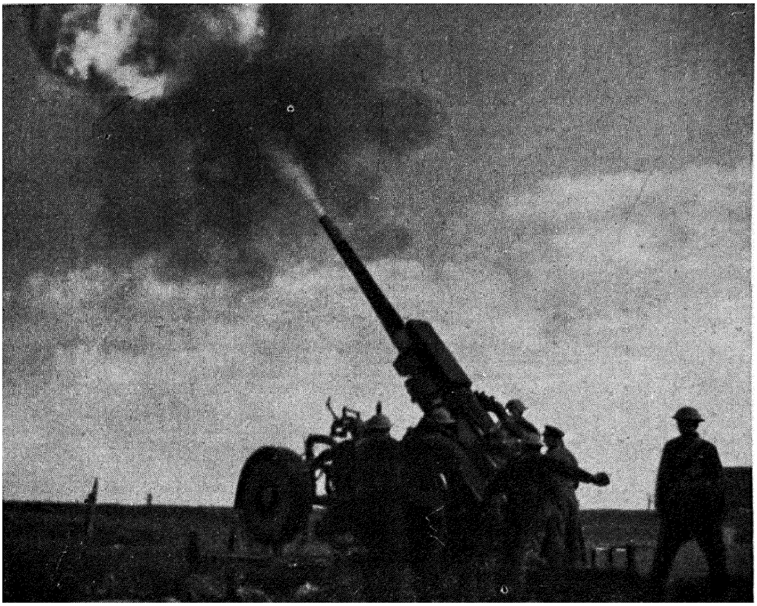
Anti-aircraft shell shrapnel picked up in Spain. The disc is about the size of a penny and the rod is 2½ inches long.

"Assuming an aeroplane to be travelling at 100 miles an hour at an altitude of 8,000 ft. it is obvious that during the time a projectile from an anti-aircraft gun took to reach this height the aeroplane could have altered its direction and movements in three dimensions over a very wide range. In order to secure a hit on it no less than 162,000 anti-aircraft guns would have to fire simultaneously."[2]

Recent experience supports this view. In the fourth R.A.F. night survey of Germany carried out in February, over heavily fortified areas in Western Germany, the bombers were caught in beams of multi-coloured searchlights and this activity was greatest ever encountered in the neighbourhood of Cologne and Dusseldorf. One section of the flight was under intense fire for some minutes and for another spell dodged spasmodic bursts. "Screaming onions" (incendiary shells which in some cases are linked by chains designed to wrap them crashing to the earth in flames) were discharged at the aircraft but they missed the mark. One battery of four guns fired greenish coloured tracer balls and elsewhere, red and orange fire balls were shot under the aircraft. These long distance bombers "ran the gauntlet of the whole German anti-aircraft defence with one exception."

1. It is reported that a new type of anti-aircraft shell has been developed in the United States. "The shell is fired in the usual manner, but it releases a parachute trailing hundreds of feet of steel tape designed to foul the propellers of the raiding aircraft" (The "Hindu" Jan. 15, 1940). Another type is reported to be used in Germany. And are described as picturesque by the R. A. F. pilots against whom they were used. The efficacy of these shells is yet to be proved.

2. Quoted; Norman Angel.



A typical anti-aircraft gun.

A. A. gun shells.

Searchlights in action.

These flights were carried out at a high altitude, but the British attack on Sylt at the end of March provides an instance of low flying raid carried out over specific targets protected by anti-aircraft defences. Successive waves of bombers attacked during a bright moon light night, the seaplane base at Hornum. For seven hours singly and in relays they maintained continuous assault on the seaplane base and obtained direct hits between the hangars and close to them. A vast quantity of bombs was dropped and reports indicate extensive damage done to hangars, workshops and slipways. All the British bombers returned safely with the exception of one. When two British bombers suddenly swooped from low lying clouds at terrific speed followed by other planes over Sylt the sirens began to wail and anti-aircraft guns and searchlights came into action. The barrage was heard over whole of the island, and the effect was that of a giant fire-works display. Yet the raid was successful and carried out by waves of bombers every half an hour from eight p.m. onwards. One of them dropped several bombs on the Hindenburg dam resulting in huge flames.

The damage to Sylt include direct hits with high explosive on two hangars, on the railway connecting Hornum and List, on the land entrance to the jetty, on or near the seaplane slipway, and on the oil storage tanks.

"Forty-nine planes took part in the raid and each worked strictly to the time-table. Each plane bombed the base at the appointed time and from the appointed height in spite of the big barrage of fire from the German anti-aircraft guns, shore batteries and from which projects reddish missiles like the Roman candles. The planes returned back in the order in which they had left. They dropped altogether forty-two tons of bombs. Each plane carried about two tons of explosives including several other missiles and incendiary bombs."

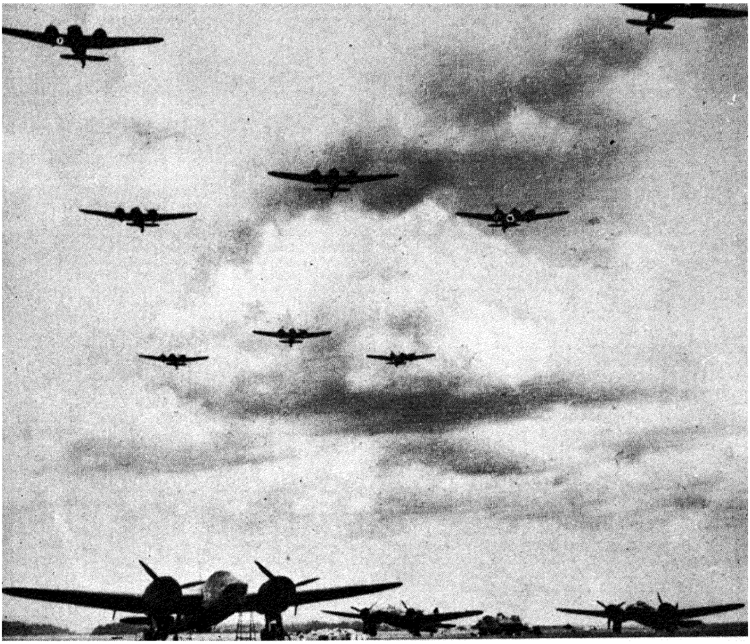
A formation of British Bombers penetrated enemy defence in the Jade estuary in April 1940, and successfully reconnoitred the Wilhelmshaven naval base, where an enemy warship was attacked with bombs. Further south four enemy destroyers were also attacked. No damage or casualties were suffered by British aircraft all of which returned safely.

A German warship lying off Bergen was attacked and bombed next week by aircraft of the R.A.F. Bomber Command. One large cruiser was hit and other ships were probably damaged. The attack which was made by relays of aircraft in quick succession was delivered by a strong force of long range bombers in the face of intense anti-aircraft fire from the warships. A series of bombing attacks were made by aircraft in sections in line astern. "Despite the intense fire to which they were subjected all British aircraft returned safely making a night landing at their base after a flight of approximately eight hours' duration."

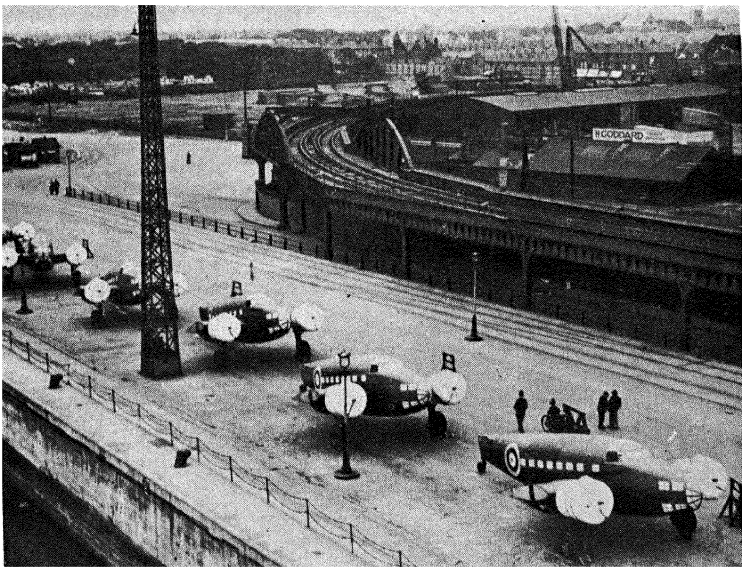
Russian air raids over Viipuri further prove that even if they were alert and active the target can be bombed successfully. 47 Russian planes raided Viipuri on the 3rd February, 1940, poured over 500 bombs into the town and obtained 150 direct hits, damaging all principal buildings. It was a day-light raid and the sirens wailed without break all day. "The machines flew too high to be in danger for anti-aircraft guns."

Especially for an attack with incendiary bombs which can be rained over a town, aircraft need not come low. Even those who pin their faith in active defence, in fighter aircraft and ground batteries to deal successfully with bombers, hesitate, to assert their effectiveness. They feel that mass attacks on Britain had not yet been made to judge the efficacy of preventive measures and admit, "If the Germans were prepared to loose, say 1,000 out of 2,000 of their bombers, . . . they might inflict serious losses."[1]

1. Some of the new American four engined bombers weigh over 20 tons with a range of 3,000 miles. So far as Great Britain is concerned it can be stated without hesitation that the average British machine is unsurpassed in the world, and the same applies to the Air Force, in which the degree of training given is of the most thorough description. The results so far obtained also by both the British and French air craft services in the present war have exceeded all expectations, and several makes of British fighting planes easily exceed 375 miles an hour for long distances. The "Hindu," Feb. 4, 1940.



**Bristol Blenheim (British) bombers.**




**Lockheed (American) bombers (wings detached).**

A new tactics already come into vogue threatens to undermine seriously the efficacy of anti-aircraft batteries. Raiders come without making noise and no warning is possible of impending attack, as reports of Russian raids over Finland indicate. Twenty were killed and fifty wounded in a series of air raids over Abo during the close of January. Dozens of houses were destroyed. "Fifty Soviet bombers silently swept down on the city with engines cut out. The raids were the worst Abo hitherto suffered."

Gliding long distances is possible and it is estimated that by reaching high altitudes and gliding after closing the machine a distance of even 100 miles could be covered. Sirens and sound detectors could be deceived and anti-aircraft batteries would never come into action.

It is also considered possible to aim bombs upon targets protected by anti-aircraft guns without bringing the bombers into their range.[1] The rocket glider type of bomb is mentioned as the weapon which would neutralise the value of anti-aircraft guns and ground defence.

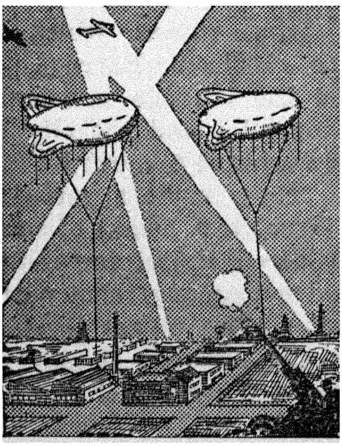
## Balloon Barrage

Bombers flying low and fast render the task of anti-aircraft batteries difficult, for the heavy guns cannot be quickly adjusted to take successful aims at rapidly moving objects. To prevent low flying attack which is particularly destructive, the Balloon Barrage is improvised. The idea behind the barrage is simple. They are light balloons floating all round the city or other important objectives and anchored to earth by fine but very strong steel cables. These make a veritable tangle of wires all round the target to a height of some thousands of feet. It is considered almost impossible for aeroplanes to dodge in and out among them particularly at night. Bombers attempting to get through would hit one of these wires and although it may be broken its propellers, or wing or tail would get torn off and mark the end of the bomber.[2]

1. "Ajax" Air Strategy for Britain.
2. L. Matters "The Balloon Barrage." The "Hindu," 24-9-1939. For the Balloon Barrage exercises and the Opposition view on the matter Vide the issues of the 29-7-1939, 26-7-1939.

The main purpose of the balloon barrage seems to be to keep the bombers high up, and to prevent them from coming low and effectively bombing the targets. Higher up, the bursting shell of the anti-aircraft guns and fighter planes would deter the bomber. These three are complementary and are intended to keep the bomber very high from where it could bomb only at random.

It serves London and other British cities as part of the defence against air raids. There may be 500 to 1,000 balloons around the city of London, and the system has been extended to ports and harbours and other important areas in England and Scotland. Bombing planes will always endeavour, if they can to unload their deadly cargoes on specific targets, and these would naturally be what are called the vulnerable spots. The chance of success in such aiming is obviously greatest when the bomber can get close; if he cannot fly low, his aim must be erratic. He can drop his bombs from any height and get some destructive result somewhere, but while he flies high he has to take "pot luck." More than that he is in his greatest danger when he flies high and cannot swoop, dive and dodge.



If the Air Staff thinks highly of the efficacy of the balloon barrage, there are others who hold that the balloon barrage is an over-rated protection—who point out that cutting edge planes are being experimented in Germany. Recent events have confirmed their belief. Royal Air Force bombers successfully dodged through the wires and bombed railway lines in Germany. And Nazi pilots have shot down the balloons in flame and attacked the targets.

All authorities therefore agree that so long as other nations possess aeroplanes, no defensive force whatever can prevent some getting through the defence, and doing an amount of damage which might settle the issue of the next war by simply putting the nation at the beginning *hors de combat.*[1]

## EVACUATION

The throwing open of Paris to the invader, the British Schemes for sending their children to America and the great importance attached to the evacuation of civilian population from large cities threatened by the air arm, sufficiently indicate that both Governments and people now recognise this truth. Warsaw, Helsinki, Oslo and other cities evacuated as many civilian population as they could on the eve of attack. From London and other centres over a million and a half, children, mothers and hospital patients were removed to less vulnerable zones in Great Britain, within a week in September last. In France a plan for evacuation was prepared even in 1931. It was the first step Marshall Petain took when he was appointed Inspector-General of Aerial Defence.

The aim of evacuation is to remove from the more dangerous and congested areas to less dangerous areas of certain groups of people whose removal is desirable on both national and humanitarian grounds. Although this may not save city structures it would reduce risk to life and is indispensable to cities liable to air attack.

Experience however shows that even this partial relief is difficult to obtain however perfect the scheme may be and if it is successful it gives birth to serious disadvantages.[2]

1. Norman Angel p. 59.

2. The following account is based upon the Home Office circulars, information published in the "Times" London, the "Manchester Guardian," the "Hindu" and the Reports of the Association of Architects, Surveyors and Technical Assistants, the Fabian Society and the A.R.P. Co-ordinating Committee. Also on Robson (Vide ante) and A. D. K. Owen, the "Great Evacuation," in the Political Quarterly, Jan.-March, 1940, pp. 30—44.

"On its personal side, evacuation results in the destruction of family life on an unprecedented scale; the separation of parents from children and of husbands from wives. On its commercial side, it leads to an exodus of banks, insurance offices and other undertakings to unsuitable country mansions which must inevitably have detrimental economic consequences. In regard to the dispersal of Government offices it has led to a great outcry from hotel proprietors whose premises have been requisitioned."

Evacuation cannot succeed and wherever it does it is highly disadvantageous. This is the lesson which the English experiment that costs £36,000 a day, teaches us !

The classes of persons included in the British Evacuation Scheme are:—

1. School children and the teachers and helpers who would be required to continue the education of the children and to assist in caring for them;

2. Children of pre-school age accompanied by their mothers or other persons responsible for looking after them.

3. Expectant mothers.

4. Adult blind persons.

The country is divided into areas of three types, sending, receiving, and neutral areas, the last being areas which though not themselves to be evacuated are not regarded as suitable for reception purposes. Evacuation is voluntary. The main source of accommodation in the receiving area is the occupied house. Hutted camps, come next. "Since any plan capable of immediate operation has to be based predominantly on the use of occupied houses, it is to the best methods of utilising this provision, the attention of local authorities have been directed."

The scheme has been planned in great detail. It includes estimates of total population in the different kinds of areas, arrangements in sending areas which cover appointment of evacuation officers, publicity, estimates of the number of persons desiring evacuation, registration of evacuable persons, provision to include teachers, efforts to secure helpers to supervise the children and the necessary arrangements for physically or mentally defective children, children in hospitals, expectant mothers and blind persons; they also include the necessary arrangements for assembling, transporting and feeding during the process. Arrangements in receiving areas cover the appointment of assistant reception officers, billeting officers, transport beyond detrained stations, billeting arrangements for children accompanied or unaccompanied by other members, registration of evacuated persons, increased supply of food to the areas, arrangements in Post Office for payment etc.; for education, recreation and equipment of children, for medical nursing provision, for hospital facilities, and welfare work.

Persons who are evacuated should take with them "a gas mask, a change of underclothing, night clothes, house-shoes or rubber shoes, spare stockings or socks, a toothbrush, comb, towel and handkerchiefs, a warm coat or mackintosh, and packet of food for the day." When a mother is evacuated along with her children or sends another woman to look after them, lodging only will be provided for the adult and for the children. In such cases therefore, adults should make arrangements where possible to obtain money for their own and the children's maintenance from their husbands or from the parents or guardians of the children concerned.[1]

The Government recognise that a considerable number of evacuated persons will not be able to provide all the articles on the list. No obligation is imposed on the householder to remedy the deficiencies of this kind. The billeting officer will look after this and will provide them by getting money from their parents or from other sources. Adult evacuated persons without means and whose husbands cannot send them money will be financed

1. Home Office Circular, D. P. Memorandum E.V.S. 3.

by the Ministry of Labour. The majority of blind persons evacuated would be in receipt of domiciliary financial assistance, and local authorities of the sending areas would pay them. Medical attendance cost for evacuated children etc. would be borne by Government and not by the householder.

The Government pays to householders at the rate of 10s. 6d. a week where one child is taken and 8s. 6d. a week for each child where more than one child is taken. Payment is made weekly in advance. These payments are intended to cover full board, lodging and all care necessary to give the child a home. The payments are not intended to cover the cost of clothes or medical expenses, which the receiver is under no obligation to meet.

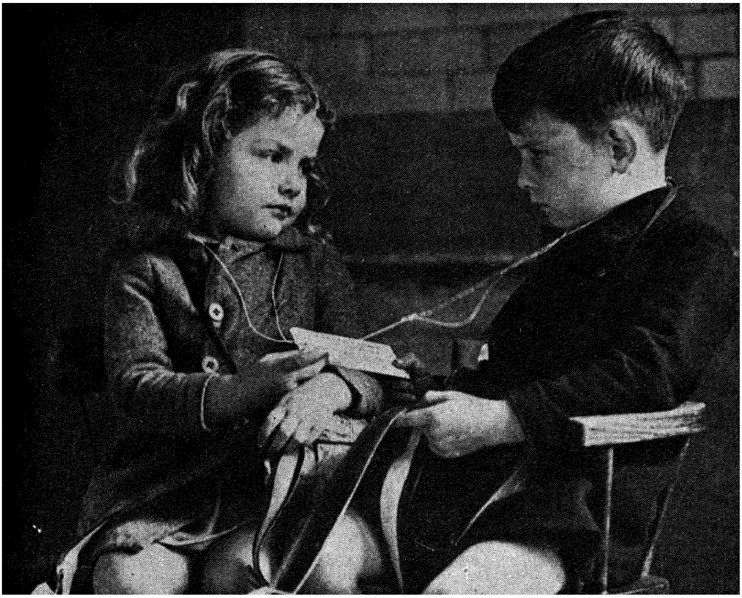
The children bring hand luggage and their gas masks, a change of underclothing, night clothes, house shoes or rubber shoes, spare stockings or socks, a toothbrush, comb, towel and handkerchiefs, and a warm coat or mackintosh. If a child is without sufficient clothes or some essential piece of equipment, the Billeting Officer or other local official should be notified.

If the child becomes ill the doctor or the district nurse would be called in the ordinary way and the cost of medical attention will be borne by Government.

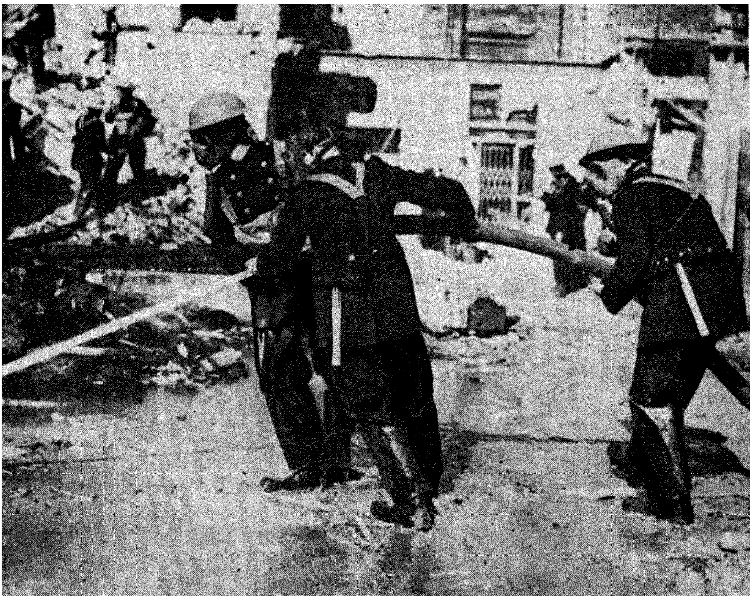
Mothers of children under school age may accompany their children. A mother may sometimes send another woman to take her place. The mothers or the women taking the place of mothers will be entirely responsible for looking after the children.

Payments are made at the rate of 5s. a week for each adult or child over 14 and 3s. a week for each child under 14. Payment is made weekly in advance.

These payments cover shelter and access to water and sanitary accommodation and no other services. Cooking facilities may be made available by the householders. The mothers and other adults who come with



**London children with destination label for evacuation.**



**A fire fighting party in action.**

the younger children would be given an identification form which will enable them if they have no means of their own, to apply for financial assistance at the Ministry of Labour's office. They will therefore be in a position to provide themselves with food and other necessaries.

In July, 1938, a Committee of the House of Commons recommended that schemes of evacuation covering the main industrial centres of the country should be worked out and the necessary organisation set up. The September crisis however necessitated an emergency scheme for the evacuation of London school children.

After the emergency had passed, preparations for working out a detailed scheme were resumed at a more leisurely pace. "Evacuation," "neutral" and "reception" areas were defined according to the estimated degree of risk in different parts of the country and plans were made for the transference of certain priority classes—rather more than 3 million school children, mothers and young children, expectant mothers, and blind and crippled people—from the "evacuation" areas to the "reception" areas. Early in 1939 a detailed survey of accommodation in the reception areas was undertaken with the help of the local authorities and a large army of voluntary workers. As a result of this survey billets for over 4 million official evacuees were discovered in addition to which it was noted that about a million billets had been earmarked for private evacuation. In response to a widely expressed demand, a modest scheme was introduced whereby 50 camps, suitable for holiday and evacuation purposes were to be constructed by two state-aided non-profit-making concerns. (The National Camps Corporation in England and Wales and the Scottish Housing Association in Scotland). Detailed arrangements were made for the registration of those who wished to take advantage of the scheme; the distribution of evacuees among the various reception areas etc. "The organisation of the evacuation scheme will probably be recognised as one of the most remarkable achievements of the British Civil Service."

During the first week-end of September, in the shadow of the breaking storm, the great movement took place. The first surprise came early. The numbers coming forward to be evacuated under the official scheme were unexpectedly low. Less than half of those for whom billets had been promised went away.

"Newcastle-on-Tyne sent away 80 per cent. of its school children and Gateshead, across the river, sent away 60 per cent. But two equally vulnerable towns on the East Coast, Sunderland and Middlesborough, sent away only 33 per cent. and 29 per cent. respectively of their evacuable school children. Leeds sent away only 26 per cent. of its school children, Bradford only 31 per cent., and Sheffield (one of the most obvious target areas in the country) a derisory 17 per cent. In the Midlands, Derby sent away 46 per cent. of its 'evacuable' school children, but Birmingham evacuated only a quarter of those who were eligible. Of course there was a certain amount of private evacuation outside the official scheme."

This kind of response is largely due to,

1. Uncertainty concerning the financial aspects of evacuation—financial difficulties and fear that a divided household would upset their precariously balanced domestic budgets.

2. Unwillingness of mothers of young children to be separated from their husbands.

3. Inability to pay for clothing to children.

4. The difficulty of separation. 38 per cent. of the parents interviewed by the Liverpool University Investigators in the course of their illuminating survey, gave as a reason for refusing to allow their children to go away, that one or other of the parents could not bear the separation.

At the reception end, barring the minor difficulties of grumbling and occasional refusal owing to wrong delivery, stubbornness of mothers to part from their children, "much more serious problems arose when rural Britain woke up to the fact that the personal hygiene of a considerable section of the urban population of these islands is anything but exemplary." In some places cleansing stations were improvised at central points, after the experience of the first day, but the chief burden fell upon the householders.

Before the end of the first fortnight of evacuation it was evident that a considerable drift home from the reception areas was in progress. The expected air raids had not taken place. The drift back was most noticeable in the case of mothers with young children. Why ?

"Even when they were not unhappy in their billets the strain of separation from their husbands, loneliness, nostalgia for familiar sights and sounds, financial anxieties, and a sense of 'not belonging' as it was sometimes put, led numbers to return. Unsatisfactory accommodation in outhouses, empty buildings, attics and cellars, resulted in the return of some more, and there were many other cases, where the accommodation itself was excellent, but where incompatibility of temperament of social habits led to friction with the hostess and an eventual break."

"A much smaller proportion returned among the unaccompanied children, though in the aggregate their numbers appear considerable. Principally due to the unsettling effects of parents' visits; failure to understand the terms of the Government proposals for billeting expenses; unhappiness due to billeting misfits created by difference in social class, religion etc. and general characteristics of the evacuees and the householders; absence of institutional provision for the inevitable 'problem cases' of all kinds.

"In spite of all the work which has been devoted to it and the sacrifices which have been made, the fact remains that very few mothers, and probably less than a third of the school population of the evacuation areas, are now away from home," wrote an experienced observer before last Christmas and predicted that levels would get lower by the time his article was published.

Day by day the defects of sudden evacuation are becoming apparent. It is expensive to Government; inconvenient to householders who receive evacuees, and difficult for the family forced to send away the mother or child. The head of the family in vulnerable areas is forced to fend for himself in the absence of the housewife. The break up of the home ideal, has drawn such attention that a deputation of the parents of evacuated mothers protested to Government. The evacuees are not happy in their new homes, as is evidenced from many stories, some amusing and others pathetic, told of them. The early reactions in many cases were favourable to children but soon many have got bored with their new surroundings as expressed by one youngster who after a week on a farm said he "would rather see it on the pictures."[1]

The set-back to education is perhaps the greatest disadvantage to the children of the present generation. "The children who have been evacuated and who are now receiving less than their normal dose of instruction are the most considerable of war victims of England. An investigation lately carried out in Rochdale shows the exact degree of deterioration among children whose school hours have been reduced and the result is sufficiently alarming to make all education committees want to reopen all their schools on a normal full-time basis in the hope that lost ground may be recovered. That wish cannot, however, be fulfilled so long as the Government holds that evacuation is necessary and that children must not be sent back to their homes. In evacuation areas "owing to the requisitioning of many schools and the absence of adequate air raid protection for most of the others, more than half the children of school age in these areas have been without normal education since before the summer holidays," and it is matter of deep concern that a whole generation of school children should be suffering such irreparable loss. The dangers of ignorance and indiscipline, it is pointed out

1. Illustrated Weekly of India, Jan. 21, 1940, p. 11.

are more serious than the risk of being killed or maimed by enemy bomb."

Evacuees also bring problems with them to the householders who receive them. Their lot is hard with unacquainted guests with different tastes and tempers. Some of them are confronted with "verminous slum children who do not know how to eat with knife and fork and who had the most dreadful parents, who visit them now and then in expensive motor cars." Unsuspected differences between town and country have brought trouble to the householders. Some of them are difficult to feed. Others show no inclination to lend a helping hand in the house even if they happen to be in their twenties and in Government employment. "Worse still they are not punctual at meals, and remember it is an offence against some law or other not to provide these people with a hot evening meal. If the weekly £1 a head which is paid for billetees of this kind covered expenses much might be forgiven. But it does not. Luckily some of the maiden ladies who have most felt the strain are being permitted to shunt their lodgers to other quarters."

An additional difficulty has arisen from the faulty distribution of food and articles of consumption. Though admirable the scheme of Government for evacuation, "it is difficult for instance to buy China tea in part of the country, though there seems to be no real shortage of it in London. Prices again vary enormously. Country folk buying bacon at 1s. 4d. a pound exclaim with horror at the idea of Londoners paying a shilling a pound more at some of the West End Stores."

With the rising price level Government payment has become insufficient. "It is proved that the housewife is out of pocket by every child she houses. 8s. 6d. a head is not enough: 12s. 6d. would be nearer the mark." This is due to the rising price level in the area, and the menus to which the family is accustomed for different menus cannot be prepared. The patriotic housewife has not a bed to spare to any relation or friend for a day. The whole woman power of the countryside in reception areas continues to be dissipated and its goodwill discouraged by house to house billeting.

As a result even before winter problems have arisen the London teachers in many areas failed in their objective; thousands of children have been called back by their parents, country children have been frozen out, and the children of the middle and the upper classes have been left as war victims, without educational facilities, and robbed the attention they might expect from their overworked mothers . . . . Many housewives have reached a point of exasperation which is near apathy. Meanwhile they are tied perpetually to their houses, slaving for evacuees, the parents of these evacuees come down on them like bees every week-end in organised "luxury cruises" of massed relations and friends and are quite prepared to spend £3 on such week-end jaunts, which unsettle their children and lead to entreaties to be allowed to return to London.

Day after day the local press publishes accounts of the many difficulties that crop up in the working of the scheme.

Enquiries and studies carried out by Technical Associations support the prevailing popular feeling.[1] The Special Committee of the Association of Architects, Surveyors and Technical Assistants, the Fabian Society and the A.R.P. Co-ordinating Committee have discovered in dumping strangers from cities into rural households the biggest cause for the failure of the evacuation scheme.

"The greatest single cause of failure is the well-nigh intolerable discomfort and inconvenience caused by the virtually complete reliance on household billeting (camp schools accommodate only 1 per cent. of evacuable school children)" observes the Memorandum recently submitted by the A.R.P. Co-ordinating Committee to the Minister of Health, to remedy the failure of the Government

1. A.A.S.T.A. Report on Evacuation. The report of the Fabian Society.

scheme. For "some 84 per cent. of those whom it was originally proposed to evacuate are now in the danger areas, and even under the fresh scheme this figure will be in excess of 78 per cent."

Whatever might be the cause of failure, the English experiment has made it clear that evacuation is difficult however thorough may be the scheme and however much willing the people and Government may be. But there is not much to choose between failure or success because the latter leads to grave consequences to the individual, the family and the nation, the inconvenience to householders, the difficulty to the evacuees, the break up of family life, and the loss of education.

"Husbands have been parted from wives, children from parents. Domestic privacy has been invaded. Urban and rural ways of life have been brought into sharp conflict. Class barriers have been not so much broken down, as ignored, often with heartening, but sometimes with unfortunate, results. The education system has been reduced temporarily to a shamble and a great strain has been placed upon local government authorities in areas which have received a great influx of population."

From the point of view of air defence, the task is not apparently lightened, unless a very large section evacuate. But this may prove more dangerous to city structures particularly if large scale incendiary bomb attack is made, immediate attention which is necessary to deal with them may not be available for evacuees' homes.

### Obscuration of Light

If evacuation schemes are organised with the aim of reducing the risk to civilian life and limb, drastic lighting restrictions are attempted with the intention of reducing the risk of destruction to cities. A night raid is particularly disastrous and difficult to resist and lights are useful pointers to the night bombers. Black-out as it is otherwise called came into vogue when Zeppelins began their raids over London in the last war.

The aim is to secure that as far as is practicable, hostile aircraft passing over the country at night would see no light which might serve to guide them to a particular objective or assist them to determine their position.[1] The restriction accordingly impose general darkening as a permanent condition from the outbreak of war. Drastic lighting restrictions now form an important feature of the precautionary measures taken as a form of security against air attacks.

They cover,

1. The masking of all windows and skylights and doors at night, of all occupied premises to prevent light inside from being visible from outside, and the prohibition of external light.

2. The prohibition of all illuminated advertisements and signs except those for A.R.P. purposes.

3. The screening of all windows and skylights from factory buildings with dark blinds or paints.

4. The elimination of normal street lighting although means for aiding movement in darkened streets by reflectors, white markings, or dim, well-screened indicator lights which cast no appreciable illumination, are permitted to mark the line of the road and also obstructions and danger points.

5. The control of lighting for essential services where absolutely necessary.

6. The restriction of lights carried by road vehicles and the screening of interior lighting in public vehicles.

7. The restriction of lighting in trains and on railway premises.

8. The control of shipping, navigation, and aircraft lights.

1. Home Office A.R.P. Circular 14th Feb., 1938. Memorandum on lighting restriction.

Without legislative compulsion it is impossible to do all these, and obscuration of light is therefore included in the Civil Defence Act of Great Britain.

Street lighting is vigorously controlled, lighting from shop windows and residences must be obscured by opaque shutters or black-out paints. Motor cars must use side lights only and trains are also run with as little light as possible. Their head lights must be closed when they approach any metropolis so as to make its position less obvious.

Tests have been carried out, and in July one of the biggest in Southern England was attempted. It was a complete black-out of fifteen counties, an area of sixteen thousand square miles, including a long coast line dotted with seaside resorts packed with holiday-makers.

The experiment cost the Government £15,000[1] and prolonged enforcement will cost much more. To factory owners too it has entailed expense, not inconsiderable when all of them are taken together. To many pedestrians it has cost them life and limb and to many more it has brought gloom and depression, and the risk of law breakers and to passengers in trains the prospect of collision.

All this is evident from the experience of Great Britain during the first six months of this war. Many people were killed and injured.

Road deaths more than doubled in the first month of its operation; 1,130 persons were killed in accidents in Great Britain in September 1939 compared with 672 in August 1939.[2] Petrol has since been rationed and speed limit has been more stringently controlled. Still hundreds of people were killed. October claimed 919 victims in the roads of Great Britain and November 1939, 926, while in November 1938, only 613 died. For September, October and November 1939, black-out deaths alone have

1. The "Hindu," Aug. 11, 1939.
2. Statistics of Road accidents published in the "Hindu." The battle of the Black Out, the "Hindu," Oct. 29, 1939.

been reckoned to total 674. 895 people were killed in December last. This is 212 more than those killed in December of the previous year. Official figures show that 1,155 were killed on roads during December compared to 683 during the year before. The total is considered highest on record for any single month, black-out contributing 895.

During the period September 1 to December 31st last namely the first four months of the war 4,133 persons, including 2,657 pedestrians, died from road accidents, compared with 2,494 in the corresponding period for 1938. In January 1940, 619 persons lost their lives on roads of whom 461 were killed in the hours of darkness. An increase of 134 or some 28 per cent. over the figures of January 1939. Twenty miles speed limit has been imposed from 1st February. A decrease has been registered for the month of February, 419 deaths, which mean 44 less than in February last year. The reasons given are, the 20 miles speed limit; the publicity campaign for greater care; the snow and ice which reduced traffic during the earlier part of February, and rationing of petrol; features upon which we can not always count for road safety.

The problem of fast moving trains is more serious. Apart from the possiblity of fast moving vehicles getting into accidents by bombed and shattered railway lines, there is the danger of collision. Train accidents have enormously increased in Germany after the advent of the black-out. They have also occurred in England. The first officially reported train accident happened at Bletchley. It cost only four lives and four carriages but it is a sufficiently grave sample.

The inconvenience and anxiety caused to road users is enormous and the interesting experiments made by individuals to escape road accidents indicate the anxiety of the public. Some have adopted white collars, hat bands, belts, umbrellas etc. to make them easily discernible by the motorist. Some cyclists put on white stripes to their coat backs for the same reason. And lonely townspeople evacuated to the country keep dogs to guide them at night.

The damage to health is also mentioned and it is pointed out that sudden switching off of light might lead to panic and normally avoidable accidents. For the eye takes some time to adjust itself to marked changes in light. In some factories black-out arrangements have resulted in shutting away daylight through the windows with consequences easily imaginable.

The depressing feeling which enshrouding darkness creates upon the minds of the old and the young should also be reckoned, while the increased scope for certain classes of criminals who are helped by darkness is really deplorable. Statistical evidence have not been made available, but the risk may become practical when black-out conditions get settled.

Strict enforcement entails not a little expense. The experiment held in August last year covering over half of England on an area of 27,000 sq. miles came to £150,000. In the Metropolitan area of London alone 20,000 police special constables and war reserve officers had to be engaged !

It also leads to hardship. During the first three months in Manchester "1,060 have been charged with offences against the Lighting Restriction Order and almost all of the number have been fined."[1]

These are the disadvantages in time of peace, but others may crop up during actual raids. Complete black-out will necessitate more number of shelters in the interests of accessibility and the additional cost on this account would not be small. Further this will hinder the efficient functioning of A.R.P. services during a night raid, and an instance is already on record that fire during black-out cannot be immediately and successfully dealt with. The risk of parachute troops dropping down from enemy planes should also be taken into consideration.

1. Illustrated Weekly of India, Jan. 21, 1940, p. 11.

Will the advantages accruing from a black-out compensate these ? Only experience can show. Although illuminated targets are more readily recognisable, experience indicates that their absence is not sufficient guarantee. On bright moonlight days the black-out has little protective value. Trained pilots can feel their way even in utter darkness. Night raids were common in Spain and China, and in Finland too the Soviet bombers were not deterred by darkness. Large congested cities where random bombing is as destructive as carefully aimed attack, black-out cannot help much. Finally the intelligent use of flares by raiders greatly reduces the efficacy of black-out.

## CAMOUFLAGE

If the black-out is designed to escape the enemy at night, camouflage is intended to deceive the airmen during day. The purpose of camouflage is to make the bombing of a specific target as difficult as possible; that is to say, either to force the enemy to bomb an area rather than a particular target, so wasting bombs, or to cause delay to the bombers over the area, thus giving a better chance to the defence.[1] Anything which makes the task of identification harder is worthwhile, for raiding bombers would have to travel a considerable distance over country that is unfamiliar. The Home Office believes that it is worthwhile attempting camouflage for targets "even if it is associated with a river or railway which may act as a pointer."

It is recommended for factories, nerve centres, aeroplanes and aerodromes, water courses, ammunition dumps, machine-gun positions and even to pets. Motor vehicles were painted white in Helsinki to harmonise

1. A.R.P.H. 11: Camouflage of Large Installations.

Vide, report of an informal discussion on the subject of camouflage published in the November issue of Air Raid Protection Institute, extracts in "The Builder," Dec. 1, 1939, p. 769.

Col. F. G. Wyatt's lecture on Camouflage, delivered to the Institution of Civil Engineers—Extracts in "Builder," June 16, 1939, p. 1,139.

Myerscough Walker—The Camoufleur and his craft. The "Builder," Sept. 22 and 29 and Oct. 6, 1939.

them with snow and passengers in public vehicles were instructed to carry white sheets to cover themselves in the event of a raid, for Russian airmen would swoop down and machine-gun pedestrians and vehicles in the street.

Although camouflage may be any measure that makes the object less readily recognisable, the term is generally associated with those measures adopted for large targets and buildings. The need for camouflage is thus explained. The bombers are in a hurry particularly when they fly low below the clouds to get a continuous and correct view of the target. For example at a height of 6,000 feet and range of five miles per hour, the angle of vision is 30 degrees (the bomb aimer's angle of vision to the target). In this hurry over un-familiar country under harassing conditions anything done to make the target less conspicuous is of advantage. We should realise that the observer in the aeroplane finally depends on his own vision although their exact location is known from air photographs.

"In order to carry out regular bombing of a target it is necessary to recognise it at a distance of several miles. Supposing he is flying at 10,000 ft., the bomb will take 25 seconds to reach the ground. Now the speed of a modern bomber is usually 200 to 240 miles an hour. Taking the higher speed, the plane travels one mile in 15 seconds, and would be nearly two miles off the target when the bomber releases the bomb. The operations all take time, so the bomber must be able to spot the target at a distance of four miles from it. If he is less than that distance away his bombs will drop beyond the target."

"The expanse of view from an aeroplane gives a vast area of country to be searched in order to find the target. A bomber looking for a factory, and not knowing whether the plane is pointing dead at the factory or not, travelling 240 miles an hour, may find himself over the target before realising it. All we need do in camouflage is to make the buildings look as innocent as possible—that is to say, as much like the surrounding country."

This is not a simple task. Successfully dealing with the factors that show the target off the surroundings is extremely difficult and sometimes impossible. Especially in the case of factories, four factors contribute to make them appear different from their surroundings when looked at from the air.

1. The large homogeneous expanses of roof, with their ploughed field aspect due to shadows in the valleys of the roofs; that effect is particularly noticeable in the case of northlight roofs.

2. The shine from roofs caused by the reflection of light from smooth surfaces; that effect is particularly noticeable when the observer is looking towards the sun.

3. The bulk; an example is the existence of large gas-holders.

4. The regularity of shadow and silhouette; that is specially prominent in the case of oil tanks or petrol depots.

The last effect is probably the most difficult of all to obliterate, and the problem has not been solved completely. There are in addition, certain other problems of which no solution appears to be possible; for example immense bulk (such as a compact covering of an area of perhaps a square mile) where a factory is so large that it might be almost said to have no surroundings. An enormous factory is so big that it has practically no surroundings at all, and it is a waste of paint to do anything to it. Smoke is a fantastic expense for such a large area and wind will blow it away.

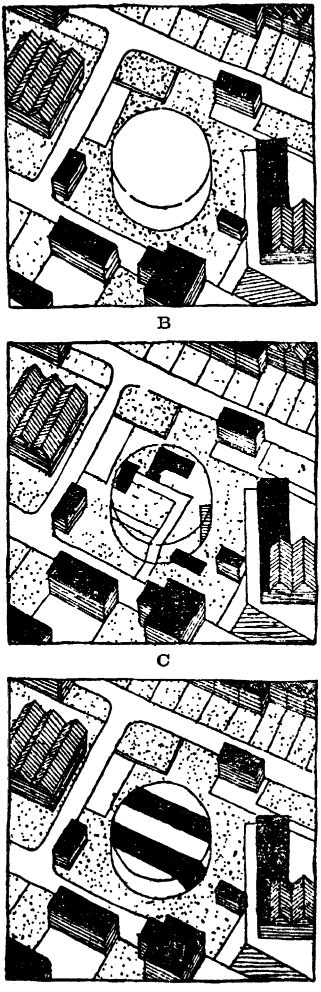
The two recognised ways of camouflaging a target are,

1. Imitation of the surroundings, be they rural or urban,

2. Disruption or distortion of the form of the building, in order to make it unrecognisable or inconspicuous.

A combination of protective colouration and disruption is also advised where necessary.

A
B
C



(*a*) A large gas holder in an industrial area.
(*b*) Imitative patterns drawn over, to merge it in the surroundings.
(*c*) Bold patterns drawn over it to cause disruption.

By suitable painting it might be possible to make quite a large building look like a meadow from one aspect and in one light, but the illusion would disappear when the building was seen from another aspect or in another light, although the meadow may look the same in both cases. The reason is that while the structure is three dimensional, the ground is more nearly two dimensional. The Home Office of Great Britain, therefore, recognise this difficulty. They point out;

Imitation of purely rural surroundings is difficult because the variations of light and shade on the roof slopes of the building itself are greater than those of the ground; the tones of the ground remain more or less constant except for the shadow cast by the building, while the tones of the building are continually changing.

Another difficulty is the selection of material suitable for merging the target in the neighbourhood. Paints should be durable and at the same time should have a mat finish to avoid tendency to shine, two characteristics that are considered almost incompatible.

