AUSTRALIAN ARMY JOURNAL

NO. 70
MARCH
1955

Notified in AAO's for 31 March, 1955

MILITARY BOARD.

Army Headquarters
Melbourne
1/3/55

Issued by Command of the Military Board.

For the Secretary to the Board.

Distribution:

The Journal is issued through RAAOC Stationery Depots on the scale of One per Officer, Officer of Cadets, and Cadet Under Officer.

AUSTRALIAN ARMY JOURNAL

A Periodical Review of Military Literature

Number 70 March, 1955

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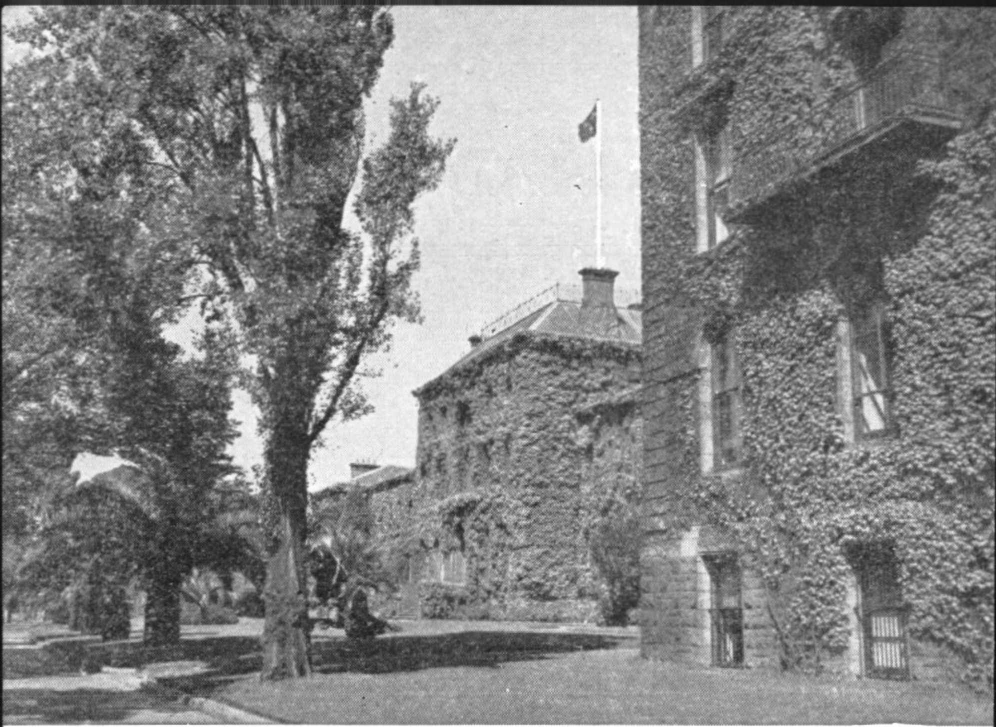

VICTORIA BARRACKS, MELBOURNE

AUSTRALIAN ARMY JOURNAL

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Contributions, which should be addressed to the Director of Military Training, Army Headquarters, Melbourne, are invited from all ranks of the Army, Cadet Corps, and Reserve of Officers.

The CHALLENGE to the ARMY

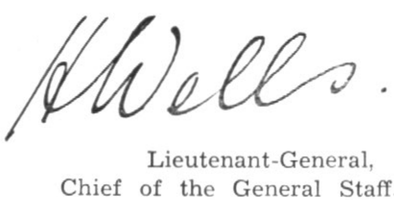
RECENTLY I heard a person prominent in the scholastic world say that the age in which we live is the most intellectually exciting since the Renaissance. In almost every sphere of human activity new ideas are challenging old concepts, stimulating the minds of men all over the world, and opening new vistas of knowledge and achievement.

The soldier, no less than the scientist and the philosopher, is faced with the challenge of the times and its limited wars of the cold war period, its new inventions and its weapons of hitherto undreamed power. With the uncertainty of war or uneasy peace in Asia, the time for preparation and adaptation to the changing situation may be brief, and we may well be embroiled in the march of events before we are fully prepared.

Readiness for war embraces many matters, including the conditioning of our thinking. We need to think and to think hard about the influence of new weapons and new methods if we are to benefit from the scientific advantages available to us. We must beware of the tempting tendency to stick in the familiar paths we know when the need for change emerges.

The Principles of War have not changed, but the new and unfamiliar weapons and machines are changing the manner of their application. We must keep abreast of these changes, we must keep our minds alert, flexible and receptive, we must readily adapt our organization and methods to new conditions of warfare.

In taking up the office of Chief of the General Staff I am acutely aware of these problems. On the other hand, I am also aware that I have taken over the direction of a better peace time army than Australia has hitherto possessed. For the first time since Federation we have a regular field force. Our training organization is more comprehensive than it has ever been, and our command and staff system is soundly based. These are real assets, not only to the Army but to the nation as a whole. However, if we are to render the service which the nation has a right to expect of us at least one other thing besides flexibility of mind is vitally necessary. Our Army, consisting of Regular soldiers, Citizen soldiers and National Servicemen, has been welded into one Army in the post-war period. It remains for each of us to do our part in bringing it to the high state of efficiency that readiness for war demands.



Lieutenant-General,
Chief of the General Staff.

Lieutenant-General H. Wells, CB, CBE, DSO, graduated from the Royal Military College, Duntroon, in December, 1919, was appointed Lieutenant in the Australian Staff Corps, and after a tour of duty in the United Kingdom served with Light Horse units in Victoria and South Australia until 1927, when he returned to the RMC as the instructor in Cavalry and Equitation. From 1931 to 1933 he was an instructor at the Small Arms School at Randwick, and then went to the Staff College at Camberley, England. On his return to Australia in 1936 he was Brigade Major of 1 Infantry Brigade until appointed instructor in Tactics at the RMC in 1938.

In April, 1940, General Wells, then a Major, was appointed to 7th Australian Division as GSO II.

In December of that year he was promoted to Lieutenant-Colonel and appointed Senior Liaison Officer on HQ 1st Australian Corps, and in this capacity took the Australian advanced party to Greece and served throughout the Greek campaign. For his service in this campaign he was made an officer of the Order of the British Empire. Subsequently in Syria he was GSO 1 Operations on Corps Headquarters, and in November, 1941, he was appointed GSO 1 9th Australian Division and promoted Colonel. He served in that appointment throughout the Western Desert operations in 1942, which culminated in the battle of El Alamein.

For his service in this battle he received the Immediate award of the Distinguished Service Order.

In April, 1943, he was promoted Brigadier and appointed to HQ 2 Aust. Corps, and later to 1 Aust. Corps. He continued in that appointment for the remainder of the War, which included the operations in Northern New Guinea and Borneo. After the war he was posted to Army Headquarters, and in July, 1946, he was promoted Major-General and appointed Deputy Chief of the General Staff.

In 1947 General Wells attended the course at the Imperial Defence College in London. On his return home he commanded the RMC Special Wings until he was appointed Commandant of the College in 1949. He remained in this posting until 1951, when he was appointed GOC Southern Command and promoted Lieutenant-General. Two years later he became Commander-in-Chief, British Commonwealth Forces in Korea, and on 16 December, 1954, succeeded Lieutenant-General Sir Sydney Rowell as Chief of the General Staff.—Editor.

THE PHYSICAL EFFECTS of ATOMIC WEAPONS

W. R. Blunden, B.Sc., B.E., p.t.s.c.
Scientific Adviser to the Military Board.

(This paper is to be regarded as RESTRICTED, and is not to be republished, in whole or in part, without the permission of Army Headquarters.—Editor.)

In this paper an attempt has been made to relate the considerable amount of information available on the effects of an atomic explosion to the problems of calculating casualties and damage when an atomic weapon is employed in military operations. This has been done with the principal object of showing how a quantitative approach may be made to a study of the employment of atomic weapons against field formations.

This paper surveys the literature and includes a bibliography. The well-known effects of the nominal bomb are given in some detail, and an explanation of the scaling laws is included to permit the extension of these effects to weapons of different power.

On the basis of this evidence, a discussion follows on the calculation of casualties and damage. Some brief remarks on the cost-effectiveness of atomic weapons are included.

Introduction.

A very great deal of information has been published on the physical effects of atomic weapons. It ranges from the wealth of authentic detail relating to the Nominal Bomb contained in the Smythe Report and the American Atomic Energy Commission's handbook—"The Effects of Atomic Weapons"—to the many speculative accounts in well-known non-scientific journals such as "Time" and "Post." The former deal with principles of operations and the physical effects, but do not relate them in any specific way to a military situation. In more recent months these latter sources have included accounts of the hydrogen bomb. Between these extremes many articles have appeared in the various British and American services' journals (8, 9, 13), and deal, in somewhat general and speculative terms, with the effects of atomic weapons on military operations, tactics and strategy. On the passive defence aspects (11, 15, 16, 17, 18) and on radiac instrumentation (5) the unclassified literature is very complete indeed. The bibliography at the end of this paper gives details of the above sources of information, and its use is strongly recommended for those wishing to pursue the subject further.

This comprehensive body of literature has in fact been largely concerned with the strategic aspects of atomic weapons and the problem of their tactical role and possibilities is only beginning to emerge (3, 10, 12), at least as far as the unclassified and lightly classified literature is concerned.

The object of these two papers is to provide an informed and, where possible, a quantitative basis for the subsequent discussions on the atomic factor in land combat. The first paper—"The Physical Effects of Atomic Weapons"—will seek to relate the known data to the military scene, whilst the second paper "The Effects of Atomic Weapons on Military Operations"—will extend this relationship to some typical tactical situations.

It may appear somewhat paradoxical that the lack of almost all classified information on this highly classified subject does not appear to place undue limitations on these tasks. The unclassified information on physical effects generally, the various public statements from people in high places, and such comprehensive surveys of the whole field of atomic energy as Gordon Dean's "Report on the Atom" provide sufficient grounds on which to base the main assumptions for these papers. They are:—

(a) The physical effects of the nominal bomb are known in great detail.

(b) Scaling laws have been derived which readily permit these effects being calculated for weapons ranging in power from one-quarter that of the nominal bomb to powers many times as great. With reservation, the scaling laws may even be applied to assessment of some of the effects of the thermo-nuclear weapons.

(c) Atomic weapons will be available in sufficient quantities for use by field forces.

(d) They will be available in a considerable variety and with a very great range of power.

(e) Appropriate means of delivery have been, or will be, developed.

Types of Atomic Weapons.

Developments in atomic weapons have made it necessary to be more specific in describing and classifying the various types. Until recently the term atomic bomb was sufficient to describe all such weapons. Now it is necessary to classify atomic weapons in terms of:

(a) Method of operation.

(b) Method of delivery.

Classification in Terms of Method of Operation.

(a) Fission or Uranium weapons, or more colloquially atom bombs.

(b) Thermo-nuclear or fusion weapons, or colloquially hydrogen bombs.

The colloquial terms are basically quite incorrect, and although it may appear something of a quibble to differentiate it is wise to remember that as developments continue loose phraseology will become more and more confusing, and may even result in serious misinterpretation at a later stage. The use of the term fusion is deprecated, because of the likelihood of confusion with fission. It is suggested that fission and thermo-nuclear be adopted as standard terms.

In addition to the above, reference is often made to a "cobalt bomb." Such a description is not fundamental to the mechanics of operation, but is intended to describe some type of nuclear weapon which is "loaded" with cobalt or some other substance that can be made highly radio active. The purpose of such a bomb would be to increase the effect of radio active contamination from such a weapon. Whilst there is little doubt that such a bomb could readily be constructed it is not generally regarded as likely —especially for weapons for employment in a tactical role. It will therefore not be considered further in this paper.

Classification in terms of method of delivery.

(a) Bombs.

(b) Mines.

(c) Shells.

(d) Warheads of guided missiles.

With the exception of a thermo-nuclear shell, the remaining seven varieties, derivable from this 2 x 4 classification, appear likely.

On a first consideration one would be inclined to eliminate from a discussion of tactical weapons the thermo-nuclear varieties. More careful examination shows, however, that this may not be justified. It has been estimated that the size of a thermo-nuclear bomb may be 100-1000 times that of the nominal fission bomb. However, a major tactical and certainly an L of C situation which would warrant the delivery of a destructive weapon of this order is not beyond the bounds of possibility. This possibility, taken together with the fact that one thermo-nuclear bomb would be vastly less costly than the equivalent number of fission bombs, would suggest that the use of thermo-nuclear weapons is possible in military operations.

Having outlined the possible range of an atomic arsenal, it is not intended to consider thermo-nuclear bombs as such in this paper, for there is little doubt that the smaller fission bombs will provide the main atomic fire power in field operations.

It may be inferred from the discussion so far, that atomic weapons are available in a considerable range of sizes, and in the further development of this paper it will be sufficient to refer only to a given weight of attack.

The question of weight of atomic attack makes it necessary to define a basic unit of atomic explosive power.

Because of the great deal of information published on the effect of the fission bombs which were dropped on Hiroshima and Nagasaki, and which were tested at Los Alamos and Bikini, together with the fact that these weapons were similar in size, it is convenient indeed to accept such weapons as a standard for calculating physical effects. In fact, weapons of this type have become known as Nominal Bombs.

The Nominal Fission Bomb.

The explosive element of such a

bomb is 235 isotope of Uranium or Plutonium, a synthetically manufactured element of atomic weight 239. Such materials undergo "fission" when the nuclei of individual atoms are struck by neutrons. The result of this fission process is to split the uranium or plutonium nucleus into two fragments of approximately equal size, and release at the same time two or three more neutrons. However, the mass of all these separate products does not add up to the mass of the original nucleus. This mass defect is transformed into energy at a conversion rate given by Einstein's equation—

$$E = MC^2$$

where E is the energy equivalent in ergs

M is the mass defect in grams

C is the velocity of light (3×10^{10} cms/sec).

If, as in the nominal bomb, 1 kilogram of uranium 235 undergoes fission, the mass defect is very nearly 1 gram, and the energy release is thus approximately equal to—

2×10^{13} calories

2.3×10^{7} kilowatt hours

6.2×10^{13} foot-pounds.

In addition to this, another 12½% additional energy is set free in the course of time as energy of the beta and gamma rays produced by the decay of the fission products.

The figure of 6.2×10^{13} foot-pounds is equivalent to lifting 30 million tons of matter through one thousand feet, i.e., half a million Centurion tanks blown 1000 feet high. In addition to these basic units of energy, the energy release of a nominal bomb has been estimated as equivalent to that released by the detonation of 20,000 tons of T.N.T. Although the energy released by fission is very impressive, it is relatively small compared with the energies involved in the forces of nature. For example, it is about the same as the energy of the sun's rays falling on 2 square miles of ground on a normal day, or to that released by a moderate shower producing a ¼ inch of rain, say, over the greater Melbourne area. A strong earthquake dissipates as much energy as about one million nominal bombs. These various comparisons are given in an attempt to give some kind of balance to the mind in comprehending orders of magnitude that are represented when 10 is raised to powers of the same order.

The explosive effects and physical damage are not, of course, a function of the total energy release only, but are also functions of time. It is the rate of release of a given quantity of energy that determines the destructive consequences, and in the case of the atomic weapons it is necessary to take into account the form in which the energy manifests itself—blast, heat and nuclear radiations. More will be said of this in the next section of the paper. Before passing on to this, however, it will be desirable to make a number of observations about the physical characteristics of the atomic weapon:

(a) The Fission Chain Reaction and Time of Explosion.

As stated above, it is not the enormous release of energy alone that makes the atomic explosion possible. The important additional fact is that the fission process initiated by a neutron is accompanied by the almost instantaneous emission of more than one neutron for each nucleus undergoing fission.

Let us assume for simplicity that for each nucleus suffering fission two new neutrons are liberated. If we start with the fission of a single nucleus, then in 80 generations enough neutrons (2^{80} or 3×10^{24}) would be produced, sufficient to cause fission in every nucleus of a kilogram of uranium 235.

The fission process itself is almost instantaneous, and the time between successive generations is proportioned to the mean distance separating the atoms in a mass of uranium and the velocity of the emitted neutrons. These values are such that the time of a generation is approximately one hundred millionth of a second. Therefore, the build-up of 80 generations and hence the fission of a kilogram of uranium would take place in less than 1 microsecond (1/1,000,000 second).

The above simple calculation is based on the assumption that every neutron liberated in a fission process produces another fission. This is not the case in practice, some are absorbed and some escape the system altogether. If the rate at which they are lost exceeds the rate at which they are formed the process would soon come to a stop. The rate at which they are produced is proportional to mass or volume, whilst the rate at which they escape is proportional to surface area. The correct relationships between the factors bring up the very important question of critical mass.

(b) Critical Size.

It is of importance to have some understanding of the concept of critical mass or size of a fission type explosive, as this sets lower and upper limits to the power of a fission weapon, and this in turn has a major effect on the operational use of such weapons.