Disruption focusses the attention of the observer to something to the exclusion of all else. Animals carry patterns of boldly contrasting colours, one of which attracts the eye of the observer with the result that the form of the animal is disrupted and becomes unrecognisable. The chief difficulty is one of cost and the Home Office does not recommend artificial distortion of the shape of a building by means of attaching shaped excrescences, although sound in principle, for the following reasons. In order to be effective they must be large—for not only must they be visible from a distance of several miles but also they must bear a reasonable proportion to the building to which they are attached. "The fixing of such excrescences so as to withstand weather is not a simple matter." A pattern in order to be seen from a disrupted point of view have to be something like 15 ft. to 20 ft. in its least dimension. It is not practicable to distort the buildings by shaped excrescences, since they have to be so big.

An object 18 in. high could be seen a mile off if the light in the background was favourable but it has to be about four or five times bigger if it was to attract attention. We should also remember that camouflaging roads by colouring is not possible. There is no known method of colouring existing concrete roads permanently; as the wear and tear of traffic may necessitate frequent renewal, it will often happen that painting will not be carried out till necessary. Bituminous emulsions are cheap, easy to apply, and proof against adverse weather occurring shortly after application. This seems most suitable but would absorb mustard gas, and complicate the situation. Most of the range required in camouflage are curiously enough covered by bituminous paint.

If these difficulties are overcome and targets made difficult to recognise, safety cannot be assured when they are situated in large crowded cities where random bombing will equally repay. In crowded surroundings the efficacy of camouflage is greatly reduced. The air camera is extremely sensitive and deception at all times is impossible. The chances of escape are further reduced when large squadrons raid a city.

That all these measures are necessary to cities as they are, and that they do help to render the task of the bomber more difficult no one can deny. But for the fighter squadrons, ground defences and schemes of evacuation, etc. English cities cannot resist the bombers as they do now. But the fact that even in spite of these Ramsgate and Coventry lie in ruins like many parts of Germany sufficiently indicate the inadequacy of these measures to obtain air security. Recent declarations that the problem of dealing with night bombers is yet to be solved establishes the truth contained in the memorable warning of Stanley Baldwin, "the bomber will always get through." If cities and civilization should be saved from destruction, it is therefore necessary that measures are devised which would resist the weapons used in air raids and protect people and their property.

# CHAPTER III

## PROTECTION TO PEOPLE

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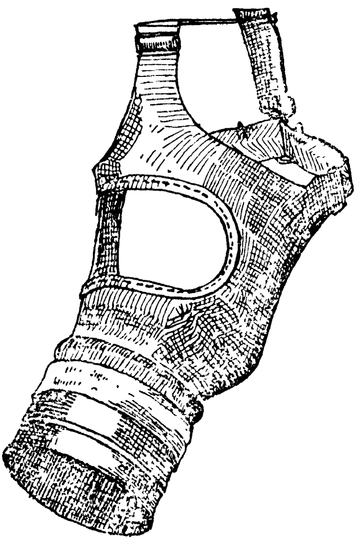
## PROTECTION TO PEOPLE

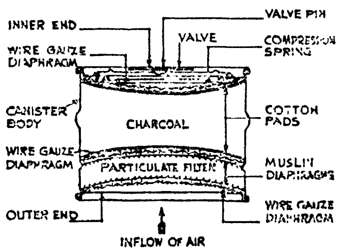
It is evident from the previous Chapter, that if inhabitants of vulnerable areas should survive a carefully engineered air attack, measures should be devised to protect them from, poison gas vapour and liquid; fire and its consequences to city structures; shock, splinters, blast, as well as the demolition of buildings and falling masonry caused by the high explosive bomb. In addition they should be saved from the falling fragments of anti-aircraft shells. In an intense air-raid most of these would happen simultaneously.

### GAS PROTECTION

Protection against gas has been considered essential and respirators have been distributed free by the State



Civilian Respirator.




Civilian Respirator Container.

to all the people in the vulnerable zones of Great Britain. This however does not mean that the "mask" will protect them against gas attack. This is clear from its function and form. A respirator consists of a rubber facepiece with a transparent window, and a container which holds the gas filters. If properly put on, it protects the eyes, nose, mouth and lungs; and ensures a supply of pure air for breathing, by means of filters which are able to absorb any gas known to be capable of being used in war.

It offers no protection against ordinary domestic coal gas or carbon monoxide. It does not protect other parts of the body from poison gas vapour and liquid. It can be effective for about 4 hours only in contaminated atmosphere. At best it can be regarded only as second line of defence.

Anti-gas clothing no doubt covers the whole body, since it consists of a jacket, trousers, hood, gloves and boots. But mustard gas liquid can penetrate the best materials of which anti-gas suitings are made. In hot weather it can offer immunity for four hours when new, and for three hours when used and decontaminated by boiling. It is also inconvenient to resort to that protection, for the non-porous nature of this oilskin material causes the heat and perspiration from the body to be retained inside the clothing. In hot weather the amount of manual work that a person wearing oilskins can accomplish is consequently limited owing to fatigue and exhaustion.

Owing to the exhaustion caused by the heavy anti-gas suits they should not be worn unless the circumstances make it essential. Where adequate ventilation can be arranged to avoid dangerous concentrations of vapour, so that the only danger is from touching contaminated objects, the lesser forms of protection may be adequate and will cause much less reduction in efficiency. If work has to be carried on in a confined space with heavy vapour contamination present, necessitating the wearing of the complete outfit with hood, it is probable that only three spells of from half an hour to an hour could be performed during each 24 hours. This depends on the temperature. In cold weather, or in less severe concentrations which do not necessitate the wearing of the hood, men might be able to work for three spells of

Service respirator and Civilian gas masks.

Complete contra-contamination suits.

two hours. The protection against blister gas vapour afforded by the heavy anti-gas suit is of limited duration, owing to the suction effect produced by movement. The inside of such suits should therefore be ventilated at regular intervals by opening the coat and letting down the trousers in an atmosphere free from blister gas vapour.

Satisfactory protection is possible only by getting into gas-proof rooms and refuges, large enough to keep the inhabitants comfortable for long hours. This is now realised and gas-proof shelters are built and wherever practicable gas-proof accommodation is improvised in the home. In essence "gas-proofing" a chamber entails the sealing up of all the openings and crevices, and making it air-tight, and providing its entrance with suitable devices to facilitate entry and exit. Usually this consists of a gas curtain of heavy material carefully attached to the door, the frame being lined with felt or similar material.

That gas-proofing rooms in a tiled house is impracticable will be readily realised, but even with terraced houses ill-fitting doors and windows would create difficulties. The problem is further complicated by the intense heat of the tropics. Granting these difficulties are overcome, safety is not assured, since the incendiary and high explosive bombs can destroy them together with the inmates. For no normal residence and building can stand the high explosive, and, most cannot resist the incendiary. If the people who reside in vulnerable areas are to be assured protection of life and limb it is essential that they must be provided with accommodation, proof to gas, incendiary and high explosive bomb. This has been realised and bomb-proof shelters have been built both by governments and by factory owners.

### Bomb Resisting Accommodation

Such accommodation has been improvised in the underground tunnels of Barcelona for 1½ million people, by the Spanish Government. The Austin Motor Factory in England, has a bomb-proof shelter deep underground for its 10,000 employees.

Built at a cost of £25,000, it is no less than a huge subterranean tunnel system excavated out of sandstone rock and conforms to a standard semi-circular design with a floor width of 16 ft. 9 in. and a height of 9 ft. being reinforced with steel arches and steel sheeting. Their average depth will be 55 ft. below the surface and with access through the gently inclined adits, it will be possible for full occupation to be effected in a few minutes after receiving an air raid warning. The tunnels would have a length of 1,000 yds. providing sitting accommodation for half the number of occupants. The air inlets situated 18 feet above a very high ground which it is anticipated will be clear of any surface concentrations of gas, will provide efficient ventilation, and the entrance and exit adits are provided with air locks. Drinking water supplies, rest and first-aid rooms, lavatories and all essential amenities are included in this scheme which also will combine auxiliary generating sets in case of failure of mains, current supplies and loud-speaker equipment throughout the system for broadcasting instructions, music and news items to those taking shelter. It has been estimated that this involved the excavation and removal of 18,000 tons of sandstone.[1]

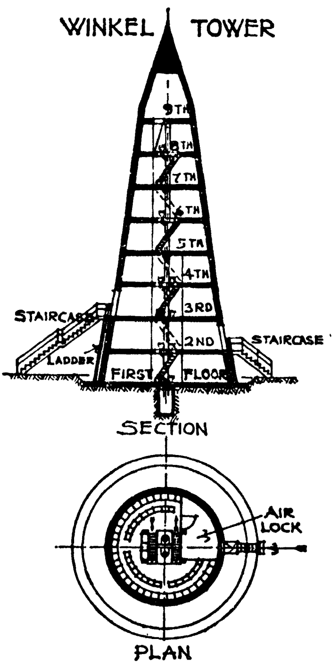
Conical and parabolic shelters above ground have been built to a limited extent on the Continent which are intended to avoid impact by offering the least possible surface normal to the surface of the shelter. Their unit cost is high.

Bomb-proof surface shelters have been erected in Valencia. Such shelters accommodate from 250 to 1,250 persons, and are provided with sandwich roofs either domed or flat. The flat roof has steel and concrete protection in addition to a 2-in. concrete slab, two 3-in.

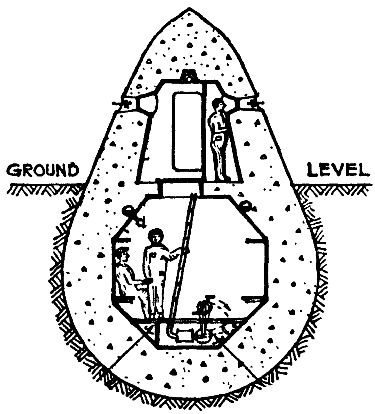
1. The "Builder."

layers of sand and a 5-ft. slab of concrete. The shelters are mechanically ventilated with electric power and have emergency dynamo equipment.

The Winkel Tower named after its German designer is also above the surface and conical in shape. This is intended to deflect bombs and prevent penetration. 'For that reason the outer walls have only to resist the effects of detonation, but have to be of constant thickness for the full height of the tower. It is also claimed that even heavy bombs exploding near or under the foot of the tower cannot imperil the stability of the structure. The Winkel Tower has been standardised . . . in four sizes, with a capacity of 400 people for the largest and 168 for the smallest'.




The Maginot Line contains large underground chambers absolutely proof to all known weapons of air attack. The pressure inside is kept higher and excludes the possibility of poison gases entering in.



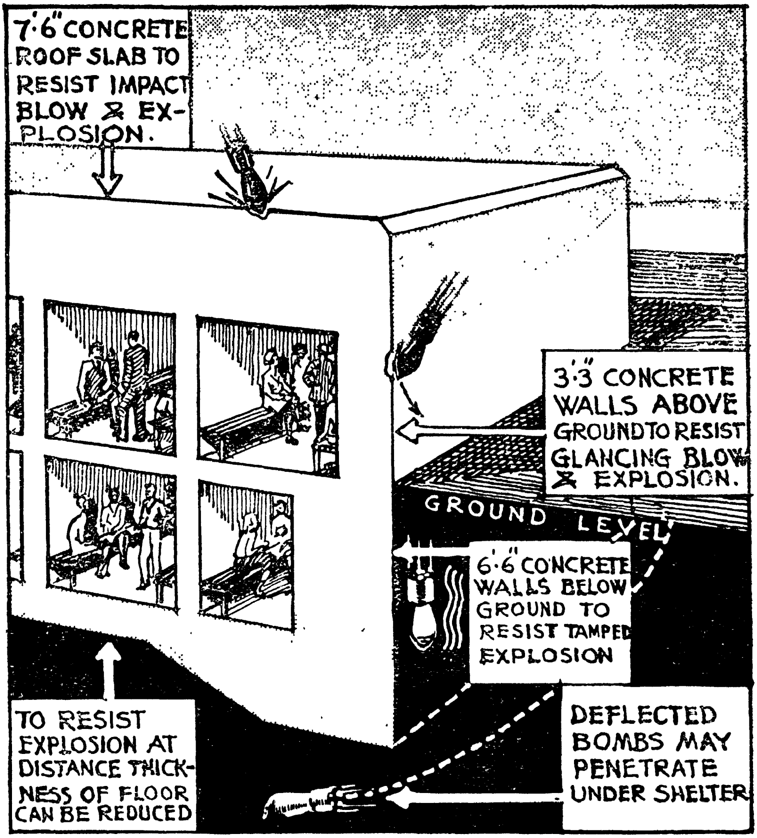

SCHINDLER STRONGHOLD

Equipped with kitchen, store, sanitary conveniences and efficient lighting, telephone, etc., they are spacious enough even for parade. The towers of the Maginot Line weigh some 120 tons, are monolithic and no shell can penetrate the concrete wall. On the other frontier are equally formidable structures comprising about 12,000 steel and concrete forts extending from Holland to Switzerland. Some of them are built deeply into the hill side and some are in open territory, massive concrete towers with conical roof intended to deflect the bombs.

Such massive structures designed with great care are essential, because, experience and research have disclosed that structures less massive and strong can not resist the impact, penetration, explosion, blast, earthquake effect and splinters of the deadly high explosive bombs now used in aerial attack. The medium size high explosive bomb can penetrate 5 feet of reinforced concrete, can attack the side as well as the floor of a structure by glancing blow and tamped explosion respectively. Protection worth the name should resist all these[1] and technical experts and leading institutions therefore strongly plead for erecting bomb-proof structures for protection. Even the Government of Great Britain which pins its faith in blast and splinter proof shelters for every home has been forced to focus its attention upon this question. From the suggestions made by the expert committee appointed by the Home Office Air Raid Precautions department to "prepare design methods and type designs for protection of varying degrees, against the high explosive bomb," it is clear that to assure protection to people from the effects of a 500 lb. high explosive bomb the shelter must be built with roofs, walls, and floors of the thickness indicated in the adjoining diagram.

1. Two instances of direct hits on air raid shelters by bombs comes from Finland. It is reported only a miracle saved the inmates from the Russian bomb. A bomb struck the air raid shelter in which the Swedish Foreign Minister M. Sandler took cover during his recent visit to Finland, with a number of other people and shortly after the raid began a bomb hit the shelter causing the pillars to collapse. He played a leading part in exhorting the people to keep calm. (The "Hindu" 23-1-1940). Eleven war planes flew over Abo on January 20, and dropped bombs from 16,000 feet. Several bombs fell on a maternity home some penetrating the air raid shelters. Mothers carrying the new-born babies, escaped miraculously by climbing a covered staircase. (The "Hindu" 22-1-1940).

These designs are based upon the shelters being divided into compartments with not more than 200 persons in each compartment. The shelters designed

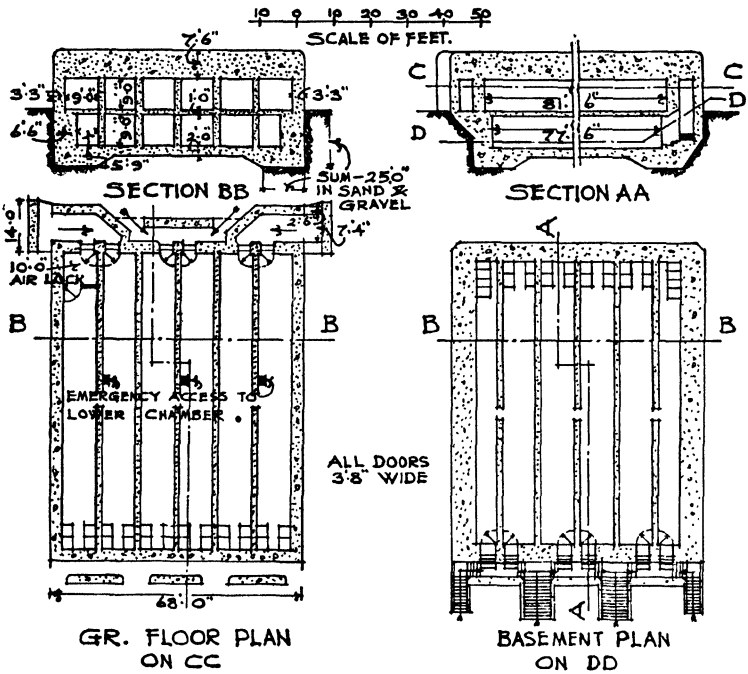



Detailed perspective view of the shelter recommended to afford protection against direct or near hits by heavy bombs, by the Design Panel set up at the request of the Home Office by the Institute of Civil Engineers.[1]

consist essentially of two storey structures of a box form, either rectangular or circular formed of reinforced

1. Mere blast and splinter proof shelters "give none of that kind of assurance and sense of security that are the real basis of civilian morale when the bombing is heavy and eccentric. The former official position to deep underground shelters is now seen to have been stupid, if not wanton, and although the authorities have constructed an enormous number of fairly reliable brick street surface shelters to supplement the individual house 'Anderson Shelter,' there still exists no

concrete and placed generally half above and half below ground, easy access to the basement storey being obtained by means of staircases. Shelters placed at a considerable depth below ground were not considered in any detail, although it was realised that there should not be any great difficulty in designing them to provide degrees of protection similar to those afforded by the recommended designs.




Bomb Resisting Shelter for 1,200 persons recommended by the Institute of Civil Engineers.

To meet the combined effects of direct impact, disruptive force of explosion and spalling effect on the inner surface, of a 500 lb. heavy case bomb striking at

confidence in those areas of crowded population where the people have seen half a block of ramshackle dwellings blasted into rubble by one bomb." Practically every newspaper is now demanding the provision of shelters that can offer complete protection. Because it is known that they cannot be built quickly, the public are now resorting to the subterranean railway tubes and stations as refuges, although official opinion did not relish the idea. (The London Correspondent, The "Hindu," November, 21, 1940).

its maximum velocity, the thickness of the concrete recommended is 7 ft. 6 in. for the roof (5 feet only for medium case bombs of 500 lb. and for heavier bombs with lighter case) 3 ft. 3 in. for walls above ground, and 6 ft. 6 in. below ground; 6 ft. 6 in. for the base except in large shelters, where under certain conditions the thickness could be progressively reduced to 2 ft. 6 in.[1]

This overhead cover of concrete of special quality adequately reinforced 5 ft. and 7 ft. 6 inches thick respectively, for the medium and heavy case bomb of 500 lb. should preferably be a single slab. The one providing an air space between is difficult and costly. If an air space of not less than three feet in depth were provided above a roof slab 1 foot 6 inches thick, the thickness of the main slab might be reduced by 1 foot. But the possibility of using such a protective covering in two thicknesses has been given up mainly for the above reasons.

Even those who feel that surface type of shelters with a sandwich type of roof protection is necessary to save the inmates from the shock wave effect of an explosion recognise a further difficulty.

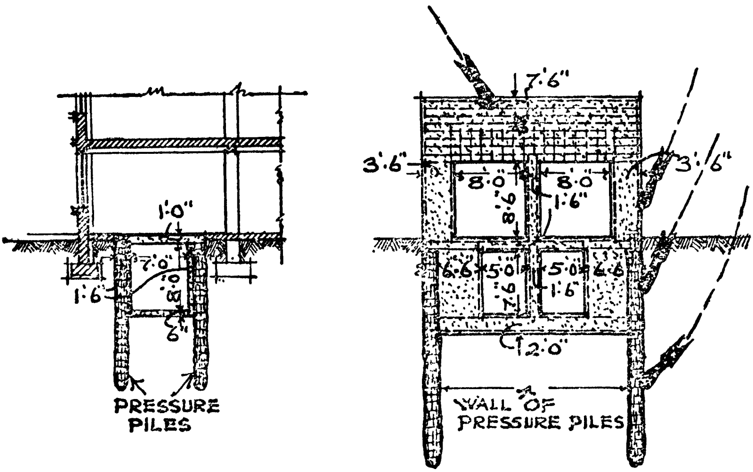
If the Bomb should penerate right through the upper detonating slab and into the pocket before exploding, the tamping effect of thus confining the explosion between the two layers may have very greatly exaggerated effects upon the shelter structure beneath. Methods of providing against this danger by sectionalising the detonating slab do not appear to be satisfactory, mainly because the sections would be considerably less likely to withstand the penetrating effect of the bomb than a continuous slab.

Owing to the oblique angle of impact with a vertical surface the thickness of vertical walls is largely governed by the explosive effect of the bomb, instead of the total impact and explosive effect. For lateral protection over ground, concrete of special quality, adequately reinforced, 3 feet 3 inches thick is required.

1. See A.R.P.H.5a "Bomb Resisting Shelters."

If the explosion occurs at or above ground level and on the surface of the protective wall, the explosion is untamped and the effect considerably less than if the bomb explodes below ground or after penetration of the concrete slab. Wall thickness below ground must therefore be greater than above ground, owing to the tamping effect of the soil when a bomb explodes near the surface of the wall below ground. Since the bomb is unlikely to penetrate the wall it is unnecessary to apply the value for the radius of rupture in concrete corresponding to the explosion of a charge well tamped within the surface of the concrete. The appropriate degree of lateral protection below ground is offered by concrete of special quality, adequately reinforced 6 feet 6 inches thick. Where the clear span between adequate buttresses is not more than 10 feet or where in a circular shelter the internal diameter is not more than 30 feet, the wall thickness below ground level may be reduced to 5 feet 6 inches.

Owing to the considerable depth of penetration of




BOMB-PROOF SHELTERS.

With pressure piles used as an alternative.

medium-case bombs into the ground and the possibility of a bomb pursuing a curved path through the ground, it is necessary to provide for the contingency of a bomb exploding under the base of the shelter except at points well within the periphery of the vertical walls. The standard thickness of base protection should be five feet.

It is important to remember that the soffit must be lined. In order to prevent spalling the lower surface of the roof slab should be faced with steel plate not less than 3/16 inch thick, which should be anchored not less than 12 inches into the mass of the slab. Alternatively a close mesh reinforcement, attached to the lowest layer of ¾ inch reinforcing bars, may be used to prevent spalling. The width of the mesh should not exceed 1½ inches, and its weight should be not less than 3¾ lb. per yard super. A similar protection is also required for the inner face of the external wall in addition to the normal reinforcement.

Since the use of exceptionally heavy bombs may wipe out the whole of the occupants of the shelter it is necessary that shelters with a roof slab 5 feet thick should not accommodate more than 400 persons, those with 7 feet 6 inches, preferably not more than 1,200 persons. The internal partition wall should not be less than 18 inches thick in reinforced concrete and shall be provided between each group of 200 persons.

## Shelter Equipment

It is estimated that the cost per person for the rectangular shelter for 200 persons would be about £25 9s. and about £21 8s. per person for the larger shelter for 1,200 people. Massive construction alone is not sufficient to assure "safety". Sanitation and equipment are equally important. Insufficient ventilation, and inadequate equipment can do as much harm as a bomb. Shelters must present as small a target area as possible; they must be as dispersed as we could afford, not to invite special attention from bombers; they must be properly ventilated and equipped with proper entrances and doors, lighting and sanitation.

Regarding the target area we should remember that it is not necessarily the same as the floor space required for inmates. The target area can be cut down by arranging the shelter in two or three tiers or by halving the floor space by installing higher capacity ventilating plant.

Secondly, lest we should invite special attention and attempt of the bomber to a particular area, dispersal is necessary. No very great distance between shelters is required but they should be not less than 25 feet clear between external walls below ground level of adjacent shelters. Where more than 1,200 persons have to be accommodated and the construction of separate shelters is not practicable, the case should receive special attention.

The third factor in safety is ventilation and this is complicated by the necessity to make the shelters gas tight. "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 all walls backed by earth, other walls not less than 8½ in. thick, floor and ceiling or roof.

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.

In the case of a shelter 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;

| Period of occupation. | Unventilated gas tight shelters—total surface area required, per person. | Mechanically ventilated shelters. | |
|---|---|---|---|
| | | Total surface area required per person if shelter is ventilated at the rate given opposite in column 4. | Ventilation rate per person. |
| 1. | 2. | 3. | 4. |
| 3 hours. | 75 square feet | 30 Square feet if shelter is above ground. | 450 C. ft. per hour. |
| | | 40 Square feet if shelter is above ground, or 20 square feet, if the shelter is underground. | 150 C. ft. per hour. |
| 12 hours. | 100 square feet | 50 square feet if shelter is above ground, or 25 square feet, if the shelter is underground. | 450 C. ft. per hour. |

Vide A.R.P.H. 5, p. 43.

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 all walls backed by earth, other walls not less than 8½ in. thick, floor and ceiling or roof.

The adjoining table summarises the requirements prescribed by the Home Office of Great Britain.

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

"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."[1]

"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 body 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

1. "Air Raid Shelters for persons Working in Factories, Mines and Commercial Buildings." Revised Code. August, 1939. Home Office Statutory Rules and Orders, 1939, No. 920. Also Memorandum on the Revised Code "Air Raid Shelters for Persons, etc."

absorption capacity of the walls, floor and roof of a shelter is an important factor in the determination of the permissible accommodation. 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.

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.[1] 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.

With the increase in the air strength of nations waves after waves of raiders coming in succession has become a possibility. For instance during the close of

1. An air-lock is simply two gas-proof doors or curtains 4 feet or more apart, with a space between them sealed like a refuge-room. Persons can then pass through without admitting gas, provided they close the first door or curtain when they are inside the air-lock before opening the second. An air-lock at the door of a communal refuge-room or at main outer door or in a corridor used frequently is a great advantage

January 1940, when the Russian air force raided Central and Southern Finland "Large sections of the population have been forced to spend many hours in air raid shelters." Helsinki had six air raid warnings during one day, forcing civilians into shelters for several hours. Several births and deaths took place in them. High officials have been forced to stay in shelters for long hours in China. A shelter will have to be very much larger to accommodate a given number of persons if there is no provision for mechanical ventilation and considering the enormous cost the latter is to be preferred. The advantages claimed for it are:

1. It reduces the size of shelters to one quarter of what it would be if unventilated.
2. Constructional costs are proportionately reduced.
3. Vulnerability to explosion and gas is lessened.
4. They make shelters an economic possibility.
5. They will help to combat panic, because plenty of fresh air for the occupants will help to relieve the strain on nerves; also, more people can be accommodated in well-ventilated shelter.

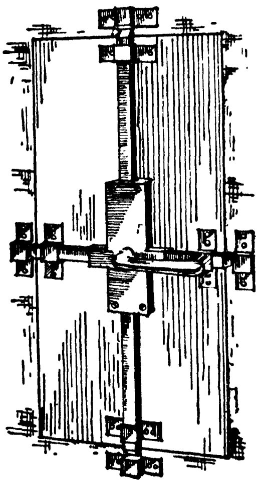
Shelters are kept in a comfortable livable condition for an unlimited period for any required number of persons by ventilating plants.

The basic principle of these gas filtration and ventilation sets for shelters depends upon the use of small compact apparatus consisting of a fancasing of special design, and connecting steel duct. In the casing the activated carbon is packed, along perhaps with other material such as porous paper and the fan sucks in air from the outside, contaminated with gas, which is then passed through the apparatus and the poisons absorbed, the purified air being discharged into the shelter, which has an outlet to the atmosphere fitted with a non-return valve. They are also provided with a small electric fan and there is also large crank handles, so that if the electricity is cut off during an air raid then the fan can still be worked by one or two people inside the shelter.

The latter is also provided with refrigerator type of door constructed of wood and having rubber tubing fixed all round, laid in grooves, so that when the door is shut with refrigerator handles the rubber makes an absolutely gas-tight joint.

The principle adopted in gas filtration plant is the same as that used in gas mask. Activated carbon combined to some extent with special varieties of porous paper is used. The former is a variety of almost pure carbon somewhat resembling charcoal but enormously increased in absorbent reactivity for a wide range of gases and vapours. There are a large number of varieties of activated carbon made in different countries. But the details are supposed to be more or less a secret. Their minute cells almost atomic in size, actually liquefy the gas and retain it in the liquid condition, and until methods are discovered to make possible the use of poisonous gas that cannot be easily liquefied, such as carbon monoxide, these plants might be useful.

Blast, splinter and gas-proof doors are required to render shelters safe and steel is the material generally recommended both for doors and shutters. Gas-proof steel doors equipped with clamping handles or double operated bolts for operation on both sides can efficiently resist blast and splinters. An observation window is provided. Window shutters are similarly provided and steel plates of desired thickness is used to overcome structural difficulties by manufacturers specialising in pressed steel plates. The principle underlying safety lies in heavy four way bolts to wedge them at four points, as shown in the adjoining illustration. The key hole is also covered outside preventing insertion of key or entry of gas into the

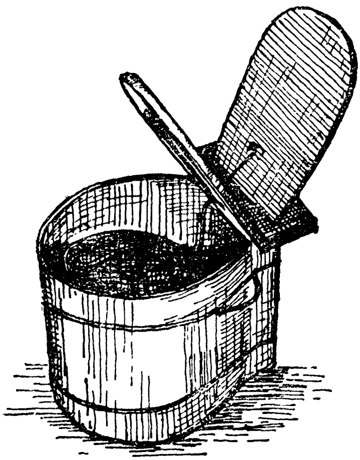


Blast, Splinter and Gasproof Shelter Door.

shelter. Strong lever handles operate latch bolt and when engaged the door is tightly drawn into frame. The thickness of the steel plate varies from $\frac{5}{8}$ of an inch to $\frac{1}{8}$ of an inch according to the degree of protection required.

Some of their features are patented but in essence conform to the Home Office Specifications of height and breadth, the provision of a gas tight spyhole and a gas tight frame. (Doors calculated to resist direct hits are not commonly sold in the market.) A popular model, consists of solid framed and laminated red cedar, made fire resistant. The fastenings are heavy refrigerator type and the door is gas proof by rubberised linen. Thermite-proof panel or steel-sheet is fitted to face. Gas proof observation panel of double reinforced glass bedded in rubber is provided. The price ranges from 87 shillings.

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 extending the whole height of the shelter. Here again the need for gas proofing leads to complications. The usual varieties do not suffice. The type considered most suitable depends upon the use of chemicals to deal with deposits and decomposition. The chemicals supplied along with the



A typical chemical closet.

set sold by manufacturers immediately deals with deposits and decomposes them. An anti-splash tray is fitted and is automatically flushed. A separate container is also provided to enable refuse to be easily removed. They remain perfectly hygienic independent of outside drainage which would be vulnerable to air attack. The sewage disposal is postponed without risk of odour or infection. A closet for 20 persons occupies 1½ square feet and for 30 persons 2 square feet. These chemical closets which fulfil the needs of A.R.P. sanitation, for women as well as for men, range in price from 50 to 60 shillings. It is claimed that maintenance cost is extremely low.

There is also the problem of drainage especially for shelters with decontamination units. Pumping out the water is necessary, if shelters are sunk below ground level. As this is not convenient, deep underground shelters are not recommended.

"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."

"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."

The question of shelter lighting has received ample attention and the British Standards Institution have prepared their specification at the request of the Home Office. The point stressed however is to ensure emergency lighting by a standby equipment to be worked by man power when electricity fails by bombing to come up into operation upon partial or mains failure.

To protect against gas and to help decontamination as far as possible walls, particularly the lower 6 feet should be finished with impervious material which can be washed and decontaminated. Very few materials comply with this recommendation and at the same time are proof against acids, gases and the like used in modern chemical warfare. Mustard gas, phosgene, lewisite, chlorine or hydrocyanic gas readily attack building material containing lime, especially cement and plasters, which readily disintegrate in their presence. Slate is recommended as the most economical material and it also gives structural stability for it is almost free from calcium in the form of lime in chemical composition. Other measures are also recommended. Non-absorbing paints are suggested for painting shelter walls.

To make shelters efficient particularly when they are large, first-aid rooms, cleansing facilities and even kitchen would become necessary and such provision has been made in some of the shelters in Europe. Recent air raids over England demonstrate that people might be forced into shelters for long periods sometimes compelling them to sleep in them.

All these are necessary to ensure safety to inmates and make their stay possible. It is therefore considered that large shelters alone are advisable.

A careful study of the relative advantages of the large communal type of shelters and the small domestic shelter reveal that large ones are considerably more economical than dispersed shelters and therefore even the same expenditure per head will make possible a much higher standard of protection.

They can be readily provided with lighting, sanitary conveniences and furniture, and existence in them can be made reasonably comfortable.

More important than all these is this consideration namely, in the most vulnerable areas, viz. the centres of large towns and cities, for a large proportion of the population, it is not possible to provide any of the various "dispersed" or "family" shelters. This is, in the main, due to lack of sufficient space immediately adjoining each house, although flooding and unsuitability of site generally are contributory factors.

Finally as the A.R.P. Co-ordinating Committee points out, large communal shelters can be built in two stages; immediately blast and splinter proof and strengthened later to resist direct hits. It thus solves the problem of combining an immediate and long time policy for partial and absolute protection.[1]

## Shelter Economy

Those who defend the policy of blast proof shelters for every home point out that these are expensive and impracticable. This is based on the assumption that during peace they are useless.

The shelter for 3,500 persons erected in Birmingham[2] and the proposals made elsewhere disprove this assumption. A large air raid shelter in a busy area, convertible into a garage, solves both the problem of congestion and finance. A peace time use can make expensive shelters economic and the Birmingham example is illuminating. This local authority made arrangements for the adaptation in the plan stage of an underground car park—for 260 cars—under the new St. Martin's Toll Market. In the space of a few minutes the car park can be converted into an air raid shelter capable of accommodating 3,500 persons.

1. For details of the scheme see extracts in "The Builder," Dec. 22, 1939, pp. 852—854.

2. Birmingham Underground Car Park Scheme. J. T. P. I. Dec. 1938, pp. 75—76.

The entire scheme, including the market hall, underground car park, air raid shelter, and a two and three-storey building for shops is of reinforced concrete.

A total floor area of 5,800 sq. yds. has been planned for the car park, which will be 250 ft. long and 209 ft. wide. Entrance and exit are by inclined ramps on opposite sides 10 ft. wide, with a gradient of 1 in 9. They connect the car park to the new road by a tunnel running underneath the street. Emergency exits are provided for use in case of fire or as entrances when the building is used for air-raid precautions.

Reinforced concrete walls, 3 ft. thick, divide the park into five sections, and arrangements have been made further to divide each compartment into two sub-sections in emergency—this will be effected by the erection of sandbag barriers 6 ft. thick, thus providing ten separate self-contained compartments 100 ft. long and 47 ft. wide, each of which will accommodate 350 persons.

The reinforced concrete walls to the basement of the market hall are increased to 2 ft. 6 in. in thickness, and the roof of the car park, which is the floor of the market hall, is divided into reinforced concrete panels 10 in. thick, these panels are expected to provide protection against incendiary, and small high-explosive bombs. The system of division into ten compartments ensures, in the event of direct hit, that the number of casualties will be reduced to minimum—it is emphasised that it is not sought entirely to prevent the roof being penetrated by heavy bombs, but rather to localise their effect should they reach the basement.

A ventilation system is provided for, to extract car fumes at ground level and supply fresh air, while movable screens are provided to isolate cases of fire, and the concrete floor grooved and sloped to aid escaping petrol. In time of war the ventilating system would be reversed to maintain a slight pressure of air inside the shelter.

It is expected that the erection of the building will aid the reduction of traffic congestion in Birmingham by taking 260 cars off the city streets. These cars will be parked under a system which will obviate the handling by attendants, while movements of vehicles will be facilitated by placing the columns of the building 37 ft. 6 in. apart, giving a depth to the wall of 16 ft. on either side. Central gangways are 15 ft. wide, and a system of one way traffic will operate, cars being parked within sections denoted by white lines marked on the floor.

Total estimated cost of the air raid shelter and car park is £48,000 of which £7,000 has been allocated for the adaptation of the car park for air-raid precautions, with a possible further £6,000 for air-filtration plant.

A convertible car park and air raid shelter has also been suggested under the Russel Square in Holborne.[1] Another useful variety is the multi-storey garage triangular in shape. Some idea could be had from the plans prepared by the joint effort of well-known experts in their particular subject. This will serve as a modern up-to-date garage in peace time, and could be converted on the possibility of war into an Air Raid Shelter, Decontamination Unit and First-Aid Clearing Station. It could be erected on a site chosen as a detached building and if possible of a shape to avoid right-angles.[2]

It is a ferro-concrete structure throughout, including the external walls, the external walls themselves also to be faced with 4 in. stone supported by the concrete construction with 2 in. hollow space forming an air cushion behind the stone as provision against blast.

The floors are arranged to make it possible for ramps to be used as a means of access from floor to floor. In addition, there is a central stair-case and a lift. The whole of the inside of the building is left with bare concrete to be distempered and the structure throughout will be of the most economical kind except that special

1. For plans and sections see the "Builder," Jan. 6, 1939, p. 9.
2. The "Builder" A. R. P. Supplement—Feb. 24, 1939, p. XVI.

provision is made by means of properly constructed steel shutters, so that all windows and openings can immediately be sealed against attack.

Of necessity provision must be made for additional electric and other services, which would be essential for war conditions.

To provide quickly for the building to be divided into several units in war time, special metal divisions and shutters should be provided and housed in the basement until required.

In case of any breakdown in the electric services a standby electrical installation is necessary.

Lock up shops could be provided where there would be a demand.

The roof is specially designed to resist the small bomb and incendiary bomb.

The upper floors, in case of a raid are to be used as the air-raid shelter, and provision is made for sanitary services, also kitchens.

The ground floor and the basement floor will be used for the decontamination Unit and the First-Aid Unit. The Decontamination Unit is complete in itself with separate access to First-Aid Unit and the shelter above.

Apart from the Decontamination Unit there is a separate entrance on the ground floor for those going to the shelters on the upper floors, and separate entrance on the other side of the building for the cases arriving for the First-Aid Unit. In this unit the male cases are dealt with on the ground floor and female cases in the basement. In the basement, in addition, two 20-bed wards are provided, one for male and one for female, with services and nurses' quarters. Both in the male and female First-Aid section is provided a small operation unit with anaesthetic room, theatre and sterilising room; the whole building will be air-conditioned by means of plant placed on the roof, adequately protected.

To residential zones where convertible garages are neither necessary nor paying, community centre capable of conversion into air raid shelter during emergency has been suggested.[1] The primary purpose of the building is to be a centre suitable for use by the various bodies engaged in social work, musical and operatic societies and local gymnastic and physical training clubs. It would also provide accommodation for the local voluntary fire brigade and also committee rooms which are for use of local bodies for various purposes. The organisation to be built up for A.R.P. purposes could usefully be housed in the same building as an A.R.P. centre and first-aid post without involving any structural alteration.

The structure may be of ferro-concrete frame and roof faced with brick. The roof must be flat, with parapets on all sides to facilitate protection by sandbags when the necessity arises.

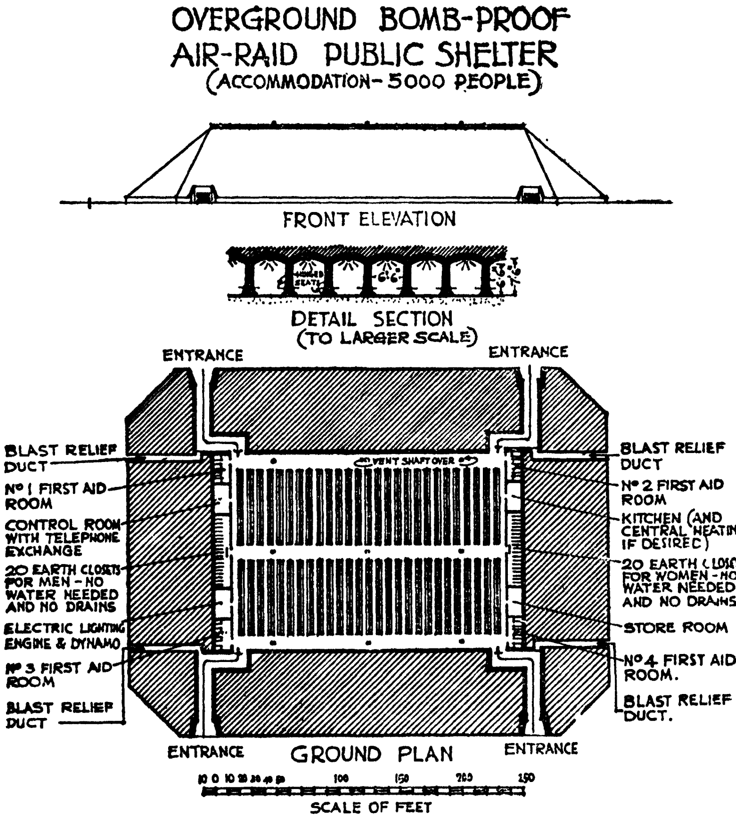
Further people could accustom themselves to the idea that in times of crisis this is the building to which they should apply for advice, instruction and possible treatment.

It is considered that the psychological effect of this permanent provision of such facilities should be very valuable.

The plan for an overground bomb-proof air raid shelter given on the next page needs careful consideration. With suitable modifications it would ideally serve residential areas in any properly zoned and laid Indian city. It is entirely above ground, with no stairs, no flood risk, no interference with any underground sewers or pipes. It has scope for ample natural ventilation and unobstructed and ample entrances at all four corners on

1. *Ibid.* p. 16—20.

the ground level. Built of common bricks in lime mortar with reinforced arches and lime washed inside with a solid earth cover 20 feet thick it is on a 2½ acre site which includes spaces for terraces of flats on the four fronts of the grassed mound.[1]




This would offer accommodation for 5,000 people. The cost estimated in England is £5 per head and it would be less in our country. The internal arrangement consists of separate tunnels interconnected by three transverse tunnels. Where the density of population is 100 persons per acre, each shelter would serve 50 acres or

1. See "Builder" Supplement, March 24, 1939, p. 26 for Ground Plan and Elevation; Supplement, May 26, 1939, p. 35 for perspective view and details.

a rectangle of 1,524 ft. × 1,434 ft. The distance from extreme boundary of area served by each shelter to shelter itself will be 191 yds. and it could be reached in approximately 2 minutes. 'The 5,000 people on a 50 acre site can all reach the shelter within two minutes.' Kitchen, store room, power room, control room, etc., are all possible. The two and half acre site permits the addition of 48 good shops (or garage accommodation for 400 motor cars, all on ground level) with 96 good flats above; and as the top of the one acre mound could be used as a communal playground this feature would be very attractive to tenants. It is considered that building societies would find them attractive and paying.

### Location and Accessibility

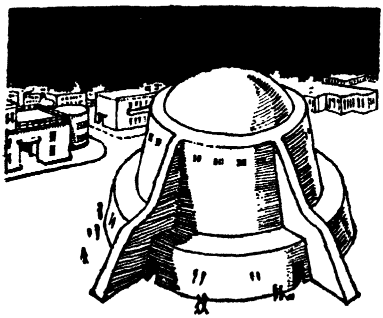
Thoughtfully located garages and carefully laid out community centres capable of conversion into air raid shelters would successfully meet the other argument that large communal shelters are not accessible and streams of people running towards it would be caught in a raid and perish. The Home Office prescribes:

> 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 from the place where they work get into their shelter within seven minutes.

Further every large air raid shelter 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.

The question of accessibility leads to the problem of adequacy. For, to be accessible to all the citizens there must be enough shelters. Further, unless a reasonably high proportion of the people can get into these, before bombing begins, a frightened population may crowd the streets and cause panic while masses of shrapnel and pieces of anti-aircraft shells begin to fall seriously hindering fire engines and ambulances from fulfilling their necessary duties. The authorities will have to face a double task of looking after the bodies and minds of the survivors as well as salvaging the devasted areas. In the main streets of Barcelona a shelter is said to be available at every 200 yds. which must have contributed largely to the civilian resistance. And again they must be known and be familiar to the public. In Germany adequate precautions are taken to familarise the citizens with their location, by permanent signs and notices and this is necessary especially if air raids happen at night.

Protection to people is possible only by massive structures that could resist the high explosive, the incendiary bomb and poison gas. Considerations of safety leads to large initial outlay but proper design can render such schemes economic and practicable. But adequate numbers should be there to make them accessible. The lay-out of modern cities require too many to provide this facility for all inhabitants. Crowded and congested areas would not only make their erection impossible but access difficult. With business, commerce and residences mixed together without zoning more numbers would be needed for the population than we must build if they were properly distributed. To economise in the number of shelters it is possible only if business houses and residences surround dual purpose air raid shelters. An altered lay-out zoning and planning of residential suburbs are necessary to make protection possible to all. The problem is therefore complementary to Town Planning, for this alone can meet the objection put forth against communal shelters by the advocates of partial protection, namely all cannot use them and have access to them.



Bombproof shelter in a Residential zone.

# CHAPTER IV

## RESISTANCE OF STRUCTURES

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## RESISTANCE OF STRUCTURES

A successful scheme of bomb-proof shelters would protect the people from air raids but life in the city would be impossible if the buildings that provide accommodation for living and work are rendered unfit for use, when they emerge from their shelters after a raid. If urban communities should stand a raid, city structures should be in a position to resist and recover from the weapons used. That is, they should be blast and splinter-proof; immune to earthquake effect and the dangers of demolition arising from the high explosive bomb; they should resist penetration and fire of incendiary bombs; as well as contamination from liquid gas. If this is not possible they must at least be capable of being rendered fit for use without great effort and expense. In short they must be in a position to recover from the blow easily. This should be considered more practical for from Chapter I it would be evident that total resistance is impossible until we cover the entire city with a reinforced concrete roof 7 ft. 6 in. thick and enclose it by walls half that thickness. Absolute protection is uneconomic, but a fair measure of security could be obtained if city structures are so designed and located as to

1. Render contamination of poison gas difficult and decontamination easy,
2. Prevent the penetration of the kilo incendiary bomb and prevent or minimise the spread of fires caused by them,
3. Prevent more than superficial damage to buildings by the high explosive bomb of 500 lb. weight.[1]

1. T. E. Scott, "Structural Precautions in New and Existing Buildings." The "Builder" April 21, 1939, p. 744.

Preventing contamination is impossible since building materials commonly used absorb liquid gas and a heavy spray or bomb explosion will bring the liquid in contact with them and even vapour would be absorbed though explosion may happen at a distance. As we cannot avoid brick, lime, concrete, and wood in our buildings the best remedy lies in designing the structures in such a way as to secure natural ventilation to prevent concentration of vapour and to facilitate washing them down thoroughly.

### RESISTANCE TO GAS[1]

The interior should be as simple in design as possible. Mouldings, unnecessary fittings, etc., should be avoided. At least lower portions of the room should be constructed of smooth surfaced non-absorbent materials which can be readily washed and decontaminated.

Good ventilation is necessary to clear away concentration of gas, and particular care must be taken.

Flooring materials should be non-absorbent to blister gases and be capable of decontamination by the normal methods. Concrete with a granolithic or cement finish, and periodical treatment with sodium silicate solution is most suitable. Quarry tiles also provide a satisfactory material. But they should be set in cement mortar with a fine joint and treated as above. Unglazed tiles retain mustard gas. Rubber flooring should not be used as this material absorbs mustard gas. Flooring of an asphaltic or bituminous nature is also unsuitable.

Bare wooden floors, may be used but repeated decontamination will injure the timber, and preservatives and varnishes add no advantage.

Walls, as far as possible, particularly the lower six feet, should be finished with smooth surfaced impervious materials which can be washed and decontaminated. Glazed bricks or tiles of the best quality set in cement mortar with a fine joint are most satisfactory. Smooth

1. This section is based upon A.R.P.H.1, A.R.P.H.4 and other H.O. publications.

METHODS OF DECONTAMINATION FOR THE STRUCTURE OF BUILDINGS[1]

| Material. | Treatment for liquid contamination. |
|---|---|
| Stone or brickwork | Hose down with water if this can be done before the liquid has had time to soak in, but not otherwise. Spray or brush surface with cream of bleaching powder and water. Leave in contact as long as possible (not less than 24 hours). Repeat treatment. |
| Concrete floors and tiles | Hose with water. Apply bleaching powder and water cream and brush thoroughly over surface. Leave in contact for 6 hours. Hose with water. Apply sodium silicate solution, when available. Prolonged exposure to gross contamination may necessitate breaking up and re-laying floors in rooms which have to be inhabited. |
| Glazed tiles | Hose with water and treat with cream of bleaching powder and water. Give special attention to the joints. |
| Distempered walls | Paint or spray with paste of bleaching powder and water. Apply alternate layers of bleach paste and paper, and leave in position for at least 48 hours. Finally wash off |

1. A.R.P.H.4, Appendix C.

| Material. | Treatment for liquid contamination. |
|---|---|
| | and treat wall with fresh distemper or sodium silicate solution. |
| Papered walls | Strip off paper and then treat as for distempered walls. |
| Painted walls (wood or plaster) | If immediate treatment can be applied, treat as for distempered walls and finally repaint. If the contamination has been prolonged, remove the paint completely. |
| Wooden floors | Absorb visible liquid with fresh earth which should be burnt or buried. Scrub the surface with cream of bleaching powder and water, and sand. Leave bleaching powder in contact for 24 hours, then brush off and wash with water. Repeat treatment two or three times when necessary. Boards soaked in blister gas should be removed and burnt. |
| Unpainted woodwork | General treatment as for wooden floors. Hard wood articles and mouldings should first be swabbed with paraffin, and then treated with paste of bleaching powder and vaseline, which should be left in contact for a short period, and then wiped off, leaving a thin film on the surface. |

portland cement and sand as well as plaster finishes of either lime plaster or gypsum plaster as practised in this country form a satisfactory finish which is improved by periodical treatment with sodium silicate solution. Corrugated galvanised sheets could be used, fixed with the corrugations vertical, with the joints done with special care.

Fairfaced brick work where ordinary building bricks are used is unsatisfactory. Wall finishings of an asphaltic or bituminous nature should not be used.

Wall linings and panelling of match-boarding, plywood, fibre board or asbestos cement sheeting are unsuitable unless all joints are covered and the whole finished with a varnished paper or a resistant paint coating to eliminate joints and porosity.

Mouldings and panelling should be avoided, and the angles between the walls and floor should be coved either with tiles or cement; wood skirting should be avoided.

The use of paint is not desirable for ordinary paints are not satisfactory. The use of materials which require painting should be avoided as much as possible. Even hard drying enamel paint under repeated contamination may prove dangerous.

Fittings should be reduced to the minimum and should be of the simplest possible design and where practicable must be situated on the upper half of the walls so as to be out of the zone of heavier contamination. Doors should be of the flush type without moulding or panels, metal windows should be provided. Hard ebonite materials are not recommended as they absorb mustard gas. Bakelite or Beatel Scarab ware are most suitable for fittings. Glazed porcelain is also satisfactory and metal pipes and fittings may be used but should be treated with a suitable paint to prevent corrosion by bleaching powder.

It is evident from the methods suggested in the table in p. 115 that in addition to simplicity of design and construction and suitable materials, furniture and household goods should also be simple and few and of material easily washed and decontaminated. Upholstery, excessive bedding, carpets and rugs and wall paper and paint, are not suitable to resist mustard gas attack. But they are not needed in our country where climate is very kind. Simplicity is not inconsistent with comfort and furnishing our homes with furniture, utensils and vessels of the traditional type seems desirable if we should face this new danger.

Ventilation is as important as design for when properly secured it would almost completely eliminate the danger from the non-persistent gases. It would help evaporation and weathering in the case of persistent gases. But care in design alone cannot help because ventilation depends also upon the location, the neighbourhood, the layout of the roads, etc. The best design will fail to succeed when these are unsatisfactory. An open layout and a road system that would help the breeze to "blow through" the streets and homes is also necessary.

Decontamination involves copious use of water, and need for it would be aggravated by the demands of fire-fighting if simultaneously incendiary bomb attack is made. Adequate water supply should therefore be provided, but this is not enough. The washed water may carry contamination down the drain and wherever it spreads.

Care must be taken to ensure that the water can drain away satisfactorily to a place where it will not become a source of danger. It should not be allowed to flow into streams or ditches where the contamination might be carried to some place where it would be dangerous. If it flows into pools or ditches near at hand where it is considered that it can be allowed to remain, those pools or ditches should be marked as contaminated. Where there is nowhere for the water to flow away safely, the method of decontamination by hosing cannot be used, and alternative methods must be employed.

## Methods of Decontamination for Household Articles[1]

| Articles. | Treatment. |
|---|---|
| Furniture (hard woods)* | Swab thoroughly with paraffin, then give prolonged treatment (not less than 48 hours) with mixture of bleaching powder and vaseline. |
| Upholstery | All upholstery must be stripped from the wooden framework. In many cases it will probably be quicker and easier to destroy it by burning and replace with new material. When it is necessary to undertake decontamination, use the following methods:—<br><br>Woollen fabrics—immerse in boiling water for 1 hour.<br><br>Leather—expose for prolonged period in a current of hot air, but if heavily contaminated, it is safer to destroy by burning.<br><br>Padding—Hot air treatment may occasionally be applicable but in general it will be safer to burn. |
| Bedding | Treat as for clothing according to whether textile is wool or cotton. Mattresses may be treated in a steam disinfector. |

* Owing to possible danger from personal contact with furniture hasty decontamination should not be attempted.

1. Vide A.R.P.H.4 Appendix D.

| Articles. | Treatment. |
| --- | --- |
| Carpets, rugs, etc. | If lightly contaminated hang in open air to weather for 7 days in mild weather. and 14 days in colder weather. If wetted with blister gas, spray with soda solution before hanging out to air to prevent tendering of the fabric. If carpets are heavily contaminated they should be destroyed by burning unless arrangements can be made to immerse them in boiling water for 2 hours. |
| Linoleum | If in good condition and only the upper surface is contaminated, treat with bleach and water cream. If it is worn and the basic fabric is contaminated, it is safer to destroy by burning. |
| Metal fittings | Swab well with paraffin or petrol and rub dry with clean cloths. |
| China glass and earthen ware | Treat in boiling water or strong bleaching powder solution, or swab with paraffin or petrol, (swabbing not suitable for unglazed articles.) |

(Oiled fabrics may be used but as they should be boiled to free them from gas poison, it is better to avoid them.)

Adequate water supply and drainage facilities are both required to enable hosing down to be carried out. If a gas attack should be prevented from rendering our city structures and buildings unfit for use, their design and construction should be improved, their layout bettered, road system rationalised, and provision made for adequate water supply and suitable drainage. And this is especially necessary for residential areas where the use of gas is most probable.

To render the incendiary bomb innocuous it is desirable to prevent penetration and check the spread of fire. Fire-proof materials in construction, fire breaks and ample water supply are necessary to solve the problem successfully. The incendiary bomb is especially dangerous as is evident from the destruction of Warsaw and other European cities; and Spanish experience also tells us that fire-proof construction would reduce the danger very effectively.

RESISTANCE TO FIRE AND INCENDIARY AGENTS[1]

It is very difficult to check the spread of fire once the incendiary bomb gets into the building and the most desirable measure is to prevent penetration by impact. Fortunately these bombs have poor ballistics, cannot be aimed accurately and hit the target perpendicularly. A resisting roof will largely solve the question and the following minimum thicknesses give the required protection, against penetration by impact of incendiary bombs of various weights.

| Bomb. | Reinforced concrete. | Sand* | Earth* | Shingle* | Mild steel plate. |
|---|---|---|---|---|---|
| 1 K.2⅛ lb. | 3½" —4" | 6" | 6" | 6" | ¼" |
| 2 K.4¼ lb. | 5" —6" | 3' 6" | 5' | — | ⅜" |
| 5½ K.12 lb. | — | 4' 9" | 7' | — | - - |
| 10 K. | — | 6' | 9' | — | 1" |

*About.

Since the one kilo bomb is most likely to be used, mild steel plate ¼ in. thick or one layer of sandbag (laid as closely as possible) or 3½ in. to 4 in. good quality reinforced concrete for the roof would be enough. But considering economy, practicability and utility buildings with a flat roof 4 to 6 inches thick in reinforced concrete is preferable, both for domestic dwellings as well as for large buildings. For the latter type 6 in. might be preferred. Erecting pitched roof of combustible material and strengthening it in emergency is expensive and less effective.

1. Vide A.R.P.H.9. Felix Samuely, the "Builder," Dec. 1, 1939.

The following materials give protection against burning of the magnesium (electron) incendiary bomb:—

| Materials. | Min. Layer. ins. | Weight per sq. ft. lbs. |
|---|---|---|
| Household ash | 2¼ | 5 0 |
| *Slate dust | 1¼ | 5 0 |
| Red Ash | 1 | 6 0 |
| Boiler House Ash | 1¾ | 6 0 |
| Refuse Destructor dust | 2 | 11 5 |
| Brick dust | 1½ | 9 5 |
| Sodium Bicarbonate | 1 | 5 0 |
| Kaolin | 1½ | 5 0 |
| Pumice (ground) | 1¼ | 4 0 |
| Dry (virgin) earth (sifted) | 1¼ | 6 0 |
| Dry sand | 1¾ | 13 5 |
| †Foamed slag (ground) | 2 | 5 5 |
| ‡Powdered chalk | — | — |
| §Asbestos sheet<br>„ wood<br>„ wall-board<br>(Types which do not fracture under heat) | ¾ | — |
| Preparations of the plaster type made up mainly of ground rock anhydrite | ¾ | — |
| Asphalt (certain types) | ¾ | — |

* As efficient as sand and lighter.
† Has advantages over sand (much lighter).
‡ Not recommended. It will react with the bomb.
§ ½" gives fair protection.

To provide against burning, dry sand 2 in. thick, foamed slag 2 in. thick, household ash 2½ in. thick, earth 2 in. thick (reasonably free from vegetable matter), preparations for instance of the plaster made up mainly of ground rock anhydrite, about ¾ in. thick, asphalt (certain types) about ¾ in. thick, are suggested but they must be carefully placed for a loose covering such as sand will be disturbed by the fall of a bomb and the protective cover would be diminished. And this cannot be avoided unless we make the layer very thick which may be too heavy for the floors or roof to bear. Even to existing buildings dismantling the pitched roof and erecting a R.C.C. roof 4 or 5-inch thick is recommended to resist the danger and wherever possible this measure must be adopted, particularly for residential areas where incendiaries will be used, and people cannot afford to maintain expensive fire-fighting organisations. Fire-proof windows and doors are desirable, and external features of buildings should be of non-combustible material.

Wherever a resistant roof is not practicable as in the case of large factories, etc., or where the target is so important as to invite heavier bombs that will render 5 or 6 in. reinforced concrete ineffective, special attention should be paid to check the spread of fire. Fire breaks are necessary and distances between different types of buildings are indicated in the following table:—

| Exposing Building. | Exposed Building. | Fire breaks (distance between buildings) | | |
|---|---|---|---|---|
| | | Dangerous. | Moderately Safe. | Safe. |
| | | feet. | feet. | feet. |
| High Fire Risk | 1. With roof and window drenchers, wired glass windows in fixed metal frames. | 20 (30) | 30 (50) | 40 (70) |
| | 2. Without the above. | 70 (80) | 80 (100) | 90 (120) |
| Low Fire Risk | 1. As above. | 10 | 20 | 30 |
| | 2. As above. | 40 | (50) | 60 |

*Note*:—These figures presuppose an adequate fire-fighting service and a fair water supply. Figures in brackets apply where there is no such service or supply; figures apply only if exposed building is of fire resisting or of brick and joisted construction with slate or tiled (or better) roof, or of iron; flying brands are not allowed for; heights of exposing and exposed buildings are taken as 50 ft. If higher, breaks should be increased by 5 ft. for each additional 10 ft. in height in case of either or both of the buildings; in high risk areas where valuable buildings are situated close together and intervening roads do not provide satisfactory fire breaks, the following measures are recommended to provide some protection:—

1. Fit wired glass in fixed iron frames to windows.
2. Fit roof and window drenchers on the ridge of roofs and over every door and window.
3. Provide water supply, adequate to enable portable directors to be used.

Incendiary bombs might be aided by high explosive bombs particularly in commercial and industrial zones with large and massive buildings and dangerous conflagration might be started. Even high explosives themselves could start an effective fire. In addition to fire breaks and open lay out provision for adequate water supply is essential. Proximity is a vital factor but an idea of the quantities required for different types of buildings could be had from the following estimates made by the Home Office:—

Class A.—2,700 gallons a minute.
For large business premises, warehouses, large works, shops and stores, munition stores and factories, aeroplane stores, docks, timber yards, railway depots, oil and petrol depots, refineries and similar risks.

Class B.—1,100 gallons a minute.
For small factories, medium-sized shops, warehouses not exceeding three storeys, store yards excluding timber yards, public garages, small oil depots and similar risks.

Class C.—250 gallons a minute.
For residential and small shop properties.

Tanks and reservoirs suitably placed both in residential areas and in other zones appear suitable because the requirements for decontamination may aggravate the need for water, and underground mains may get shattered by high explosive bombs.

An efficient road system is also necessary to resist and recover from the incendiary danger. Broad roads would help to provide fire breaks, and facilitate quick movement of fire fighting services. This is impossible in narrow streets blocked by debris and bomb craters and immediate attention so very essential will be prevented.

## Resistance to Blast, Splinters and Demolition

The high explosive bomb is far more difficult to deal with than the incendiary bomb and liquid gas. All that is practicable is

(*a*) to reduce the likelihood of total collapse in the event of part of the building being seriously damaged.

(*b*) to reduce the amount of secondary damage to the building and to adjacent buildings caused after the explosion itself by flying missiles and falling masonry.

(*c*) to ensure that the building will resist blast effects to the maximum extent possible with the form of construction used.

As the high explosive bomb will be selected for important objectives, large structures and strategic centres, the problem of big buildings should be first considered.

To achieve this six factors need consideration.

1. The force of impact of the bomb upon the surface which is directly struck.

2. The force of the explosion throughout its immediate zone.

3. The pressure of air or suction caused by the explosion.

4. Vibrations set up through the surrounding ground.

5. The effect of large blocks of building material and fragments of the bomb itself being thrown about.

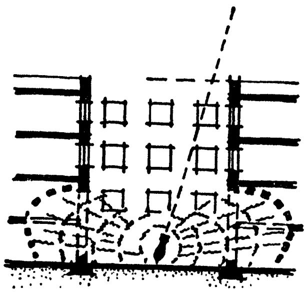
6. Fire.

What type of building is best constituted to resist these forces and what special precautions should be observed in designing it? It is considered hazardous to lay down definite rules in the present state of our knowledge. Abstract theorizing may not prove useful. When all these forces act together the position is difficult to judge. But certain observations of the results of air raids during the last war, in China, Spain, Poland, Finland and Western Europe recently, enable a few guiding principles to be suggested which may serve as direction posts to the further study of the problem.

Framed structures have been able to withstand high explosive bombs better than unframed ones with load bearing walls. Direct hits were made on the Shanghai Administrative building by one ton high explosive bombs but the damage rendered was more or less local. The building is of conventional design having reinforced concrete frame, and R.C. floors and roof.[1] Similar instances come from Spain. Photographs taken during the Spanish Civil War show the effect of direct hits on reinforced concrete frame buildings. The infilling panels give way, and some bays of the structures partly collapse but the edifices are not demolished.[2]

1. Indian Concrete Journal, Oct. 15, 1939, p. XVII, XVIII.
2. The "Builder," Oct. 3, 1939, p. 544.

The fact is blast has terrific force and the lateral pressure exerted is so high that the walls get shattered if they are near. When those walls support the roof and the structure, their collapse leads to the destruction of the building. Separation of the load bearing and enclosing functions of walls is absolutely essential if the destructive power of blast should be reduced. The infilling panels subject to damage or destruction could be replaced or repaired. This method is absolutely essential for large and multi-storeyed buildings in densely populated areas, industrial works, etc., likely to be the objective of repeated attacks, and where the probability of a direct hit or a nearby explosion, is greater. The maximum security against the effect of explosion is afforded only by a framed structure in which the walls are so constructed that they will yield readily to the air pressure resulting from the explosion of a bomb inside the building, and thus prevent injury to the structural framework itself and permit of the repair of the building in the shortest space of time.



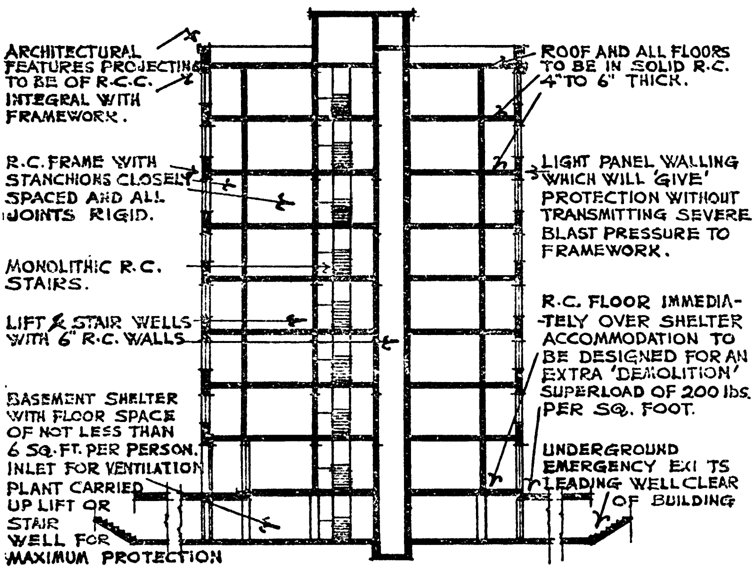
Effect of blast upon walls of buildings in a narrow street.

This does not mean that the safety valve type of walls must be fragile. A reinforced wall in which the reinforcement is not tied to the frame will suffice. But as such walls are liable to cause great damage in falling and parts of them are likely to form very dangerous and destructive missiles, it is better that the panels are of light construction. The danger of splinters is increased by thin panels but as high explosive bombs penetrate to the ground floor before explosion it is enough if the walls enclosing the upper floors are as light as possible. 13½ in. thick wall of brick or stone in cement mortar for the ground floor is considered suitable in the interest of safety.

Careful designing of the roof is also essential but bomb-proof roofs are impracticable. Apart from the fact bombs may strike the walls, a very thick and heavy roof is a possible source of danger, as the impact shock

MULTI-STOREY BUILDINGS

DIAGRAM ILLUSTRATING RECOMMENDED PRINCIPLES OF DESIGN FOR MAXIMUM STRUCTURAL A. R. P.




TYPICAL SECTION

of a large bomb might cripple the supporting member and bring the whole roof down. A number of solid concrete floors for cumulative stopping and bursting effect, is recommended as the better proposition, especially as some of them would probably be in the path of a bomb penetrating the wall obliquely.

A solid concrete floor with light reinforcement running both ways is to be preferred to a hollow floor of equal strength since they offer less resistance to penetration except at the joints.

Windows are a problem. The requirement for blast and splinters have to be compromised and they do not always blend happily. It has been suggested that windows should be rather at a higher level and be smaller or omitted if possible. This is desirable for the ground floor of multi-storeyed buildings, which could be used as garage. Blast and splinter-proof walls would make these garages fit for conversion into shelters, if other accommodation is not available.

Splinter-proof glass is now available and light need not be sacrificed for safety.[1] They could be suitably used to light the blast and splinter-proof interior. Armour plate glass has been used in some of the hospitals in London. Lift stacks, staircases and store rooms could be effectively lighted this way and yet rendered splinter-proof which would be impossible by windows in general use.

To reduce the dangers of demolition and flying masonry from endangering the neighbourhood, a stream-lined exterior is helpful. Or the projecting members should be such as being capable of getting tied to the frame. Open railings well anchored and stayed are to be preferred to solid parapets, since these are difficult to anchor, stay or buttress. But where solid work is to be used it should be reinforced, anchored, stayed and buttressed as solidly as possible. Coping stones are

1. Glass considered brittle and unfit for use structurally during war times, has by recent improvements been made fit enough for war time use. Experiments carried out show that some forms of glass show considerable resistance to blast, and glass bricks can be used where gas proofing requires windows should be closed without excluding light. In several London Hospitals windows opening on to landings where special protection is required have been partially bricked up, leaving a narrow vertical slit which is glazed with "insulight" glass bricks. It admits light and can be easily and cheaply blacked-out at night (for illustrations see "Builder," Nov. 24, 1939, p. 741).

"Armourplate" glass is blast proof from 500 lb. high explosive bomb detonating at a distance of 50 feet. Triplex armour plate 13 by 16 inches, of laminated design is bullet proof, but affords considerable protection against flying splinters. The toughened lenses when used on concrete roofs withstand thermite and electron incendiary bombs and their heat.

The "Builder," Nov. 24, 1939, Supplement p. 17 for "Triplex" products. For Insulight Glass Bricks and the view of the bricked up window at the St. Stephen's London County Council Hospital, see "Builder," Supplement, Jan. 21, 1940, p. 62.

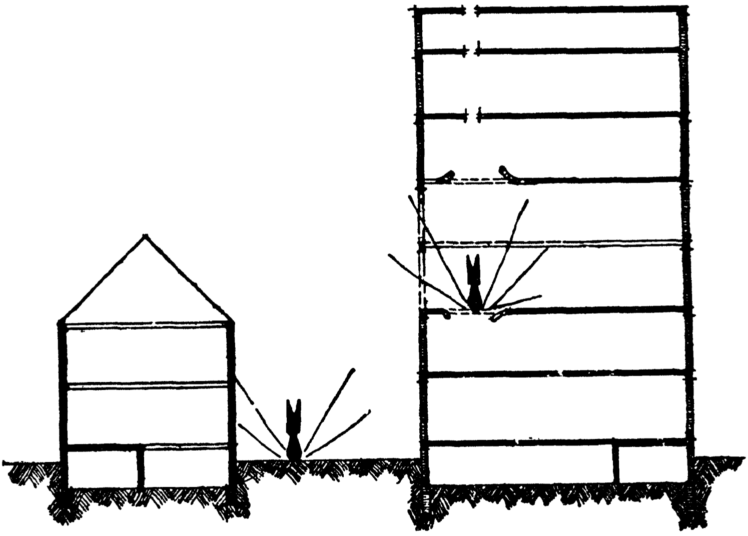
readily dislodged by blast or shock from blast and should be anchored down or linked to the vertical reinforcement in the parapet. External balustrades, balcony walls and the like should be strengthened if they cannot be omitted in the building. Open metal railings and balustrades should be used as they are safer, easier and more economical.

Canopies, balcony slabs and like cantilever features should be omitted since these are liable to catch the violent upward blast of nearby explosion; otherwise they should be as small as possible, and more heavily reinforced, and well anchored to the structural frame.

Chimney stacks are not many in this country, but where they are to be erected they should be built against adjoining construction for the greater part of their height or else kept as far away as possible from adjoining buildings, so that should they collapse the damage will be kept to a minimum.

Incendiary bomb resisting roofs cannot prevent high explosives getting through and starting an effective fire. It is necessary to adopt precautions to check the spread of fire. For it is impossible to make the contents of buildings all fire-proof. Both horizontally and vertically the building should be divided with fire-proof barriers, into a series of relatively small cells, each capable of confining the fire, should the bomb explode within the cell. The design and planning of buildings should be such as to develop "a simple type of fire-resisting door which will be self-closing in the case of fire, but can be opened and shut in the normal way."

Most of the principles mentioned regarding large structures apply with equal force to smaller ones. But steel or concrete frame construction is expensive compared to their size and use. Since the probability of a direct hit is less, in detached buildings and small ones the "protective wall" type could be used. In this case the building will be constructed as a structural framework, and the external walls, which will be designed to withstand the pressure or suction of air following the explosion of a bomb outside the building, will be monolithic with the frame. Some consider it "essential to incorporate in the construction some form of frame which although it need not carry the building wholly in the accepted sense of the term "framed construction" should nevertheless be so designed that it will support the building in an emergency should some part of it be destroyed." But the adoption of frame construction in small buildings does not produce economy proportionate



'Protective' and 'Safety Valve' Wall and Floors.

with those obtained in large tall buildings. Framing may increase the cost by about 25 per cent. and it is doubtful whether the increased resistance offered by it would be proportionate. With blast and splinter-proof walls 13½ in. thick and with the frame members so close to each other the blast force will have nearly equal effect on the entire structure. The difference in force will not be appreciable and the cost of repairs would be equally great. As shown in the adjoining diagram protective walls are to be preferred.

The use of reinforcement in brick work to form columns in the walls are suggested to provide the necessary vertical framing but this will not cost less than reinforced concrete.

For a large residence a frame is desirable. Reinforced brickwork may be used. A subsidiary framing may also be adopted. "If horizontal reinforcement is provided in the brickwork at floor level and vertical reinforcement at intervals throughout the length of the wall, a subsidiary framing will be formed which can be designed to carry the floors and superstructure should the panels of brickwork between be destroyed." The interior walls should be similarly treated so that a beam is formed on every wall at each floor level unless a wall beam is formed in the floor construction.

The linking of reinforcement is also necessary. Throughout the work the horizontal reinforcement in the external and internal walls should be linked together wherever possible, and the vertical reinforcement in the walls should be linked to the floor construction to provide a tie to resist the suction wave from an external explosion.

The wall areas between the sections which are reinforced vertically as columns can with advantage be reinforced horizontally to increase their strength, this reinforcement should however in no circumstance be linked up with the columns.

Stated summarily[1] small buildings in addition should incorporate the following features, if they should reduce their vulnerability to destruction.

(*a*) Walls should be 13½ in. in brick and cement mortar or its equivalent.

(*b*) Roofs should be 5 inch solid reinforced concrete or its equivalent.

(*c*) Windows in some circumstances should be protected.

1. Vide Oscar Bayne, "Structural Precautions against Air Attack." The "Builder" A. R. P. Supplement, Jan. 13, 1939, p. 11.

(*d*) Cornices, hoods and other projections should be avoided or else be abnormally well anchored.

(*e*) Parapets should be avoided, and open grilles, or railings used. If parapets must be used, they and their copings should be abnormally well anchored to the structure.

(*f*) All external members liable to be dislodged or torn away by the blast of an explosion should be avoided.

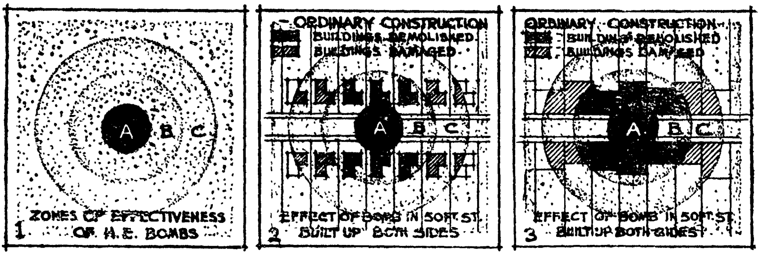
(*h*) All structural work, finished surfaces, furniture and fittings should be fire-proofed as far as possible.

In fact the two most important problems affecting small structures and residences are incendiary bomb and liquid gas. Here again we have to stress the provision of fire breaks between buildings as well as water supply.

Building them entirely with gas-proof material is impractical as in the case of larger ones already noted. We could only facilitate decontamination, washing them down thoroughly and making air circulate freely inside; large windows are necessary. The flooring should be of concrete or like material fit for washing.

Although some precautions helpful to resist gas and incendiary bombs may go against the resisting requirements for the high explosive, for instance, large windows, the weight of reform should fall on the side of the former since, when small structures and residences are separated from large buildings, the use of high explosives is less probable.

As in the case of large structures, detached buildings with space around could stand a high explosive raid better than closely packed houses. The vibration effect would be counteracted and no more than one building would suffer for each bomb if they are spaced 50 feet apart. A compound with 25 feet of space all round would be needed to provide some garden and could be secured if residences are properly zoned and planned in convenient suburbs; when the commercial, industrial and other activities of the city are separated from them.



Diagrams showing the value of space around buildings in reducing destruction by high explosives.

Whether it is a small or large structure it is now apparent that in addition to improvement in design and construction, open space around, ample water supply, proper road system, open layout, parks and gardens are necessary to make city structures survive an air raid. Whether it is the high explosive, the incendiary or gas or a combination of all these we are again led to the problem of planning and zoning if we should save our cities from destruction.

# CHAPTER V

## IMMUNITY TO ESSENTIAL SERVICES

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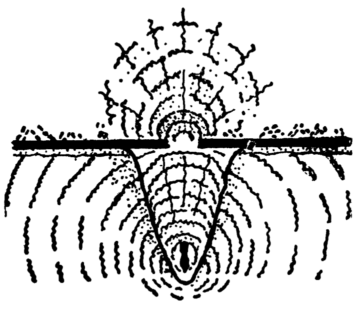
Water supply, drainage facilities, electricity, telephone and telegraph, efficient transport system, regular supply of food and food articles, as well as dairy products and vegetables are essential for the normal functioning of modern urban communities. Their destruction or dislocation will make this impossible. Unfortunately the methods of production and distribution of these essential services in modern cities render them extremely vulnerable to air raids. The high explosive bomb, the incendiary bomb and liquid poison gas both independently and when used in combination will affect the present system. The underground system is generally adopted for water supply and drainage and they are not laid deep. They are shattered by bombs as recent happenings in England show, and precautions are being taken to prevent the consequences. Lengthy channels connect cities to the sources of supply of water which is either a large tank or a river. The large filtration plants could also be destroyed or poisoned.



High explosive bomb with delayed fuse exploding in a street.

### Vulnerability of Essential Services

Electric mains are also laid underground but less deeper, electric power houses are generally overground. Telephone wires are overhead and telephone exchanges are similarly situated. Railway stations, docks, harbours and aerodromes are not merely overground but in or close to congested quarters or residences. The railway sometimes traverse through cities and in many industrial centres serves as the means of transport for large numbers. Narrow streets rendered increasingly inadequate by uncontrolled growth of towns form the distributive system defective also from the ventilation point of view.

Markets and food storage centres are generally located in crowded residential and commercial areas, and cow sheds and stables are found all over. Dairy products are largely produced within the urban area and transport animals are kept within its limits.

Even in times of peace some of these have been found inadequate and when the stress is greater in times of war they are bound to fail and their destruction by weapons of air attack could easily break the resistance of the inhabitants. Water supply is inadequate to meet the needs of peace in many urban centres in India and the road system is getting unbearable with the lateral and vertical expansion of cities. Roads that cannot take a holiday crowd could rarely cope with the demands of evacuation and the needs of fire-fighting and decontamination squads. And when bomb craters cover the roads they would be practically useless.

Experience in Poland and Finland, Norway and Holland bring to light that these are made the objectives of attack. Electric power houses, aerodromes, railways, bridges and even moving passenger vehicles have been subjected to attack. Precautions have been taken in several European countries to prevent dislocation. The Civil Defence Act of Great Britain compels the owners of public utility services to camouflage their premises and even a grant is made by the Exchequer. According to Clause 39:

There may be paid out of moneys provided by Parliament towards approved expenses of public utility undertakers in taking measures, whether before or after the passing of this Act, to secure the due functioning of their undertaking in the event of hostile attack, grants not exceeding one-half of those expenses.

They are further subjected to obscuration of light in the interest of safety. Clause 45 insists that along with factory premises, or mines these public utility undertakings, may be compelled "to take over or complete such measures as may be specified in the notice to secure that the factory premises, mine or as the case may be, any of the premises of the undertaker, can be made less readily recognisable by aircraft in the event of hostile attack." The Government grants half the expenditure incurred by the party who is compelled and if they do not comply they are liable to a heavy fine and conviction.

In France the height of buildings was regulated to prevent demolished buildings blocking the road and hindering movement of traffic when it is most needed. The Town Planning regulations of Poland according to an order issued in May 1939, prescribe: "roads and streets must be straight and should run in the direction of prevailing wind, leaving at least 60 yards between the fronts of buildings on main thoroughfares."

In India, soon after the outbreak of hostilities in Europe, police guards were placed near aerodromes, electric power houses, water supply sources etc.

That these precautions cannot save destruction will be evident from the experiences already recounted. Attempts are being made to prevent the flooding of underground systems by the damage done by high explosives. The effort made in London is noteworthy. The London Passenger Transport service has taken steps to prevent flooding in the tubes in case of severe damage by air raids. They consist of the installation of massive steel doors or gates at stations where the railways pass under the Thames and also in the immediate neighbourhood of water mains or sewers which might probably be burst by bombs. By closing these new steel gates flooding of the underground system may be prevented. Special sector gates have been placed between the foot of the elevators and the platforms on the northern line at Charing Cross which if necessary will close the passages leading from the district station above. At Charing Cross there are six of these sector gates each weighing 4½ tons. During an air raid they could be raised or lowered in two minutes by electric motor with a push button control. In addition there is emergency hand gear for raising the gates.[1]

When the war started these openings now controlled by the steel gates were completely plugged up with concrete as a precaution, the one at Charing Cross weighing 25 tons. Such costly precautions would become inevitable if underground systems are to be adopted. In residential zones for Indian cities an underground system is undesirable both by its initial cost and by its risk and the expensiveness of protection.

To underground systems if they are not very deep gas bombs may prove doubly dangerous when they combine high explosives with them and when they are equipped with a delayed action fuse. They may damage service mains under the roads. The water, gas, and electricity mains may be contaminated by gas and may also be damaged by explosions. The gas may burn and water may carry contamination down the sewers, electric cables may absorb the liquid. They might have to be cut off before decontamination work could begin and after decontaminating the crater, metal pipes carrying gas and water may have to be cut out and replaced. Drain pipes of concrete or stone have to be treated with bleach paste. Electric cables may absorb the liquid in their bitumen coating. The copper strands may get corroded. If the rubber coating is heavily contaminated that section of the cable must be replaced. Underground telephone wires if encased in stoneware ducts would have to be washed with paraffin or petrol.

Overhead telephone wires are unlikely to be heavily contaminated unless they are blown down by an explosion

1. The "Hindu."

but telephone exchanges would be rendered unfit for use by a gas spray or a combined high explosive bomb. Gas can similarly dislocate the transport system by contaminating the vehicles. If the contamination has been heavy it is possible that corrosion will develop later.

Several methods have been suggested to prevent dislocation. Removal of plants and power houses is advocated. But a spasmodic removal is inconvenient and costly and sometimes impossible. Now that the threat of air raids prevail for fairly long periods this measure cannot help. A permanent removal outside the city limits would appear desirable but cannot eliminate the danger unless the distributive system is rendered bomb proof. Keeping more than one source is suggested on the principle that if one is destroyed others would function. This is uneconomic and impossible for drainage systems and the like. An alternative source to be harnessed during emergency might be admirable for a railway station but not for water supply etc.

Although the problem is simpler in our country the preceding chapters would show that protective measures are uneconomic, otherwise unreliable. Public utility services liable to dislocation when one part of the organisation is affected are unsuitable from the point of view of air defence. The desirable system should be one which will make dislocation by throwing a few bombs impossible.

### WATER SUPPLY AND DRAINAGE: RESIDENTIAL ZONES

That this is possible is now disclosed by researches in Public Health, Nutrition, Sociology, Town Planning and other sciences directly affecting human welfare. A proper combination could give birth to a system immune to dislocation.

The needs and finances of the residential and non-residential zones of a city differ fundamentally and in approaching the solution, the two aspects need to be viewed separately. Regarding residential zones the supply of water could be immuned by tube wells, one or more for every house or groups of houses. This would provide protected water supply immune to gas attack and dependable during emergency. Wells properly constructed and protected would also serve and help the needs of fire fighting and decontamination. The problem of drainage can be solved if adequate open space is allotted for every residence. A kitchen garden would provide necessary green vegetables and would prevent underground drains and cess pits. The plants will use the water of the household. "Sanitation is purely an agricultural question and the country where every cottage has or should have its patch of garden there ought to be no difficulty."[1] This observation made by a well-known medical authority has great significance in planning for air defence. The problem of sanitation will be automatically solved by this method.

The need for sufficient space around is also stressed by sociologists who emphasise the need for a correct balance between men, occupations and land for ensuring optimum welfare for humanity. The neighbourhood unit idea is rapidly gaining ground in U.S.A. and space around the house, garden and vegetation are deemed essential, to give the correct perspective to life and to make man healthy. Town Planning principles restrict the number of houses per acre to twelve and individual town planners consider six or nine better. A system of suburbs where six to nine or twelve families live per acre, water supply and drainage could be made immune to air raids. Where higher density is inevitable Dr. Poore's idea could be applied by combining groups of families in residential estates or blocks of houses each self-sufficient for water supply and drainage. Where even this is not possible small colonies could be made self-sufficient by locating them in proper surroundings. Three to five hundred families, it is considered offer optimum unit for ensuring social intercourse, personal contact, and community interest, after years of research in American Universities.

1. Vivian Poore, Essays in Rural Hygiene.

Recent opinion considers 750 houses as the minimum number for a self-sufficient community and was advocated at the International Federation for Housing and Town Planning at its 16th Congress at Mexico by those responsible for the Green belt town now being built by the Federal Government.[1]

The optimum size for groups of families have yet to be discovered for India but 750 families may not be unsuitable to form residential estates, that could be rendered air raid proof regarding essential services. The average village in India contains from 200 to 500 families and these were autonomous self-governing and self-sufficient units over which India's prosperity rested for centuries. Indian Town Planning insists on tanks, open spaces, water courses and fields around as essential parts of the village plan. Indian villages in the early Buddhist age more or less conformed to the requirements for resistance dictated by the needs of air defence. A cluster of houses with streets laid to harness light and breeze to help ventilation with tanks and gardens, surrounded by pasturage, can defy raiders better and it is not impossible to form a city with such residential surroundings.

## WATER SUPPLY AND DRAINAGE: NON-RESIDENTIAL ZONES

Non-residential areas of large cities create a problem owing to lack of space and the necessity for multi-storeyed structures. Open drains and independent systems are not possible. But the occupiers could pay for a bomb proof system. In fact a deep underground system has been suggested by experts in the West.

Drainage, water supply, gas, electric power, light and telephone should be grouped together and run below the roads and made safe from bombing by running in tube subways constructed of reinforced concrete, and kept about 20 feet below the surface. The road surface should be formed of heavy reinforced concrete to serve as a detonating slab. "This road surface would never require to be cut up for alterations and renewals of the

1. J. T. P. I., Oct., 1938, p. 412.

service conduits, as they could be freely got at from the armoured tubeway formed for this purpose."[1]

Regarding power stations, the bombing aeroplanes are already causing considerable reform. The dangers of "all-the-eggs-in-one-basket" policy are becoming obvious. It is a dangerous policy to erect new gigantic central power stations of say 500,000—1,000,000 K.W. capacity which might be put out of action by a single concentrated attack from aircraft. The sensible policy is to have half a dozen widely scattered stations inter-connected of the same total capacity.

Already power stations have been designed and in some cases constructed with heavy concrete walls, up to 2 feet thick, with no windows to reduce the dangers from splinters and blast from a considerable distance. A new development is the construction of special completely bomb proof emergency power stations which it will be impossible to put out of action, say by burrowing into a hillside or by construction underground with an enormously thick concrete and earth roof. For these emergency stations not only are diesel and petrol engines being employed but also super pressure forced circulation boilers and steam turbines. Manufacturers on the Continent are already producing bomb proof power station plants, suitable also for ordinary peak loads.[2]

Lighting could be made independent for each unit and in emergency the dwelling could be lighted by mineral or vegetable oil. Overhead electric cables connecting one suburb to the other or any hydro electric-station could be suitably laid and camouflaged by vegetation abundant in the tropics.