If the quantity of material is too small, that is to say, if the ratio of surface area to volume is too large, the loss of neutrons will be so great that the propagation of the fission chain reaction, and hence the production of an explosion, will not be possible. As the size of the system undergoing fission is increased, the relative loss of neutrons by escape is decreased, a point is reached at which the reaction becomes self-sustaining once initiated. This is known as the critical size. By surrounding the system with a suitable neutron reflector the critical size may be reduced to some extent. Because of the presence of stray neutrons in the atmosphere, a quantity of fissionable material which exceeds the critical dimensions would be liable to spontaneous explosion. Therefore before detonation it is necessary that the weapon should consist of two or more separate parts, each less than the critical size. To cause an explosion these parts must be brought together very rapidly, because if the reaction were initiated by stray neutrons before the parts had reached their closest position a relatively weak explosion or a "fizzer" would result.

(c) Size of a Fission Weapon.

In the discussion this far it has been stated that the energy release of a nominal bomb would be produced by the fission of 1 kilogram of uranium 235 or plutonium. If the efficiency of the fission process were 100%, then such a bomb would in fact only require that amount of fissionable material. Details of construction and technical performance of these weapons are highly classified. However, it has been generally accepted that the efficiency of the fission process of the early weapons was of the order of 1%, which indicates that something like 100 kilograms of uranium or plutonium would be required in a nominal bomb. More recent references (Report on the Atom, Gordon Dean, p. 110) suggest that these early efficiencies have been substantially improved, and it would not seem unreasonable to suppose that a modern fission weapon using the "implosion" process would require little more than 10 to 15 kilograms of fissionable material. Such an amount would be of the same order of size as a cricket ball.

The improved efficiency of the fission process has in all probability resulted in a reduction in the critical mass, and this in turn has permitted the production of weapons of smaller size and power, probably of the order of one-quarter that of a nominal bomb—hence the atomic shell.

The actual size of a fission shell or bomb is largely a function of the mechanism of bringing the subcritical masses of uranium together (the amount of actual uranium being virtually insignificant). Whilst there are no blue prints available of any kind of atomic weapon, it is possible to deduce from various published data that an atomic shell may have external dimensions of, say, 11 in. calibre and length about 30 in. The dimensions of a nominal bomb would be unlikely to exceed those of a 5000 lb. high explosive bomb.

Some Physical Characteristics of the Thermo-nuclear Weapons.

There is no authoritative detailed information available on the physical characteristics of the thermonuclear weapons that have so far been developed. However, recourse to basic nuclear physics permits a reasonably accurate assessment of their characteristics, especially those which bear on their military employment.

(a) The Thermo-nuclear Reaction.

Unlike the fission weapon which releases energy when a large and heavy nucleus breaks down into smaller components, the thermonuclear process depends on the fusing together of light nuclei to form a heavier one, e.g., hydrogen isotopes combine to form a helium; lithium (6) deutride transformed into two helium atoms and certain others. In doing this, there is a mass "excess" which is converted into energy by Einstein's Law. For a given mass of reacting materials this fusion process is about three times as efficient as is the fission process. Furthermore, the light elements that enter into these reactions are much more plentiful in nature or easier to produce artificially. The fusion process is not, however, self-initiating or readily triggered, as is possible with fission reactions. In fact, the fusion processes take place only under conditions of very high temperature—greater than 10^6 degrees absolute.

(b) Initiation of the Thermo-nuclear Reaction.

It is generally considered that the high temperatures required to start a thermo-nuclear reaction are only possible by using a fission bomb as a detonator. This presents no technical difficulties. However, it sets a lower limit to the explosive power of the weapon, and to some extent infers that thermo-nuclear weapons will only be made in very large sizes in order to provide some kind of balance between the detonator and the main explosive charge.

(c) Power of a Thermo-nuclear Weapon.

It is generally regarded that smallest weapons would be 50 to 100 times more powerful than a nominal bomb. There does not seem to be any practical limitation on the maximum power of such weapons.

The Physical Effects Resulting from the Detonation of a Nominal Bomb.

The actual effect on troops and military installations of an explosion of an atomic weapon depends on a very large number of parameters. For a bomb of given size delivered against troops in a specified geographical disposition there are more than twenty likely cases to be considered, depending on the nature of the burst, the passive defence condition of the troops, the atmospheric conditions, their geographical disposition and the accuracy of delivery of the weapon. These various factors will be considered in more detail in the section dealing with lethality of atomic weapons. In this section the principal known effects of the nominal or standard fission bomb will be considered. Then, after considering the problem of scaling, it will be possible to make some attempt to analyse the problem of lethality. This, taken together with the logistic cost-effectiveness of atomic weapons, should provide the foundation for consideration of their tactical employment.

The detonation of a nominal fission bomb in the air (say 2000 ft. above ground) produces four major effects—

(a) Blast,

(b) Heat,

(c) Initial nuclear radiations—neutrons, gamma rays,

(d) Residual nuclear radiations.

It will be desirable to consider briefly the principal features of each of these effects in turn.

Blast.

When a great quantity of energy is released in a very short time there is considerable rise in temperature (in this case $10^{6\circ}$ K). As a result, the products of the fission are almost completely vaporised, and consequently a very high pressure is set up in the immediate vicinity of the explosion. This pressure is transmitted through the surrounding medium with the speed of sound. The pressure front in such an explosion as this becomes very steep indeed, and builds up into a shock wave. This is due to the fact that the initial disturbance heats up and pressurises the medium through which it has passed. As the speed of sound increases with temperature and pressure, the trailing portion of the pressure blast catches up on the initial disturbance, producing a shock front with a long tail. This is quite different to the shock wave from an ordinary bomb, where the limited amount of energy does not cause the same integrating effect. An ordinary bomb blast is more like a single impulsive blow. The two effects are shown in Fig. 1. It results in

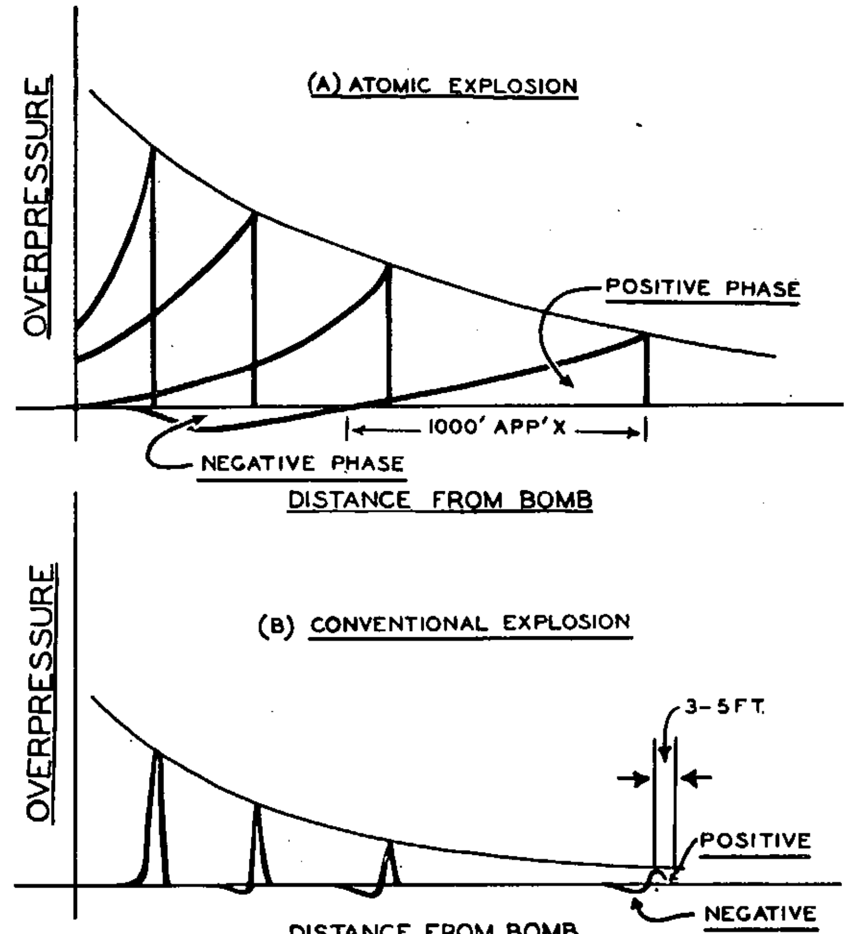


FIG. I.

BLAST WAVES FROM ATOMIC & CONVENTIONAL BOMBS.