### ROAD SYSTEM AND TRANSPORT FACILITIES

A strong impervious road surface is essential to prevent contamination and facilitate decontamination. A

1. W. Braxton Sinclair, "Town Planning in Relation to A. R. P."

2. For a short description of a plant of 9,400 K.W. comprising a "Velox" forced circulation super pressure steam generator and condensing steam turbine plant supplied by Brown Broveri and Co., Ltd., of Baden, Switzerland, see *Hindu* 5th May, 1940.

gas spray on concrete paths or paving stones need no treatment other than hosing. But if they have been splashed with the liquid they must be left to weather in addition. In a congested centre elaborate methods of decontamination are essential and the road surface should as far as possible resist absorption. In warm or mild weather as in India it is unlikely that any danger will persist by fine spray after one hour. If the streets can be kept clear for an hour after the spray has fallen there will be little danger.

But traffic must be closed at least for three hours and constant hosing at intervals of one hour and immediate attention will be required for gross spray and decontamination. Pavement stones or slabs or concrete do absorb the liquid and porous joints surrounding stone setts will do similarly. "If the stone or concrete is hot, as may be the case in sunny weather or in a tropical climate, a good deal of the liquid will be vaporised in a short time and the remainder though quickly absorbed will be given off again later as vapour. This means that the danger from vapour in the streets will be great, though the problem of decontamination will be less."[1]

This consideration indicates that roads must be so laid as to facilitate the breeze blowing through, to clear away the vapour. The need for wide roads will now become apparent. This factor should also determine the location of different zones of a city. Cities in India should be prepared to meet heavy vapour from mustard gas. Tar and bitumen dissolve blister gas especially in warm weather and should not be used for road surfaces. Tarred macadam, bituminous and asphalt surfaces are equally unsuitable, for decontaminating them is particularly difficult if immediate action is not possible. Heating up the road surface is necessary if the liquid has been completely absorbed but this will damage the road surface. Water bound macadam surface may not absorb much blister gas but its rough

1. A.R.P.M.3 "Organisation of Decontamination Services."

### METHODS OF DECONTAMINATION FOR ROAD SURFACES

| Surface. | Method of Treatment. |
| --- | --- |
| *Treatment for Fine Spray.* | |
| All surfaces | In busy thoroughfares hose down with water if this can be done within 30 minutes. In all other circumstances leave to weather. |
| *Treatment for Gross spray and outer zone of bomb contamination.* | |
| All surfaces | Hose down with water as quickly as possible for 10 minutes. Repeat treatment. Pavements for immediate use can be brushed with thin cream of bleaching powder and water. |
| *Treatment for Gross contamination round bomb craters.* | |
| Stone setts | Cream of bleaching powder and water. Brush well into joints. Leave in contact for 15 minutes. Finally hose down with water. |
| Stone paving and concrete | Hose with water for 10 minutes. Sprinkle with dry bleaching powder. Brush well into surface for 5 minutes. Also treat gutters. Finally hose down with water. |

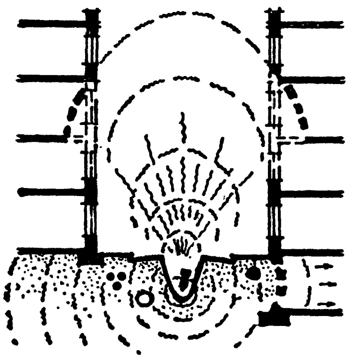
METHODS OF DECONTAMINATION FOR ROAD SURFACES

| Surface. | Method of Treatment. |
| --- | --- |
| Wood paving | Hose with water for 15 minutes. If jointing material is soft, cover with sand. (If heavy liquid splashes visible, treat with bleaching powder and sand before hosing: brush well over surface and leave in contact for 1 or 2 hours.) |
| Tarred macadam, bitumen or asphalt | Hose with water for 15 minutes. Use dry bleaching powder treatment for grossly contaminated areas. In certain cases road heating machines may be used. |
| Water-bound macadam | When possible leave to weather. If treatment essential, sprinkle with bleaching powder and leave for 10 minutes. Then hose gently with water for 10 minutes. |
| Natural earth, grass, etc. | Cover with 2 to 3 inches of fresh earth and leave to weather. If contamination very gross and near to occupied premises, add top layer of earth and bleaching powder 3.1. |

(Vide A.R.P.H.4 Appendix B).

surface renders hosing down with water less effective. Hard brushing will damage the surface and be wasteful.

A hard surface no doubt increases the danger of blast to adjacent structures but sufficiently wide roads would reduce this danger. They would further minimise the danger of vibration of traffic and bomb explosion and are also essential to prevent traffic congestion.



The dangers of a hard surface in narrow streets to the walls and foundation of buildings.

These considerations need not be literally applied to open country and residential zones for weathering might be depended upon to do the task of decontamination. As the Home Office handbook recognises elaborate methods "may be entirely unnecessary and wasteful on an open high way."

The road system therefore requires great attention and care. Its layout, its surface, its width, etc., need special attention. It also forms the physical basis of the system of transport and to satisfy the requirements of air defence the road system should: (1) facilitate quick movement, (2) protect underground systems if any, (3) increase the resistance to vibration of buildings, (4) reduce vulnerability to gas contamination, (5) help ventilation by securing sunlight and breeze and (6) provide fire breaks.

These are essential if the road system should offer resistance to air raids and make transport possible. But these are equally necessary to make them useful in times of peace. The military requirements coincide in the main with civil needs of the population, so that the ideal military road system of communication would well serve civil needs in peace time. A number of important planning questions converge around the type of road plan adopted equally vital to military and civil needs. The military demands require an excellent service of straight broad roads, free of risk from falling brick debris, linking up the many defensive positions, such positions to be distributed at required intervals, generally through the city area and would have a spread of about 10 to 15 acres, each to give an ample field of vision.

Civil requirements dictate that roads should form a network to divide up property into business units and the main arteries to be adequate for traffic and provided with diagonal connections with subsidiary centres, which should occur about every square mile of city area.

A road system that would fulfil all these various requirements is a combination of the chess board plan with a simple system of spider web plan to subsidiary centres which would give the best road results, and at the same time provide an elastic basis for the open spaces of greens and parks; thus the dark squares of the chess board would indicate the varying disposition and area of the open spaces or defence positions according to the density required. This type of plan would give excellent opportunities for the town layout with open squares, small parks, gardens, athletic grounds, and at the same time would produce a very effective part of the camouflage of the disposition of city zones and buildings when viewed from the air. Large groups of trees and parks in cities and towns have the effect of breaking up the forms and making identification of targets more difficult from the air.[1]

In addition to the layout of roads, the transport units that convey passengers and goods must be capable of surviving air attacks. Railway trains are vulnerable to bombs and machine-gun fire and should be discouraged within urban areas. If economic conditions warrant goods may be conveyed by a deep underground line to the heart of the city from a station situated in the outskirts. Bomb craters would hamper the movement of

1. Vide, Braxton Sinclair.

tram cars and they must be discarded. Although instances of machine-gunning moving buses have come to light, small mobile units have better chances of escape and are preferable in the interest of security.

Cleansing station for vehicles or vehicle decontamination depots also form part of this scheme. Yards large enough to accommodate contaminated vehicles must be situated in localities where the risk of vapour from them will not cause danger or inconvenience. Provision for ample water supply to these depots must be made. "The process of decontamination would involve copious use of water and the actual decontamination stands on which the vehicles would be washed should therefore have a hose water supply (a high pressure of water is unnecessary), and ample drains for carrying away the contaminated water." Since washing road surfaces also require copious water, tanks and reservoirs suitably placed on the road system form part of a system of transport and communication which might be considered reasonably safe.

### FOOD SUPPLY

The production and supply of vegetables, milk and dairy products as well as food grains and other essential articles also need protection. Modern urban communities depend for their protective food on cattle housed within city zones. Markets, oilman stores, restaurants and boarding houses are situated in the most crowded parts of cities. Their contents are liable to be affected by poison gas and cattle and other animals are seriously injured and disabled particularly by mustard gas.

It is suggested that edible articles should be packed with gas-proof materials and they must be kept covered as far as possible. The Home Office insists that attention must be bestowed during transport and distribution and advises to make "all store houses as gas-proof as is practicable." The protection of food stuffs against poison gas is the subject of a special booklet. Airtight bottles or sealed tins offer complete protection against all forms of gas. Air-tight glass or earthernware jars offer similar protection if covered with glass, metal or bakelite. Sealed wooden barrels provide complete protection against vapour and moderate amount of liquid gas. For prepared edibles however, waxed cartons and cellulose transparent films give good protection against gas and liquid.[1]

The problem of protecting food supply thus covers, the location, design and protection of hotels and markets, etc., the preservation of pasturage and fodder for cattle and their housing, and the provision of cultivation in close proximity to supply as far as possible food grains and food articles.

Restaurants and hotels should be housed in gas-proof structures or in buildings which could be converted into gas-proof ones. Their design and construction should be such as to render contamination difficult, and washing down easy. Their location should also be helpful to defy contamination. Uncovered foodstuff should not be displayed in windows or on counters or shelves. The period of warning before an air raid is likely to be short and would not give sufficient time to pack away a large quantity of food which was displayed without protection. This precaution against gas is equally welcome in times of peace for health and sanitation.

The storage of food grains in large quantities in the suburbs and the surrounding agricultural belt also needs attention. Terraced houses which could be rendered gas-proof are preferable. Where this is not possible, as during the harvest, they must be covered by large tarpaulins and left in the field. Strong thatched stacks of grain could also be similarly protected. Grain Silos, not very tall, granaries convertible into air raid shelters in the surrounding areas would help the storing of grain not merely for protection but for better prices.

1. The Protection of Foodstuffs against poison gas.

The question of maintaining an adequate supply of protective foods leads to the problem of protecting animals during air raids, and ensuring them with fodder and food. Horses and bullocks used for transport purposes need protection.[1] But they could be treated along with the milch cattle. Sheep and goats should be reared to make meat available. Fortunately pets, dogs and birds do not give us as great a problem as they do in England.

"Animals, like human beings, will be exposed to the risks of air attack in a modern war, and everything possible to protect them should be done. Around docks, railway goods depots and industrial centres there may be considerable number of transport and other animals and such areas are likely to be attacked. On the other hand it is unlikely that the destruction of farm animals would be considered as a primary objective of hostile attack owing to their normal dispersal, and if such stock were affected it would probably be merely incidental, but the effects would be no less serious on that account."

Evacuation is not possible in the case of transport animals, or food animals, awaiting slaughter. To some extent milch cows could be evacuated but this will lead to inconvenience. No satisfactory animal gas mask has been yet produced and gas and bomb proof stables in city zones are not practicable. Although fodder exposed to the true gases, arsenical smoke or the vapour of blister gas will not remain dangerous if aired for a few hours they may become unpalatable.

The ideal remedy is to remove them outside the city zone and the residential areas and to house them in pasturages surrounding the city. Ample water supply, open air and sunlight necessary to help resisting and recovering from a gas attack are possible only in this green belt. The general advice given regarding A.R.P. for animals and their treatment tend to show that protection is possible if live-stock are kept in the outskirts of cities with plenty of open space, with ample water

1. A.R.P.H.12 Air Raid Precautions for Animals.

for washing and drinking and plenty of sunshine and open to make them recover quickly from contamination. Even in non-urban areas it is considered advisable as far as possible to keep large animals such as horses, milch cows, etc., in the fields rather than in stables. The remedies suggested to recover from gas attacks prove this need. For mustard gas affection of the skin the animal should be hosed down with water for half an hour. Affected eyes should be freely irrigated with water and if it is a respiratory tract plenty of fresh air and rest are essential. Lewisite gas injuries need washing with soap and water or water alone within 20 minutes after contamination. For Phosgene gas attack, the first essential is to remove the animal from dangerous atmosphere. The animals should be kept in the open air, rugs and bandages being put on for warmth.

All these require plenty of fresh air and expansive areas. Non-persistent gases can do little injury if cattle are housed and grazed in a green belt surrounding the town. Persistent gases can not be made to cover the entire belt and even if one part is endangered grazing could be had in the other. Dairies are best situated in the wide areas surrounding the city. The high explosive and the incendiary bombs cannot dislocate milk supply.

Vegetable gardens in the adjoining areas would ensure steady supply and if the food grains needed for the city are raised in the land adjoining this green belt the problem of 'grow your own food' during war will not arise. A nation composed of cities and villages whose food supply is assured from the surrounding area can resist aggression successfully. It will also help to achieve the correct balance between occupations, industry and food supply and population and thereby a stable foundation to civilisation.

## Research

The main difficulty however is the absence of data to determine the various standards and quantities to form the ideal patterns and compositions. Whether it is the residential unit and the kitchen garden, the quantity of food and population, the number of cattle and the grazing area adequate data are lacking. The size of the group of domestic dwellings in residential suburbs that would be the optimum unit; the size of the plot for each residence; the proportion for the built up area to the open surrounding; their location with reference to the air raid shelter as well as to open parks and vegetation; the arrangement of different groups of families according to their occupation and economic condition; the optimum size for the urban community and the ideal pattern of spacial arrangement; the proportion of population to business, administration, occupation and work, etc., all these must be discovered to plan a successful scheme and to evolve the ideal pattern. This alone can make it possible for the normal functioning of the society during air raid and make dislocation by destroying essential services well nigh impossible. Elaborate precautions now being taken in the West are too expensive to our country and a peaceful agricultural civilisation cannot afford to be extravagant for emergencies. Self-sufficient and self-reliant units capable of making their parts work independently during emergency would form the ideal basis for the urban community particularly in this country where money is limited but land and nature are abundant.

# CHAPTER VI

## ESSENTIALS OF AIR DEFENCE

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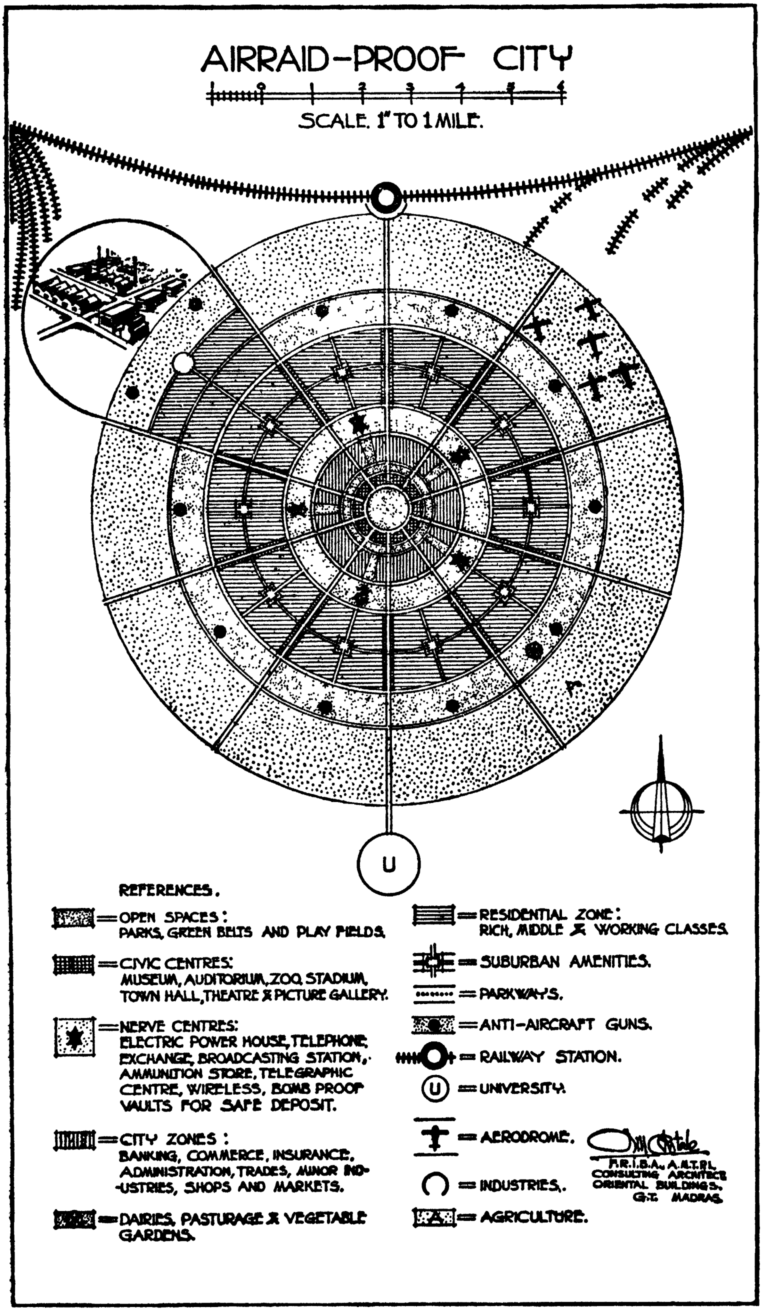
## ESSENTIALS OF AIR DEFENCE

It would be evident from the previous chapters that the essentials of air defence are, bomb-proof shelters for all the people, structures that would resist and recover from air raids and services the supply of which is immune to dislocation. To these should also be added a suitable contingent, anti-aircraft guns, and ground defences, balloon barrages etc., to prevent low flying attacks as well as fighter planes. Without such active defence the task of the raider would be enormously simplified and passive defence measures would prove inadequate. A defenceless city will fall a prey to a handful of bombers and machine-gun fire as did Steinkjer in April last. They are needed to force the raiders to attack the targets from a great distance and in great hurry—the two factors which render destruction difficult. If anti-aircraft defences are not successful and effective now it is largely due to the defective layout and development of modern cities which impose too heavy a burden upon them. A properly planned city will be a helpful combination, minimise their difficulty and enhance their effectiveness.

These four fundamental requirements would assure to people reasonable security from the air menace. Where these four features are combined to produce the optimum effect, the community housed there would defy the most carefully engineered air attack. This would produce a degree of resistance that would make air raids uneconomic and not worthwhile and would undermine the enemy's incentive to adopt this course as his method of aggression.

### CITIES FOR AIR RAID PROTECTION

What is the ideal combination and how will this pattern of a city would look like? Local conditions and


AIRRAID-PROOF CITY
0 1 2 3 4 5 6
SCALE. 1" TO 1 MILE.
U
REFERENCES.
=OPEN SPACES: PARKS, GREEN BELTS AND PLAY FIELDS.
=CIVIC CENTRES: MUSEUM, AUDITORIUM, ZOO, STADIUM, TOWN HALL, THEATRE & PICTURE GALLERY.
=NERVE CENTRES: ELECTRIC POWER HOUSE, TELEPHONE EXCHANGE, BROADCASTING STATION, AMMUNITION STORE, TELEGRAPHIC CENTRE, WIRELESS, BOMB PROOF VAULTS FOR SAFE DEPOSIT.
=CITY ZONES: BANKING, COMMERCE, INSURANCE, ADMINISTRATION, TRADES, MINOR INDUSTRIES, SHOPS AND MARKETS.
=DAIRIES, PASTURAGE & VEGETABLE GARDENS.
=RESIDENTIAL ZONE: RICH, MIDDLE & WORKING CLASSES.
=SUBURBAN AMENITIES.
=PARKWAYS.
=ANTI-AIRCRAFT GUNS.
=RAILWAY STATION.
U =UNIVERSITY.
=AERODROME.
=INDUSTRIES.
A =AGRICULTURE.
F.R.I.B.A., A.M.T.P.I.
CONSULTING ARCHITECT
ORIENTAL BUILDINGS.
G.T. MADRAS.

requirements would affect this a great deal but the disposition of the different parts of the civic organism would be more or less as shown in the diagram.

Around a large central park would be located the civic buildings, surrounded by a green belt of parks and vegetation separating the city zones, business, commerce, administration, etc. A green reserve of 500 to 1,000 yards would separate this area from the surrounding residential suburbs, and prevent the bombs aimed at the City Zones from harming them. These suburbs would be self-contained, in matters of drainage and water supply and amenities could be provided suitably. Preferably with a population of 10,000 each, the suburbs will have suitable areas for the residences of working classes, the middle class and rich class. Pasturage and vegetable gardens, will surround the suburbs and help to improve urban nutrition. The University however will be taken out of the busy city zones, as well as the factory and heavy industry. Encircling this will be an agricultural belt to avoid "digging for victory" in times of war. The city's requirements in cereals and pulses and other food grains would be obtained from this area. Around this would be village units separated from each other by green belts. They would be rendered attractive enough to draw townsfolk to them, whenever they can.

An efficient and economic transport system would help this scheme and connect the city with other important centres of the nation. The road system within would combine the spider web plan and the rectangular scheme to ensure easy and quick movement of people and vehicles in normal and in war conditions and provide sufficient visibility and ventilation and other requirements of civic welfare.

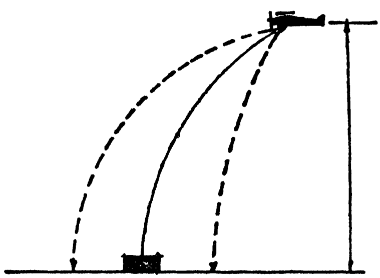
The railway would provide easy access both to the industrial zone and the city and the emergency line will come into use if the main line is destroyed. The aerodrome is so located that the anti-aircraft guns would help the defence of the railway and the industry in addition. In times of war fighter planes and ground defences would dot the encircling pasturage. Playgrounds, wide open spaces, tanks and reservoirs in the green belts and built up areas will help to defy gas attack and the spread of fire. All zones will possess air raid shelters which would ensure safety to people in emergency and serve as community centres and garages in times of peace. Buildings would be dispersed and carefully located to reduce the chances of direct hits. The design and construction would be improved and they would render gas and incendiary bombs ineffective and considerably reduce the destructive effects of the high explosive. Although air raids cannot be made impossible they would be rendered uneconomic and inadvisable.

Now it will be clear that the fundamental needs of air defence are zoning and planning and the dispersal of men and buildings. These simple and wholesome principles are not merely effective in times of war but are essential for the welfare of mankind in times of peace. When these principles are properly applied we obtain urban communities invulnerable to air raids. The essential features of such urban communities, in other words the essentials of air defence are, green belts, parks, vegetation; a rational road system; wells, tanks and reservoirs; carefully laid out residential estates and non-residential zones; industries and universities, drawn out; nerve centres carefully placed, and anti-aircraft devices adequately arranged.

## GREEN BELTS

Green belts, parks, playgrounds, and pasturage are needed for separating the different units of the city as well as for encircling it and fulfilling "a military need to enclose and limit the city boundaries and to provide dual encircling road communications with ample scope for the provision of aerodromes, anti-aircraft gun positions, searchlight stations etc. within the belt area." The parks, playgrounds and open spaces within would help to separate the different aspects of the city and ensure safe distances from likely targets to residential areas. Bombing is a very inaccurate job particularly when bombers are in hurry and thus arises the need for separating residences from important objectives.

As General Winkleman pointed out while explaining why he abandoned resistance to German invaders, "in a densely populated country like ours, it is difficult to distinguish between military and civilian objectives. Rotterdam has undergone a dire fate which a total war brings to towns and cities. Utrecht and other towns would have undergone the same fate . . . we were unable to defend the country against the invader." Green belts and parks are eminently suitable and desirable to help zoning a city.[1]



The probable range of variation in bombing a target.

Half a mile width is considered to be the minimum at a radius of five to fifteen miles from the centre by some. In India a greater width may be allowed to be used as pasturage and an inner belt about half a mile in width is preferable to separate the city zones from the residential areas. In times of peace these would serve a very useful purpose. In the inner green belt could be situated schools, community centres, health clinics etc. as well as small industries such as laundries, to cater to the needs of the people. The outer belt would help to provide the city with vegetables and dairy products and protective foods. It is now realised that towns of to-morrow should provide for an optimum diet and food

1. "Hindu," 14th May, 1940.

must be fresh and the citizen should draw the greater part of his protective food from his neighbourhood.[1] The surrounding region should therefore be planned to give the maximum efficiency to an association of recreation and agricultural needs. The Barlow Commission on the geographical distribution of the industrial population of Great Britain after exhaustive enquiries observe: "it is important to have high cultivation near large centres of population" and agriculture should be considered regionally, and the best possible use should be made of the agricultural land in the region.[2] To secure a proper local balance between rural produce and urban needs, building schemes or industries must be prevented from encroaching on rich agricultural land necessary for fruits and vegetables for city consumption.

The medical profession claim the importance of a close relationship between agriculture and men for healthy living. Healthy soil and healthy people are inter-related. A better agriculture in close connection with a neighbouring city will do far more towards abolishing the disease of tuberculosis than any well known methods adopted under the guidance of sanatorium experts. An anti-tuberculosis campaign based on agriculture would do untold good in our country.

A belt of agricultural land around the city will help to solve the drainage problem. Urban dietary, the purification of sewage and urban waste, a belt of agricultural land around the city are inter-related.

A wide green belt is further necessary to maintain the distinction between the town and the country. Wide country belts should be preserved around all cities and towns and the density of urban areas limited sufficiently to permit of the building of houses with gardens for all who desire them, and also to permit of the provision of

1. "Requirements of To-morrow Town," by A. A. Rowse, Principal of Planning and Research for National Development, London. See J.T.P.I. Nov.-Dec. 1939, p. 23.

2. Vide extracts from the Royal Commission on the Geographical Distribution of Industrial Population, Report: J.T.P.I., March-April, 1940, pp. 69—85.

playing fields on some accepted standard at reasonable distances from all houses.

The problem of food supply in times of war also necessitates agriculture surrounding the town and immunity to animals is possible only if they are maintained outside cities. The "grow your own food" campaign should serve as the eye-opener and a green belt of pastures and fields must surround a city both for air security as well as human welfare.

As many large trees as possible should be preserved in these green belts and parks and pasturage and their preservation encouraged to maintain the correct balance between the animal and the vegetable kingdom. They are essential to mitigate the severity of tropical heat and to help camouflaging likely targets. Experts predict that the present rate of consumption of wood would lead to a world timber famine in thirty years. Wars with less planting and more cutting may bring the famine appreciably nearer.[1]

The world is just becoming conscious of the folly of neglecting forestry. Forestry is being carried out in many countries. The "New Deal" in the U.S.A., has kept thousands of men permanently at work planting trees. Britain formulated a forestry policy after the Great War. Even a thick wood adjoining the agricultural belt around urban communities is desirable while trees in parks and pastures are essential.

## RATIONAL ROAD SYSTEM

The next requirement is a sound road system. Here again requirements of defence coincide in the main with civil needs of the population so that the ideal military road system of communication would well serve civil needs in peace time. A number of important planning questions converge around the type of road

1. Vide D. G. Johnston, "Disappearing Forests," the *Hindu*, 5th May, 1940.

plan adopted equally vital to military and civil needs. The military demands require an excellent service of straight broad roads, free of risk from falling debris, linking up the many defensive positions, such positions to be distributed at required intervals, generally through the city area and would have a spread of about 10 to 15 acres each, to give an ample field of vision. Civil requirements dictate that roads should form a network to divide up property into business units and the main arteries to be adequate for traffic and provided with diagonal connections with subsidiary centres, which should occur about every square mile of city area.

A road system that would fulfil all these various requirements is a suitable combination of the chess-board and spider web pattern. This would give the best road results and at the same time provide an elastic basis for the open spaces, of greens and parks. This type of plan would give excellent opportunities for the town layout with open squares, parks, gardens, playing fields and at the same time would produce a very effective part of the camouflage of the disposition of city zones and buildings when viewed from the air.

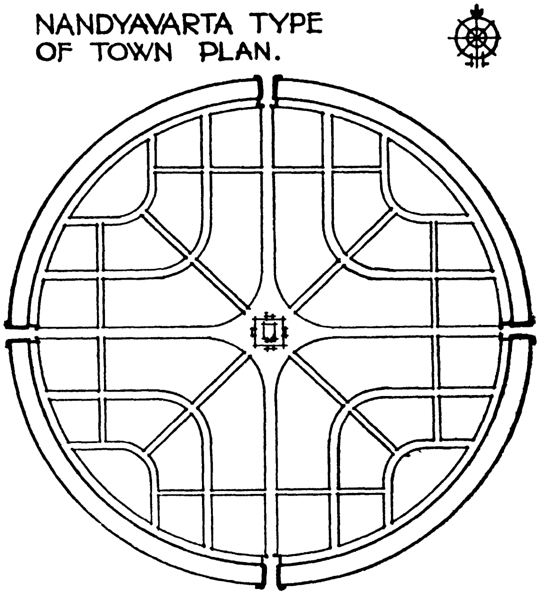
For residential areas the road system advocated by the ancient Hindu Town Planners and practised for centuries by the exponents of her Vastu Vidya, seems desirable. Even in countries where the rectangular system proved highly disadvantageous, such a system is now considered desirable for residential areas. "Internal service roads" observes Clarence Perry of the Russel Sage Foundation, "should in fact be aligned deliberately in such a manner as to discourage all but essential domestic traffic from using them."[1] The road system should further divide the surrounding land into areas suitable for residential zones and in a manner permitting their expansion as shown in the diagram.

The internal road system would in addition consist of boulevards and parkways not merely along the green

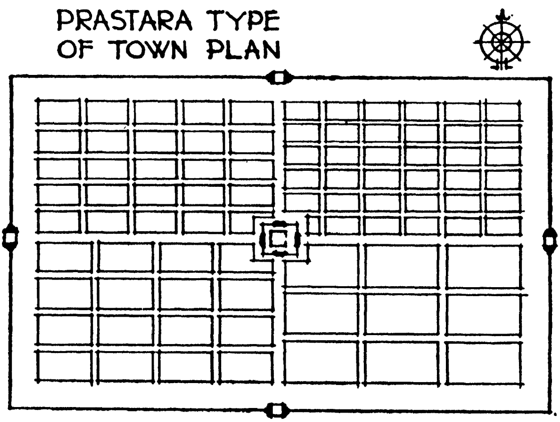
1. Clarence Perry, "Housing for the Machine Age." Review in J.T.P.I., Oct., 1939, p. 371.

belts but also through them reaching the University and

NANDYAVARTA TYPE
OF TOWN PLAN.



PRASTARA TYPE
OF TOWN PLAN



Road Systems and Town Planning according to the ancient Hindu traditions.

Railway Station. Externally arterial roads will connect the city with other important centres of the country, and suitable subsidiary roads would provide access from these to the minor centres.

### TANKS, WELLS AND PONDS

Tanks, ponds, wells and bathing pools suitably located and dispersed all over form the third requirement. Copious supply of water required to deal with fire and gas attack can not be had by underground systems liable to destruction by bombs. Even otherwise, they may not cope with the demand. The strain can be met with only by the former means and cisterns with water are being placed even in London streets. Even medical authorities on A.R.P. have proclaimed this need for European cities and they would be welcome features to tropical towns, in peace and in war.

### CENTRAL PARK AND CITY ZONES

A large central park about half a mile in diameter around which the civic buildings, stately edifices, art gallery, museums, temples and the like may find location, is another essential especially to provide chances of survival to monumental structures. This location would help the enemy who cares to spare them for they would be away from probable targets. A stadium could also be located within the park. Anti-aircraft guns and balloon barrages could be located here to protect the buildings around, which for obvious reason can not be made to conform to the principle enunciated for resistance in Chapter IV. All architecture cannot be sacrificed to air defence and only this can assure chances of survival.

The next requirement is properly located city zones, commerce, administration, trade, banking, insurance etc. preferably situated around the central area, separated from each other by parks and open spaces and gardens and roads. These activities need proximity and should be kept close to each other but separation is needed to localise the destructive consequences of raids. Drainage and water mains must be laid deep underground and roads must be wide to check the spread of fire and vibration effect on buildings. The buildings would of course be framed structures not more than 6-storeyed located around garages which would serve as bomb-proof shelters in emergency.

## TOWNSHIPS AND VILLAGES

Of supreme importance is the residential estate planned in the form of township and village, self-sufficient and self-reliant in matters of drainage and water supply and amenities; these to be removed from the city zones by a green belt at least half a mile in width; with community centres convertible into air raid shelters during emergency, forming the foci of each group of residences. Tanks, parks, playgrounds would intersperse residences. The dwellings must be one or two-storeyed, fire resisting detached buildings, one for each family with sufficient open space around so as to render the incendiary bomb ineffective, gas concentration impracticable and the use of the high explosive bomb not worthwhile. A group of thousand persons should have an air raid shelter and the size of each unit about 10,000 population.

Such a scheme is considered essential to avoid the breakdown of the social and utility services and to check the force "beating down the will to live" produced in large crowded cities like London, Glasgow, Birmingham, Manchester and a dozen other cities of Great Britain. It is feared that unless this is done urban communities will disintegrate.

The peace time value of such schemes is considered to be immense. In fact sociologists emphasise that such re-grouping is needed to prevent the disintegration of urban communities. The model "To-morrow Town" prepared by the School of Planning and National Development recently exhibited in London indicates that in the interest of tranquillity and healthful domestic life, "the towns must be planned to contain a series of communities isolated from each by green belts and woodlands which are the natural projection of agriculture into urban life since live-stock should graze these areas. In these belts should be situated the schools, community centres, health clinics, and local administration and public buildings, which serve the community. The foci of each group of residences should be community centres, and the town should be a system of villages co-ordinated into an urban region of approximately 30 square miles, of which the built up area should occupy a little over three. Each community centre should focus about two thousand families of all classes, and sub-community centres should concentrate the life of an "acquaintance group," of about 2 to 3 hundred persons. A "communal drawing-room" should form the centre of a "friendship group" of about four or five families. This is the number which Sociologists and Psychologists tell us constitutes the intimate circle in which friendship can really grow."

Main shopping and recreation centres would be provided for each group preferably in the middle to facilitate transport and proximity to consumers but their numbers should be restricted to avoid over competition. The figures for proportioning of shops to population are sometimes given as 1 to 30 for middle class families of Great Britain, based upon their needs gathered from Family Budget Enquiries and similar investigation will be required before the proportion could be fixed for this country.

Regarding the density and type of dwelling, the Joint Committee of the Medical Colleges of Great Britain recommends (in its evidence to the Royal Commission on the Geographical Distribution of the Industrial Population) "not more than 12 houses should be erected per acre of building site; each family should have a house with a garden; and it is suggested that the scheme of the garden city is a model towards which the location of industry should work."

A recent survey of the problem of housing has revealed that "the single family dwelling is almost essential for the lower income groups." A single storeyed residence to accommodate one family is preferable; a large one carefully designed wherein a few families are to be housed might be tolerated. For richer folk two or three storeys is permissible if larger space around is possible. More than this is not advisable for residential purposes.

Open spaces, playgrounds and parks are absolutely essential if some of the vital human needs must be met within the suburb efficiently and if recreational centres should be provided for small children within a quarter of a mile from their homes. The Barlow Commission emphasises that in laying out of new towns proper foresight should be exercised to secure adequate open space for the recreational needs of the population. Consideration should also be given to the question of the best possible distribution of the recreational areas; "for instance, five parks or areas of 10 acres each, well distributed may be of much greater utility from the point of view of recreation than a single park or area of 50 acres."

With children up to 14 years of age it is vital that their recreation grounds should be near their homes and the best solution of this difficulty is so far as possible to supply this need in connection with their suburbs. School playgrounds cannot suffice, for proximity is essential. Children use streets as playgrounds and this is a common feature in many urban areas. Playgrounds for smaller children are a park economy and incidentally will help to obtain the correct regional balance of man.

In the residential zone or sectors formed by the green belt and the main roads provision is to be made for the poor, the middle and the rich classes. A composite character is necessary to avoid the dull uniformity that would result from one class of people and from the deadening monotony with which the region would suffer. But a mixed group is possible, only when the entire layout is cleverly done and the architecture is properly controlled.

Slum areas could be rebuilt in such a manner that people of higher income groups may be perfectly happy in living in such neighbourhoods because the attractive window vistas, the parks and tidy streets will be such as to give the locality a definite tone.

A sound environment is essential for the welfare of the people and such a suburb would make possible this vital requirement. Here it will be possible to view 'man' as part of the region and plan his home, his garden, his leisure and his work accordingly. The importance of this consideration will be realised by the fact that a new council has been formed and conference called on problems of social environment in February last in London.[1] Believing that the welfare of the people depends on the sound environment for the individual, resolved that a Council should be established with the immediate object to promote through research groups and by other means, the planning of social environment on a national scale and to make widely known the need for such planning.

Opinion differs as to the maximum size of the suburb. The estimates made in the United States and by Principal Rowse have been given. To India the criteria selected by Clarence Perry would be suitable. "A residential unit development should provide housing for that population for which one elementary school is ordinarily available within rather less than that distance from any home. One tenth of this area should be allocated to open space and no through traffic road should traverse the area, although such roads may conveniently bound it."[2]

## PASTURE AND AGRICULTURE

The next requirement is a wide belt of pasturage preferably surrounding the residential areas to feed and house cattle and live-stock, catering for the dietary, transport and other needs of the city. This would eliminate the dangers of mixing cattle shed and residences

1. Report upon the conference on Problems of Social Environment and the War, held in the R.I.B.A.; the "Builder," 9-2-40, p. 162.

2. Clarence Perry. Vide *ante*.

together and the difficulty of protecting animals in air raids. Aerodromes and anti-aircraft positions would lie in this area and check the raiders in advance and the anti-aircraft shells would do less damage to the city.

### NERVE CENTRES

Carefully located railway stations, aerodromes, nerve centres etc. are also needed for air defence. Regarding the location of docks, railway termini, factories and other vital points one school of thought with the idea of reducing vulnerability would advocate their splitting up into a large number of small groups in different areas in order to reduce the risk of complete disablement. This is desirable to some extent but the loss of economic operations and coherent and well organised defence are disadvantageous. To meet this difficulty it is suggested "to make for halfway provision and provide only dual groupings for vital zones, which has become a common rule of precaution in many spheres tutored by A.R.P." This is not possible for all the items above mentioned. Electric power houses might follow this principle. The railway line is best removed outside the city and connected by an efficient bus system. To the average Indian city it is advantageous to have the station as shown in the diagram. For emergency use an alternative line must be provided at a safe distance from the normal one. When the usual line is destroyed the other might be used and temporary platforms and stations could be improvised.

Aerodromes are large and easily recognisable from the air and constitute a very important objective for the raider. They must be equipped with anti-aircraft devices. Lest anti-aircraft shell fragments should injure men and building, aerodromes must be located at a safe distance from the residential and business areas. This is also necessary to ensure civic comfort in times of peace. Aircraft noise is especially distracting to those who live in the neighbourhood of aerodromes where people are learning to fly and where a great deal of low flying necessarily takes place. The Goral Committee which studied this problem therefore consider it advisable that Town Planning Schemes should in their very earliest stage make provision for the preservation of aerodrome sites by suitable zoning in order that difficulties that may be met with in the past may not be perpetuated.[1] They also feel that care should be taken to ensure that the future use of lands adjoining intended aerodromes (Service or Civil) should be so restricted as to prevent its development for such building purposes as would render impracticable the enlargement of aerodromes should need arise and obviate possible complaints of nuisance. Locating them in the pasturage surrounding the town would meet these requirements and when sited as shown, will facilitate access to the city and the railway, and also economise the need for anti-aircraft devices by making possible for lesser number of units to safeguard both the railway station, the aerodrome and factory suburbs.

Nerve centres not easily destroyed are essential and their location should facilitate effective camouflaging. The post and telegraph office, the telephone exchange, the wireless station, electric power houses, etc., as also bomb-proof safe deposit vaults for the use of the public and bomb-proof chambers for preserving government and public records, manuscripts, and rare books which cannot be replaced when once destroyed and bomb-proof ammunition stores must be situated in green belts. Minor industries that cater to the needs of the citizens would also make use of this land if required. Government offices and administrative departments which need not be in the busy zones could also be located here. The trees and vegetation and parks would make identification of targets more difficult and when creepers and plants are grown and allowed to cover these structures, in the fashion of the village homes covered by plants which provide vegetables for the inmates, an effective camouflage would become possible at very little expense.

1. Report of the Goral Committee on the Control of Flying, J.T.P.I., p. 212.

## SEPARATION OF INDUSTRY

The factory and the heavy industry should be located outside the city zone. They are particularly liable to attack and even unsuccessful attempts would amply reward the bombers by the casual destruction. Proximity to residences and city zones is conversely disadvantageous to them for this same reason. Separation is dictated by the requirements of air defence as also splitting very large units into smaller ones. Diversification of industries is also essential to infuse strength into civic communities and to prevent the destruction of one city from affecting many others. Defence must influence the choice of location and this applies even to consumer goods industries, whose labour supply, raw materials and markets would be very much affected by the large scale evacuation of target areas planned in the event of war. Vulnerability of transport and utility services would also be another serious consideration. The Report of the Regional Development and Location of Industry of the P.E.P. points out:

"In order to make important industrial plants less attractive to the bomb, it is necessary to consider the possibilities not only of local defence but of spacing out buildings on the site, particularly where the risks of fire or explosion are high and of moving production out of the most vulnerable areas." They conclude "that dispersal of works away from target areas is needed, as well as dispersal of sections of works on the site; that new locations should as far as possible be chosen away from obvious landmarks, such as bends of rivers; that the more fragile type of factory construction should be avoided; that duplicate means of transport and raw material supplies should be found and brought into regular use; and that large stocks should be maintained at the points of consumption or procession."[1]

Diversification of production and occupation is necessary both for resistance as well as to obtain a balanced regional development. While it is impracticable

1. The Report by the Regional Development and location of Industry Group of the P.E.P. J.T.P.I., April, 1939, p. 202.

to assure that every town should be feasible to secure considerable diversification in every region a large region composed almost exclusively of cotton towns or coal towns or a city specialising in soaps or steel etc., has been shown to be highly precarious. The objective of policy should be the attainment of maximum earning capacity with minimum risks and liabilities in the long run over a wide area, instead of the pursuit of maximum earning capacity in peak years in towns of narrow areas with high risks and with liabilities left uncovered.

Requirements of peace also dictate that industries must be removed, dispersed and located outside the towns. This is further necessary to facilitate the location of residences for the workers at satisfactory distances from them. Separation will avoid traffic congestion, fatigue to workers as well as the noise and smoke problem to citizens. It is now felt that there is no evidence to show that noise associated with industrial life is diminishing and it is felt that population can be protected in a large measure from its effect by enlightened town planning and decentralisation and that the same is true with regard to smoke. Statistics submitted to the Barlow Commission appear not only to establish a correlation between smoke pollution of the atmosphere and the excess mortality but to show that though the harmful effects of the smoke-producing heavy or textile industries upon health have diminished in England during the last 20 years, those effects are still very potent.

The position is thus summarised; "a policy of decentralisation or dispersal of industry from over-crowded areas is definitely to be recommended on strategical grounds: of this there can be no question, and such a policy coincides with and reinforces the general proposals on similar lines already shown to be desirable in connection with the social and economic disadvantages of concentrations."[1]

The location shown for industry simply represents the need for separation and suitable sites could be selected

1. Report of the Barlow Commission.

according to the prevailing wind and site conditions.[1] The question of housing industrial workers should also be considered in choosing the site. It is advisable that their residences should have proximity to the city zones and at the same time separated both from the city and the factory. A green belt of parks and gardens should separate the residences from the factory. From 500 to 1,000 yds. might be considered reasonable for its width.

In European countries it is now realised that the industrial worker has to spend a good deal of his time and money on travel to and from work. In England it has been estimated that expenditure on transport by public conveyances within the London Passenger Transport area comes to, about 15 pounds per family per annum or about 8 per cent. of the average income of working-class families in London. This great waste will be avoided if industries and houses were suitably grouped in garden suburbs near the large city. Only one industrial suburb is shown but according to the needs and facilities more might be located at convenient spots. The question of size is difficult to decide. After careful investigation it has been found that industries employing 10,000 workers are justifiable. Expansion of Industry would be possible by total relocation, or by ancillaries located on the main national speedway and the railways.