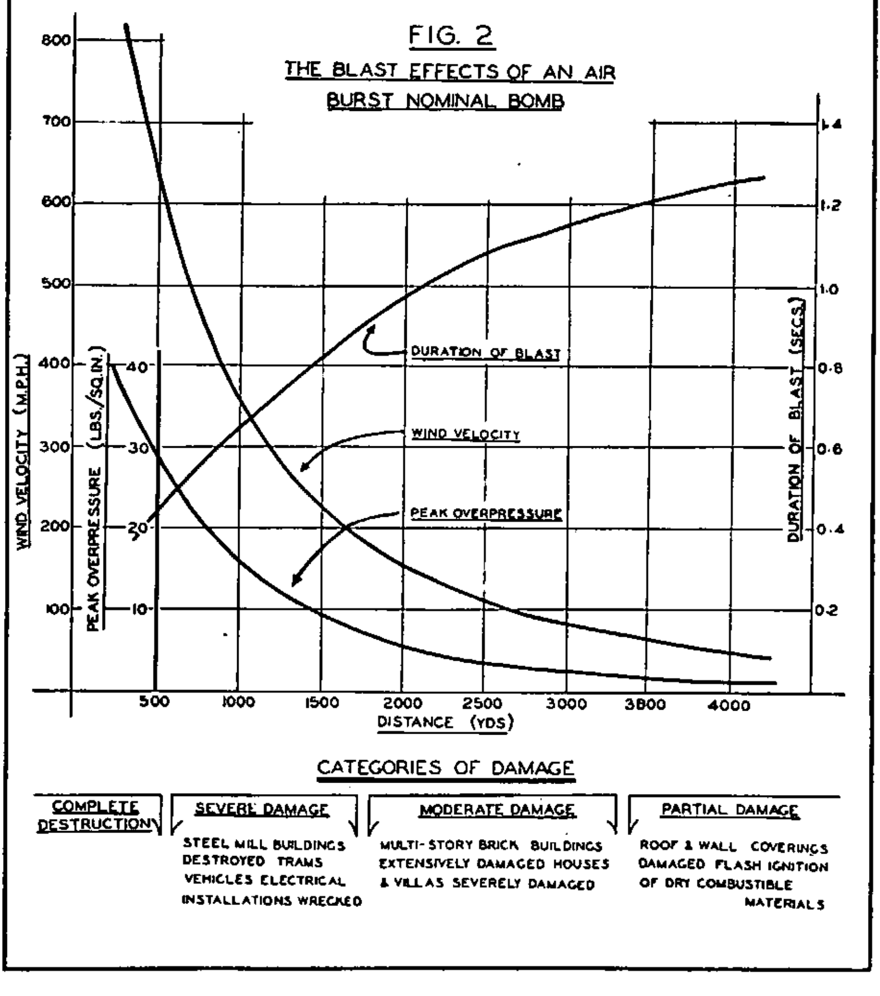
quite different effects for the two types of blast on structures. For a given amount of energy the impulsive blast would cause the greater damage. A detailed understanding of the difference between the conventional and the atomic blast is important to military engineers who may be concerned with the design of field works and structures.

In the case of the atomic blast wave it is the peak pressure that determines the destructive effects. An overpressure of 5-6 lb./sq. inch would cause severe damage in a built-up area, cause severe structural damage to steel frame buildings, B-vehicles and the most substantial of camp buildings. In the case of the nominal bomb this pressure occurs at about 2000 yds. Fig. 2 gives an annotated graphical picture of the blast effects of a nominal bomb.

The effect of blast on personnel is rather more difficult to assess. The human body is capable of withstanding peak overpressures of up to 35

FIG. 2

THE BLAST EFFECTS OF AN AIR BURST NOMINAL BOMB



Categories of Blast Damage.

Classification of Damage	Distance in Miles		Area of Damage
	Min.	Max.	Sq. miles
Complete destruction	0	5	.75
Severe damage	.5	1.0	1.00
Moderate damage	1.0	2.0	9.5
Partial damage	2.0	4.0	40.0
Light damage	4.0	8.0	150.0

TABLE 1.

lb./sq. in. or more. At distances closer than 400 yds., therefore, a human being is almost certain to die as a direct result of blast. However, by far the greater danger from blast arises from secondary effects. As indicated above, a peak pressure of 5 or 6 lb./sq. in. causes severe damage to structures—troops in the vicinity are likely to suffer heavy casualties. This would apply particularly to troops either in or close to B-vehicles.

The various categories of blast damage are set out in Table 1.

Thermal Radiation.

Because of the very high temperatures attained in an atomic explosion—initially approaching that of the sun's interior—there is a large amount of thermal radiation. In fact, about one-third of the energy of the nominal bomb is released in this manner, i.e., about 8 x 10^6 kilowatt hours. At 0.1 milliseconds after detonation the ball of fire consists of an isothermal sphere of 50 ft. radius at a temperature of 300,000° K. The proportion of the radiation at various distances from this high temperature source depends on the clarity of the atmosphere and the distance from the burst. Because of the absorption by various components of the atmosphere, this radiation will be in the spectral region of wavelength exceeding 1860 Angstrom units (1 Angstrom Unit = 10^{-8} cm.), i.e., it will consist of—

Ultra violet radiation (1860A-3850A),

Visible light (3850A-7600A),

Infra red rays (greater than 7600A).

One of the principal factors relating to the radiation of thermal energy is the absorption and scattering it experiences in passing through the atmosphere. Many factors influence this, and it is not proposed to discuss them here. However, the physical effects are markedly influenced by the atmospheric conditions, and they are thus of great importance in estimating casualties and other effects caused by the heat flash. Table 2 and Fig. 3 summarise the situation in this regard. Table 2 shows the approximate attenuation factors for various atmospheric conditions, whilst Fig. 3 gives the total thermal energy delivered at varying distances for a range of attenuation factors.

An important feature so far as the resultant physical effects are concerned is that the whole of this radiation is emitted in a very short time—3 seconds from the initiation of the explosion. The time intensity is thus high, and as a result the radiation falling on any combustible object has little time to dissipate by conduction. The temperature of such objects thus rises rapidly, and ignition takes place much more readily than it would if the same quantity of heat were applied over a longer period. Fig. 4 shows the nature of the relationship between total energy and its rate of supply in the case of ignition of wood.

From the considerations described above it is clear then that the principal criteria for determining the effect of the heat flash in combustible materials and skin is the total energy received per unit area. A great amount of experimental work has been carried out on the determination of the critical energies (expressed in calories/sq. cm.) required to cause ignition of various mate-

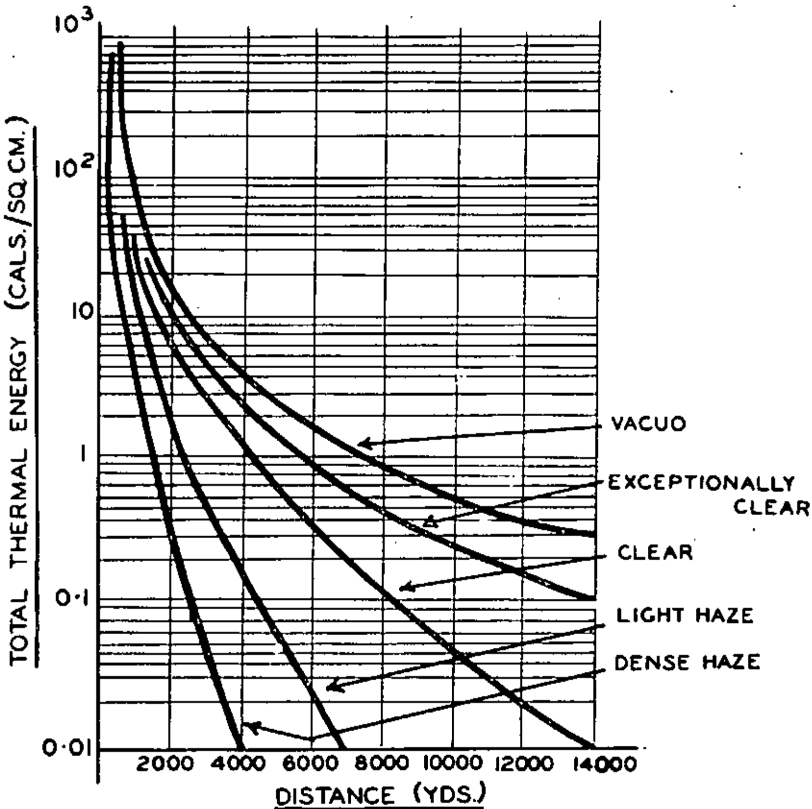


FIG. 3. THERMAL ENERGY/DISTANCE CURVES FOR VARIOUS ATMOSPHERIC CONDITIONS

Attenuation Factors for Various Atmospheric Conditions.

Atmospheric Conditions	Attenuation Factor Km^{-1}	Attenuation Factor/1000 yards
In vacuo	0	0
Exceptionally Clear	0.1	0.09
Clear	0.2-0.4	0.18-0.36
Light Haze	0.8-1.2	0.73-1.09
Dense Haze	1.6-2.0	1.45-1.82

TABLE 2.

rials. The results of this work are summarised in Table 3. In addition, the effective distances from ground zero of a nominal bomb at which the given critical energies will occur are given. These distances are given for attenuation factors $K = 0.2\ km^{-1}$ and $0.4\ km^{-1}$. These factors represent the limits of attenuation on what would normally be described as a clear day.

It has been assumed, so far, that the damaging effects of the thermal radiations have been due to the high temperatures resulting from the rapid absorption of the heat energy. Damage to skin tissue can be caused by the direct chemical effects resulting from the ultra-violet radiations. The symptoms of this effect are known as erythema.

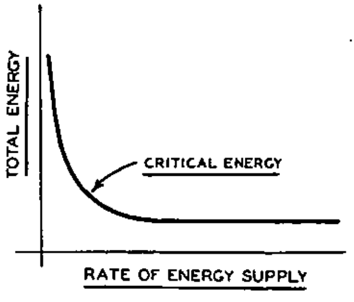


FIG. 4. CRITICAL ENERGY FOR IGNITION OF WOOD

A considerable amount of work has been done to determine what percentage of burn casualties are likely to fall into this class. The results of this work show casualties from ultra violet radiations are not likely to occur, except to the most sensitive individuals at distances greater than about 2000 yds. At such distances severe burning would occur from infra red radiations.

These facts are of more than academic interest, as the bulk of the ultra violet radiation is emitted almost instantaneously when the temperature falls to 10,000° K. Infra red rays are emitted from 0.3 to 3 seconds later, and this means that there is a very good chance of minimising burn casualties if individuals take immediate cover after the initial flash of the explosion.

In addition to the direct effects of thermal radiation, an extremely serious effect will result from the interaction between blast and thermal radiation in built-up areas and above ground base and L of C installations. Blast damage to physical structures is in itself likely to cause many fires, and this, taken together with the intense heat flash, may cause the situation to become extremely critical.

However, on the credit side there is some evidence to show that fires started by the heat flash in certain structures in the absence of inflammable accessories such as gas and electric installations may be extinguished by the blast wave which follows. This is likely to occur under certain conditions in wooded country, and it would minimise the possibility of bush fires.

The Initial Nuclear Radiations.

Nuclear radiations from an atomic explosion fall into two classes—

(a) Initial radiations,

(b) Residual radiations.

There is a continuous transition from one type to the other, and so the demarcation between the two

Critical Energies and Distances from Ground Zero for an Air Burst Nominal Bomb.

(Reprinted from "Effects of Atomic Weapons.")

Material		Critical Energy	Effective Distance	
			$K=0.2Km^{-1}$	$K=0.4Km^{-1}$
		cal/cm^2	feet	feet
Skin	Moderate burns	3	10,000	8,000
	Slight burns	2	12,000	9,600
White paper	Chars	8	7,000	6,000
	Burns	10	6,300	5,400
Black paper	Burns	3	10,000	8,400
Douglas fir	Burns	11	5,900	5,200
	Chars	8	7,000	6,000
Douglas fir (stained dark)	Burns	3	10,000	8,400
Philippine mahogany	Chars	7	7,300	6,300
	Burns	9	7,150	6,150
Maple (black)	Chars	8	7,000	6,000
	Burns	25	4,300	3,800
Cotton shirting (grey)	Scorches	8	7,000	6,000
	Burns	10	6,300	5,400
Cotton twill	Scorches	10	6,300	5,400
	Burns	17	5,100	4,400
Gabardine (green)	Brittle	7	7,300	6,300
	Burns	10	6,300	5,400
Nylon (olive drab)	Melts	3	10,000	8,400
Rayon lining	Scorches	3	10,000	8,400
	Burns	8	7,000	6,000
Wool serge (dark blue)	Nap gone	2	12,000	9,600
	Loose fibres burn	7	7,300	6,300
Worsted (tropical khaki)	Nap melts	4	9,100	7,600
	Burns	15	5,400	4,700
Rubber (synthetic)	Burns	8	7,000	6,000
Lucite	Softens	72	2,400	2,300
Bakelite	Chars	75	2,400	2,300

TABLE 3.

kinds is fixed more or less arbitrarily by considering those which occur within one minute of the explosion as initial radiations. The residual radiations may exist for days and even weeks afterwards, but, of course, with diminishing strength. The characteristics of both types of radiation, but more particularly of the residual radiations, depend on the nature of the burst (air burst, ground burst, underwater burst, etc.). As the two types of radiation are characterised by very different properties, they will be discussed separately—initial radiations in this section and residual radiations in the succeeding one.

The detonation of an atomic weapon is accompanied by the release of gamma rays, neutrons, beta and alpha particles. The neutrons and some gamma rays are emitted in the actual fission process, i.e., simultaneously with the explosion, while the remainder of the gamma radiation and the beta particles are liberated as the fission products decay. The alpha particles result from the normal radioactive decay of uranium and plutonium. The range of the alpha and beta particles is small, and for an air burst bomb they will not reach the earth's surface. The initial radiations may therefore be considered to consist of neutrons and gamma rays.

These radiations are very penetrating. For example, at a distance of 1000 yards from the explosion the initial nuclear radiation would probably prove fatal to 50% of human beings, even if protected by 12 inches of concrete.

The properties of neutrons and gamma rays are novel, and lead to many results of interest to soldiers as well as scientists (1, 2, 15, 21). In this paper it will be necessary to limit the discussion to some brief remarks concerning their range in air and their lethal effects. As the properties of the two types of radiation are so different, they will be considered separately.

Neutrons.

The neutrons emitted in the fission process carry about 3% of the energy of the explosion. Of this something less than 1% escapes because of the loss of energy to components of the exploding bomb, i.e., the escaping neutrons have about 0.03% of the energy of the explosion. This seems small compared with the 33% of energy appearing in the heat flash. However, the lethal effect of neutrons is considerable, and in addition they will penetrate many inches of shielding material, whereas shielding from the thermal effect is comparatively easy.

The spectrum of the neutron radiation is characterised by fast and slow neutrons, the latter predominating in the ratio of 10 to 1. The intensity of the neutron flux, for fast and slow neutrons, at various distances from the explosion is given in Fig. 5.

The interaction of neutrons with animate and inanimate matter is a complex study. It is sufficient to say here that the principal effects cause transmutation of elements and induce radioactivity. These effects produce serious physiological effects. The lethal number of slow neutrons may be taken as 5×10^{11} per sq.-cm., and that of fast neutrons 10^{11} per sq.-cm. Reference to Fig. 5 shows that their lethal range is approximately 600 yds. If allowance is made for neutrons of energies intermediate between the slow and the fast varie-

$$\text{NEUTRONS/SQ. CM.} = \frac{N}{4\pi r^2} e^{-r/\lambda}$$

APPARENT SOURCE STRENGTH (N) = 3×10^{22} (FAST)
= 3×10^{23} (SLOW)

APPARENT MEAN FREE PATH (λ) = 630 FT. (FAST)
= 600 FT (SLOW)

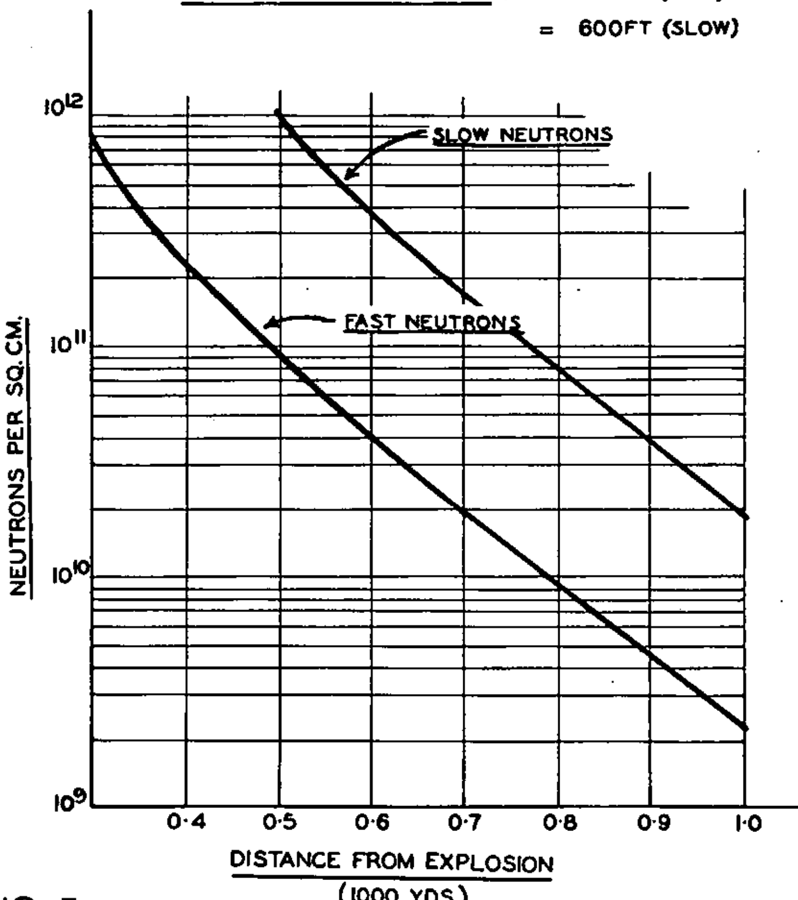


FIG. 5.