## UNIVERSITY

The University and seats of higher learning must be drawn out of the busy areas of the city, for obvious reasons. From the increasing importance attached to residential universities and colleges it would be evident even for peace times this is necessary. At the same time

1 The principle of isolation and segregation of industrial residences is now recognised by Government in Great Britain In dealing with a proposal by Messrs H G Cuff & Sons recently, regarding the development of land zoned for industry for residential purposes, the Ministry in their recommendations suggest that in dealing with plans for the development, they should consider the lay-out from the point of view of A R P "In considering this aspect of the matter the Council came to the conclusion that protection of the civil population from air attack could best be secured by isolating the areas which are most likely to be the object of attack from the air (viz., factories) . . ." ("Ministry of Health Appeals" J T P.I., Nov-Dec., 1939, p. 11).

access to the city should not be cut off. Tranquillity, peace, and healthy atmosphere cannot be obtained if they are situated in the hearts of cities. Other educational and allied institutions might also be similarly located.

### SIZE AND SHAPE

The determination of the size of the ideal city, raises difficult issues. Local features and requirements, municipal finance, civic amenities to be provided, etc., would be the governing considerations. Although cities in India cannot compare in size with those in the West, some of them are large enough and have developed the evils gripping European cities. Thirty-eight cities contain over hundred thousand inhabitants and two of them over a million. The Royal Commission on the Geographical Distribution of the Industrial Population of England arrives at the conclusion that it is not practicable to define when a town has reached such a stage, either in size or in extent. It is suggested that considerations of space and distance in the case of the larger urban areas, involving problems of transport and traffic congestion, should serve to mark the stage when decentralisation must be contemplated.

Mere size need not in itself be a disadvantage, but it is size without system, chaotic growth without the adoption of proper principles of planning alike for social well-being and for industry, that are to be avoided. But the Commission seem to think that there is something to be said for a city with a million inhabitants. The optimum size for India would be smaller considering the predominance of agriculture in her national economy. Perhaps half a million might be fixed as the limit for population and 50 to 60 square miles as the maximum size. The open pattern for residential suburbs and decentralised supply of essential services would make possible the management of the city with the normal taxes and income from the city. Expenses now incurred upon curative measures would be avoided and the municipal budget reduced to the smallest dimension.

But cities grow and it is difficult to put a stop at any particular stage even if it were possible to discover what the correct stage is. Three methods have been suggested to control urban expansion.[1] One is an embargo on all buildings within a fixed distance from existing boundaries, thus providing a green belt from ten to twenty miles in width; another is a combination of this method with the development of satellite towns; the third is the use of a system of radial development. These are put forth to prevent cities from extending to unwieldy proportions without placing unwholesome restrictions.

The first is drastic and impracticable. The density in urban area would increase by natural expansion and when the district begins to decline in prosperity the trades will be transferred to more free areas, and give rise to other problems. This defect is also present in the second method.

The development of satellite towns would have to be accompanied by some provision for their limitation of size, as otherwise they would become rival centres to the parent city and would create again the same problems of control. Limitation of size, however, would result in the creation of many such areas because of the rapid growth of population, and the multiplication of small satellite towns could hardly be a desirable feature.

A system of spur development defining directions and limits within which urbanisation would be allowed, would provide a solution to the problem which would not suffer from these rather serious defects. The result would be the creation of spurs linked like spokes to the central hub and providing for open country between as a general amenity and for agricultural purposes. Provided that the width of these spurs was limited to approximately two miles the open land need never be more than one mile from any of the newly developed districts, and yet proper development would not be restricted but would only be controlled in direction.

1. Vide J.T.P.I., February, 1940, p. 41.

Contact between the various areas would be maintained, proper amenities would be preserved, and the products of agriculture would have a market ready to hand. Road communication would be made easier, and could lead directly from centre to centre without restriction. Ring roads could be built more easily, since they would be largely across country without development alongside. Railways could run along the spurs supplying premises on the route and airports could be sited near to the areas they were designed to serve instead of many miles away, with the consequent loss of much of the time saved by extra speed in travel.

The circular design is therefore helpful to control the size of the cities as well as to facilitate the development of the surrounding country, and even where development alround is not practicable as for instance on a coast, the main principles could be followed. The circular plan has been recommended by well-known experts in Town Planning. Sir Raymond Unwin has emphasised the need for maintaining a sound relation[1] between the town and the country, the rural and the urban economy and for urban folk having easy access to the extensive open country, and concludes that open green belts should surround urban areas and intersperse residential units of families. Says he: "One type of design which fully meets these conditions, which while facilitating the desirable pattern in detail for each urban unit will provide a plan for expansion, and will allow the units to grow in number, and to be federated into the larger groups demanded for the support of many modern economic and social activities; that form consists essentially in a central unit or town, planned to reach a certain maximum size, within which the right detail, relation of parts, or the pattern, can be maintained. Further growth of population would be provided for by planning of new units of urban development, each as complete as possible, intended to localise the daily life of the inhabitants, while securing such relation to the

1. "Urban development, the Pattern and the Background."

parent town as will open its greater central opportunities to all who need them, and secure that the new units are at once linked to the parent unit by easy communications, and separated by a sufficient background of open land to maintain definition and satisfy all the needs already referred to both of the centre and the satellite units as we often call them."

The circular plan is further considered helpful for political progress, and as indispensable for the preservation of democracy and democratic ideals. Perfect equality of situation is secured by settlement in a circle and among the nomadic peoples who, though their numbers might increase, only met periodically for a religious festival or marketing, the circle in which they pitch their tents is easily enlarged. The circular plan appears to be actually the basis of some of the earliest built cities. Other advantages are also claimed for the circular plan. It obviates the popular objection to the perfectly straight facade, and helps to give individual tones to groups. The proper arrangement of a group that is not too large to allow scope for the individual, is the square or crescent of houses representing the original ring settlement.

"Living in such cities we should be, as it were, seated around a table and we should know what that means. People who enjoy life within sight and hearing of one another cannot avoid developing feelings of generosity and kinship."[1]

A city formed by several small and compact communities located around the chief commercial and administrative areas will satisfy the criteria postulated by Aristotle for preserving democracy. According to him democracy could not survive in a city too large for the town crier's voice to be heard throughout it. Anything which guarantees the equal dissemination among all the citizens of the knowledge of events as they happen, and an equal opportunity of the response of each citizen being heard, is a guarantee of democracy, and the ground plan

1. J.T.P.I., Nov.-Dec., 1939, p. 23.

of a city has much to do with this. The formation of that powerful force, public opinion, fails to-day because of the geographical isolation of sections of the population in inaccessible parts of the cities or in the country where so many people are refugees from the unbearable towns.

The Greeks planned their cities for democracy and although representation renders restriction on size not essential the principle expounded by Aristotle is valuable. "Equality of situation for all its citizens in regard to the enjoyment of the public amenities and common services which the city exists to supply." This requirement of democracy is also good for defence. A circular city has less perimeter to protect than one of equal area rectangular or square in shape. Active defence would be easier as also protection by land forces of the city's boundary. Economy in anti-aircraft guns and balloon barrages will also be secured. This need can not be overlooked for reasons already explained but the plans and details are best entrusted to the defence department.

These are the essentials of air defence for modern urban communities and cities planned and laid upon these principles can be considered safe for all practical purposes. How can a change in the pattern of our existence prevent the enemy from sending bombers to raid. But a careful examination will show that destruction will be reduced to the minimum to city structures and dislocation will be nearly impossible and citizens will be absolutely safe. This may not make air raids impossible, but will defeat the purpose of the attempt and render it wasteful and ineffective. These would make raids not worthwhile and ultimately impracticable. Herein lies the chance for cities and civilization to survive the air menace.

Even if more powerful weapons are discovered and brought into use cities built as suggested would render possible effective precautionary measures and precautions would pay. Added resistance could thus be secured and more deadly raids could be defied.

The expense and effort of preserving civilization and culture in its modern abode—uncontrolled agglomeration of men and buildings—is prohibitive. 360 thousand pounds a day are needed for partial evacuation and A.R.P. Organisation for England; not to speak of the 9 million pounds expended every day to resist aggression mainly from the air. Is it too much to ask then to spend much less to obtain much more—a permanent abode of peace and security for man and his material culture?

The peace time advantages alone are sufficient to recommend a change in the pattern of our existence towards the ideal described above. Re-shaping existing cities is worthwhile and a long time view of municipal finance and civic economy would justify and warrant the attempt. The expense needed in times of war for protection makes this change imperative.

### Bomb-resisting Cities

This pattern has the advantage of preserving the normal life of the people in healthy surroundings and avoids the difficult solutions suggested to produce bomb-proof cities by Le-Corbusier and Air-Commodore Charlton. According to the former, the city will be deep underground; the railways, roads and factories, and power houses would be out of reach of air bombs; nay the entire city! Suggestions have also been put forth to solve the various problems that would arise as a result of locating cities deep underground; such as lighting, power production, etc.

Air-Commodore Charlton however believes that bomb-proof cities overground are possible. His plan consists of fifteen storeyed dwelling towers, cruciform in shape as to ground plan. Each arm will end in a T-head and similarly crossed twice between head and centre joining. From above they will resemble two equal lengths of codfish backbone laid crosswise. Circular-shaped reservoirs, one to each group of four towers, would provide a never failing supply of water for fire-fighting purposes whatever damage the mains or pumping stations might suffer. They will look like noughts.

According to Charlton,[1] the dwelling towers would be widely spaced and stand separate, nothing in the shape of built-up streets or walled enclosures which might retard the dispersion of gas, being permitted. The life of the place will go on in these tall erections, each of which will be connected with its neighbours by deeply situated underground passages. The wall would be of concrete, as also the foundations, and an apron of concrete 12 feet thick, would be laid as a wide footing, so that a bomb explosion nearby may not jeopardize the main structure. The flat roof will be of reinforced concrete, 10 feet thick, and the attic storey lumbered up with material, such as cement and compressed wool bags, best calculated to resist the passage of a bomb.

Each edifice would be housing 1,500 persons in the eight storeys beneath the attic, the remaining six, from the ground floor upwards, being dedicated to a different use. The idea is to obtain the maximum possible security at one and the same time against the three forms of aerial bombardment, high explosive, gas, and incendiary bombs. The plan of the buildings should be designed to afford a minimum surface on which a bomb might strike, and the constructional material of roof, walls, foundations, and footings to be capable of resisting penetration and impact. The water-reservoirs secure the means of fighting flames if an incendiary should take effect.

As regards gas protection, more necessary than the other two, the inhabitants only dwell in the high-up part of the building the altitude of which places them out of reach of the low-lying gas clouds. They could breathe pure air at all times, and if necessity compelled them to go down, the masks and special clothing which is to be universally provided would protect them during a short absence.

1. L. E. O. Charlton: War over England.

The ground floor, and the five storeys above it are to be adopted for non-living purposes, shops, markets, theatres cinemas, restaurants, and all other amenities of town life for the use of the public at large in a sense of non-privacy. These lie within the gas zone, it is true, but they could be immediately evacuated in case of alarm and the people could ascend to their upper floors. "In this way herding in subterranean shelters in conditions of fright, artificially ventilated, with the knowledge that gas lay all around outside, the danger of imprisonment from overhead collapse, and all the other serious objections to that form of security is avoided. Private life undergoes a minimum of disturbance and the gas peril ceases to exist."

Such a town of "Noughts and Crosses" is also bomb-proof as regards its ordinary water service, its electricity supply and its telephone system. These are canalised in concrete underground conduits running side by side simplifying inspection and repair, and permanently laid. Drainage is to be conducted in the same way. Lighting would be diffused from the kerb and one main switch could plunge the town in outside darkness. Overhead life will proceed normally in normal times and the life would be happy.

Balloon barrages and machine-guns would guard against low-flying attack; searchlights, obstacles and aerial mines would meet high bombers. In certain special localities these means might be supplemented by smokes and camouflage.

## Town Planning and Air Defence

A deep underground city or a "Noughts and Crosses" might become indispensable for a highly industrialised country where scope for lateral expansion is slight, but they are neither necessary nor practicable for a poor and vast agricultural country like India. The open pattern for reasons already explained would obtain as much security from air raids as these cities and would be very much cheaper. And while those patterns may secure air safety they cannot help to achieve the balanced dispersal of population and industry and the correct proportion between urban and rural interest in the Nation's social economy. The open pattern described is essential to give the nation the proper physical basis for developing a stable and healthy civilisation. The Memorandum of Thomas Adams on "Town and Country planning during the War" circulated for the information of planning authorities in England and Wales lays special emphasis on the balanced development of the nation as a whole. "What is most vital is that the nation should be planned in its units of urban and rural areas in order to promote most efficiently the wealth-making activities of its population and to provide them with higher standards of living and working conditions."

Planning in its most comprehensive sense alone can thus obtain air security for India by re-grouping and locating her population and industry in towns and villages in suitable proportion. That planning is necessary to meet the air danger, and re-planning existing cities on proper lines alone can help the survival of cities and civilisation is now recognized by leading authorities and governments of Europe.[1] Legislation with this object in view is gradually developing. In France the height of buildings was subject to regulation with reference to the width of the road. According to an order issued in 1938 in Poland "all new urban developments must be planned in sections of irregular form. Roads and Streets must be straight and should run in the direction of prevailing wind, leaving at least 60 yards between the fronts of buildings on main thoroughfares."

Fortyfive per cent. of the area developed must be left as open space used either as recreation grounds, aerodromes or for agriculture. Industrial districts must be laid out in small widely separated areas and the ratio of industrial districts to the whole town should not exceed 1:7.

1. Sir Alexander Rouse, "Town Planning in Relation to Defence." J.T.P.I., Dec., 1938, pp. 39—46.

Modern dwelling houses of over 2,500 cubic meters must have an air raid shelter for the residents. The shelter must have two entrances, one of it must be beyond the area which would be covered if the bulding were to collapse.

Closely built up areas in existing large towns must be broken up by the introduction of open spaces.

The Town Planning laws of Germany go further and regulate the distribution of industrial production, choice of sites, size of plants and their layout, as well as works operations and supplies. "Under the town planning regulations of the Reich and Federal States, the construction of new plant or extension or alterations must be so carried out as to achieve a marked decrease in the vulnerability of German industry to air attack, with a view to re-distribution of industry so that finally industrial production will be spread more or less evenly over the whole country." The choice of site should in the interest of air protection be not conspicuous from the air and workers' houses should also be kept well away from the works. To minimise the destruction to productive plant, measures are in force to deal with the size, position, and nature and method of operation of industrial plants. From this point of view many small buildings irregularly scattered over the site are preferable to a few large ones in ordered rows, and it will be the works engineer's task to satisfy in his layout both the economic necessities of the plant and air protection requirements.

To restrict the effect of an air raid to a part instead of the whole of the plant, the various buildings comprising the plant should be separated from one another so as to segregate the works' processes to some extent, and in large works technical and administrative departments are recommended to be outside danger zone of the plant. The provision for an alternative supply of electricity, gas, and water is specially stressed. A sufficient large strip of unbuilt land must be left between the works and the workers' houses and they must be laid out some distance away from the works. Shelters for small houses should be constructed so as to serve as storage cellars during peacetimes and must be built with solid ceiling, the entrance being rendered splinter and gas-proof by such make-shifts as sand bags, sand boxes, stone packing and the like. If the houses are flats likely to be bombed the shelter must be in conformity to official regulations.

Reliance is placed on dispersion. It is aimed at extending Berlin over twice its present area without increasing its population. No house would be allowed with more than six floors.

Researches made in Germany regarding the relation of Town Planning "to the total economical life of the nation in its future form under state control" are considerable. And the investigation of Stadrat Niemeyer, President of the German Academy for Town Planning, Reich and Regional Planning, pays attention to the question "How does protection against air attack affect the position and a territorial distribution of Industry and Commerce expected."

Even in Great Britain considerations of Air Defence are influencing Town Planning. The Civil Defence Act has made the following important addition to the Town and Country Planning Act, 1932.

There shall be included among the general objects for which a scheme may be made under the Town and Country Planning Act 1932, the object of rendering the whole or any part of the area to which the scheme applies less vulnerable to air raids, and that Act shall have effect accordingly as if the said object were included among the objects enumerated in Section one thereof.

In future therefore, the machinery of planning schemes will be available as a means of rendering an area less vulnerable to air raid. The Town Planning Institute after careful consideration finds in general that it could be readily adapted to deal with this new objective and the amendments they propose have the effect of making it certain that the object of safety from attack from the air shall be taken into consideration in all appropriate cases. They also suggest appropriate dimensions and proportions with regard to space around buildings, maximum proportion of site to be covered, the height of buildings and the width of protective buffers of open space, etc.[1]

The requirements of air defence and principles of Town Planning agree on many fundamentals. As pointed out by the Council, "there is a considerable measure of agreement between the generally accepted principles of planning and those of A.R.P. in as much as large concentration of population or industries and crowded developments are bad from both points of view." Although the whole life of a civilised community cannot be planned on a war basis the eventuality must be taken into consideration and planning our requirements should be adopted to minimise to the maximum extent, the dangers of air attacks.

The fundamental principle governing A.R.P. in relation to Town and Country Planning is dispersion, and this is possible if the groups are kept relatively small and have an open pattern.

Secondly, the road system should consist of through routes clear of building development, and commodious in centres of population.

The layout of administrative buildings, national and local, should be spaced apart, decentralisation should be encouraged and provision made for suitably placed alternative accommodation to be available in case of need. While their grouping necessarily increases vulnerabilty to attack from the air, the practical and social advantages of grouping and zoning are predominant.

1. Memorandum of the Town Planning Institute on "A.R.P. and Town Planning in Great Britain."

The single family house at a density not exceeding twelve houses per acre is considered the best form of development. Large multi-family dwellings are therefore undesirable and where indispensable, should be widely spaced and provided with air raid shelters. Their safety is enhanced by interspersing small parks, playing fields, and allotments.

A.R.P. demands that industries must be widely dispersed, but experience shows that a certain amount of grouping is essential regarding communications, homes, power services, raw materials, markets and ancillary industries.

"Large concentrations of industries should be avoided and in all cases they should be well separated from residential areas by a belt of open space. Industrial areas and warehouse areas should be laid out on spacious lines so that the buildings can be spaced wide apart. A spacious form of layout will minimise the risk of direct hits, will provide fire breaks, and will afford facilities for the digging of shelter trenches for the employees."

"The relation between home and place of work is of considerable importance as ease and comfort of communication is desirable both in peace and war. A relatively close relationship separated only by a buffer of parks affords an ideal solution as it should meet the needs of convenience, safety, recreation and amenity."

Ribbon development is undesirable in peacetimes but as it makes easily distinguishable mark from the air they are unfit for air defence. Developments in small groups related to but not lining main roads, railways, rivers and canals should be preferred.

Whenever opportunities occur towns must be re-planned on these lines to encourage decongestion and dispersal; the development of holiday camps is also emphasised as useful for children as well as for adults.

How these general principles should be applied? For instance an adequate area of open land within industrial and residential areas is always desirable but is of particular importance in relation to safety from air raids. Warehouses storing essential commodities are liable to attack and need separation from residential areas. On the question of the width of the buffer it is felt that "the appropriate width of the buffer will vary according to such circumstances as the configuration of the ground, and whether industries or warehouses are likely to form a particular object of attack (*e.g.*, electric power stations, gas works, docks and warehouses, water works, aerodromes, armament works, food stores), and whether the industries themselves are likely to spread havoc if hit (*e.g.*, explosive factories, oil refineries or stores, varnish works, timber yards".) It is suggested that the width of the belt might vary from 100 to 400 yards according to circumstances including adequacy in relation to appropriate peace time use.

Possible peace-time uses for such buffers would be parks, playing fields, allotments, private open spaces, and possibly cemeteries.

The Town Planning Committee lays emphasis on space about buildings and suggest modifications to existing Clause 42 of the Town Planning Regulations of Great Britain in view of the importance of open pattern of development and of a spacious form of layout, for industrial and warehouse areas. The following maximum is suggested for the proportion of site which may be occupied by buildings.

| | |
|---|---|
| Dwelling houses, residential buildings, other than blocks of flats, places of instruction and institutions .. | 1/4 |
| Blocks of flats .. .. .. | 1/6 |
| Other buildings .. .. .. | 1/3 |

The breaks between buildings, are also emphasised. They suggest alterations in accordance with the requirements given in A.R.P. Hand Book No. 9. The safe fire break (distance between buildings) respecting buildings of low fire risk is given as 30 feet. They suggest a minimum standard of 30 feet should be applied (15 feet as between the building and the boundary.) Regarding Industrial buildings they consider 40 feet suggested by A.R.P. Hand Book No. 9, necessary.

The possibility of collapse and debris falling off to other buildings or blocking roads or foot paths is a fresh consideration, with regard to the height of the buildings. Its limitation is necessary to keep the roads free from being blocked. Having regard to A.R.P. they recommend that one angle only namely 45 degrees should be specified as a general guide.

The siting of buildings is also emphasised to enable the development of adjoining estates to be properly related and access to be safeguarded. Finally they remind us that authorities should bear in mind the value of trees as a screen from observation from the air. The preservation of trees becomes a question of outstanding importance.

The principles of air defence lead to garden city types—a federation of residential suburbs with a suitable proportion of non-residential zones. Lateral expansion is essential to re-shape existing cities to conform to this ideal. This is not difficult in our country where most large cities are surrounded by level open country. A series of satellite towns would serve as district headquarters, marketing and industrial centres, and other important towns. Factory centres would do well to retain more the complexion of garden cities. A "hundred small towns" ideal could be achieved which would restore the lost balance between town and country as well as the homogeneous distribution of towns and villages. In making India proof to the air danger, her industries and factories would be suitably dispersed and located, not merely with a view to ports and capitals but also their efficient distribution over the country.

Thus a network of air raid proof provincial and state capitals surrounded by suburbs and connected with garden towns, satellite towns and industrial centres, holiday resorts, places of pilgrimage etc. serving as the fountain heads of rural betterment, and with the seven hundred thousand villages suitably grouped forming the back-ground, would obtain air security for India. The importance of passive defence can not be exaggerated in this vast country of poor finances, both central and provincial. To defend a territory less than a tenth of ours in extent it costs Great Britain 10 crores every day. When sixty crores a year upon defence is considered an intolerable burden upon the poor peasants of India, can our country bear to spend hundred crores a day?

# CHAPTER VII

## DECENTRALISATION

# CHAPTER VII

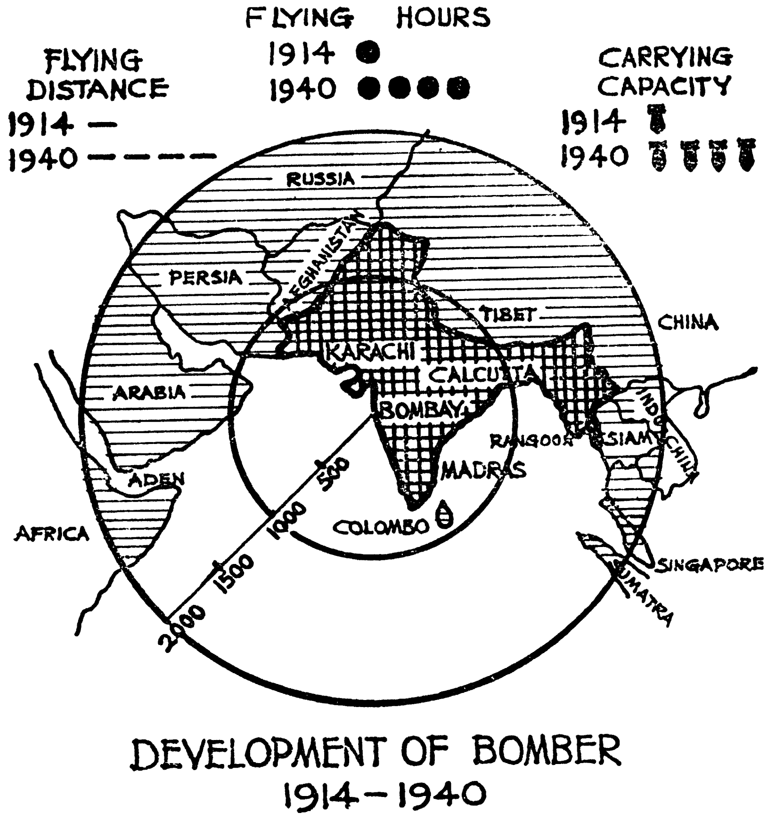
## DECENTRALISATION

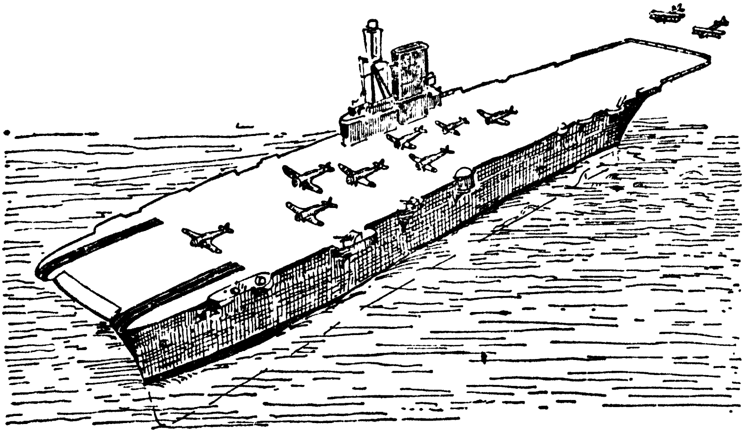
No nation can successfully resist air attacks until her people are provided with cities and towns, planned on the model described in the previous chapter. If urban areas are left as they are air security becomes not merely expensive but impossible. Defence costs nine million pounds a day for Great Britain largely because of her cities, their form and location. A.R.P. and evacuation alone amounts to £360,000 a day to which must be added the cost of maintaining ground batteries, balloon barrages, coastal patrol and other organisations. More than £10 millions have been spent on shelters that would give some protection. In spite of these air attacks are proving highly destructive and the expenses must continue so long as the threat of air attack remains. Reshaping existing cities is therefore recommended to obtain air security for nations both in the interest of economy and dependability.

### INDIA AND AIR SECURITY

This process can not be quick. It has been found that a maximum of only one-sixtieth of the total area of a large town changes every year to replace existing buildings by entirely new ones, and 30 years if only the older half of them were brought up to date. If this is the case in a country where legislation for Civil Defence touches almost every aspect of the nation's life, a longer time must be allowed, for widening the roads, zoning cities and establishing residential estates of the correct type in this country. Can we afford to wait for such a long time? The long range of modern bombers, the possibility of aircraft carriers bringing aeroplanes to our shores have broken the air security of India.

Raids have been made upon Aden and Italy's entry into the war renders less difficult attacks upon India with



A typical Aircraft Carrier.

a long coast line. Our country is particularly vulnerable to the fleet air arm and the destruction it can cause is no less terrific. For instance naval aircraft inflicted terrific losses upon the enemy in Norway; they attacked transport and supply ships, destroyed aerodromes and buildings and aircraft harassed the enemy and also protected their own carrier fleet. As the Bombay A.R.P. Report points out, this danger is particularly serious for the coastal towns.[1]

"there is a real danger that the City of Bombay would be subjected to attack by hostile air forces. . . . Attacks by air forces would be either (*a*) by seaborne aircraft, that is aircraft operating from an enemy ship standing off Bombay, or (*b*) by aircraft based in a hostile country. The latter method of attack is only a possibility at present but with the ever increasing range of modern bombing planes, the possibility may become a probability in the near future."

## URBAN CONGESTION AND DECENTRALISATION

The destructive consequences of air raids would be not in any way less than in other countries. Average density in India is 39 homes per square mile and 5 persons per house, but this does not indicate the vulnerability of India. The layout and the physical features of towns and even large villages are very helpful to air attacks. Dwellings are clustered together, packed closely with little space around each dwelling. A number of such narrow strips surrounded by pastures form the village while many more such streets form a town. Detached houses surrounded by garden as found in parts of the West Coast in Malabar and Travancore, and in rural Bengal and Assam form a very small proportion of India's houses. Both Indian towns and villages are extremely vulnerable to incendiary bombs, gas and the high explosive. If Spanish experience should guide us (towns of 10,000 inhabitants were not spared) over 10 per cent. of India's population need protection against air raids. The following table showing the distribution

1. Report of the Bombay A.R.P. Sub-Committee.

of India's population according to the size of villages and towns would indicate the number of centres and population liable to danger.

*Towns and Villages classified by population.*

| Size. | No. | Population. |
|---|---|---|
| 1. Under 500 .. | 509,786 | 97,516,496 |
| 2. 500 to 1,000 .. | 113,541 | 79,189,377 |
| 3. 1,000 to 2,000 .. | 53,908 | 73,707,758 |
| 4. 2,000 to 5,000 .. | 18,836 | 53,556,566 |
| 5. 5,000 to 10,000 .. | 2,330 | 15,412,217 |
| 6. 10,000 to 20,000 .. | 632 | 8,537,719 |
| 7. 20,000 to 50,000 .. | 269 | 7,940,572 |
| 8. 50,000 to 100,000 .. | 66 | 4,566,885 |
| 9. 100,000 and over .. | 38 | 9,640,132 |
| | 699,406 | 350,558,841 |

(Census of India 1931, Vol. I, Part II.)

India (including States)

Area in Sq. miles=1,808,679.

| | No. | Occupied houses. | Population. |
|---|---|---|---|
| Towns .. | 2,575 | 7,935,898 | 38,985,427 |
| Villages .. | 696,831 | 63,126,239 | 313,852,351 |
| Total .. | 699,406 | 71,062,228 | 352,837,778 |

For the present we could leave out of account those residing in villages of less than 5,000 inhabitants; those who dwell in those between 5,000 and 10,000 might be harassed by machine-gunning and incendiary bombs by low flying aircraft; those who live in centres where more than 10,000 dwell, definitely need A.R.P. measures, while the inhabitants of 38 cities with 100,000 and over should come in for special consideration. In other words 30 million people need protection from air attack in our country. Although arbitrary this grouping would help to show the intensity of the problem in India.

Average densities are not of great practical value for this vast country with varying conditions and features. As the Census Commissioner remarks "the indeterminate nature of the village limit, which may be a definite residential site, walled or palisaded or, may be an administrative unit containing several residential villages or a number of scattered houses, impairs the significance of the figures of the population as distributed in villages of various sizes." Averages for India reveal the following figures:—

| Census. | Persons per House. | Homes per Sq. Mile. |
|---|---|---|
| 1901 .. | 5·2 | 31·6 |
| 1911 .. | 4·9 | 35·8 |
| 1921 .. | 4·9 | 36·1 |
| 1931 .. | 5·0 | 39·3 |

(Census of India, 1931, Vol. I. Part II, p. 55.)

The house for census purposes is "any part of an inhabited building with a separate entrance." And averages per house and houses per acre cannot reflect the situation for one building may contain many homes and families. Overcrowding is extremely vulnerable to air raids and parts of Indian cities are very congested as the following table would show:—

| City. | Ward or Division. | Extent acres. | Density per acre. |
|---|---|---|---|
| Bombay | Kumbharwada | 44 | 727 |
| | 2nd Nagpada | 33 | 636 |
| | Kathipura | 62 | 602 |
| | Khara Talao | 41 | 565 |
| Calcutta | Kumartuli | 27 | 226 |
| | Kalutola | 45 | 219 |
| | Puthapukur | 32 | 213 |
| Madras | Municipal Division No. 9 | 67 | 250 |
| | „ 25 | 88 | 228 |
| | „ 34 | 89 | 193 |
| | „ 13 | 149 | 183 |

*Housing congestion in Bombay.*

| Number of Rooms per Tenement. | Number of Tenements. | Average per room. |
|---|---|---|
| 1 | 197,516 | 4·01 |
| 2 | 26,231 | 2·51 |
| 3 | 7,416 | 2·01 |
| 4 | 6,169 | 1·70 |
| 5 | 2,953 | 1·50 |
| 6 & over | 3,836 | — |

The position in India is not less grave than it is in Western Europe. In fact important areas in our large cities are more vulnerable to air raids than some of the most dangerous spots of urban Britain. Town Planning laws have done something to secure a minimum proportion of open space to built up areas, etc., whose counterpart we do not find in India.

The task ahead is therefore vast and planning in advance alone can secure some measure of safety for the 30 million people of our land. The most thorough scheme of evacuation failed in Great Britain and fell far short of the aim in spite of enormous expenditure. Sudden transfer however desirable for emergency can not be advocated for reasons explained in Chapter II.

"The evacuation of these areas on a voluntary basis has failed" concludes a careful observer[1] who recommends compulsory evacuation particularly in areas within a certain distance of obvious targets and total prohibition of school children who are living in them. This may not be feasible where adequate accommodation for the evacuees does not exist in the reception areas. Housing in Indian villages is deplorably inadequate even to meet the demand of the villagers in normal times and it can never accommodate extra population accustomed to life in cities. Even in Great Britain where accommodation in private homes was available for 5 million people according to surveys carried out before the great evacuation, technical authorities and the press have made out a strong case for billeting camps and permanent structures if evacuation should be successful. The Committee of the Association of Architects, Surveyors and Technical Assistants who studied this problem draws attention to the fact that permanent camps could be erected for the same expense that the Government might incur on paying billeting charges to householders.

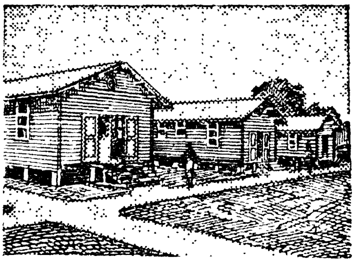
The report shows that on the assumption that the war will last for three years, the Exchequer will spend more than £60 in that time on the weekly payments for lodging (excluding food) for a mother with her child. The report states that for a little more than this sum they could be provided with a place in a new building designed for them.[2] Their comprehensive survey of Wantage and eleven surrounding villages in Berkshire made twelve weeks after evacuation took place, presents

1. Owen.

2. A.A.S.T.A. Report on Evacuation. The "Builder," Oct. 20, 1939, p. 596.

an overwhelming case for the creation of special buildings for evacuation including camp schools, new buildings for education and feeding, nursery schools and day nurseries. They are considered absolutely essential on health, education and moral grounds and their absence is considered the cause for the collapse of the scheme, particularly regarding mothers and children.[1]

These structures would not become valueless after the war, like other defence constructional measures, but could serve a great social and educational need in that town children could in summer spend part of their term time in these fully equipped camps. A part of the capital cost could be recouped through individual local authorities taking over one or more camps for the use of the children of their areas. The example of a London Borough which has already commissioned the design of a holiday centre on the Kent coast is mentioned. Far greater is the other advantage. In their own words.


Evacuation camps erected near London.

"There are no short cuts to successful evacuation. A programme such as we have outlined gives us a chance to end that lack of sympathy between town and country which the present scheme has exposed. We can enrich rural life and at the same time broaden that of the town. We can keep our children in safety by measures of defence that will not only protect from attack, but will give lasting benefits when the war is over."

1. The question of Evacuation camps is receiving the attention of designers, social workers and architects. For plans and details refer; R. C. Butler, "Billeting Accommodation." "Builder," Nov. 3, 1939, pp. 641—646 and Nov. 10 and 17, 1939. Goldfinger, Mary Crowly and Anne Parker, "Builder," Oct. 27, 1939, pp. 615—616; W. H. Hamlyn, "Prestatyn Holiday Camp." "Builder," June 30, 1939, p. 1234; Frank Bennett, Children's Large Scale Camps. "Builder," April 7, 1939, pp. 654—656. The Planning and Design of National Camps. The "Builder," Aug. 11, 1939, pp. 233—238.

The Fabian Society which examined the problems raised by this great migration in an impartial manner feels "the early stage of improvisation must merge into the stage where evacuation can be made a complete success; in other words, the social pattern of the countryside has to be re-fashioned in a relatively stable direction." Their emphasis upon the value of permanent buildings to rural betterment is interesting.

"A well-designed experiment in social reform would leave the country a heritage of camp schools, village halls and clubs, nursery, hostels and the like, such as it had never before enjoyed. Permanent links could be established between urban and rural communities; a sense of the values of right feeding, of air and sunshine, of child nurture and of social enterprise could be carried to half the homes of Britain."

The need for permanent structures and holiday camps is so much felt that even an exhibition of plans and models of evacuation camps for families and a village settlement for mothers and infants, a rural centre for young children with class rooms and dormitory was recently held in London. These plans are of interest to India for they suggest how the problem might be solved especially when husbands remain in cities, by small communities of the scale of family groups, with privacy as well as such social amenities as necessary. These could be planned near existing villages or market towns. The structures it is considered, should be of such a character and quality as to be of service and permanent value in times of peace as well as war.

The adaptation of existing buildings in rural areas was examined by a well-known Committee who finds that "while much can be done by adapting existing buildings, a considerable constructional programme is required." Although considerable sums would be required it is considered it would be economic.

"The complete programme would employ some 150,000 of them for 18 months or two years, and would cost about £104,000,000. That the expenditure is quite in proportion to the importance of the matter is apparent if one realises that the capital cost, if repayment were spread over two years, would add less than 6d. to each £1 at present being spent on the war. Further, the measures undertaken would bequeath a valuable legacy to peace-time England."

The Government of Great Britain is also convinced of the value of permanent structures as proved by their scheme of National Camps. 31 Camps were being built by the National Camps Corporation at the beginning of this year. Camp managers were appointed for 25. Two were occupied by the end of January.

Considerable economies and a healthy national growth would become possible if these structures in villages were used for securing permanent decentralisation of population and industrial production. This would end to a large extent the need for evacuation whenever National Security is endangered. Evacuation cannot be a permanent part of our life as Principal Rowse pointed out in one of his recent addresses.

"Is it to be the background against which our younger generations will grow up? If so, is it not time that human beings, thus wrenched from their habitat, are given shelter, in a psychological as well as physical sense, from the overwhelming dread of the bombing planes of Eastern Europe? That sense of shelter can only be had when the technique of dispersal followed does not involve the breaking up of families, but ensures in an orderly manner the transfer of homes, nay whole communities, with social services, industries and the means of leisure, to the safer zones throughout the country."

The need for permanent decentralisation is being forcibly urged by Town Planners. The uncontrolled growth of cities was being viewed with disfavour during the last many years which culminated in the appointment of the Royal Commission, two and half years ago whose terms of reference emphasise the "social, economic or strategical disadvantages" arising from the concentration of industry and population in large towns or in particular areas. All the members agree "the objects of national action should be the continued redevelopment of congested urban areas and decentralisation or dispersal of industries and industrial populations therefrom and the encouragement of a reasonable balance in development." After surveying exhaustively the social, economic and strategical effects of population movements in the post-war period and also their causes the members emphasise the need for decentralisation.

A strong case has been made out for permanent decentralisation even if it were possible to organise programmes of evacuation with success.

### EVACUATION AND RURAL BETTERMENT

A peacetime use has been pointed out as the strongest case for permanent structures but the arguments adduced by the Council for the Preservation of Rural England possess special value for India where ordered movement for the dispersal of towns could be harnessed to the task of village betterment so much desired in this country.

The need for dispersing the town population in India over the neighbourhood to create living links between rural and urban parts and encourage flow of men and ideas would become apparent when we analyse carefully, the causes of India's poverty and low standard of living.

It is now realised that the first factor responsible for India's poverty is the continuous drain of money and resources from the rural to the urban area. Year after year crores of rupees are brought to the treasury in the shape of land revenue, remitted to students for university education, sent to creditors as interest and principal, and more crores are taken away by the absentee landlords for spending in towns. Every one knows that over 75 per cent. of our university students are drawn from the rural area, and that cities and towns form the financing centres to the surrounding area.

Several factors have tended to make absentee landlordism a universal phenomenon, and if the ryot does not migrate to towns, the townsman is ready to purchase lands from neighbouring villages. Finally, we may mention lawyers and law courts that draw out the villager's wealth. That the sum total of all these is considerable nobody can deny though it is impossible to estimate the total accurately.

The second factor is the constant drain of men—the powerful and intelligent—from the rural to the urban parts. The enterprising poor are forced to leave the village for a livelihood, and the idle rich are lured away by urban pleasures and city comforts. The huge gulf between our urban and rural standards of living, the enormous disparity between agricultural earnings and income from employment and service (till recently) has tended to drive many a potential leader of the village away from home. Thus, men whose stay in the village would have checked the pace of deterioration, whose initiative and enterprise would have improved the conditions of living are almost lost to the village.

These two factors constitute a "net drain" upon our rural economy. Very little is put back into the village; all that goes back being the salaries of the village officers and servants, and the touring officers of the district, and a part of the public works expenditure that goes towards the wages of labour, etc., and the price paid for food grains by 10 per cent. of the population which is urban. Highly paid officials, and even retired officials, rarely stay in villages, and a very large part of the total State expenditure is incurred in the urban areas.

The break down in the self-sufficiency of the village has only facilitated the "drain" from the country to the town, and has overburdened our agriculture and created unemployment for the artisan classes and industrial communities and upset the balance between agricultural and manufacturing industry. The other factor is the colossal indifference and apathy of the public towards rural problems in general. It required a disastrous fall in agricultural prices and a catastrophic depression to focus public attention on the need for rural reconstruction in a country where 90 per cent. of the population live in villages. The indifference of the so-called enlightened urban public which is largely responsible for the stagnation of the rural uplift movement in India can be got over successfully only by bringing them in touch with rural folks and problems. And a balanced dispersal not merely from cities to townships but from tiny villages to larger ones is required to restore the correct balance between agriculture and industry and the town and country. This will provide the basis over which a prosperous India could be built.

How can schemes for evacuation and decentralisation help rural reconstruction. The inter-connection between rural poverty and urban apathy to problems connected with ameliorating such conditions would become apparent when we realise that this is largely due to the constant drain of men, money and enterprise from rural to urban areas. If village India is not able to succeed in resisting gradual impoverishment penetrating her, there are not sufficient men and resources left to evolve schemes to check it. Improvement is possible if enterprise and resources are directed from urban to rural centres, if enlightened interest in rural welfare is made possible to those responsible for governing the country who generally reside in towns and if frequent contact is maintained between the two.

Holiday camps and week-end resorts would serve this purpose admirably. They may serve as evacuation camps for those who must remain in towns, until air raid proof cities come into existence; they would also serve to enrich the countryside with urban resources and earnings. Many attractive places abound all over the country which would serve as welcome resorts to the overstrained citizens. This is vitally necessary to improve the health of urban folk. If English evacuation teaches us a lesson it is this. Children in reception areas are now found to be healthier than when they came. The improvement is considerable. They are able to withstand hardships better.

A proper road system and communication and transport facilities would make this practicable. The development of electric power will make the decentralisation of industry feasible. These two would pave the way for more extensive decentralisation and "hundred new towns" ideal preached for England would materialise in India. These would form the nucleus wherefrom the movement for village betterment would draw sustenance and rural improvement would become practical and successful. A permanent basis to build India's prosperity could be secured by this balanced dispersal which would avoid the dangers to which the excessively urbanised industrial civilisation of Europe is exposed.

Indeed a balanced dispersal not merely from cities but from very small villages to larger ones is essential to restore the correct balance between industry and agriculture, town and country, urban and rural interest.

This will be difficult if not impossible if India gets industrialised on the lines of England. Attempts are made in Europe to decentralise production over the nation and such expenses could be avoided by adopting this step in advance. Widely distributed centres of industrial production are necessary to this vast agricultural country to minimise the cost of transport as well as to help the development of local tastes and requirements.

Various forms have been suggested for camps in the West. Prefabricated materials are recommended. Temporary make-shifts in furniture and equipment are considered. School camps with dormitories, common dining rooms, facilities for study etc. are suggested as a very desirable ideal, for, this would help urban children to live in rural areas during holidays and recoup their health. The improvement in physique of children in the reception areas of Great Britain proves their value.