FAST & SLOW NEUTRONS AS FUNCTIONS OF DISTANCE FROM EXPLOSION ties, this figure may be increased to 800 yds. Although these ranges are small compared with those resulting from other causes of lethal effects, it is important to note that at points very close to the explosion (say 400 yds.), where field works may protect personnel from the effects of blast and heat, the penetrating power of the neutrons may cause casualties which would not otherwise occur.

The problems associated with the shielding from neutrons are very complex, as the interaction of neutrons on many shielding materials produces gamma ray photons, which if *not absorbed constitute an* additional hazard. Concrete is a satisfactory material, as it contains a large amount of hydrogen to slow down the neutrons, and calcium silicon and oxygen to absorb the gamma photons. Addition of scrap iron improves the properties of concrete as a shield.

Gamma Rays.

The energy associated with the gamma rays is of the same order as that carried by the neutrons, i.e., 3% of total bomb energy. As with neutrons, only about 1% of this amount penetrates to any distances from the source of the explosion.

The gamma rays are of two kinds —prompt and delayed. The prompt gamma radiations are produced within a few millionths of a second of the detonation. However, associated with the explosion are various fission fragments, many of which are radioactive. As these decay, gamma rays are emitted. There will be appreciable liberation in the first minute from this decay activity after this, the decay continues, and *the accompanying radiation merges* into the residual category.

Although gamma rays may induce some radioactivity in other substances, the amount is negligible. On the other hand, they have very strong ionizing effects on matter, and this may have profound physiological consequences. For this reason the radiation dosage is a measure of their ionizing capacity. The unit dosage is the roentgen, which is the amount of gamma radiation

Probable Effects of Single Exposure. (Ref. 5.)

Single Dose R.	Mortality at 24 hrs.	Mortality at 6 weeks	Number incap. within 24 hrs.	Probable time of unfitness for duty
0-25	0	0	Negligible	2-3 days
25-75	0	0	A few	2-3 days
75-100	0	0.1%	Half	1-2 weeks
100-150	0	0.5%	Half	3 weeks
150-200	0	5%	Three-quarters	Not less than 3 weeks Some very ill
200-400	Not likely	About ⅓	Prob. all	3 months
400-600	A few	About ½	Prob. all	3 months
Over 800	Some	Almost all	Prob. all	

TABLE 4.

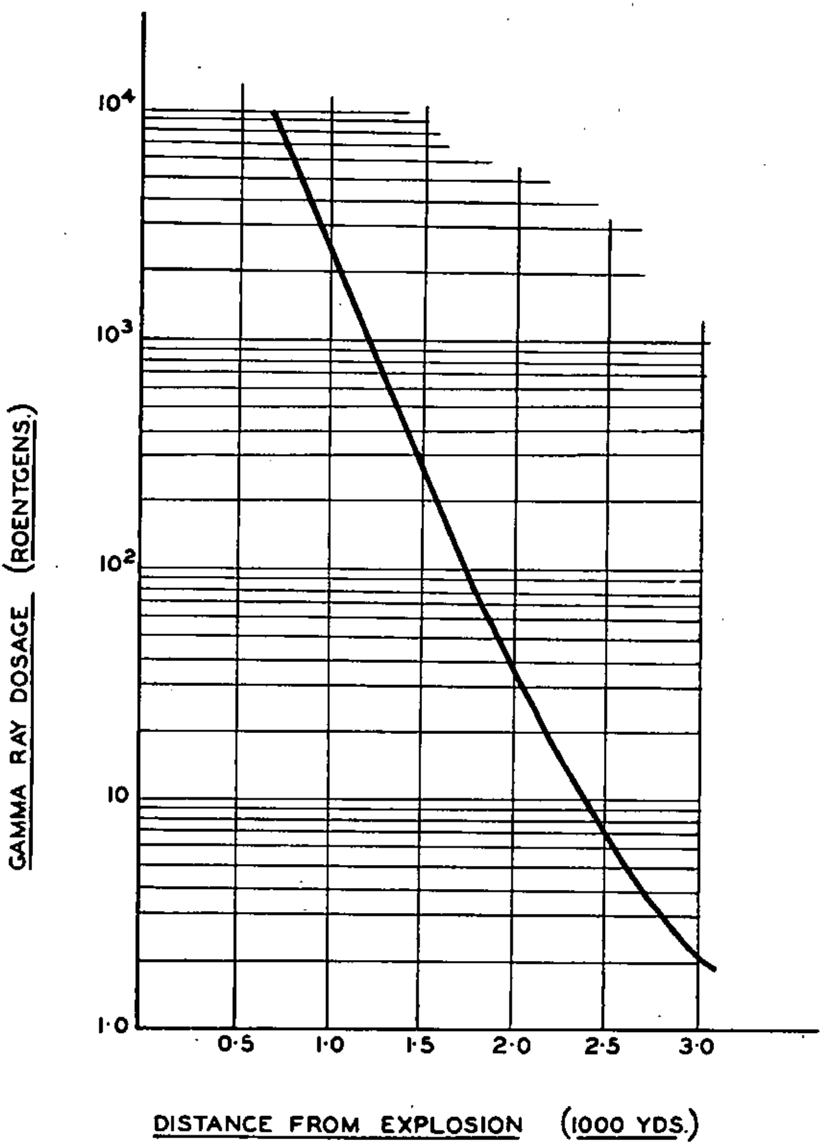


FIG. 6. DOSAGE OF INITIAL GAMMA RADIATION

which will produce electrically charged particles carrying 1 electro static unit of charge in 1 c.c. of dry air at 0° C. and 1 atmosphere pressure.

The dosage (in roentgens) of gamma rays which occurs at various distances from a nominal bomb is given in Fig. 6. This graph, taken in conjunction with Table 4, which relates the dosage to its resultant physiological effects, will permit the determination of the lethal effects on human beings. If we take 400 roentgens as a median lethal dose (one causing a 50% likelihood of death), then reference to Fig. 6 indicates that this would occur at 1400 yards from the explosion.

The intensity of gamma radiation is reduced by shielding. Figs 7 and 8 show the thicknesses of concrete and steel required to reduce the radiation to given levels at various distances from the explosion. Compacted earth produces about the same shielding effect as concrete. Examination of these graphs shows that the armour of an A.F.V. will produce a worthwhile radiation shield, e.g., 3 inches of armour plate will reduce the dosage to 25% of its original value.

Residual Radiations.

Consideration of the effects of the residual radiation from an atomic explosion is a subject to which several papers should be devoted in their entirety. The residual radiations will not cause large numbers of fatal casualties. If proper attention is given to passive defence measures, such casualties would be extremely small. In large scale operations the effect of certain areas being uninhabitable for varying periods will need to be taken into account in tactical plans. More important, however, will be the medical problems, resulting from non-lethal dosages to troops; and the multitude of administrative problems arising from contamination of food, other supplies and equipment. Procedures associated with "mapping" contamination intensities, inspection and decontamination will produce many new training problems. It is not intended to do more than mention these problems here. The remaining part of this brief discussion of

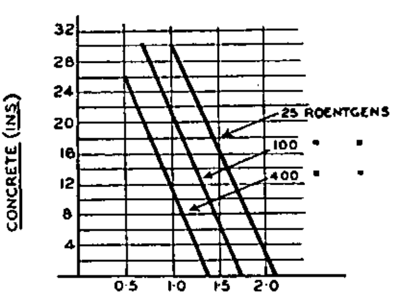


FIG. 7
SHIELDING THICKNESS OF CONCRETE

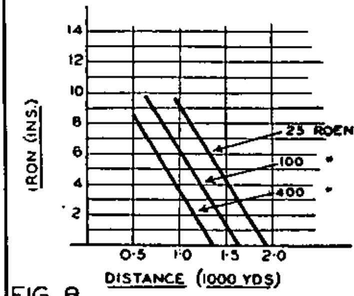


FIG. 8.
SHIELDING THICKNESS OF FERROUS METALS

residual radiations will be devoted to an explanation of the principal characteristics of the residual radiations.