The planning and design of National Camps is being given great attention by experts in England and designs suitable for camouflaging the entire area are recommended. They are nothing less than small towns of peculiar design specifically laid out for the collective entertainment and fair-weather accommodation of thousands.

To India permanent decentralisation is to be preferred and immediate steps must be taken to survey the country and select suitable sites for locating her industries and townships. Seaside resorts, pilgrim centres, marketing places and healthy areas fit for sanatoria should form a network wherein permanent structures built of local materials would provide for evacuation if need be. In peace time they would form community centres and house the local rural uplift branch. After some years this centre will develop into a township.

Spacious halls with verandahs, with rooms in the form of a quadrangle and vegetable gardens, poultry farms, tanks and playgrounds as also accommodation for cooking for holiday makers would be essential. A school for the children of the surrounding area would also be helpful. But provision must be made for facilitating periodic demonstration and shows to bring home to the residents of the region, improvements and ideas in different aspects of life. These holiday camps properly designed and located would be economic and paying. These centres might send supplies to the neighbouring city. Handicrafts and small scale industries could be developed. The development of electric power in our country will help the progress of small industry and properly guided would prevent the tragic growth of industry and slums now facing Great Britain.

This is perhaps the best method of arresting the drain from country to town already noted and these centres might even now be selected and the accommodation surveyed to prepare camps for temporary schemes of evacuation for emergency. The war clouds of Europe have sufficiently gathered to make this task imperative and immediate plans must be made to minimise destruction. The level country surrounding the Indian cities is helpful and places must be found to evacuate citizens and their belongings in emergency.

This plan for evacuation should in the interest of the country constitute a temporary phase and never replace the scheme for permanent decentralisation and the prevention of excessive urban expansion.

### DECONGESTION

Equally urgent is the third aspect of this question namely, the decongestion of overcrowded centres in the important cities, and the removal of people residing around obvious targets at least to the outskirts of cities. Slum clearance assumes a new significance for they will contribute most to the destruction and panic when there is a raid. Indeed air raids are a challenge to slums, to inadequacy of our street systems and our neglect of the requirements of planning and healthful living. A policy immediately launched would provide the basis for reshaping our cities on the model suggested in Chapter VI. The provision of facilities for transport, water supply and policing would make this decongestion possible and practicable. Even slum clearance in the accepted sense of the term will not cost more than what will have to be incurred on A.R.P. for the slum areas, together with the recurring expenditure on civic services maintained to prevent its dangerous consequences to the civic organism.

A scheme for permanent decentralisation and regrouping of population and industry, plans for holiday camps and week-end resorts and evacuation and a programme for decongestion should be made if the destruction from air raids should be minimised and ultimately prevented. The problem in India is less expensive than in European countries but not less urgent. This is further necessary to make possible the provision of shelters and protective accommodation in cities. Without these measures not merely shelter provision would prove inadequate but impossible.

# CHAPTER VIII

## AIR RAID SHELTERS

# CHAPTER VIII

## AIR RAID SHELTERS

Until our cities are readjusted on the principles expounded in Chapter VI a scheme of protection however partial it may be should be improvised to minimise the danger to urban folk who cannot evacuate vulnerable areas, not merely from enemy bombs and their consequences, falling masonry, fire and gas but also from anti-aircraft shell fragments of our own defence forces.

That at best a scheme improvised in emergency can only be partial is evident from the shelters erected in most countries preparing to meet attacks from the air. Air Raid Shelters as such protective accommodation are styled have been erected in China, Spain, France, Germany and other European Countries, in Norway, Sweden and in Great Britain.

Great Britain allotted "more than 70 million sterling during the financial year 1939-40 for Civil Defence" and during the first six months of 1939 "nine hundred thousand steel air raid shelters capable of efficiently sheltering nearly five and a half million people" had been supplied, free to householders in vulnerable areas with incomes not exceeding £250 per annum. A million and a half more would be further supplied. In addition by legislation compelling persons employing more than 50 persons to provide shelters for their employees, shelter protection has been made available for a considerable number of people in the vulnerable zones.

Many kinds of shelters have been erected and existing accommodation wherever suitable is also strengthened and converted into shelters. Some of them are within a building, some outside and independent. Some are overground, some deep underground. Brick, cement and steel are used and even timber has its place in their construction or conversion. They are large, medium or small in size; small shelters are for families; medium size ones are for commercial and business premises; large shelters are designed for factories, floating population and large communities; shelters for key men are perhaps the smallest. The small shelter is recommended for families for access and proximity. The Home Office of Great Britain, relies largely upon this feature. Large shelters are preferred for efficiency and economy. Medium shelters are ideally suited for offices and commercial concerns.

## Domestic Shelters

Great Britain relies upon the small steel shelter to 'break the back of the shelter problem.' Popularly known as the Anderson Steel Shelter this is distributed free to householders with incomes not exceeding 250 pounds a year. This is to be installed in the garden, sunk three feet in the ground and covered with earth and sand bags. Blast and splinter-proof to 500 pounds H.E. bombs exploding not nearer than 50 feet it is regarded as the most practicable solution for safeguarding the people.[1]

The shelters are constructed of very strong galvanised corrugated steel sheets and have been subjected to rigorous tests to ensure that their strength when erected would take the weight of any debris that might fall upon them from a house of the type for which they are designed.[2]

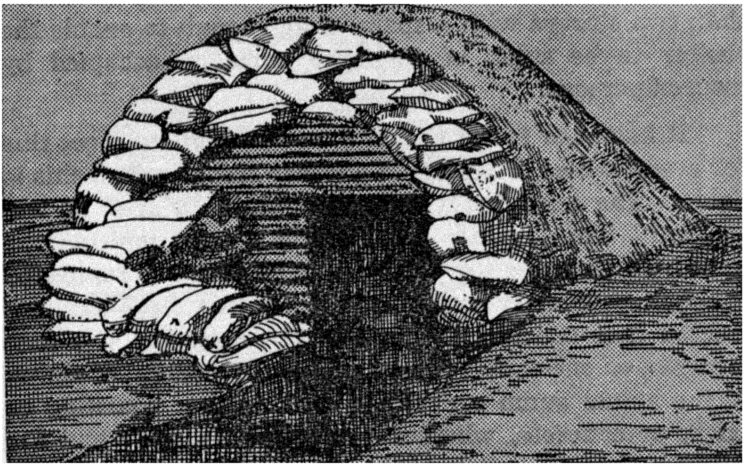
They are made in sections and can be put together by two persons without any special skill or experience.

1. These shelters are distributed free to the following:
   (a) Persons whose occupations are compulsorily insurable under the National Health Insurance Act.
   (b) Persons not compulsorily insured under the National Health Insurance Act, who are mainly dependent on earnings (or pension) not exceeding £250.

This amount would be increased by £50 for each child of school age in excess of two.

2. Vide A.R.P. Dept. Circ., Jan. 9, 1939, "Provision of Air Raid Shelter," pp. 13—18.

They will be supplied as units of dimensions of approximately 6 ft. 6 in. by 4 ft. 6 in. by 6 ft. high, the completed unit weighing about 8 cwts. A unit shelter of these dimensions will provide shelter for from four to six persons, and sections can be added to take more persons if there are more members in the household.



The Anderson Steel Shelter.

While the unit is provided with channels which enable it to rest on the ground, it is designed for being partly sunk and for the earth excavated to be used as additional cover to make the shelter more secure against blast and splinters.

The shelter, as supplied would accommodate from four to six persons, and when sections are added to this unit may take two or four more persons.

The maximum number of persons that can be accommodated in the standard shelter with extensions, is ten. If it is desired to accommodate more than ten persons, two shelters of appropriate size should be erected.

The standard shelter with the extensions may be used for houses of three or even four storeys if it is possible to site the shelter at a distance from the house or any neighbouring building of at least half the height of the nearest wall of the house or other building. Where that distance exceeds 15 feet an earthen or other wall should be erected to provide splinter-proof protection for the shelter entrance.

Generally they are suitable for houses of not more than two storeys with a space large enough to enable the shelter to be sunk, of the type normally occupied by insured persons.

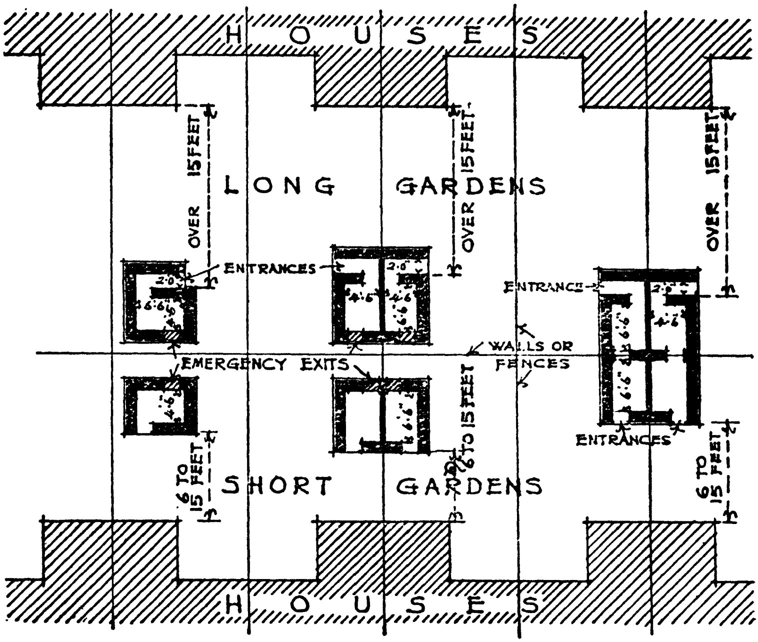
It has been found that it is not possible to erect this for every home. Flooding is another risk to which this is liable. The Lord Privy Seal recognised "a spell of wet weather" may produce trouble and special instructions have been given by Government. Measures are suggested for shelters already erected and where they have not been erected it is considered expedient to construct a 4 inch concrete, or one-course brick floor in the shelter; or lining of the actual sump excavation with timber boarding or brick, or concrete, whether precast or in situ; and the lining of the inner walls of the shelter, up to ground level. This may entail an extra cost ranging from £1 5s. to £3 13s. The cost of a steel shelter is about £8 according to manufacturers.

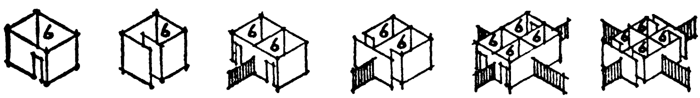
Where the problem appears to be almost insoluble by reason of high subsoil water level, domestic surface shelters are provided free to eligible householders where a site is available which is not suitable for the steel shelter.

The plans given opposite show the type drawings prepared by the Home Office[1] indicating the single unit shelter and the various multiple lay-outs. The cost of the single unit shelter (without floor or traverse) to accommodate 6 persons has been estimated by the Home Office to come up to £19-10-0 erected complete.

It has a reinforced concrete roof, and a concrete floor (if required). The walls could be either of brick, mass concrete or concrete blocks.

1. Directions for the erection of Domestic Surface Shelters.



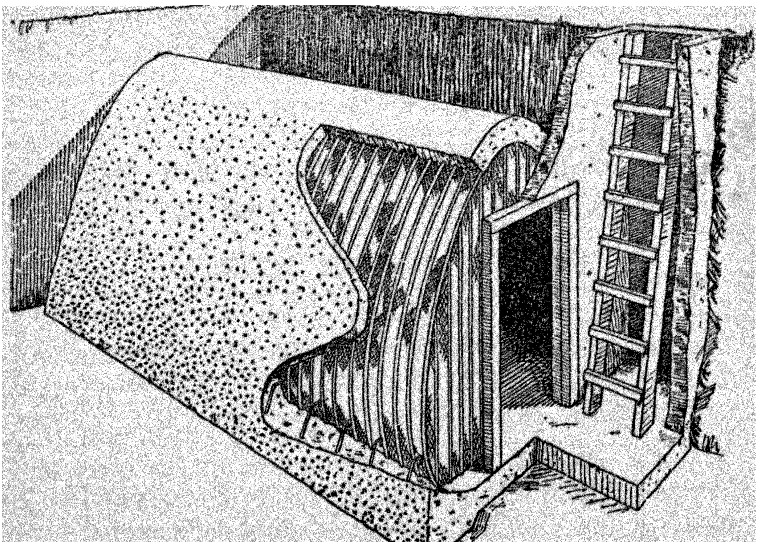
DOMESTIC SURFACE SHELTERS

Various other kinds have been suggested. They consist of steel shells like the Anderson Shelter to be embedded and covered with earth or concrete or erected on the site like the domestic surface shelters in brick or concrete.

The Wilmot's "Fortress" is let in the ground to a minimum depth of 2 ft. 6 in. and may be covered over with concrete, earth or sandbags. The inside can be made comparatively comfortable by forming the floor and seats with boards. It is made of galvanised corrugated sheets, built in the form of a rigid arch, mounted on angle-iron frame. The ends are formed of stout timber, covered with flat galvanized steel. One end is provided with aperture and doors can be fitted if desired, also 21" square hinged shutter at the rear end for use as escape shaft. The two standard sizes will seat six or twelve adults. The actual height of the shelter is 4 ft. As the base is fixed on the seating level, the necessary extra height is obtained by excavating for leg room. Prices in Great Britain are:

| | |
|---|---|
| Six seater 5 ft. long 4 ft. wide .. | £4-10-0 |
| Twelve seater 10 ft. long 4 ft. wide .. | £6-10-0 |

Similar to these are Booth's garden shelters. They could be covered with sand bags or sunk in ground and covered with earth or concrete. They could also be erected partly sunk. Concrete shelters reinforced with steel as shown in the figure are recommended by another manufacturer. The "C" type shelter (concrete cut away to show curved "Self-centering" steel framework)



Concrete shelter with steel reinforcement for six persons.

accommodates 6 persons. Top of arch is 3 feet below ground level and the access is through a ladder. The frame work is curved ready for fixing, and can be quickly and easily placed in position.

Under certain conditions they may be placed under the ground floors of buildings. Both partial frame work and reinforcement are offered by this kind of prefabricated steel shells.

There is another type semi-circular in shape for open ground away from buildings to accommodate 6 persons. Different varieties of domestic concrete shelters have been suggested by associations established for furthering the cause of cement. The circular pit shelter is erected in the garden at least 20 feet away from the building. The cost of materials comes to about £7 and it is considered that it can be erected by any amateur who has experience of concrete work in the garden.

Concrete blocks could be used for the erection of surface type of shelters and may be covered with sand bags and earth; sand bag on the roof above the entrance and a layer of earth 1' 9" deep over the remainder of the roof, and earth piled all round the wall. A gas curtain could be fixed to complete the shelter.

Large diameter concrete pipes make excellent splinter-proof shelters, if buried, or if covered with a layer of concrete or a mound of earth. The pipes are laid like a section of a sewer, with blank ends. Suitable pipes or tubes may be obtained from concrete pipe manufacturers and installed by any builder or contractor who has the necessary lifting equipment. In Spain large diameter concrete tubes were driven into hill sides to provide protective accommodation.

If possible the tube should be installed either well clear of buildings, or at right angles to the house, so that the emergency exit is always free and available.

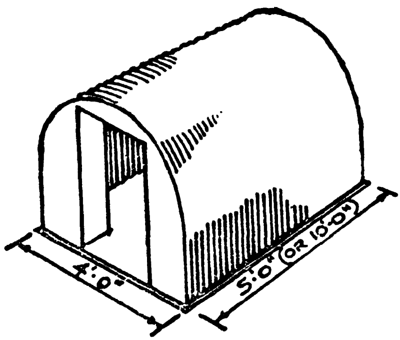
If the shelter is ventilated by having the entrance left open, it may be occupied for an unlimited period, gas masks being carried by the occupants for use in the event of a gas attack. If the shelter is provided with a gas-tight door or screen it can be occupied for only a limited time, unless the door is opened periodically to admit fresh air; alternatively, a ventilation and gas filtration plant, capable of delivering 150 c. ft. of filtered fresh air per person per hour, may be installed.

Such concrete tubes could be manufactured locally as also concrete blank ends, door frame sections, and other parts necessary for complete tube shelters.

Tube shelters may be placed entirely below ground level or partly above ground; in the latter case the protruding portion of the tube should either be encased with concrete 10 in. thick, or covered with a mound of earth (30 in.). In either case the tubes should be placed on an even bed of mass concrete laid in the bottom of the excavation.

Suitable diameters range from 4 ft. to 7 ft. 6 in. In the smaller sizes a single bench seat may be provided, allowing a 2 ft. length for each person. In diameters of 6 ft. and over two benches may be installed so that the occupants sit in two rows facing each other; in this case one person can be accommodated for each foot length of tube. This assumes that either a ventilation plant is installed, or fresh air is admitted.

With corrugated iron shell as a frame and reinforcement small family shelters could be erected with concrete. Curved, corrugated iron sheets may be purchased. Alternatively corrugated iron air raid shelter "Shells" complete with framework, bolts, door, etc., may be purchased from various firms. A small "Shell" as shown is obtainable from many builder's merchants and is made in sizes 4 ft. wide and 5 ft. long to seat 6 persons, or 10 ft. long to seat 12 persons.



A typical steel shell for erecting family shelters.

The entrance steps and sides are also concreted and opposite to the entrance a masking wall is erected to give protection from splinters.

The pill-box dual purpose A.R.P. shelter discussed in detail later is erected above ground and is blast and splinter-proof. Both stone, brick and cement concrete could be used and is perhaps the most desirable over-ground shelter for the family.

In principle there are two types of concrete shelters. Both involve a covering of earth to protect the occupants from splinters unless the concrete itelf is of splinter-proof thickness; 15 in. of unreinforced concrete or 12 in. of reinforced concrete. One type comprises precast units, which may be purchased from precast concrete firms, and erected at the site: the other type which is especially recommended for wet situations is constructed of reinforced concrete, which involves mixing the concrete at the site, and placing it in a plastic condition between temporary wooden shuttering erected in advance to give the shelter the shape required.

Although the above-ground or surface splinter-proof shelter possesses undoubted advantages, such as immunity from flooding risks and greater suitąbility for use as a garden shed or cycle store, etc., the below ground or partly buried shelter is in some cases considered preferable and in normal times may serve as store for fruits, vegetables, etc. For example, considerations of available space, the slope of the ground, interference with the garden layout, or the fact that the standing water level in the ground is permanently below that of the floor of the proposed shelter thus facilitating excavation, may influence the choice of type and favour below-ground construction.

In all sunk or half sunk shelters care must be taken that the floor is strengthened to resist upward water pressure if the ground water level is more than about 1 foot above the underside of the floor slab.

Another variety is the Garden Trench.[1] Where space is available in a garden a trench provides protection except against direct hits. In order that the trench shall be clear of any chance of being buried under wreckage it has to be at least of 20 feet from a building. A trench for 6 persons is shown below.

Fig. 1

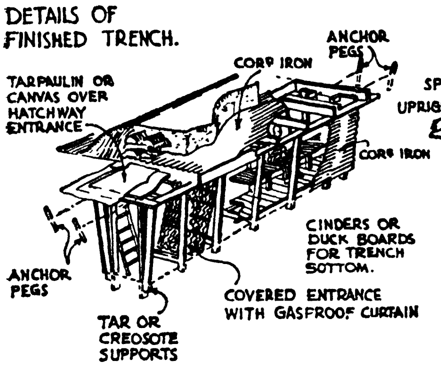
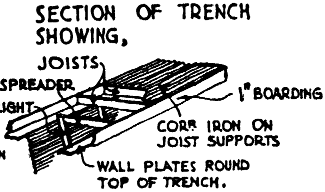
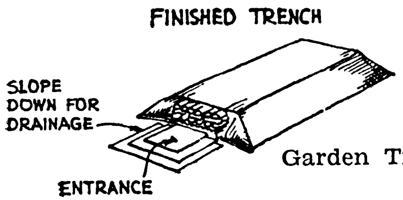



Fig. 2




Garden Trench

Fig. 3

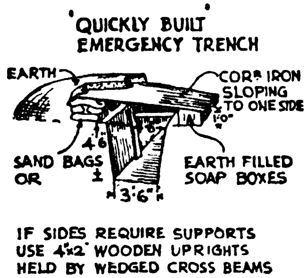



Fig. 4

The bottom of the trench is 6 ft. below ground level and the width is 3' 6" at the bottom of the trench and 4' 6" at the top. It is divided into three sections.

1. A Shelter, 10 ft. long, in which the occupants sit on a seat along one side.

2. A covered entrance, 3 ft. long, with a sloping gas curtain resting against a wooden frame.

3. An entrance, 3 ft. long, giving access to the shelter from the outside by means of a ladder. Over the entrance is a wooden cover or trap.

1. Home Office Pamphlet on Garden Trenches.

The bottom of this entrance should be lower than the floor of the trench to collect any water leaking into the trench.

The trench is lined to prevent the sides falling in. The drawings show how this can be done using corrugated iron sheets held in place by wooden frames. The frames consist of 4" x 2" uprights on each side of the trench, placed at 3 ft. intervals, with 4" x 2" spreaders fixed between them at the top and bottom to hold them apart (see Fig. 2); instead of corrugated iron, wooden planking or sheets of any available and suitable material can be used for the lining.

The top of the trench, except the entrance, is covered with the earth which is obtained from the excavation. The earth is carried on a roof consisting of corrugated iron sheets laid on 5" x 2" wooden joists 2 ft. apart resting on 6" x 2" wall plates. Instead of corrugated iron, planking or other suitable material can be used. If joints smaller than 5" x 2" are available they can be used, but would have to be closer than 2 ft.

The gas curtain can be made of blanket. Light wood slats are fastened to the blanket about 2 ft. apart to keep it hanging flat and closely against the inclined frame. Twelve inches of blanket should be left trailing on the ground to prevent air passing underneath it. In actual use the blanket should be kept wet. When not in use the blanket should be rolled up the inclined frame and held at the top by cords.

The fitting of the lining of the sides will require at least two workers. When it has been completed, the wall plates, joists and corrugated iron for the roof should be fixed in position and finally the earth placed on the corrugated iron sheets, as shown in the figure. The earth face over the entrance should rest against a wall of earth in sand bags, sacks or boxes as shown.

At the two ends of the trench, the tops of the four uprights should be anchored back by means of wire lashings to the anchor posts driven into the ground.

If the number of persons to be accommodated exceeds 6, an extra length of 1' 6" per person should be added to the 10 feet length of the shelter; similarly if the number is less than 6, the length of the shelter can be reduced by 1' 6" for every person less than 6.

The length of the shelter shown in this design is the minimum required to accommodate 6 persons when sitting close together. With the gas curtain and trap closed, the air in the trench may become oppressive after some time and it may be necessary to open the entrance and admit air, after the occupants have put on their respirators. If the trench is extended to provide a length of 2' 6" per person in the shelter, the six occupants should be able to remain therein, with the gas curtain and trap closed, for a period of 3 hours.

It is important to provide drains to prevent surface water from running into the trench.

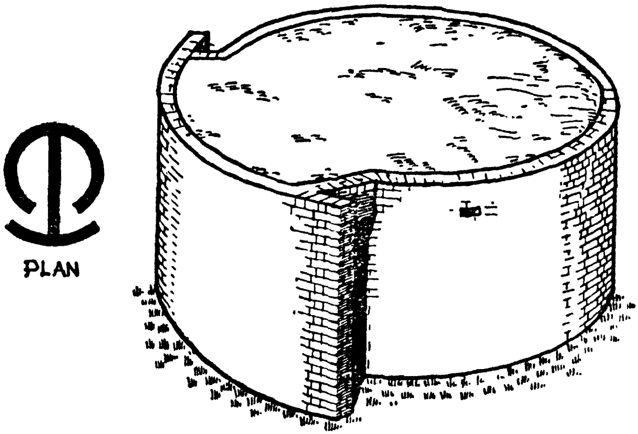
If, when digging the trench, water is found before the depth of 6 ft. is reached, work should be stopped above the water level and the extra height required should be obtained by banking up earth above ground level.

In some loose soils it may be found that the sides begin to fall in before the full depth is reached, and in this case it will be necessary to use some of the revetting material as temporary supports to the sides whilst the full depth is being dug.

The design of the shelter is so simple that the Home Office of Great Britain considers that it should be possible for most persons to construct it themselves and it may be practicable to use other materials which the householder may happen to possess.

If new materials have to be bought, the average cost of the materials alone (excluding labour) is estimated to come up to about £8 in Britain. If circumstances do not allow of the trench being completed as shown in Fig. 1, it can be brought into use as a means of refuge from blast, splinters and weather, if dug to a depth of say 4' 6". Walls could be built on the ground at the sides of the trench about fifteen inches high and corrugated iron sheets laid on the walls as shown in Fig. 4. A few inches of earth could be spread over the corrugated iron to keep the sheets in place.

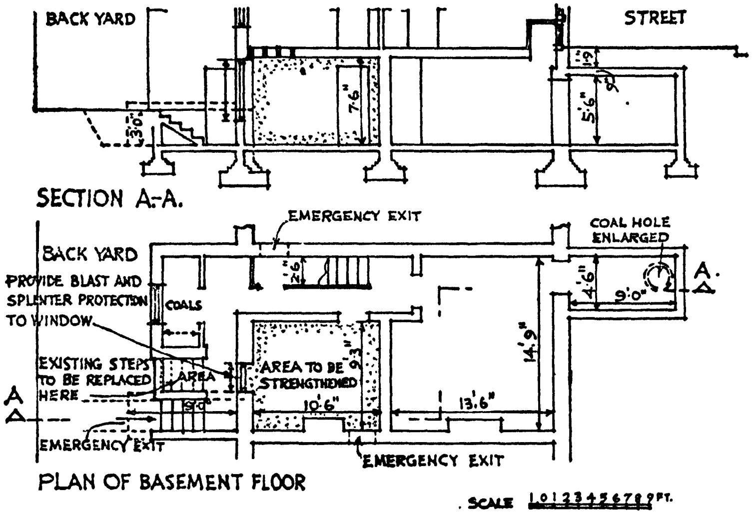
The shelter thus made is, of course, not gas-proof and if, after a period, the sides show signs of falling in, some sort of lining will have to be provided.




Brick Surface Shelter.

Brick shelters are also largely advertised and several have been built in the streets of London. Among those recommended for families are many types. The Pill Box pattern brick surface shelter could be erected at a cost of under £2 per head by eliminating concrete for the roof and utilising a construction of railway sleepers, light rails and earth cover. Shelters are designed to accommodate either 12 or 24 persons with a space allowance of 3¾ sq. ft. per person in accordance with official requirements. An alternative roof construction is 6" of unreinforced concrete with 18" of earth cover.

These are independent types. But protected accommodation is also possible in basements of buildings if they are fit for strengthening. If basements of houses are suitably strengthened to provide the required lateral and overhead protection and equipped with emergency exits, they would serve as air raid shelters, proof to blast and splinters. In fact many European countries rely upon the strengthened basement a great deal, and it holds the second place in the shelter policy of Great Britain, the first being sectional steel shelter. For commercial and business premises this is even more strongly advised.




A Strengthened Basement for a family of seven persons.

Basement shelters resemble cellars provided with easy access. Being below ground level they offer good protection from blast and splinters but care should be taken that the ceiling is sufficiently reinforced to bear the load of the building, should it collapse and the access is not covered up by debris. A single chamber is sufficient and gas locks could easily be equipped. A small toilet room and a chemical closet as well as emergency exit are also recommended. Existing basements could by suitable strutting be strengthened to form a safe shelter. But even otherwise a dual purpose basement could easily be constructed in houses built without them. Twelve inches of reinforced concrete is suggested for the walls and it is desirable that the roof and floors are equally thick. By suitable design daylight could be admitted into such shelters. We need not enter into the detailed specifications of roof, walls, floors, water tightness etc., but we should emphasise the need for a gas filtration plant if it is to be large and the shelter to be gas-proof.

The advantages claimed for such shelters are; they are not exposed to blast and splinters; they will not require extra space; they will be easily accessible; twinning and double twinning of individual shelters beneath one roof and with common party walls will enable marked economies to be realised whilst preserving the exclusive use of each shelter to its owner; they will have a peacetime use.

But we should remember that these are possible only where basements are common unlike Indian homes. And where available they could be safe only when properly located and the overhead protection given and the lateral strength obtained are adequate, when they do not interfere with the underground drainage and mains, and when they are properly ventilated and safe to get in and get out.

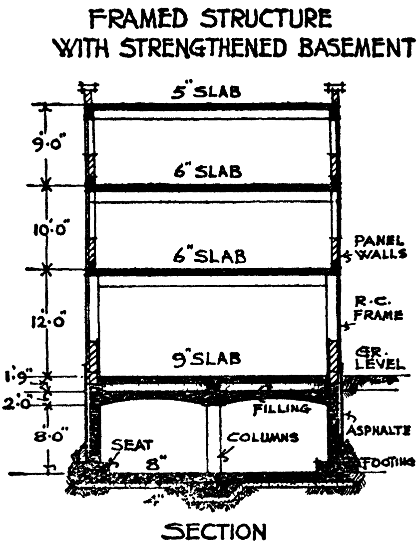
Where neither basement nor independent shelters are possible, a ground floor shelter planned for a dual purpose would be suitable. A small room such as the scullery or larder can be constructed. The walls should be splinter and blast-proof in concrete or brick and concrete or lime mortar; the doors and windows should be gas-proof. Timber about 2" thickness, may also be used for the door.

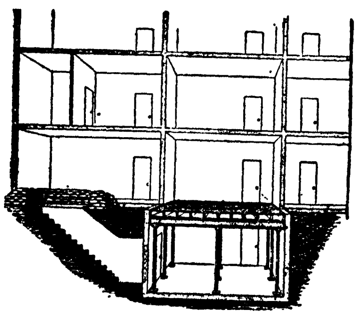
To many houses in India it would be useful to build in the ground floor a strong room convertible into blast and splinter-proof shelter when required. This is especially suited to the residences of the well-to-do who live in houses without space around, situated in congested areas. They obtain fire-proof strong room which is ever useful. In rural areas this type will be particularly valuable.

For urban houses where space is available a lean-to-shelter can be made. Only subsidiary bearer wall will be needed to support the roof. The roof may also be flat and covered with a flower bed giving extra protection. During normal times it could be used as a store for combustibles or valuables or as servants' quarters. The entrance may be direct from the house or independent but both are desirable.

### MEDIUM SIZE SHELTERS

There are many types of shelters which are larger than these and intended for 20 or more persons, for offices, business premises, etc. Pre-fabricated steel unit shelters with concrete or earth cover, concrete trench shelters, semi-sunk dual purpose independent ones, strengthened basements and other varieties are in vogue. All who occupy factories or own commercial buildings in vulnerable areas if there are more than 50 occupants, provide shelters, in Great Britain. Strengthened basements are a prominent feature for space around commercial premises in crowded localities is not generally obtainable. Special attention has therefore been devoted to this question by the Government of Great Britain. Exacting conditions are stipulated to render them safe.



A Strengthened Basement with emergency exit for an office building.

Where it is proposed to make a shelter within a building, either in a basement or in the ground floor, 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 below.[1]

Overhead protection should be provided by means of not less than:—

1. ¼ in. thickness of mild steel plate.
2. 4 in. thickness of structural concrete reinforced if and as necessary or otherwise suitably strengthened or effectively supported.
3. 6 in. thickness of ordinary concrete, reinforced if and as necessary or otherwise suitably strengthened or effectively supported.
4. Concrete in hollow type construction conforming with the requirements of the Home Office.[2]
5. 8½ in. thickness of arching in sound brickwork or sound stonework.
6. 1 ft. 6 in. thickness of ballast, broken stone or earth.
7. A corresponding aggregate thickness of a proportionate combination of such materials, or
8. 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.

Adequate provision must be made to afford protection from falling loads due to the collapse of any

1. Vide "Revised Code for Air Raid Shelters for Persons working in Factories, Mines and Commercial Buildings."

2. See Appendix to Part I of the Revised Code, p. 11.

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 load as representing the effect of impact.

To provide protection from falling loads due to the collapse of the structure above. It is prescribed "provided that where such falling loads would include heavy machinery, materials and goods of abnormal weight for 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 shelters.[1]

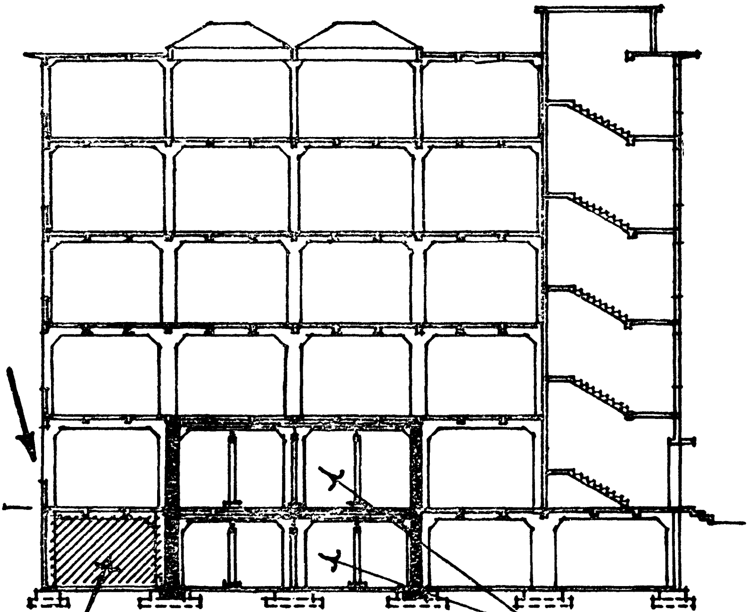
1. For space required, limits to number of persons and separation of shelters, access to shelters, emergency exits, sanitary accommodation and lighting, see Air Raid Shelters for persons working in Factories, Mines and Commercial buildings, Revised Code, August, 1939, Home Office Publications.

There are three other methods by which the required shelter may be obtained within a building. Trenches or tunnels may be constructed beneath the lowest floor of the building; existing rooms on the ground or other floor may be adapted to provide shelters. The walls must be made to afford the standard of lateral protection indicated already 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. Shelters may be specially built within the buildings or "lean-tos" may be erected against a wall of the building or against a boundary wall.

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. It offers the advantage that alterations to the structure of the buildings are reduced to a minimum. The tunnels normally should be kept well clear of stanchion bases, etc. The external openings should 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 stanchion so that they do not interfere with the footings and foundations. 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. 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. The emergency exit would also assist in ventilating the trench.

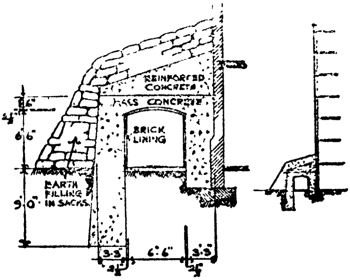
Where there is no basement but where there is a substantially built section of the building as, for instance, a section of an office block adjacent to a single storey block with roof lighting, it may be possible to select a room or rooms in this section for conversion into shelter. These rooms should 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




Correct and incorrect location of shelters within a building.

large window openings, such as show rooms or shop fronts the shelters should be made in inner rooms or corridors protected by adequate walls. As the enclosing walls of the shelters should be not less than 12 inches of reinforced concrete some thickening of the existing walls and protection of door and window openings may be necessary, so that the installation can be completed immediately an emergency arises. The floor or roof over the shelter must be strengthened as for basement shelters and all loading occasioned thereby safely transmitted to the ground.

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 sheds or store. An entrance can be made to give access directly from the main building in an emergency.




A lean-to air raid shelter easily accessible from the street.

Entrances and passages giving access to them should be boldly marked and be straight and unobstructed. 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. The minimum width of 2 feet 6 inches is required for the convenient passage of a stretcher.

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 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.

Among the many types of shelter outside the premises overground shelters in brick and rectangular in shape may be considered suitable to our country. Such ones in concrete partly or wholly beneath ground level has been recommended even in Great Britain.

In the interest of safety and efficiency,

1. Parties should be limited to 50 persons.

2. Distance between underground shelters must not be less than 25 ft. Distance between isolated shelters completely above ground must not be less than 50 ft.

3. Entrances should be 2 ft. 6 in. wide.

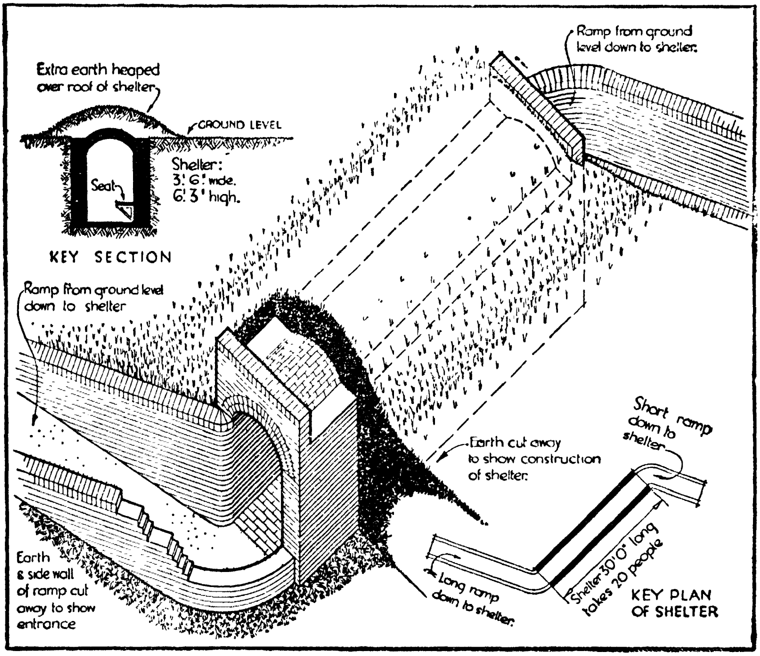
4. Sanitary accommodation should be provided; one seat for 25 persons with subsidiary facilities.

5. The emergency exit must be such as to provide an opening to the air adequate to natural ventilation.

6. Shelters need not be gas-proof, but it should be possible to make them gas-proof in an emergency.

A convenient type of independent shelter erected with brick and concrete is the trench as shown in the opposite page. It could be constructed for 20 to 50 persons at a cost ranging from £2-0-0 to £2-14-6 per person.

The trench air raid shelter is a simple unit capable of taking 20 people (allowing 1½ feet run per person). The accommodation of such a system can, of course, be increased by building short traverses to link such a trench up with one or more parallel trenches, additional entrances being provided as necessary. The minimum width of




Brick trench for twenty people.

such a trench system should be 3 feet 6 inches and may be increased to 6 or 7 feet where the trench system has to be placed in a limited area of ground and the accommodation required is maximum. The brick arch roof is capable of carrying a considerable load and earth banking should be superimposed thereon as an additional protection. The Code attached to the Civil Defence Bill lays down that Trench Shelters shall provide 3¾ sq. feet of floor area for every person. The trench shown above gives 5¼ sq. feet per person.

The actual cost of one example of a brick lined and roofed trench system was £54-10-0 per 30 ft. of trench holding 20 people *i.e.*, £2-14-6 per person or 36/2 per foot.

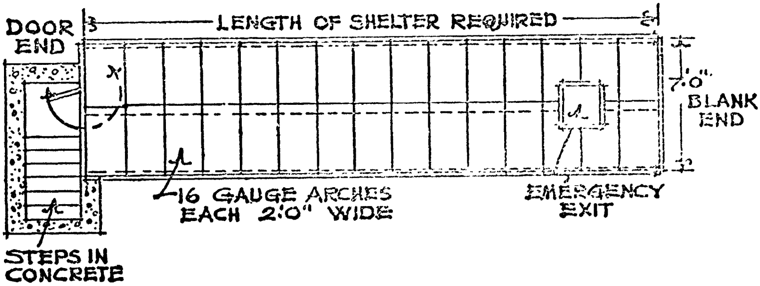
Precast concrete units as well as pre-fabricated steel shells are used for medium size shelters. Sectional construction enables accommodation to be provided quickly to suit requirements.

Shelters erected with precast concrete slabs are clean, easy to instal and need no up-keep expense. Expanded metal is also used, cut into units of standard dimensions. These independent shelters are more or less similar in design and are equipped with an emergency exit. An air lock is also provided.

Steel units all bent bundled and referenced ready for immediate assembly by the contractor in accordance with detailed drawings, are manufactured by engineering firms and shelters can be easily constructed. Ranging from 2 pounds per head, if it is overground and £2-5-0 if partly sunk, these provide safety, from blast and splinters. An air lock in the entrance would protect against gas.

Dovetail steel sheets 16 gauge, bowed to form an arch, and connected by an interlocking joint at the centre, dipped after corrugating in black bitumastic paint could be used for shelter construction. They should be covered with concrete, and sunk full or half into the ground. Ends, footings and doors framed in 10 or 14 gauge cold rolled sections, assembled by arc and spot welding are obtainable. A standard type recommended by a leading manufacturer of Great Britain is shown below.

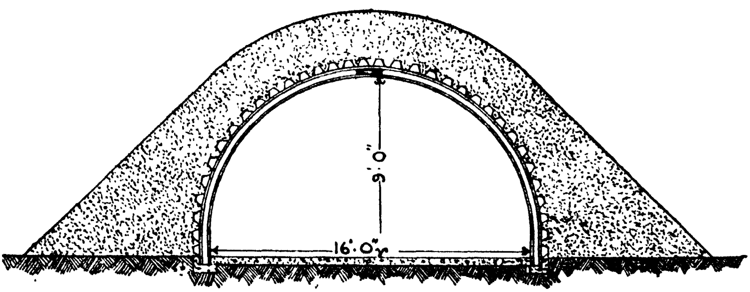
MEDIUM SIZE SHELTER FOR 50 PERSONS




The steps are in concrete. There is an emergency exit. It is 7 ft. wide and 6 ft. 6 inches high. An alternative arrangement of the 7 ft. wide shelter is with the door at the end, instead of at the side. The entrance is then protected by a concrete retaining wall. The steps down to the entrance are at right angles to the length of the shelter. The price of a shelter, 30 ft. long needed to accommodate 50 persons as given in England is as follows:

| | | | | |
|---|---|---|---|---|
| 30 ft. run of 16 G. arches .. | £39 | 0 | 0 |
| 1 Door End .. | £ 7 | 16 | 10 |
| 1 Blank End .. | £ 5 | 16 | 9 |
| 1 Emergency Exit .. | £ 1 | 18 | 11 |
| Nett ex-works .. | £54 | 12 | 6 |

Another variety consists of ready made arches, struts and arcuate sheets. The arches are spaced 3 feet apart. The width inside the sheeting is 7' 6" and seating can, therefore, be arranged as in an omnibus (a normal omnibus is 6' 9" wide inside) with two persons on either side of a central gangway. In this way people can enter their seats without disturbing those already there. An average of six persons can be seated per yard.



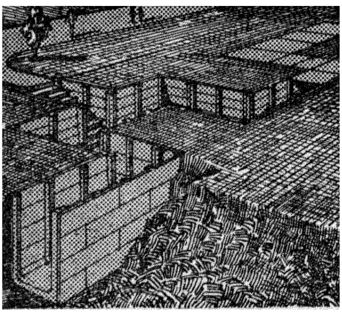

Section showing dovetail steel sheets fixed in position in an overground air raid shelter.

This shelter can be installed on the surface partially above ground, or completely submerged. A blast and splinter-proof shelter to accommodate 50 persons with emergency exit is priced £50-13-4 in Great Britain.

## LARGE SHELTERS

Shelters for larger numbers especially for the floating population and for employees in large establishments call for larger accommodation and two varieties are suggested. The simplest is the trench which will provide some protection to those caught in the streets and the other is the large bomb resisting structure. The former is advocated on the principle that something is better than nothing and the latter is suggested for fear that if they are only blast and splinter-proof a direct hit may entail large number of deaths.

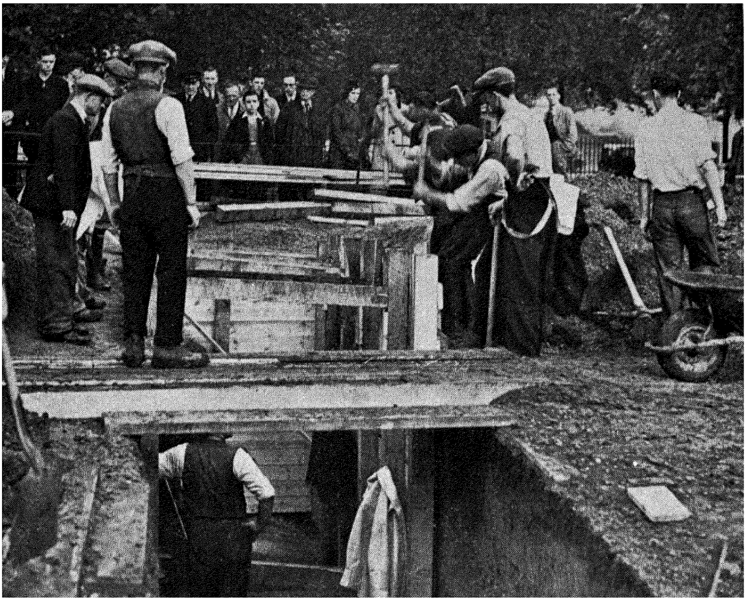
For immediate policy bomb-proof shelters are not advised and trenches are suggested as the solution for protecting the public. Those permanently lined with concrete slabs give a fair measure of protection against blast and splinters. If precast concrete slabs are used to cover the trenches they may be covered with earth or sandbags for extra protection in emergency. Careful instructions for the design and construction of trenches are therefore given by government and specifications etc., regarding permanent lining of trenches and trench construction are specially dealt with in their A.R.P. Handbooks and pamphlet by the Home Office of Great Britain.



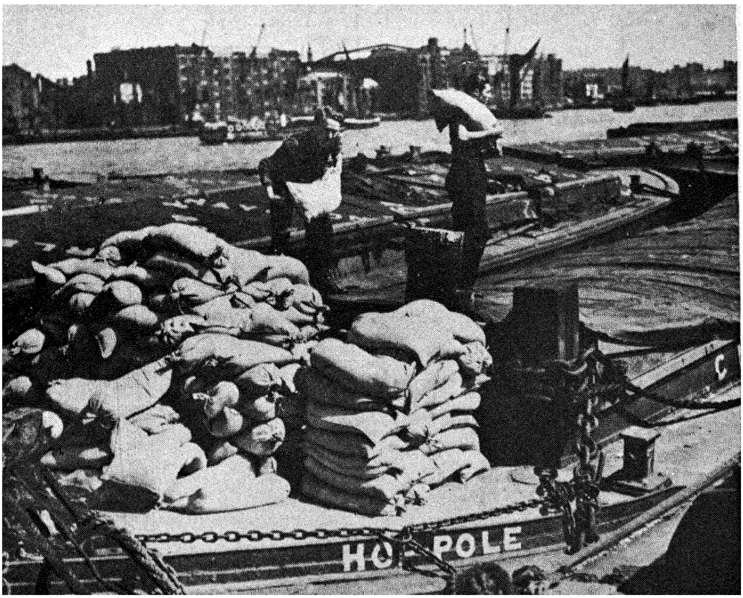
Trench Shelter lined with Concrete Slabs.

## SHELTERS FOR KEY MEN

Protective accommodation required for key men engaged in A.R.P. services and other duties during an air raid form another class since they need not be as big as even family shelters. But shelters recommended for them must be efficient and strong. There are portable all welded steel shelters affording good measure of

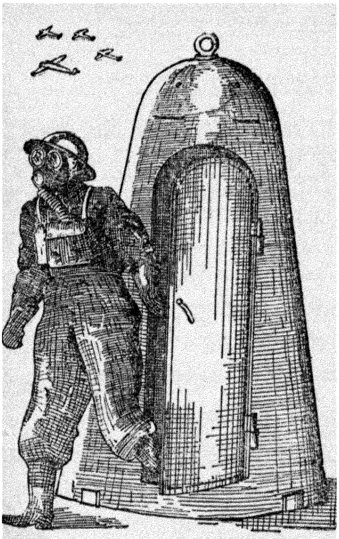


Covered trenches under construction in London.




An air raid shelter for 25 persons on a 120-ton barge.

protection for one or two or four men. They are equipped with efficient doors, some times gas-proof, with natural ventilation and fitted with a seat. Eye slots are provided to give the inmates a clear vision and also permit sufficiently high vision in the sky. Diagram No. 1 below illustrates the chief features of a type manufactured in Great Britain which is claimed to be proof to shrapnel, falling masonry, blast etc. It is made in two sizes for two or four men.



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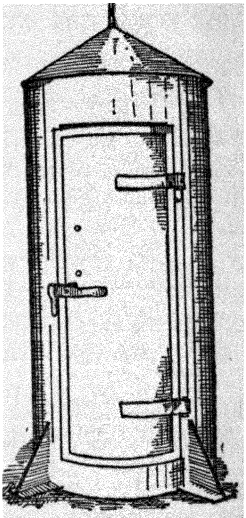


2

All welded steel shelters for key-men.

Essentially similar but slightly differing in external appearance is No. 2 variety which looks like the pillar post boxes of India. These have one piece cone-shaped dome, glazed look-out panel with splinter-proof guard; gas-tight rubber gasket; are portable and could be manufactured quickly in large numbers.

Brick shelters, are also built for air raid wardens affording good measure of protection. Brick warden posts have been erected in Great Britain and brick and stone ones are advisable for India where welded steel shelters may be comparatively expensive.

The problem of providing protection for people against air attack is a new experience and measures were improvised according to exigencies. Overground shelters affording partial protection were erected in Spain and were soon discarded since they proved dangerous. Deep underground tunnels were converted into shelter accommodation when raids became more deadly. The shelter policy of Great Britain too has come in for sharp criticism and experts point out several defects. But the policies are based upon local conditions, requirements, materials and exigency.

### Designs for India

In India shelter provision is needed for key men, the floating population, the very poor and the slums, the employees in fairly large establishments, for middle class families, and for the well-to-do.

For keymen, all welded steel shelters might suggest themselves, but in this country wardens' post could be erected with brick, stone and concrete at less expense and they would have peacetime use in addition.

For the floating population, the slums and very poor, state provision of protective accommodation is inevitable. The cheapest and the quickest type is the covered trench. When recommending this type for such large numbers who contsitute the majority of Indian urban population we should keep in mind that it is a very defective measure however necessary. In fact the covered trench was given up in Spain.[1] The reasons given are:—

1. The protection given in proportion to the work entailed was much less than with the other types.
2. The difficulties of finding suitable sites in which to place them, especially owing to the fact that with this type of shelter the area of the site needed to accommodate them was many times larger than the effective floor surface of the shelter.

1. R. Perara, A.R.P. in Catalonia. "Builder," Dec. 15, 1939, p. 28.

3. The volume of earth to be excavated was practically the same as that for the more satisfactory types.

4. The open spaces, parks, gardens, suitable for such a type were usually too far from the places for which there was need to provide shelters for it was considered that the entrance to a shelter should not be further away than 110 yards from the place of those for whom it was meant to be a protection.

5. The provision of this type of shelter, without overhead protection, except against splinters, could not be accepted as the responsibility of the Government in the general programme of protection, for, as it was building at the same time bomb-proof shelters, it was decided that it should not provide shelters with such varying degrees of protection. Excepting the last, other reasons hold good equally well for our country.

To these considerations might be added in India, the danger from gas attack. In a poor country where people can not afford the mask, trenches will turn into death traps when gas is used, unless they are gas-proof; but this will render them very un-comfortable owing to tropical heat. Further the cost of better class trenches lined and covered with concrete slabs is itself a deterrent factor. Can civic authorities who cannot provide adequate water supply and public conveniences to the poor and the slums, provide all of them with shelter accommodation however cheap it may be? If a beginning has to be made, it should in the interest of economy, be such that while offering partial protection at once for emergency it should not prove waste later on.

The problem of "how a programme of partial protection can be rapidly prosecuted in such a manner as to lay the basis for a programme of heavily protected shelters, thus avoiding the enormous waste in time, material and labour which would result if the two programmes were not linked together," has been solved by a reputed A.R.P. body[1] whose designs seem particularly useful to India.

An important feature of the design is that the shelter can be constructed in two stages. In the first stage it gives greater safety than the standard covered and lined trench, but it is capable of being subsequently more heavily protected to give any degree of protection desired, solving the crux of the shelter problem namely provision for immediate as well as for long time use.

In reinforced concrete this type of shelter can be constructed either above or below ground and is consequently suitable for both dry and water logged soils. The shelter is made up of compartments each containing 50 to 80 persons according to the nature of ventilation provided, to localise the effects of bombs. The number of compartments could be varied and the shelter capacity adjusted to local requirements. Seating, lighting, and sanitary conveniences are provided.

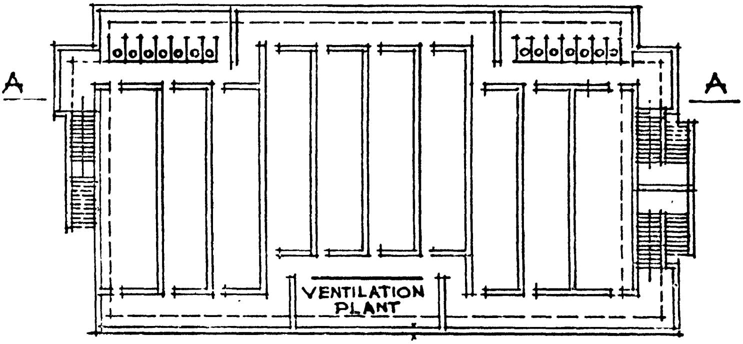
In this design attention has been mainly directed to the problem of planning rather than to considerations of details. Shelters of very similar designs already constructed cost about £6 per head for the first stage and without forced ventilation. The cost would however come down if mechanical ventilation is provided or if the shelter is over the ground.

This design needs careful investigation for "the final solution of the problem of protection for the civil population in large towns and cities lies principally in the provision of heavily protected shelters." At the same time we cannot ignore the provision of partial protection.

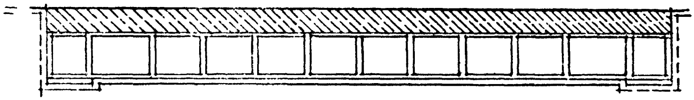
The design has been evolved from the trench. In essence it consists of series of parallel units, either above

1. A.R.P. Co-ordinating Committee's Scheme.

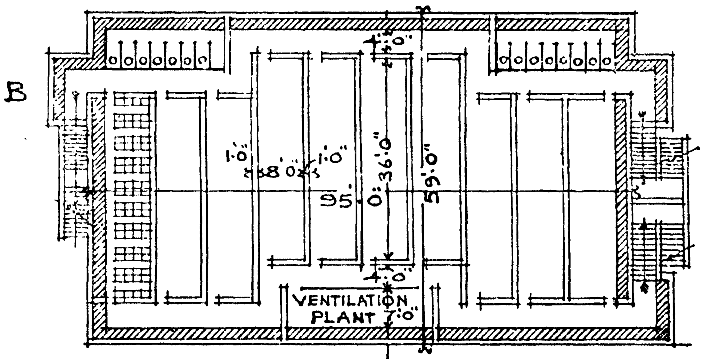
# A COMMUNAL AIR-RAID SHELTER




PLAN



SECTION AA
STAGE 1. BLAST & SPLINTER PROOF PROTECTION

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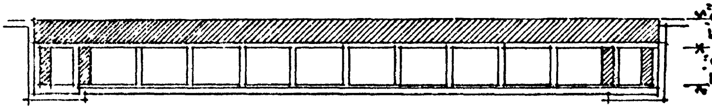



SECTION BB
STAGE 2. HEAVY PROTECTION

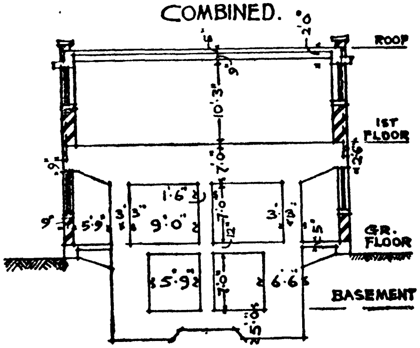
or below ground, separated by walls of reinforced concrete. Two communicating corridors link up the units and also serve to protect the occupants from the effect of shock waves transmitted through the shelter walls.

The diagram given shows the design for a shelter below ground level. The corridors and the stairways serve to isolate the unit from the shock waves transmitted through the surrounding earth. In the second stage the thickness of the walls outside may be insufficient when compared to the roof to resist the effect of bomb exploding immediately alongside. This could be altered if required but with a given amount of material and up to a certain point better protection is afforded by thickening the roof slab at the expense of the wall thickness . . . . because the probability that a bomb may fall immediately alongside the outer wall is very much less than that it may strike the roof.

When the shelter is naturally ventilated it will accommodate 576 persons.

By introducing mechanical ventilation, at a rate of 450 cubic feet per person per hour, it is possible materially to increase the capacity of the shelter, and at the same time to reduce the cost per head. The shelter would then accommodate 770 persons. Seating capacity could be provided for 720 persons, leaving 50 standing occupants.

OFFICE AND BOMBPROOF SHELTER COMBINED.




SECTION

The problem of the workers and employees is less difficult, for, by legislative compulsion, as is done in Great

Britain, employers might be compelled to provide shelter for them. According to the Civil Defence Act 1939 owners of factories or employers of more than 50 persons must provide air raid shelters for their employees in vulnerable areas. A Government grant of 27½ per cent. is made to them. Similar legislation could be helpful to our country.

A.R.P. being a provincial subject, local legislatures should tackle the problem. The Civil Defence Code provides a valuable guide but the designs should be evolved to suit Indian requirements. A convertible garage with possibilities for extension and reinforcement seems the ideal solution both from the point of view of safety and economy.

This will provide for a good section of urban workers. If space is not available around, it could be provided in the basement or ground floor. The narrow streets of Indian cities would be relieved of congestion if the ground floors of large commercial buildings are turned into garages convertible into air raid shelters. This will not interfere with underground systems like drainage etc., and would be suitable to most premises, for a ground floor shelter, would be easier than a basement shelter in buildings.

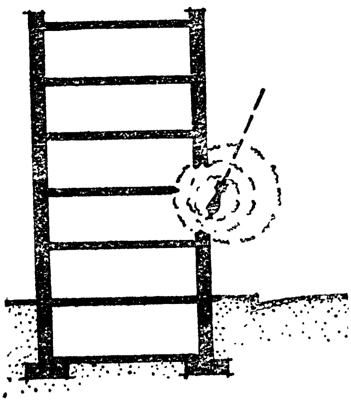
If the Government in England depends upon the strengthened basement as the companion of the sectional steel shelter to protect their people, Indian cities will do well to strengthen ground floors as the solution to this problem. Since most buildings in India are without basements, and since the walls of good buildings are thick enough to afford the standard protection (15" brick in mortar) and as they are load bearing walls, by shoring and strengthening the ceiling of the ground floor to withstand the debris load, convertible garages could be speedily improvised.

In fact even in countries where basements are a common feature of buildings, the strengthened basement is becoming less and less popular.

After examination, many basements were found unsuitable, in Catalonia. Nothing could be done when the basement needed reinforced protection at the sides or overhead because, the work and material expended in this way could be utilised to better purpose in the building of proper shelters. Secondly owing to difficulties of internal wall, conduits, entrances frequently narrow, low ceilings, etc., only a mediocre result could be obtained even after a long period of work. Thirdly the need to provide uniform degree of protection, could not make this officially accepted as shelters.

Even when the basements were suitable independent shelters were constructed in buildings as a more advisable proceeding. When the basement had not sufficient head room but otherwise suitable, it was increased by sinking the floor level.

"The strengthening of those basements and the idea of providing support against the debris weight of the collapsed building is considered useless and experience shows that the cause of such collapse is obviously overlooked. If the collapse of the building is a result of a direct hit over the same building, the hits would reach the basement passing through the wall openings and special care is necessary to provide the shelter in a central area in the basement and affording a substantial lateral protection by means of additional walls. On all suitable occasions the large cellular type and the tunnel type were built in Catalonia."


The vulnerability of basements to the high explosive bombs.

These arguments have great force particularly to countries like India where storeyed houses are of poor strength.

The share the government should bear in their erection, the form legislation should take, are matters of detail but we should remember that they must be such as to be capable of extension and conversion into bomb-proof shelters if required. Their location should be decided with a view to make them the centres of business houses in the city of to-morrow.

For the middle and rich class folk protective accommodation should be provided close to their residence, preferably in the compound and where no space around is available, within the house. The task is best entrusted to owners of residences though advice and guidance might be given free by the State.

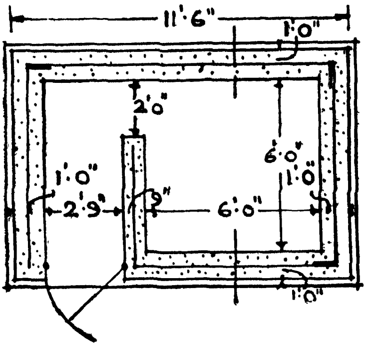
For houses without compounds the strengthened basement, the ground floor refuge room, a specially built scullery or larder are suggested in European countries. Considering the requirements of the middle class and the well-to-do households and the general type of construction adopted in our country, a convertible strong room in the ground floor suitably placed might be preferred. Erected with brick, stone and concrete and equipped with good quality doors and overhead protection these could replace costly iron safes generally owned. It would be useful throughout the year and would save the transport charges incurred for heavy safes. Particularly in the mofussil such strong rooms are of real value and they could also be used as granaries.

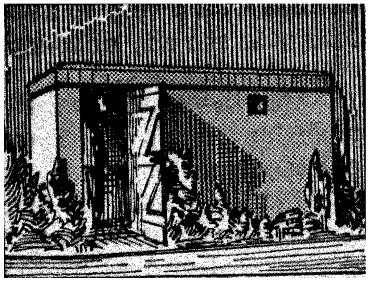
For houses with compounds, the pill-box shelter is advisable. A unit shelter will suffice for an average family and a double unit for a large one. A twin double unit if constructed at the inter-section of 4 compounds would meet the requirements of 4 households at proportionately lower cost.

The unit shelter provides a room 6 feet square with an entrance lobby.[1] Being protected by 12 inches of reinforced concrete, or 13½" of brick in cement mortar,

1. Indian Concrete Journal.

the pill-box shelter is blast and splinter-proof to medium size high explosive bombs exploding not nearer than 50 feet, and does not require a protective earth or sandbag covering.



The Pill Box Shelter.

If concrete is used in the construction of the shelter it should not be weaker than 1:2½:4 mix. The walls should be 12 in. thick reinforced with ⅜ in. diameter bars at 12 in. centres in both directions and the roof slab 9 in. thick reinforced with ⅜ in. diam. bars at 12 in. centres in both directions. If the distance between the shelter and any building which might fall on it is more than half the height of the latter, the thickness of the roof slab may be reduced to 5 in.*

Ventilators 4 in. x 4 in. splayed horizontally on the inside are formed in the walls and should be fitted with plugs.

The foundations should rest on well consolidated ground, and should normally consist of a 6 in. thickness of plain concrete, but the part beneath the walls may be thickened and the thickness of the floor reduced should this seem advisable.

At the junction of the wall with the roof or floor and at any other horizontal joints, a longitudinal groove should be formed in the concrete to provide a key.

* If brick construction is preferred, walls should be 13½" brick in cement mortar.

Timber plugs 2 in. x $1\frac{1}{2}$ in. dovetailed for fixing hooks, shelving, etc., should be set flush in walls 12 in. apart 9 in. down from ceiling. Two tapered vent holes should be formed in the walls and in the positions shown on the drawing. The holes should be 4 in. square on inner face, 7 in. square, on outer face and each fitted with a concrete plug having contact faces covered with plyboard.

The door should be 1 in. thick, ledged, and hung to a 4 in. x 3 in. timber frame set flush in the walls and secured by iron holdfasts or bolts.

A blanket or carpet weighed down with wooden slats should be provided of which 1 ft. should be left trailing on the floor, over the side frames.

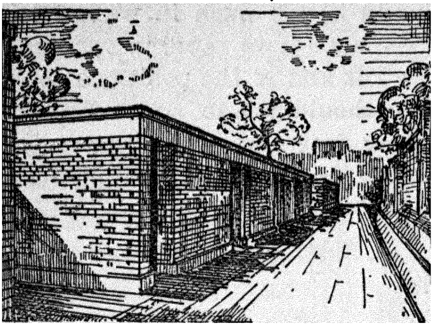
A timber combined bench and locker should be fixed along one side of the shelter, to contain emergency equipment such as first-aid box, candles, matches, disinfectant, water jar, toilet requisites, spare blankets, hammer, shovel, etc.

## Brick Shelters

All the types recommended for Indian dwellings could be erected of brick and cement mortar or stone masonry. The domestic surface shelter in the compound whether overground or sunk, the strong room within the house convertible into shelter for houses without compound, the convertible granary for village homes could be conveniently erected with bricks and cement mortar provided with the proper thickness.

Brick trenches could also be constructed for the floating population. For medium size shelters for commercial and industrial concerns too, bricks could be used. In India where local artisans are used to brick work for ages and where bricks are available all over, there is a strong case for brick shelters. Even in Great Britain interests representing clay products are bringing home to the people the utility of brick for A.R.P.

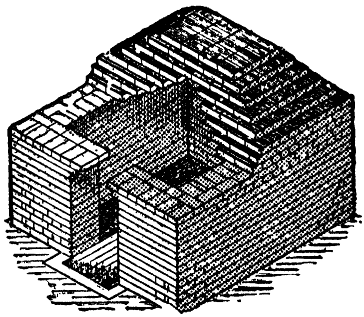
It is interesting to find that the Home Office of Great Britain in their recent announcement recommends brick and concrete shelters, and brick shelters have been built in the streets of London. Tests have shown that brick work affords a degree of resistance to blast and splinters comparable with anything so far either generally used or proposed. The problem of shelters must be met by utilising and adopting normal building methods, materials and workmen's experience. The simplest form of single (one family) brick shelter envisaged by the Clay Products Technical Bureau of Great Britain costs less than 20 pounds; a figure which can be very much reduced in India, especially if the occupants of neighbouring houses cooperate to enable their individual shelters to be semi-detached, with a common party wall replacing two or more separate walls. A further saving will be attained by would-be shelter-owners in a locality combining to place a single contract for all their requirements.



Brick shelters erected in the streets of London.

Lateral protection to blast and splinters recommended in Great Britain for shelters proof to a 500 lbs. H. E. bomb exploding not nearer than 50 ft. could be obtained by bricks and cement mortar 13½" thick. With brick work construction every builder is familiar and bricks are available everywhere. A higher degree of protection will be obtained if reinforcement into the joints of walls are introduced. For overhead protection from bomb splinters, falling shell fragments and debris consequent on the demolition of neighbouring superstructures, and also against the penetration of the roof by the kilo incendiary bomb concrete roof at least 5" thickness of such strength and so reinforced as to be capable of supporting more than the 400 lb. sq. ft. maximum load is recommended. Now that reinforced concrete work could be done in most cities and towns a five inch R. C. Roof is preferable to the Madras and the Bombay terrace. For, to obtain a corresponding strength to resist debris and penetration the latter types of construction would be costlier.

The surface shelter is the least costly and at the same time, of most peace time use. But partially and fully-embedded shelters are also possible. These latter types would be much less exposed to blast and splinters but since they involve excavation will cost rather more. Further they will look different from normal structures which is not desirable from psychological point of view of fright and risk upon young minds.



Brick surface shelter erected without timber or steel.

It is somewhat difficult to strike a balance as between surface and embedded types of shelters but where strict economy is not imperative and little peacetime service is expected of the shelter, embedded types are preferable.

Such partial or complete, embedment will, of course entail extra expenditure on account of both the necessary excavation and the waterproofing of the walls below ground level. In addition, the provision of properly protected entries and practicable emergency exits is not quite so simple and the peace-time uses of the shelters will be rather restricted as compared with surface shelters.

Moreover, on wet sites, where the water level is just below the surface, the danger of partial flooding of the shelter at the crucial moment must be kept in mind, although on many sites such flooding is not likely.

If the entrance to the shelter is situated between 6 and 15 ft. from and facing a substantial wall of the house or work place, that wall will act as a baffle to cut down the blast effect travelling towards the entrance. If it is situated more than 15 ft. away the entrance should be guarded against blast by means of a baffle wall, forming a part of the shelter. Or alternatively be similarly protected by an earth wall whose least thickness is 30 inches. The passage running from one end of the baffle wall to the real shelter entrance can be guarded by a door and equipped, if desired, with a gas curtain.

Baffled entry shelters are preferable and twinned and foursome units are advisable wherever possible. For small houses small shelters would suffice but for large houses, shops, small hotels, etc., sizes accommodating 24 would be useful. No specific provision for cross ventilation, other than that likely to arise between the entrance and the joints of the plates and loose bricks of the emergency exit are mentioned in the directions for Domestic Shelters for six persons issued by the Home Office. If desired, however, an air brick aperture can be inserted for peace-time service in one of the walls, always provided, adequate measures are provided at the same time to provide a blast-resistant closing device over the air brick apertures, for use during air raids. A plate device similar to that used for the emergency exit would be adequate. In the case of certain of the larger types cross ventilation will be set up naturally by the flow of air between the two or more entrances.

In conclusion we should emphasise that all these shelters offer limited protection to blast and splinters. They cannot stand the direct hit of high explosive bombs of medium weight. Emergency measures cannot be better; bomb-proof shelters for all the citizens is impossible within a short time due to the heavy cost. To lessen the magnitude of the danger, until existing cities are readjusted with protective accommodation for all the inhabitants, every future residential building should have its air raid shelter, which would give reasonable protection and which will have no adverse psychological effect, upon the minds of children and adults and "entering of which would in war time be no novelty."

# CHAPTER IX

## PRECAUTIONS FOR STRUCTURES AND SERVICES.

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## PRECAUTIONS FOR STRUCTURES AND SERVICES

Wherever possible precautionary measures must be adopted to minimise the consequences of air attack to city structures and services. Care should also be taken to protect valuables, records and documents, art treasures and manuscripts that cannot be replaced when once destroyed. Historic monuments should be preserved. Key positions must be guarded.

Art treasures were removed from the Helsinki Museum on the eve of attack. Valuable radium of a London hospital has been deposited in a tube sunk deep into the ground. The City of London has been transformed by sandbags. Underground tubes have been protected against the risk of flooding from burst mains. In every city in Europe threatened by air raid diverse measures have been adopted. For unless everything is done to increase resistance, collapse would be quick and the consequences terrible.

Regarding city structures absolute protection is out of question. But even precautions are not worth the while for small structures built in the traditional style in highly congested areas especially when they are situated close to important objectives that would invite the high explosive. Every existing building must be examined on its own merit and measures to be adopted should depend upon the type of construction and the quality of the building as well as its location and neighbourhood. For most of the buildings built in local style and which are old and situated in congested quarters with solid masonry load bearing wall no major structural precaution can be taken without practically reconstructing the building. For tall structures like temples, cathedrals, mosques etc., precautions might prove uneconomic. To multi-storeyed structures of modern design and construction, something could be attempted.

A survey of city structures will make it clear that measures for resistance would be expensive. For instance gas-proofing is almost impossible for structures with tiled roofs and even to terraced houses which are old. Even painting the walls up to eight feet as suggested for cleansing stations will not be possible for many residences. All that can be done to resist a gas attack is to provide ample water supply and to make provision for draining away water used for decontamination.

To large commercial premises, government and municipal offices gas-proofing by sealing up the crevices and equipping doors and windows with gas-proof curtains and devices and painting the walls up to 7 or 8 feet with washable paints must be attempted. To restaurants and boarding houses, to oilman stores and to depots where food grains are stored special precautions must be taken and State compulsion might become necessary. They must be gas-proof and provision for decontamination must be made. As most building materials in use absorb liquid poison gas preventive measures would prove uneconomic, and provision for decontamination must be made.

### Precautions against Fire

The danger from incendiary bomb attack may perhaps be most severe to congested Indian cities. Even in the West this is considered serious and measures to equip cities with fire-fighting organisations have been made. In London over 2,000 fire-fighting parties are organised. Fire-fighting squads form the necessary complement to precautions that would minimise the risk of fire and its spread. For adequate water supply may not be available and immediate attention might not be possible.

There are three methods of fighting incendiary bombs.

1. To prevent the bombs from reaching inflammable objects.
2. To prevent fires from spreading.

3. To fight fires which have already gained a considerable foothold.

The last method is almost useless while there is water scarcity when fire breaks out wholesale. The second method advocated by the Government of Great Britain in A.R.P.H. 9 assumes that persons are in the house or in the building when the bomb strikes it, that anybody is skilled in the difficult art of fighting the incendiary bomb and that people do not go into shelter when there is an air raid. These assumptions are hardly true.

(*a*) Houses may be empty, women and children having been evacuated and the men away at work or in military service.

(*b*) The enemy will not announce beforehand whether he will use incendiary or high explosive bombs per raid or gas.

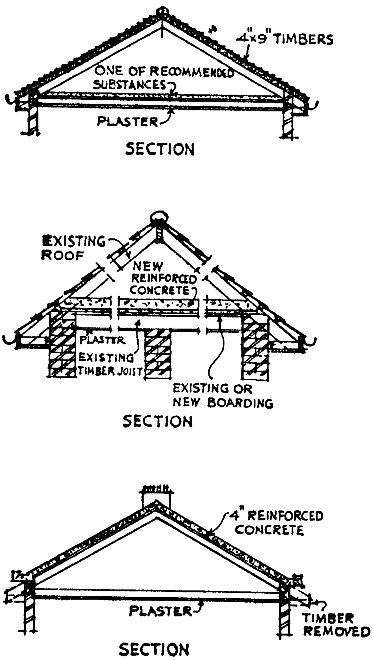
(*c*) Enormous skill and courage is needed and protective clothing is essential to reach the bomb. Many incendiary bombs spray their contents causing many fires at once.

The most effective method therefore lies in preventing bombs from reaching inflammable objects.

Unlike the high explosive bomb the incendiary when dropped from a great height will fall almost vertically owing to air resistance. Naturally they will penetrate the roofs of houses and not openings in the walls.

Structural precaution against fire should take into account the two different effects wrought by the Incendiary: (1) The direct destruction to vital structural members, (2) The damage caused by the exceedingly large stresses directly or indirectly due to difference or change in temperature. Although brick walls could never be destroyed directly by fire it would often collapse by the thrust due to the expansion of the beams owing to the increasing temperature. The latter action is more important and dangerous to buildings with timber floors and roofs.

There are two ways of protecting houses and other properties against incendiary bombs. The first is more expensive and assures full protection while the second is cheaper and will protect 60% of cases when 2-lb. bombs are dropped. To give full protection to houses with timber roof, the vulnerable parts of the house should be covered with 4 in. concrete or ¼ in. steel or 3 in. concrete and 16 gauge steel sheeting or other material which will prevent penetration. 4 in. timber boarding will prevent this but to prevent catching fire it should be covered with asbestos or sheet steel. But even if it burns it would have stopped the bomb. Any bomb resisting material could be applied to the outside of the roof. Reinforced concrete or protected timber could be used for sloping roofs as shown in the diagram. The tiles may be removed or replaced on the top of the concrete to preserve the original appearance.




Methods of strengthening roofs to resist the Kilo Incendiary Bomb.

A flat concrete floor at the level of the eaves is usually cheaper than the above. Incendiary bombs will burn into the roofs but will not affect the residents nor burn down the building. Another method less expensive is to use tight fitting timber boarding with a double steel plate on top. Two 10-gauge sheets are better than one 20-gauge sheet although the total thickness is approximately the same. Such double sheets supported by 4 in. timber properly anchored to the existing walls will localise the fire on the roof. Asbestos sheeting between these two will prevent damage to timber by red hot steel. Such a protective measure could be utilised to convert the building into a flat roof one after a fire.

Even two inches of concrete on the outside of a roof steeper than 40 degrees will make most of the 2 lb. bombs glance away or if 2 in. of concrete is used for the attic floor will prevent incendiary bombs already checked by the existing roofs, from reaching the floor. Similar will be the result if 2 in. boarding is used instead of the 4 in.

Partial protection can be achieved and the fire localised by attic floors as mentioned in the previous paragraph. But we should remember two additional precautions,

(*a*) The walls must be properly tied together.

(*b*) A layer of fire-resisting material must be arranged on top of the attic or the attic beams in such a way that the presence of an incendiary bomb on top does not result in damage underneath.

Care must be bestowed in choosing the proper fire resisting material. Steel, kaolin or foamed slag, asbestos, ashes, etc., are mentioned by the Home Office; but the consistency of these materials must also be taken into consideration before using them. Powdered kaolin will be scattered when a missile falls over it and there will be no protection. Steel sheets might be bent upwards by the terrific heat and through the gaps formed burning material might fall down and set fire to the attic beams. Steel sheeting placed over powdered kaolin will prevent their flying about and also the gaps through which burning matter will come down. Where attics are connected with staircases special care must be taken to prevent fire coming down. The opening should be closed and made part of the floor. A manhole cover should be provided if communication must be maintained.

Flat roofs of 4 inches of reinforced concrete are incendiary bomb proof; if hollow tiles are used 2 in. of concrete on top of the existing insulation or asphalt would strengthen it sufficiently. Flat roofs with timber construction with only a thin covering of a kind of bitumen paper or corrugated sheet particularly when old cannot resist incendiaries. A new reinforced concrete roof is essential. If the existing construction is strong enough which is not generally the case, two layers of sand-bag would be cheaper than concrete slabs.[1]

To most tiled houses in our cities these reforms may prove uneconomic and beyond the means of many owners. To many other dwellings these will be definitely impossible, in the slum areas and in poor quarters where even thatch is a prominent feature. Organising fire-fighting services and making provision for adequate water supply is essential.

## PRECAUTIONS AGAINST BLAST AND SPLINTERS

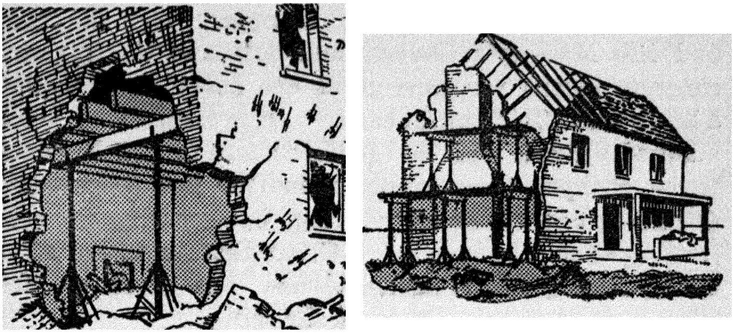
Regarding high explosive bombs precautionary measures taken should cover framing, walls, windows, roofs—both flat and pitched—projecting features like parapets, cornices, etc., and gable ends. The main principles to be followed are briefly indicated below.[2]

Load bearing walls are extremely vulnerable to air attack for the blast by destroying a part of a wall can bring down the whole structure not directly affected in the original explosion. To meet this danger two methods are possible. A frame could be incorporated or

1. Vide, F. Samuely, the "Builder," Nov. 17, 1939, p. 712.

2. Vide, Oscar Bayne, "Structural Precautions against Air Attack," the "Builder," Jan. 13, 1939, pp. iii—xxxi; E. L. Bird: Conference on Structural Air Raid Precautions, R.I.B.A., June, 1938; J.R.I.B.A., June 27, 1938. T. E. Scott: Conference on Structural A.R.P., J.R.I.B.A., June 27, 1938. "The Indian Concrete Journal"; A.R.P. Number, Sept., 1939. Vide also "Structural Damage Caused by Recent Air Raids to some Single-storey Buildings" Bulletin No. C8, Research and Experiments Department Ministry of Home Security. The examples of the damage given show the need for (1) full framing, (2) rigid steel frame work and (3) "Safety Valve" type of construction, if maximum resistance to collapse is to be obtained.

constructed within the building. For large masonry buildings an internal framework would prove economical and feasible. But for a small one it would be expensive,



Blast effect upon buildings strengthened with internal and external supports.

the cost will be almost prohibitive. A frame could be constructed within the building independent of the enclosing walls. This would carry the floors and relieve the walls of their load bearing functions. It is however extremely difficult to design a means of carrying the external walls on this frame without practically reconstructing them. Buildings in partial frames are not common in this country. Where they exist it is easier to complete the frame. The framing required will consist only of columns and beams on external walls which can be linked to the ends of the existing beams relatively easily. In many cases the existence of a wall beam in the external wall will solve to some extent the problem of carrying the wall at each floor level.

Walls in general are 14 to 18 inches thick in this country, and the Home Office recommends 13½" in brickwork to resist blast and splinters from 500 lb. bomb of the high explosive type exploding not nearer than 50 feet. Where the walls are thinner they must be strengthened by bonding extra material throughout the length and height. The addition of piers or buttresses at intervals may increase the stability but will not add resistance to penetration.

Sandbagging and sandbag walling are adopted and England provides a notable example. But the same country now discloses the serious defect of this measure and His Majesty's Government are substituting hollow concrete blocks for sand bags.[1] In a number of areas a brick wall 13½" thick bedded in cement mortar has been adopted. Brick wall in cement mortar is now revealed to be cheaper than sandbagging, by experiments conducted in one of the cities in Great Britain where after investigation the use of sandbags was given up for strengthening public basement shelters.

"The use of sandbags for baffle walls and for the purpose of closing the windows was in principle abandoned right from the start, as a careful investigation into the relative cost of splinter-proof sandbag and brick walls showed that a 13½" brick wall built in Feltton bricks in cement mortar, resting on existing concrete with no footings and finished on each side with fair face, would cost between 20s. and 25s., per yard super, as against a cost of 35s. to 45s. for an equivalent sandbag wall 2 ft. 6 in. thick, including the cost of the sandbags, sand, labour in filling, tying and placing in position and treating the exposed surfaces after erection with some preservative. This comparison of the cost of brickwork and sandbag walls does not take into account the fact that the sandbag wall will in all probability have to be repaired if not replaced, even when treated, after a period of one or two years approximately. On the other hand,

1. Sand bagging is receiving wide attention and its deterioration has aroused good deal of comment. The Ministry of Home Security have issued a technical circular recommending the use of preservatives. (Vide, "Hindu," Jan. 7, 1940). Treatment for rot proofing sandbag revetment. J.R.I.B.A., Nov. 20, 1939, p. 15. See also Frank Bennett, 'Sand bagging its defects.' "Builder," Oct. 17, 1939, p. 613. A. O. Vincent, "Builder," Nov. 17, 1939, p. 711, suggests a mixture of Hydraulic lime and sand instead. The quest for alternatives like brick walling, hollow precast concrete blocks etc. "Builder," Nov. 24, 1939, p. 741. A. R. F. Anderson—Protecting London Statues. "Builder," No. 3, 1939, p. 639. Sand bag walling Oct. 13, 1939, p. 566. Prof: R. V. Southwell, the Protection of Windows against Bomb Splinters, the Pebble screen. *Ibid.*

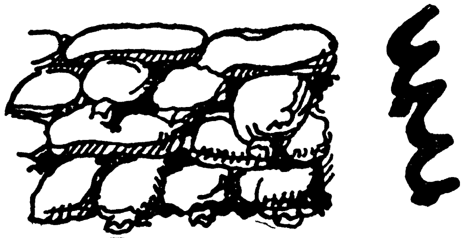
the cost does in neither case provide for removing the walls when the emergency is over. It was anticipated that in such an event there would be very little difference in the cost of removing the two types of wall."

In the narrow streets of our cities the danger of sandbags blocking them in the event of an explosion should be recognised. Some streets are so narrow that sandbag walling on two sides would hinder traffic even in peace time. Further, deterioration would be more rapid owing to the monsoon and the heat. Even in England vegetation, sagging, bulging out of alignment, earth tumbling out, the formation of gaps, have become apparent and the government departments and local authorities have been forced to devise measures to check deterioration and to discover a more permanent substitute for this type of revetment. Sand filling between timber boardings is not considered feasible owing to scarcity of timber. Hydraulic lime free from expansion, mixed with sand in the proportion of 1 to 7 or 8 or even leaner has been suggested. This mixture when placed in position and wetted would set and the whole would then be reasonably stable and permanent and would not collapse even when the bags burst, as the hard contents of each bag would support its share of the weight. It will not be so hard as to increase the risk of richochets and there would be a minimum of splinters, as the hard contents of the bag would tend to pulverize rather than splinter.

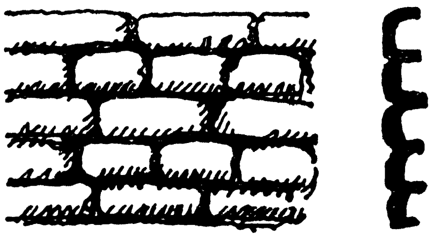
This would cost about ¾d. extra per bag at the most while the cost of germicidal treatment comes to about ½d. per bag.

The considerations mentioned against sandbag equally apply to this kind of protection so far as space is concerned and thickening the walls wherever possible is desirable.

To city statues a revetment of hollow precast concrete blocks may be preferred since they have a neat appearance and the cost will not be very much more than building a brick wall around. The cost of a concrete block revetment however is approximately half that of one of sandbag type of equal protective value and once erected the concrete blocks require no further protection or maintenance over a long period of years. It is already felt that time has approached for replacing the majority of sandbags in the vulnerable areas of Great Britain, by this method.



Emergency.



Military.
Sandbagging methods.

Where sandbagging is inevitable treatment for rot proofing is essential. Two types of preservatives are suitable for application to sandbag revetments. They are respectively a creosote or tar distillate, used as a water emulsion, or a solution of an organic copper salt in creosote made up into an emulsion. The former treatment is for revetments in position which have already deteriorated by being exposed to the weather for some time. The latter is more potent but is also more expensive and its use will not generally be justified unless the bags are in good condition and unless it is desirable to take down the whole revetment, treat all the bags and then re-pile them. Creosote must be applied when the sand is dry and treatment should be repeated at intervals not exceeding three months.

These germicides will only protect the outside surface of the revetment, but the rot and decay starts in the inside, between the bags. Even if the bags are treated with rot-proofing chemicals before filling with sand, there is still the certainty that the lower bags will burst as weight settles: the seams being so very weak, and seams cannot all be inside.

Drying the sand before filling the bags and then covering the work in timber or felt would probably lengthen the life of the protection, but would be uneconomic and extremely difficult without the proper plant. It is well to remember in this connection, another serious disadvantage, the spread of infection. They are polluted by dogs and cats and become "up-to-date semi-detached residences for the rats of the metropolis," as well as the breeding place for beetles, cockroachs, ants and other kinds of parasites. This may prove a source of infection and spread disease. There is no satisfactory method of preventing decay and the consequent collapse of sandbag protection.

The problem of protecting windows is far more difficult to solve since the measures to be adopted should be devised to suit both the nature of the building as well as the neighbourhood. They could be let alone to function as safety valves in the event of an explosion or they might be protected to resist equally with the walls. Heavy shutters, removable slabs or sandbags are suggested but,

(*a*) In buildings surrounded by wide streets or open spaces and without internal courts the value of protection against external explosion given by protected windows would be sufficiently great to justify the risk of increased damage in the event of a direct hit.