The residual radiations, as has been indicated already, are emitted after a minute from the instant of the atomic explosion. They arise from—

(a) Fission products,

(b) Uranium 235 and plutonium that have escaped fission.

(c) Activity induced by neutrons in various elements present in the earth and sea.

The major portion of the residual radioactivity is due to the decay of the fission products. The induced activity is important only in the case of ground, underground and underwater explosions. Confining the discussion once again to the air burst nominal bomb, it will be seen that the residual radioactivity hazard is due to (a) and (b) above.

The radioactive fission products and the uranium and plutonium being heavier than air, eventually fall to the ground. The intensity of the radiations they produce and the area over which they occur are determined mainly by the meteorological conditions at the time of the explosion. This precipitation of radioactive materials has become known as "fall-out" and the area over which they spread is the "fall-out area." It would appear that field meteorology will become an important service to a field commander.

The residual radioactive effects are due to gamma rays and alpha and beta particles. Brief mention has already been made concerning the interaction of gamma rays with matter. Although the properties and the mechanics of interaction of the alpha and beta particles are different, the overall effect is the same —i.e., they cause ionization, and hence are a physiological hazard. The range of the alpha particles is such that it would produce no harmful effects unless the material emitting it is ingested or finds its way into an open wound. Beta particles, on the other hand, would cause harmful effects if deposited on the skin or even on clothing.

Consideration of the lethality of residual radiation leads to the question of the effects on the body of small doses which continue over a period of time as distinct from the flash dose received from the initial radiations. It has been stated that 400 roentgens "one-shot" dose would result in a 50% chance of survival. However, if 400 roentgens were received over a period of one month (12-14 roentgens/day) the chance of death would be considerably less. Not very much is known of the detailed effects of small continuous doses of ionizing radiations on the human body, and as a result the standards employed in industrial environments are conservative. The figure generally employed for people continuously subject to such radiations is 0.1 roentgens per day, with an over-riding provision that it shall not exceed 0.3 roentgens per week. There is no doubt that soldiers, civilians and civil defence workers in a future war will be called upon to endure continuous doses much greater than those accepted for peace-time industral purposes.

The Scaling Laws.

The value of the great amount of quantitative information on the nominal bomb is very much enhanced by the facility with which scaling laws may be applied to derive similar quantitative information for atomic explosions in general. In spite of the complex conditions that exist in the immediate vicinity of an atomic explosion, the justification for applying simple scaling laws to explosions of different power rests on the following foundations: —

(a) The energy source resulting from the explosion is concentrated.

(b) The distances at which the results of the scaling are required are large compared with the radius of the sphere in which the initial build-up of the explosion takes place.

(c) The attenuation of the various radiations in the atmosphere obeys an exponential law.

Different atomic explosions may thus be considered, with reasonable precision, to have originated from a point source or more correctly a small isothermal sphere. On the foregoing premises the various state variables—pressure, temperature, radiation intensity, etc., may be considered as functions of distance from the explosion. The results for any explosion may be obtained from those of the reference explosion multiplied by a function of the initial energy release and where appropriate an exponential decay function.

The variables of greatest interest in assessing military effects are—

(a) Blast overpressure,

(b) Intensity of thermal radiation,

(c) Intensities of nuclear radiations.

Blast Overpressure.

If E_n is the energy release of the nominal bomb and r_n is the distance from the explosion, it may be proved that—

$$\frac{r}{r_n} = \left\{\frac{E}{E_n}\right\}^{1/3}$$

This means that the peak overpressure is a universal function of $r/E^{1/3}$. Reference to Fig. 2 shows that a nominal bomb produces a peak overpressure of 5.2 lb./sq. inch at a distance of 2000 yards from ground zero. If a bomb with an energy release of 8 times that of the nominal bomb were exploded, this same overpressure would occur at a distance given by—

$$r = r_n \left\{\frac{E}{E_n}\right\}^{1/3} = 2000 \times \left\{\frac{8}{1}\right\}^{1/3}$$
$$= 4000 \text{ yards.}$$

A thermo-nuclear bomb one thouhand times as powerful as a nominal bomb would cause severe damage (i.e., 5.2 lb./sq. inch overpressure) up to a distance of 20,000 yards—perhaps not as far as one would expect!! One thousand nominal bombs appropriately distributed would devastate an area ten times as great.

Thermal Effects.

If e_n is the total thermal energy associated with the explosion of a nominal bomb having a total energy E_n, then at distance r_n the quantity of heat energy Q_n per unit area is—

$$Q_n = \frac{e_n}{4\pi r_n} 2 \cdot e^{-kr_n}$$

where k is the atmospheric attenuation factor.

For a second atomic weapon liberating an amount of heat energy e, the distance at which it will produce a heating effect similar to that of the nominal bomb is given by

$$Q_n = \frac{e}{4\pi r} 2\, e^{-kr} = \frac{e_n}{4\pi r_n} 2\, e^{-kr_n}$$

$$\frac{r^2}{r_n^2} = \frac{E}{E_n}\, e^{-k(r-r_n)}$$

In considering two bombs whose energy release does not differ by more than a factor of (say) 2 the exponential term may be ignored, and radii at which equal heat effects are produced are approximately proportional to the square root of their respective energy release. When the energy ratio is considerable, and when the attenuation is high, the more accurate result may be obtained graphically by reference to Fig. 3. The ordinates are scaled in the inverse ratio of the energy release, and corresponding abscissae measure the respective distances at which equal radiation intensities are received.

Scaling of Effects of Nuclear Radiations.

The problem of scaling the effects of nuclear radiations is more complicated than for blast and heat. This is due to the fact that the neutron and gamma ray intensity depends on the geometry and other design details of the bomb, as well as the actual energy release. In other words, these radiations do not carry a fixed percentage of the energy of different bombs, for example, the neutron energy that escapes from a nominal bomb has been stated as approximately 0.03% of total energy—this is not necessarily the case for thermo-nuclear weapon. However, for two fission weapons which are not too dissimilar in construction and size it is reasonable to suppose that the energy associated with neutrons and gamma rays is proportional to the total energy. In such circumstances the ordinates of Figs. 5 and 6 may be scaled in the inverse ratio of the energy release, and the corresponding abscissae will measure the radii at which similar intensities of radiation will occur.

As an example, consider the gamma radiation for a bomb with energy double that of the nominal bomb. From Fig. 6 it will be seen that a median lethal dose of 400 roentgens will occur at 1400 yards. If the ordinate is now multiplied by ½ to give a dosage of 200 roentgens, the corresponding abscissae is approximately 1600 yards.

Lethality of Atomic Weapons and the Estimation of Casualties and Damage.

The considerable amount of data on the physical effects of the nominal bomb, together with a knowledge of the scaling laws, provide a quantitative basis for—

(a) The estimation of casualties,

(b) Calculation of damage to military installations and equipment.

Careful and painstaking study of these problems is most important, as the results of such study provide the starting point for all subsequent work on the effect of atomic weapons on military operations. A further point of importance is that this work must of necessity be mainly theoretical, for it is clear that in future wars experience of the effects of atomic weapons will not be gained in sufficiently small steps to permit the build up of knowledge by trial and error methods.

Estimation of Casualties.

The estimation of casualties depends on a large number of factors, the more important of which are—

(a) Power of the atomic weapon,

(b) Nature of the burst, i.e., air burst, underwater burst, etc.,

(c) Passive defence condition of the troops (this factor is influenced by warning time),

(d) Atmospheric conditions,

(e) Geographical (including topographical) distribution of troops,

(f) Accuracy of delivery.

The first four factors may be taken together to define a *lethality function for the weapon.* The remaining factors define a *distribution function* for the troops in the area. It is reasonable to assume radial symmetry for the lethal effects of an exploding bomb, i.e., same effects take place in all radial directions. The lethality function, therefore, may be considered as a function of distance only from the explosion, provided that the passive defence condition of the troops is uniform over the entire area. If this is not the case, it would be necessary to introduce a passive defence function which depends on both distance and bearing. Alternatively the lethality function could be described as a function of both variables. For the purpose of this discussion, however, a uniform passive defence condition will be assumed, and the lethality function will be dependent on r, the distance from the explosion.

The troop distribution function may in general be considered as a function of distance and bearing, i.e., $G(r, \theta)$.

It is easy to prove, then, that the total casualties over a given area is given by—

$$C = \iint L(r)\, G(r, \theta)\, r dr . d\theta$$

and the limits of integration are defined by the particular area under consideration.