(*b*) In buildings surrounded by narrow streets and, with enclosed areas such as light courts and courtyards, the danger of increasing the damage caused by either interior or exterior explosion would be so great as to outweigh any advantages.

In practice protection is obtained by heavy steel or composite sheet steel shutters and units of like construction and it is recommended that if brick or concrete is to be built into position at the time of emergency it is essential that all necessary material should be stored ready for use. It is best to make shutters and removable frames larger than the opening so that they over-lap the brickwork all round. When fitted on the outside of the wall the force of an external blast will be transmitted to the wall directly by the bearing edges and not through lugs or other anchorages. In case of an internal blast the strength of the shutters would depend upon the fixing lugs which would probably fail as we desire if the pressure was great. In either case it adds resistance and safety to structures to protect windows with steel shutters and units larger than the opening and fixed outside.

To poorer class of buildings where closing the window with brickwork would entail difficulty and darkness, a pebble screen made up of a frame containing two flat layers of wire netting enclosing a layer of pebbles not less than 4 in. thick might prove useful against splinters. The thickness could be increased to add its resistance. The two faces should be reasonably flat when the frame is filled but able to bulge largely if the pebbles are struck by a flying fragment. Before the pebbles are inserted the two faces should be tied together by "stays" of thin wire or string, strong enough to prevent bulging under the mere weight of the pebbles (say 80 lb. per cubic ft.) but on the other hand weak enough to break when the frame is struck, thus leaving the wire-netting free to bulge. The aim of the whole scheme is to obstruct a flying fragment, not by anything strong, and rigid, but by a "clud" of heavy particles (the pebbles). This cheap device is easy to fit any window, and when filling the frame if a few inches are left at the top and a reserve of pebbles is provided to fill in time of need, daylight will not be shut out. The whole point of the pebble protection is its ability to yield freely, and there must be nothing to resist the bulging of wire netting if a bomb splinter should hit. All that is needed is a little rough timber some wire-netting and a few pailsful of beach or gravel pebbles.

Projecting features should as far as possible be removed since they would be dislodged by blast or flying fragments. Otherwise they should be either anchored down or stayed at short intervals. Cornices are particularly dangerous and it is almost impossible to strengthen them in any way. Small ones may be allowed to remain but those with large over-hanging projection should be either removed or cut back to a new profile. Hoods, porch-roofs and other non-structural projecting members should be adequately anchored down if they cannot be removed.

Gable ends are extremely dangerous, and liable to be blown away by blast or drawn out by the suction wave, after an explosion. If they are of brick, or concrete, gable ends should be both buttressed and tied to the structure. "If an internal partition abuts the wall below the gable, it may be carried up into the roof space and toothed into the brickwork of the gable to provide good buttressing and a reasonably good tie."

Regarding roofs nothing more is advisable than what was suggested in the previous section to resist the kilo incendiary bomb. Attempting to stop the high explosive is not worth the while; both terraced and pitched-roofs should be dealt with as indicated.

To modern storeyed buildings precautionary measures to minimise the dangers of collapse of upper floors are necessary. Support by planking 2 or 3 inch thick at about three inch interval also supported at suitable centres by beams and pillars is necessary. The planking should easily be fixed close to the ceiling but should not be wedged up tight so as to take the initial impact of the falling debris.

A careful examination of each structure is essential to determine the kind of precautions to be adopted but a survey of city structures is needed to choose those that would repay the trouble taken and those that deserve to be preserved. This has been stressed by experts and technical advisers as well as by the Home Office of Great Britain, in the interest of economy. In a poor country like ours this is vitally necessary to prevent waste of resources particularly in times of war when the demand for them is greater.

Buildings and structures in Indian cities might be classified as follows:

1. Middle and poor class residences, small buildings and structures, most of them built in local style.

2. Large buildings, residences of the well-to-do, shops and business premises built in local style.

3. Multi-storeyed structures and large residences of modern construction and design.

4. Temples, Cathedrals, Mosques, Art Galleries, Museums, Libraries, Civic Buildings in the old style and city embellishments.

As already pointed out the first group do not warrant expensive precautions, particularly if they are situated in congested localities. Even fire-proofing the rafters by suitable paints would be beyond the means of most owners and the best alternative is perhaps the organisation of fire-fighting services. Most buildings in the next class possess splinter-proof walls but blast proofing is impossible since incorporating a frame may not be feasible, especially to one and two-storeyed buildings. The next class deserve possible measures which could be undertaken. Most of the measures suggested in the opening pages could be tried but congested surroundings would reduce their efficacy. Narrow streets and packed surroundings, might render most measures useless by inviting the high explosive bomb.

### PRECAUTIONS FOR TEMPLES, PALACES ETC.

It is very difficult to preserve the miscellaneous group from destruction but they cannot be abandoned for obvious reasons. Against direct hit no protection is practicable to tall structures and monuments, as the expert committees which studied the problem of protecting Cathedrals in Great Britain feel. The Guardians of the Westminster Abbey and St. Paul's Cathedral are therefore focussing their attention to fire-fighting measures. The Building Committee of the Liverpool Anglican Cathedral after careful consideration as to how the Cathedral could be protected from air raids have "decided to leave the building as it is and hope for the best." For, protection "would involve an outlay which the Committee did not feel themselves justified in facing." Their view is that if the worst happened, it would cost less, to replace shattered glass and its stone framework, than to enter on an extensive protective scheme.

The measures adopted by the Dean and Chapter of the Westminster Abbey however indicate what might be done to preserve as much as possible of the invaluable contents of Cathedrals. Some have been removed, others have been preserved in place and protected, while some others have been left to take care of themselves. For instance the unique thirteenth century retable, the coronation chair, the contemporary portrait of King Richard II, and the splendid series of early bronze effigies together with a number of smaller objects including manuscripts, have been moved to a safe refuge. The shrine and the royal tombs which surround it have been enveloped with sandbags. The mosaic pavement of the presbytery has been covered with a layer of felt on which heavy timber (3 in. by 9 in.) has been laid and these monuments are considered reasonably safe from anything less than a direct hit.

Tall canopies present considerable difficulty. The body of a tomb can be sandbagged; but the elaborate tabernacle work supported by slender piers may not be able to bear a heavy load. Adequate protection can only be given in such cases by the erection of a special protective structure.

In a great church, there will be many beautiful works that will have to take their chance. For instance the censing angels in the corners of the transept, which adorn the more or less inaccessible parts of the fabric, could hardly be given effective protection.

The crypt of the Chapter house has walls nearly 18 feet thick; and it has been planned to convert the stone vault into a shelter for the staff. Many temples in our country possess strong rooms and stone vaults which could shelter both people and valuables. If there is risk of air raids the most advisable thing is to remove all valuables that could be removed to places of safety. Wall paintings and carvings can be protected to some extent but it is very difficult to assure safety. Old records, ancient plates, etc., should be removed. Weaker parts of the building should be strengthened.

The problem of how a church or temple that has been damaged should be treated is equally important. The very most that should be attempted is to render the fabric safe and weather-proof in order to preserve what remains intact. A broken roof or shaky wall would call for immediate repair, and if there has been a fall of masonry, special attention should be paid to any carved features (bosses, capitals, corbels and the like) which may have come down with it. All debris should be cleared away. All measures necessary to enable services to continue, where these are possible, should be of a temporary character, pending the time when proper attention can be given to the matter.

It is necessary to have good photographs of the views and details of all monuments and historic buildings for they might be destroyed in a severe raid.

In the Indian temple the Garbagraha usually consists of impregnable walls and a very strong ceiling. They could be easily rendered bomb-proof. The Vimanas could be converted into hemispherical domes resistant to the direct hit of the high explosive and the walls of the Sanctum could be thickened to ward off glancing blow and explosion. This is not beyond the finances of temples in India. But to the tall Vimanas in Northern India and the magnificent Gopurams of the South, protection against direct hit is impossible. Only balloon barrages and anti-aircraft guns could prevent certain destruction by low-flying attack.

These are also necessary for the numerous historic monuments such as the Taj at Agra, the Kailas at Ellora, the numerous Moghul mosques and mausoleums. The Palaces of Indian Princes need special attention, not merely because they form part of India's architectural treasure but also because they form the abode of the rulers of a third of this vast country. To these large structures no one measure will suffice and a scheme of precautions should be planned after careful survey.

## PRECAUTIONS FOR MUSEUMS, LIBRARIES, ETC.

There is then the problem of protecting picture galleries, museums, libraries and state and public records, as well as the valuables of individuals and Governments.[1] Immediate attention should be paid to the preservation of documents and records and gold and silver of the State and the public. Removal to less vulnerable zones will be inconvenient for proximity is essential. The risk of air raids might persist for a fairly long period and access cannot be shut off. H. E. bomb-proof vaults should be constructed to house them. Adequate accommodation should also be made available to the public to deposit their valuables.

For protecting art collections in museums and art galleries three methods are possible. Material might be

1. Vide Air Raid Precautions in Museums, Picture Galleries and Libraries. Printed by order of the Trustees of the British Museum.

protected in place or transferred to safer storage on the premises, or removed to repositories elsewhere. The policy to be adopted depends upon the nature and value of the collections, the design and structure of the building, the risks to which the locality is exposed and the alternative accommodation and means of transport which are available. In most cases it will be found expedient to divide the risks by adopting protective measures of all three kinds.

Only the most valuable should be evacuated, for packing, transport etc. may be difficult at the outbreak of hostilities. Secondly this is possible only if the repository chosen is definitely less exposed to air attack than the original premises. Even slight vibration will harm certain pictures and are better left in their place.

The repository should be at a safe distance (not less than two miles) from any aerodrome, factory, railway junction or other place likely to constitute a target for air attack. Caves or disused railway tunnels, ought not to be used for books, pictures or works of art in any way alterable by damp, though they may serve to shelter certain classes of ceramics, sculpture and the like. Country houses or public buildings, situated in the localities remote from danger of air attack are most desirable. But attention should be paid to

(*a*) the control of access, security of doors and windows and invigilation.

(*b*) proper ventilation and freedom from damp.

(*c*) fire-fighting arrangements.

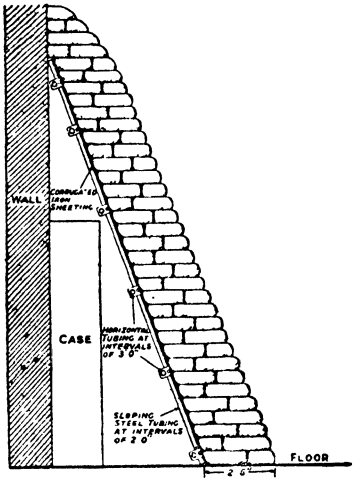
Great attention is necessary during transport and in packing.

Care should be devoted when packing museum material. They are so various in kind that no particular rules for packing them can be given. They should also be rendered damp-proof during transit and water-proof lining is essential for cases containing books, manuscripts, prints or drawings. As far as possible evacuation of pictures should be avoided if transport would harm them.

The most important movable material which cannot be evacuated should be assigned to places of greater security on the premises. There will generally be rooms which have a sheltered situation and strongly built or capable of effective reinforcement. The rooms selected should resist blast and splinter and incendiary bombs. They must have better protection against fire and danger of flooding or other damage from broken service pipes. Good ventilation and freedom from damp are necessary for perishable materials, like paper, vellum, and leather, paintings, textiles, wood and unfired clay; ethnographical specimens other than those in stone, metal, or fired clay; natural history specimens with the exception of most fossils, and some minerals; bone and ivory; corroded metals, and terracotta or stones impregnated with hygroscopic salts.

Humidity, temperature and ventilation should be taken into account when selecting the storage room, particularly if it happens to be a basement. Floors and fittings should be fit for storing them. Library material must not be left in closed boxes. The method of storage is of vital importance for pictures. Atmospheric condition in the storage room should be capable of being controlled if furniture should be stocked. On account of the inflammability of spirit and the fragility of the glass containers which are normally used, the protection of natural history specimens, preserved in spirit, presents a special problem. Elimination of bottles is desirable and one container might be used for the contents of each cupboard or room. It is necessary to plan in detail all these, including the method of removal and the means of handling material in bulk.

The third method is protection in place. Entire evacuation or removal is impossible and in most Museums this would be necessary. Rooms containing objects which are too numerous, too large or too fragile to be removed must be given such protection as is practicable and the material should be moved as far as possible to the safest parts of the room. Book cases, pictures and other objects may best be protected by sandbagging as shown. But it should be solid enough to bear the shock of falling roofs or girders. Care also should be taken not to introduce a heavier weight of protective material than the floors can bear without strutting or other reinforcements in the rooms below. The bags should be filled with foamed slag to reduce the weight. Sandbagging should be made so as not affect ventilation. Chemical units may also have to be used to regulate humidity.



Sandbag protection for pictures, book cases, etc.

Large objects such as statues or architectural features may be dismounted, laid in the angles of floors and walls covered with asbestos wool and shielded with sandbags laid on a supporting framework. But it is undesirable to use wood in the supporting frames since they are combustible.

Large paintings may be similarly screened with sandbag walling. A limited amount of protection can be given by hanging mattresses in front of them. If it is covered with sheets of corrugated iron or of steel and asbestos composition it would offer increased protection. Vapour gas does not affect pictures but liquid gas splashes can not be decontaminated. Glass fronted show cases can resist liquid gas but will not withstand shock of an explosion or the heat of an incendiary bomb. But it is better to shield all such objects which are not protected by sand-bags, with fire-proof and water-proof covers.

If book cases are kept as free as possible from air-spaces damage by fire may be lessened. Books which cannot be removed to safe storage should therefore be packed closely on their shelves, and the empty spaces should be filled with asbestos, pumice blocks, bricks, bags of foamed slag, or other dry and fire-proof substances. Projecting galleries should be emptied and books must be carried to cases on the floor. Books and manuscripts will quickly absorb splashes of liquid gas, and their decontamination, if at all practicable, could only be effected by expert laboratory treatment. They must be wrapped in transparent foil (cellophane) or waxed paper wherever possible for single books. There is no reason to suppose that gas in vapour form will damage books or other library material.

How difficult and expensive the problem of preserving our art treasures, books and records are, would now be apparent. As a temporary measure these might be resorted to. But in the interest of safety during the years to come an immediate attempt should be made to equip museums, art galleries, libraries and record rooms with bomb-proof accommodation, preferably over-ground where space is available or in the basement, just sufficient to accommodate their contents in times of need. Considerations of economy cannot apply to these irreplaceable objects but a dual purpose design could be evolved which will meet even this exacting condition.

Statues in cities are also liable to damage and destruction. Those which must be protected should be removed to places of safety. To others, sandbagging suggests itself. This was adopted for four statues in London by the Office of Works (Charles I at Charing Cross, Charles II at Chelsea Royal Hospital, James II, outside the Admiralty and George II at Greenwich.)

Apart from the difficulty of sandbagging tall ones such as equestrian statues, the disadvantages already mentioned renders this method unsuitable. The recent remedy adopted in London could be copied. Hollow concrete blocks could be used to cover the statuary to offer protection from blast and splinters without occupying undue space alround, in crowded parts of a city.

### PRECAUTIONS FOR SERVICES

A successful scheme of evacuation would minimise the strain on the supply of services essential for maintaining the community. Yet in the interest of the many who must live in vulnerable zones they must be guarded from destruction and dislocation. As described in Chapter V, water supply, lighting, telephone, telegraph and communication, transport facilities, food supply and drainage etc. should be maintained. Their destruction would render life in the area impossible. The Government of Great Britain insists that public utility undertakings should adopt "such measures as may be specified in the notice to secure that the factory premises, mine or as the case may be, any of the premises of the undertaker, can be made less readily recognisable by aircraft in the event of hostile attack."

The Civil Defence Act 1939 draws special attention to the safety of railways, docks and harbours as well as electricity undertakings and the State grants half the expenses incurred for measures adopted to safeguard them.

There may be paid out of moneys provided by Parliament towards approved expenses of public utility undertakers in taking measures, whether before or after the passing of this Act, to secure the due functioning of their undertaking in the event of hostile attack, grants not exceeding one-half of those expenses.

These grants are in respect of measures to secure the due functioning of public utility undertakings. These

**A sand bagged hospital in London.**


**Hollow concrete blocks are used instead of sand bags.**

are further subjected to obscuration of light in the interest of safety. Even in India soon after the outbreak of hostilities in Europe police guards were placed at aerodromes, electric power houses, sources of water supply etc. Camouflaging is insisted upon in European countries and the State will provide expert advice to those compelled to adopt it in the vulnerable zones of Great Britain.

No one measure can be suggested to immunise these services from dislocation but measures to be adopted should as far as possible lead to the realisation of the ideal visualised in Chapter V. The problem is less complicated in Indian cities and immediate steps are possible for some of them to be made resistant, at a cost which would be less than the expense to be incurred in compulsory evacuation and allied measures.

Water supply could be made independent for every building or groups of buildings either by reviving the system of wells and opening them up where possible or by a system of tube wells all over the town. This will provide urban folk with protected water supply. The problem of underground drainage is more difficult to solve especially were the flush-out system has come to stay. Several towns do not possess underground drainage and the cess pit in use could be reformed and retained. In the residential areas of cities some similar system must be devised and the magnitude of the task will be greatly minimised by planned evacuation. These may prove useful to hold the water used for decontamination and would help to prevent the spread of liquid gas contamination. In important commercial areas the underground drains must be protected by concrete road surfaces that would prevent penetration by bombs. Allied to this question is the problem of flooding and other consequences of shattered mains and precautions must be adopted to prevent this effect endangering life in the locality.

Electric power houses must be camouflaged if they cannot be removed to the outskirts of the city, and schemes must be prepared for this transfer. The Indian home could be made self-reliant by reviving the oil lamp but where electricity is used for power, dislocation is inevitable unless other sources are improvised for emergency. Attempt should be made to decentralise sources of production so that when one of them is destroyed, others might function.

Transport units can withstand a raid if they are small. Instances of machine-gunning and bombing, of buses have come to light, but yet they are preferable to trams, light railways and bigger units within city limits and on the borders. A system of transport by buses should be encouraged and railway termini removed outside the city zone.

Special precaution should be taken for restaurants and boarding houses as well as grain stores and food depots and markets. By State compulsion the premises must be strengthened and rendered gas-proof and wherever possible these stores and depots should be removed to less vulnerable spots.

Railway stations, harbours, important public offices and key positions should be equipped with anti-aircraft devices, such as balloon barrages and anti-aircraft guns. For they cannot be successfully camouflaged. The glitter of water would show the port in the darkest night, and the flares would show the tall and extensive railway stations.

### ORGANISATIONS

Organisations to deal with the consequences of destruction and dislocation such as decontamination, clearance of debris, rescue parties etc. as well as reliable and competent advice on the various aspects of precautions necessary, also form part of the measures needed to meet the air menace. Without the former even little destruction would magnify the difficulties of living in the area and without the latter effort and expense incurred on precautions might prove wasteful and even harmful.

Different kinds of organisations, each with a special purpose are necessary; for instance a rescue party is essential "to rescue living persons who are trapped in the wreckage, to recover the bodies of persons killed in the collapsed building, to temporarily shore up or otherwise provide support for the building so weakened that a further collapse is likely which would endanger life or obstruct an important roadway, or where necessary to demolish it; and if necessary to salvage food stock buried under debris." In addition to the immediate work of rescue it will be necessary to provide for the repair of roads and for heavy demolition and clearance work.

Decontamination squads are needed to fight the consequences of gas attack for buildings and roads, and their task would be particularly heavy in India. Arrangement for adequate water supply, decontamination centres for vehicles and animals also form part. A very efficient organisation is required to fight fires and again adequate provision should be made for water supply.

The number and kinds of organisations depend upon the nature and size of the area to be guarded but efficiency is essential and therefore the need for training should be recognised. This is impossible in emergency and plans should be laid in advance in times of peace.

Competent advice is equally important. Expert guidance is indispensable even for apparently simple measures like sandbagging and strengthening of floors. Even in Great Britain such advice is freely made available by the State to owners of factories and producers of essential services in vulnerable zones, who are compelled by the Civil Defence Act to camouflage their premises. In countries where A.R.P. is new this is even more necessary both to facilitate the public to adopt precautionary measures as well as to ensure that they are sound. It is the duty of the State to make expert advice freely accessible to the citizens in a poor country, and this measure would amply repay.

# CHAPTER X

## ORGANISATION AND EDUCATION

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## ORGANISATION AND EDUCATION

It will now be apparent that if a nation should successfully resist air attacks, reforms of a far reaching nature affecting the physical basis and pattern of society must be undertaken. Otherwise our efforts will not bear adequate fruit. Recent happenings in France, Belgium, Poland, Norway and England prove this conclusion. One raid resulted in 250 deaths and 900 casualties in the heart of Paris equipped with anti-aircraft defences. An anti-aircraft cruiser itself was sunk by Nazi bombers. Lord Baldwin's prophecy is getting increasing strength in spite of enormous expense incurred for defence.

Why so much expense and effort in Western Europe have not succeeded in reducing the vulnerability of their country to this danger will become clear when a careful study is made of the measures adopted and the remedies required, described in Chapters III to VI. Air raids planned to destroy the national economy of a country can only be counteracted by methods which will render such dislocation and the breakdown of morale nearly impossible. Only careful planning and building of society and re-grouping of people and industry can achieve this goal.

The measures adopted in the West however reveal that elaborate organisations are needed to deal with the immediate prospect of destruction and to minimise the consequences of disaster. And it is not possible to do more when the danger is at the door. This should serve as an eye-opener to India, not merely to organise the respective bodies to deal with an emergency but also to assess their value. These cannot make the country invulnerable.

Two sets of organisations are necessary to deal with the air menace; one to formulate plans and programmes for the permanent re-distribution of population and industry, and the re-shaping of cities, towns and villages with a view to make India invulnerable to air raids; and the other to improvise measures and programmes for immediate relief in the event of a raid, more or less on the lines of A.R.P. Organisations found in Great Britain and Western Europe.

## THE PLANNING COMMISSION

Both these should function side by side and as far as possible the former must provide the basis to work upon for the latter except for temporary emergency measures which does not involve the re-grouping of communities. Even in England where town planning has made considerable headway, considerable defects and difficulties are found to exist in the present planning legislation and practice. "Planning is essentially on local basis; it does not, and was not intended to, influence the geographical distribution of the population as between one locality and another. As the law stands no authority is charged with the duty of considering the local or regional planning schemes in the light of national resources, requirements and interests as a whole."[1]

It is also pointed out that schemes for central areas of cities often provide for an increasing height, coverage and bulk of business and industrial buildings for such areas, while the permitted density of dwellings in such areas in practice follows, rather than obstructs, the centralising tendency. With regard to suburban areas, the view is expressed that while schemes for such areas, set a better standard of density and are effective by zoning methods in preventing an ill-considered jumble of houses and businesses and in securing convenient road lines and often a reasonable provision of local open spaces, etc., they follow in the main the principle of accepting the established tendency.

1. Vide J. T. P. I. March-April, 1940, pp. 80—85.

Present statutory town planning does not concern itself with the larger question of the general and national grouping of population and the task had to be left to a Royal Commission. While local and regional planning schemes may in due course cover all the land of a nation, a national plan conceived as a whole would be likely to differ substantially from a national plan constructed by merely piecing together the local and regional plan. The local and national interests may easily clash. Another difficulty referred to in the case of Great Britain by the Barlow Commission is the absence of reference to agriculture in the Planning Act although conservation of fertile land is a matter of national significance. But the national aspect of the subject is one with which local planning authorities are clearly not competent to deal.

The creation of a special body is suggested to plan for the nation as a whole whose activity would extend beyond those within the powers of any existing government department.

The objectives of this body should be, the re-development of congested urban areas, decentralisation or dispersal of population and industry and the encouragement of a reasonable balance between the different regions and different aspects of production. Even those who differed from the majority laid special emphasis upon

(*a*) "Enquiry and research, devised to lead up to a systematised plan for distribution of industry on a national scale, bringing with it the attainment of a better balance in the distribution of population than now exists.

(*b*) "Pending the evolution of such a national plan, control of changes in the present distribution of industry as, and if, they occur in the ordinary course of business development."

A permanent Board of Research composed of technicians and others as found advisable should carry out research and advise the body. This central Advisory Board must be helped by Boards constituted on a suitable regional basis.

The advisory and non-executive functions of the body must include

(*a*) Collection and co-ordination of information relating to the location of cities, industries, etc.

(*b*) Research and collection of information as to the various natural resources—land, agriculture, amenities, etc.

(*c*) Advice to government, local authorities, industrialists and others on problems connected with the location of industries, holiday resorts, transport, agriculture and afforestation, grouping of population and housing and provision of centres of economic life.

(*d*) Publicity and annual reports.

An All-India organisation assisted by Provincial Boards should therefore be set up on these lines for controlling the progress of national development with a view to obtain the maximum air security. But this body could also be entrusted with surveys and planning for immediate action to be adopted by the organisation set up for immediate relief. For instance the survey of the neighbourhood of cities to prepare schemes of evacuation, survey of city structures with a view to adopt structural precautions; and this body could also help to obtain uniformity of procedure in different parts of the country.

Different kinds of surveys will form one of their most important functions. Their utility is immense and comprehensive surveys are being carried out even by borough councils in Great Britain. A careful survey has been made by the Islington Borough Council. Both the Government of Great Britain and technical bodies repeatedly recommend it for almost every aspect of A.R.P.

The Home Office points out the need for a survey for 'the location of casualty clearing stations, first-aid posts, location of shelters, or precautions for structures.'

As regards casualty clearing stations, a survey of hospital accommodation generally was conducted by the Ministry of Health and the Department of Health for Scotland in co-operation with the Medical Officers of Health. The Home Office insists that it is essential "that consideration of the problem of public shelters should proceed from a careful survey of the accommodation distributed throughout the area and particularly in relation to shopping thoroughfares, which could be made available for members of the public by arrangement with the owners or occupiers of the premises . . . . Until such surveys, which might be included in the scheme, are completed, it will be impossible to judge the extent to which special construction should be considered or the parts of the area for which this may prove to be necessary. Authorities are, therefore, recommended to arrange for such a survey to be undertaken."

A survey of city structures in which people have to carry on vital work in war time, combined with maps of danger zones are necessary to furnish information for an economical plan of protection. There are buildings of inferior construction for which protection might prove uneconomic. A survey is necessary to select the worthy ones and determine the type of protection required.

The need for organising and controlling A.R.P. services also require careful survey and mapping of the area. The scheme should be accompanied by a map indicating the situation of first-aid posts, depots and other centres specified in the scheme. It is suggested that for large towns and cities the map should be on a scale of 6 in. to the mile. For rural areas a map on a smaller scale will suffice. The most suitable size should be determined with reference to local conditions and no definite scales could be prescribed, for circumstances vary widely.

A comprehensive survey of the neighbourhood of the cities, the communication and transport systems, water supply, accommodation and amenities available must be made to prepare plans for evacuation. In fact a million homes in the reception areas were visited and the accommodation studied prior to the great evacuation schemes launched in England at the outbreak of hostilities. To build temporary camps, to house the evacuees, to provide facilities for food supply, medical aid and education, careful investigation is required.

### A. R. P. ORGANISATION

On this basis provided by the research and investigation departments of the National Planning Commission for India, the Provincial A.R.P. organisations would work. A.R.P. is a provincial subject but in addition to the Provincial bodies local and regional organisations would be required to carry out the work. The functions of the A.R.P. body are numerous and varied. As done in England they would cover in addition to those mentioned in Chapters VI to IX the following.[1]

1. Air raid warnings, to provide as far as possible warning of an impending air attack.

2. Lighting restrictions.

3. Reporting damage. Information about the fall of bombs including the presence of gas.

4. Police forces, to supplement the regular police for emergencies. Fire brigades, strengthening them, to enable them to deal effectively with the results of attack from the air.

5. Rescue parties, etc., to relieve the police and fire brigades and to rescue persons who are injured or trapped and to shore up dangerous walls, etc.

1. Vide Home Office Circular "Air Raid Precautions," July 9, 1935. p. 4—5.

6. Treatment of casualties. Mobilisation and expansion of the medical and first-aid resources. To provide first-aid posts, casualty clearing stations, and hospitals for more extended treatment, together with an adequate ambulance service. Facilities for decontamination of gas casualties and their clothing are also essential.

7. Anti-gas services. Separate arrangements will have to be made for the decontamination of vehicles, buildings, and their contents and contaminated ground, as well as for the organisation of expert gas detectors who can determine whether a bombed area is free from gas or whether decontamination measures are needed.

8. Maintenance of essential public services. Public services such as water, gas, and electricity should be kept going at any rate on a basis of minimum requirements.

9. Road repairs and clearance of debris.

A separate organisation deals with evacuation and the allied problems. The free distribution of air raid shelters is made by the Government directly and through local authorities in Great Britain. Several non-official committees such as the A.R.P. Co-ordinating Committee also help this task in England.

Air raid precautions, to quote Capt. Liddel Hart, cover "measures for the dispersion and concealment of works which may form likely targets; the duplication of sources of essential supply, so as to limit the effect of damage to any one of them; the evacuation of population so far as possible from specially endangered areas; the provision of bomb-proof or splinter-proof shelters for workers in and inhabitants of such areas; the organisation of emergency services to give warning of impending attacks, to maintain order, to clear debris, to deal with outbreaks of fire or the dissemination of gas, and to restore communications."[1]

Nation-wide organisations to deal with these numerous measures have been set up in most European countries and A.R.P. has almost become part of the daily routine of the inhabitants of the crowded cities of Europe.

Over a hundred million sterling has been spent upon Civil Defence alone in England where the Civil Defence forces number a million and a quarter men, of all ages and classes.

Sixty million respirators, including children's respirators and babies' helmets, have been issued as well as 3,000,000 steel helmets, and 1,500,000 oil skin suits, while the number of stirrup pumps issued run into six figures. The total establishment of civil defence personnel, paid and unpaid, is just short of a million. Fire services account for an addition of 200,000, auxiliary police 60,000 and personnel in connection with health casualty services over 250,000, while for evacuation services the total numbers enrolled and kept available amount to 100,000. Every family whose head earns less than £250 per annum is to get an air raid shelter free, if the family lives in vulnerable zones. The current daily rate of expenditure on Air Raid Precautions and Evacuation average nearly £300,000 and £36,000 respectively! These fade into insignificance when compared with the expenditure upon active defence.

In other countries precautions to minimise the consequences of air attack were afoot many years ago, and France had a plan for evacuation ready in 1930. Germany was even more particular about incorporating A.R.P. measures in her buildings and structures and the location of industries. France and Poland also, adopted legislation affecting road widths and building heights to minimise the consequenes of air attack.

An idea of how the A. R. P. Organisation works could be had by studying the system in Great Britain. The A. R. P. Schemes centre round the air raid wardens.

1. Encyclopaedia Brittanica: Year Book 1940, "Civil Defence."

Both the cities and the country side are divided into clearly defined areas, each with its Control Post where Wardens are on duty day and night. Both men and women are enlisted some on a salaried basis, others voluntary; the full time male wardens in Great Britain receive £3 a week. The women £2. Plans for reporting air raid damages are ready the moment a state of war exists; so the Wardens can be compared to the Royal Corps of Signals in an army on active service.

The Control Posts form the units of the organisation.[1] It is from these Posts the Wardens are sent out on patrol; it is with these posts that they keep in perpetual touch. Each Warden is as familiar with his own area as a policeman on his beat; it is his duty to make personal contact with the families that live in his area, and he gives them advice on a multitude of points connected with air raid protection. He examines the splinter-proof shelters provided by the Government or constructed by the individual householder. The lighting restrictions are his special care. And he has a dozen other duties, all of them connected with the safety of the civilians in his area. The Wardens are the eyes of the Control Posts by day and their feelers during the hours of darkness. Vigilance is their watchword.[2]

When the report comes through, that enemy raiders are approaching the boundary, the word is transmitted to the Control Posts. By the time the "Action Warning" comes through, every Air Raid Warden is ready. The undulating note of the sirens can be heard if the raiders continue on their course; the whistles of the Wardens carry the news far and wide; and when the raiders have

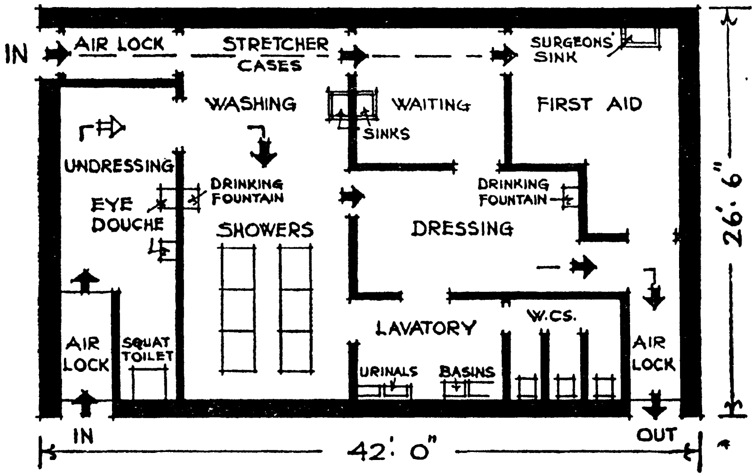
1. In the event of an emergency the London areas Civil Defence Organisation is controlled from one central control room. On receipt of an air raid warning on the teleprinter, direct from the Fighter Command, the watch on duty immediately go to "battle" stations. From this room there is direct communication to all A.R.P. Group headquarters, Scotland Yard, and the Home Office. From here the Operations Officer can transfer as many A.R.P. forces as necessary to cope with severe damage in any one quarter—this is known as "mutual assistance."

For a view of the nerve centre of London's Civil Defence, see 'Sphere,' Feb. 13, 1940, p. 161.

2. The "Indian Express," Oct. 11, 1939.

passed, the sirens sound a long steady blast. If gas-bombs have been dropped, the Wardens' rattle proclaim the tidings, the public must continue to take precautions until the "All Clear" hand-bells can be heard in the streets. Wherever he goes the civilian carries his respirator with him; so that every man, woman and child in England is ready for the signal of a gas attack.

It was under the A. R. P. Scheme that the great evacuation took place; teachers, helpers, mothers, expectant mothers, cripples, blind people and hospital patients were conveyed from their danger areas. It was the biggst scheme of its kind that has ever been conceived; nearly one million children apart from adults left the towns. Everything went through with an efficiency that was almost miraculous; and the power of the enemy to break down civilian resistance by air raids has been enormously reduced.




A.R.P. Decontamination & First Aid Post.

In cities and villages, First Aid Posts and hospitals are prepared for casualties caused by enemy bombers. Rescue squads, first-aid parties, and ambulances are ready for instant duty. 200,000 new beds and mattresses are being provided by the Government, and nearly one-quarter of a million stretchers.

Provision has been made for fires that may be started by incendiary bombs. Even the distant villages have their Auxiliary Fire service with full equipment; and under the A.R.P. scheme, public shelters have been provided at thousands of points in English towns. As for poison gas, no country could be free in Europe but none is in a better position to resist attack than England; the Government have supplied gas masks for all and full instructions have been given to make suitable rooms gas-proof. By means of pamphlets that have gone out to millions of homes, by lectures, by radio-talks, and by the newspaper press, the public have been given copious instructions for their personal safety in an enemy air raid. By day and night the work has been carried on; and the A.R.P. machine, is now in motion throughout the land.

The A.R.P. Organisation in France is styled the "Defence Passive." Its duties are similar to those detailed above and cover various aspects of precautions and protection to the civil population. In addition to shelter provision of different kinds in Paris numerous other precautionary measures were undertaken, including "a series of underground first-aid post hospitals, already provided and equipped for all possible contingencies in various parts of Paris."

Even in the peace loving democracy of Switzerland the A.R.P. Organisation has been set up and sooner it is organised for this country the better. India's economic condition cannot permit a close copy but the main features might be incorporated. This is evident from the recommendations of the A. R. P. Sub-Committee recently appointed in Bombay. The report suggests:

1. Arranging air raid and "all clear" warnings,
2. Control of lights,
3. Organisation for dealing with damages caused, and
4. Education of the public.

The A.R.P. Organisation recommended by them consists of a whole time officer, a number of air raid wardens especially for premises or companies employing more than 300 or 400 persons. Air raid warning and all clear signals should be given by means of sirens to the general public, and by telephone to a selected number of subscribers who are intimately connected in concerns associated with civil defence and public utility services. Each siren would have a two mile range and the "warning" signal would be denoted by the sirens wailing up and down at a four-second interval over a period of two minutes, the all clear signal would be a steady blast of two minutes' duration as recommended by the Home Office of Great Britain.

For controlling street lights in time of war, it is suggested that a combined scheme would be necessary to provide for:

(*a*) Permanently reducing the number of lamps lit and the strength of each lamp lit;

(*b*) Providing shades to prevent glare; and

(*c*) Extinguishing all street lights on the receipt of an air raid "warning."

Measures recommended for the treatment of casualties and repair of damages to hospital accommodation, auxiliary fire services, volunteers, salvage work, provision of anti-gas equipment and education of the public, are also included.

For urban areas with a population of over 10,000 such organisations are essential. But the question of rural areas may be postponed for the present. The main risk to inhabitants of a rural area is from bombs dropped at random, and the likelihood of a house being hit, or of casualties occurring depends on the relative areas of occupied and unoccupied ground. Casualties should therefore be few, even if many bombs fall, and such as would occur would be more likely to be single casualties.

Such a state of affair does not justify elaborate precaution. Local organisations with air raid wardens on the scale of perhaps 3 per 500 population with first-aid boxes and some protective equipment as suggested by the Home Office of Great Britain for rural England might be adopted for villages of over 5,000 inhabitants. A first-aid point and some trained attendants and provision to get decontamination squads from the nearest urban centre should be made. Voluntary help from the villagers must be enlisted.

Air Raid Precautions in rural districts will therefore consist in the main of enrolling and training the allotted number of wardens, and providing the allotted number of first-aid parties, rescue parties and decontamination squads.[1] First-aid posts and points will also be provided. The assistance to purely rural areas, in the unlikely event of serious damage or a number of casualties occurring in them will depend on mobile parties coming from elsewhere.

## EDUCATION AND TRAINING

The success of these organisations depends largely on public co-operation, for A.R.P. affects every aspect of life. Education assumes great significance. Citizens enlightened in A. R. P. constitute the foundation of air defence. "If the emergency comes the country will look for her safety not only to her sailors and soldiers and air men but also to the organised courage and foresight of every household."[2] Authorities feel that "it is of essence of any such preparation that the Civil population should be informed of the present and future possibilities of air attack and instructed in the precautions designed to meet it." Even in enlightened England the Home Office has taken particular care to disseminate correct and ample information through its invaluable handbooks and circulars and the need in India where A.R.P. is new can not be exaggerated.

1. Home Office A.R.P. Dept. Circular No. 10/1939. Air Raid General Precautions in Rural Areas.

2. The Protection of your Home Against Air Raids. (Home Office).

The other aspect of education consists in the training of personnel directly engaged in A.R.P. work. From decontamination and fire-fighting to the handling of evacuees and erecting air raid shelters, efficient training is required. St. John's Ambulance, the Red Cross organisation, etc., form valuable nucleus. The foundation for an anti-gas training centre now exists in Belgaum as also a factory for the manufacture of gas-masks. The training centre at Bombay imparts instructions to air raid wardens and informative lectures to enlighten the public.

But these must be supplemented by schools of A.R.P. on the model of the Home Office Air Raid Precautions School at London. Courses of this school last for three weeks. The full cost of instruction is borne by Government. The course is intended for officers engaged in the preparation of Air Raid Precautions schemes under the Air Raid Precautions Act and Regulations, whether they are permanent officials of the authority selected for these special duties or whether they are officers specially appointed for the purpose. Officers should not normally be sent to the School immediately on appointment. Before attending a course they should have had an opportunity to make themselves familiar both with the organisation of local government in their districts and with the handbooks and memoranda issued by the Home Office, as otherwise they will not be in a position to take full advantage of the course.

The purpose of the school is to train officers charged with the preparation of general air raid precautions schemes and the instruction given do not in any way supersede the specialised training in anti-gas measures which is at present being conducted at the two Civilian Anti-gas Schools at Falfield and Easingwold. The type of course given at present is designed to provide a background to the subject of air raid precautions organisation and to convey information about certain national aspects of air raid precautions with which officers of local authorities would not normally be familiar. Arrangements are made for specialised lectures to be given by officers of the Air Raid Precautions and other Departments on general questions of organisation and on special questions such as medical organisation and problems of structural protection.

The school also serves as a focal point for the accumulation and dissemination of the knowledge and experience acquired by Air Raid Precautions officers in handling the practical difficulties arising in applying the general principles laid down to the circumstances of their own area.

One such school[1] for every province attached to the Provincial A.R.P. Organisation and the Board of Survey and Investigation is absolutely necessary for this vast country, more will be needed to produce enough persons to man the A.R.P. Organisation for India to cover thirty million people distributed in over 1,000 centres.

Enlightening the public on A.R.P. is the other vital aspect of education and all conceivable methods are utilised in England to render this successful. The radio, the cinema, lectures, handbills, pamphlets, etc., are all resorted to; the series of most authoritative publications on the subject has been published by the Home Office. The services rendered by technical bodies and associations, through their publications, discussions and memoranda are invaluable.

It is imperative that the public in India is enabled to possess correct ideas as to the different aspects

1. The range instructions should cover will become apparent from the syllabus adopted by the Home Office A.R.P. School. It includes Lectures on: Elementary A.R.P.; A.R.P. Publications; A.R.P. Act; History of A.R.P.; County Organisation; Borough and District Organisation; Warning system; Allocation and administration in a County; A.R.P. Department Organisation and Regional Inspectors; Organisation for Fire Fighting; Incendiary Bombs; Air Tactics; High Explosive Bombs; Construction of small houses; Construction of multi-storeyed buildings; Protection against High Explosive Bombs; Public Shelters; Active A/A Defence; Chemical Warfare; Police Organisation; Air Raid Wardens; Decontamination; Rescue and Demolition; Casualty Organisation in a Borough; Casualty Organisation in a County; Foreign Information; Equipment and Storage; Organisation of communications; A.R.P. in Factories and Business Premises; Industry and air raid Precautions; War Organisation and Control; Lighting Restrictions. Publicity and Public Instruction; A.R.P. Training by Inspectors. Vide "Air Raid Precautions School" Home Office Publication, Aug. 22, 1938.

of the problem and the task would be facilitated if the Provincial Government, the local bodies like Corporations and Municipalities, and Unions managing urban areas, District Boards, and educational institutions undertake this task before India is plunged into gloom. It is desirable that local bodies are compelled to know the ABC of A.R.P. It is even more essential that students and the coming generation should be acquainted through their institutions, of the art of planning for peace and protection from raids.

Air raids have come to stay, and unless some miracle happens and changes the nature of man, it is necessary to concert measures to resist them. "I can see little hope within any measurable period of time" said Sir Clement Hindley "of obtaining for the Human race in any part of the world permanent immunity from attack from the air of evilly disposed persons or organisations." If Sir Clement's warning should not go unheeded, it is incumbent on our part to prepare ourselves and nothing is more valuable in this preparation than the imparting of correct knowledge to the citizen of to-morrow. If the principles of Civil Defence should form part of the curriculum of studies the justification is to plan ahead for decades to minimise India's vulnerability to air attack, probably to such a level as to render air raids not worth while.

Herein lies the goal of A.R.P. for India—the ideal that should always guide the measures we undertake, however urgent may be the immediate need for precautions. The need for a two-fold programme has been emphasised in all vital aspects of A.R.P. whether for shelters, or for evacuation or for precautions for structures. Technical Press has demonstrated the importance of a dual programme; and the Government of Great Britain, in their innumerable circulars repeatedly emphasise the idea. We will do well to realise however oppressive the need of the hour may be, that real security for our teeming millions lies in effective planning for protection.

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