This expression for the casualties cannot be evaluated analytically in all cases. A number of simple ones may readily be solved, and the answer to more complicated cases can always be obtained by resorting to graphical or numerical integration.

Solutions have already been obtained in cases characterised by the following conditions:—

(a) Power of bomb—nominal or standard,

(b) Type of burst—air burst,

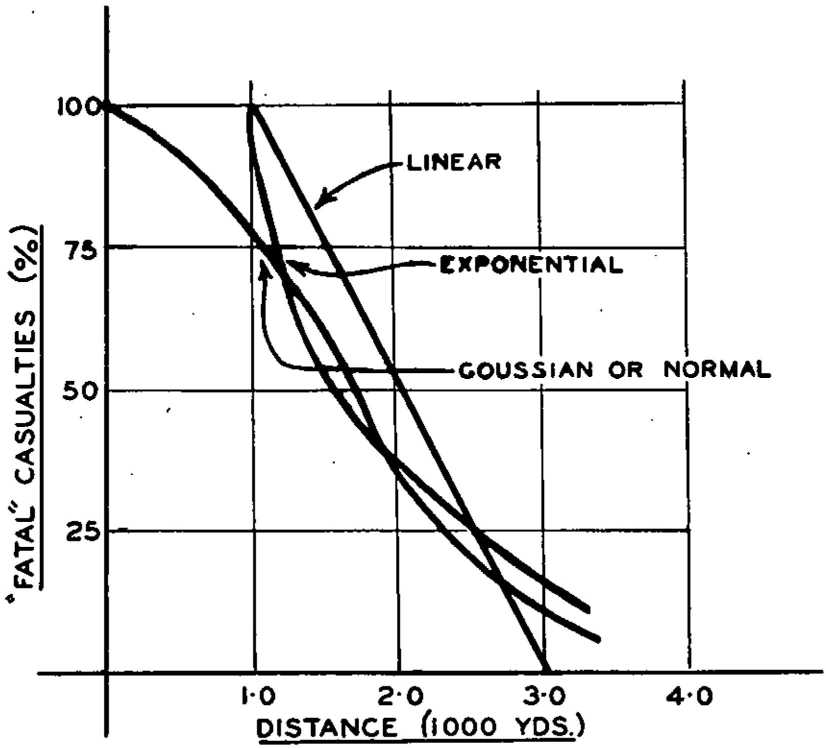
(c) Passive defence situation,
  (i) Troops in open,
  (ii) Troops "well dug in."

(d) Atmospheric conditions—very clear,

(e) Troop distributions,
  (i) Uniform two-dimensional or area distribution,
  (ii) Linear distributions.

(f) Accuracy of delivery—miss distances of 500, 1000, 1500, 2000 yards from centre line of the linear distribution.

Under these conditions it is possible to determine the lethality functions for the two passive defence conditions. There is a number of types of curves that may be used to represent the function. Three types are shown in Fig. 9. The results given below are based on the linear approximation. The lethality function for the case of troops in the open has been obtained from the data given in Figs. 2, 3, 5 and 6. It is approximate, and admittedly is a "worst" case. However, as the



LINEAR APPROX'N. $L(r) = 1$ $0 < r < 1000$

$= \frac{1}{2}\left(3 - \frac{r}{1000}\right)$ $1000 < r < 3000$

EXPONENTIAL $L(r) = 1$ $0 < r < 1000$

$= e^{-\left(\frac{r}{1000} - 1\right)}$ $r > 1000$

GOUSSIAN $L(r) = e^{-\left(\frac{r}{2000}\right)^2}$ ALL r

FIG. 9.

METHODS OF APPROXIMATING THE LETHALITY FUNCTION main purpose is to compare casualties for different distributions and miss distances, the exact form of the lethality function will not materially affect this.

The question of troop distributions demands that consideration be given to the intensity of troops in the field. A study of conventional defensive layouts indicates that in a brigade group the intensity of troops is approximately one per 2500 sq. yards. If this figure is halved to make an initial allowance for the atomic situation, then a concentration of 1/5000 tps./sq. yd. would be obtained. This is approximately one man per acre, and such dispersion is considered to be the maximum that would permit effective tactical and administrative handling of troops without considerable reorganisation of field forces.

In dealing with linear distributions the same figure for the concentration has been used. The linear distribution is further assumed to be 500 yards wide.

The results of the calculations are given in Table 5.

Linear distributions suggest a lattice system of field formations—the bars of that lattice giving depth and the uprights providing for support.

The large ratio in casualties for the area and the linear distribution must not be taken as an indication of the merit of the two systems without further qualification. The casualties in the 500-yard strip are low, mainly because there are many less troops in the strip in the first place. If a given number of troops is to be deployed in a given area, the density of troops in the lattice would need to be increased, and hence the casualties would increase also. If the area is not fixed, then the lattice arrangement automatically gives greater depth for a given number of troops. This is most desirable, provided it does not result in individual lattice members becoming too weak. Certain other attractive features of the lattice layout depend on the following considerations:—

(a) Reference to Table 5 shows that the casualties for an area distribution, even with a troop concentration of one per acre, could not be tolerated — in other words, the dispersion would need to be much greater, and as a result problems of tactical and logistic control would become serious. On the other hand, one or even more per acre could be permitted along the members of the lattice.

Fatal Casualties from Atomic Attack on Troops in the Open.

Type of Distribution	Miss Distance (yards)	Casualties
Area	—	3000
Linear	0	400
	500	380
	1000	280
	1500	195
	2000	110

TABLE 5.

(b) The lattice distribution can be designed to set a top limit to the number of casualties any one atomic weapon can inflict.

(c) As the casualties fall with miss distance, the enemy is faced with an additional factor in ensuring the cost-effectiveness of his atomic strike is sufficient to warrant its employment.

(d) The linear distribution leads naturally to the "strong-point" method of deployment if the distribution along a lattice is contracted until the troops are concentrated at centre points of its members.

These remarks have been based on a lethality function which has been constructed to deal with a worst case. If instead a "best" case is taken, i.e., a maximum of digging-in and other passive defence preparations, the lethality function may be modified to give—

(a) 100% casualties from G.Z. to 500 yards.

(b) A linear regression from 100% casualties at 500 yards to nil at 1500 yards.

If this is applied to the calculation of casualties, then the results given in Table 5 are altered to those given in Table 6. Table 6 also shows casualties if the concentration is increased to four soldiers per 5000 sq. yards, as it is felt that elaborate passive defence works would demand a somewhat greater concentration of troops than one per acre.

In applying these figures to the design of a lattice system of troop distributions, the tactical and logistic problems are reduced in complexity as size of the lattice mesh is reduced from something of the order of 6000 yards to 3000 yards. This means that with an intensity of four men per acre there are approximately 1200 men for deployment on a 3000-yard front.

Damage to Military Installations.

An estimate of damage likely to be caused to military installations, such as ordnance depots, base camps, port facilities, can be made from the data assembled in the foregoing sections of this paper. Space will not permit any very full investigation being recorded here. However, the following observations are of interest:—

(a) Assuming a peak overpressure of 5-6 lb. per sq. inch will

Fatal Casualties from Atomic Attack on Troops "Well-Dug-In."

Type of Distribution	Miss Dist. (yards)	Casualties	
		1 per 5000 sq. yds.	4 per 5000 sq. yds.
Area	—	680	2720
Linear	0	200	800
	500	150	600
	1000	55	220
	1500	0	0

TABLE 6.

cause severe damage to steel mill buildings, ordnance sheds, workshop buildings, and all kinds of camp buildings, then the area over which such damage would occur is of the order of 1.5 square miles.

(b) Over the same area the intensity of the heat flash would be such that it would contribute materially to initiation of fires. In conjunction with the blast effects, the fire hazard would extend the area of severe and permanent damage to something like 3 to 4 square miles.

(c) A perusal has been made of the ground plans of certain ordnance and R.A.E.M.E. base installations, and it is at once obvious that some depots would be totally and completely destroyed. Others would not fare much better.

(d) A typical training camp would also be destroyed, and most of its occupants would be fatal casualties. (Concentration of troops at such a camp is about 12 per acre.)

(e) Much of the heavy equipment (guns, trucks, etc.) at the ordnance installations could be salvaged, but there would be a serious decontamination and repair problem associated with making it suitable for issue.

These observations indicate that the damage problem to existing type installations would be very serious indeed. The analysis given in the previous section of the paper may have even greater application to the problem of layout of military installations—a linear layout would certainly minimise the damage. A study should be made of the problem of "phasing" stocks in various depots to ensure that the complete stocks of no essential store were located in one depot.

There is no doubt that the greatest contribution to the reduction of physical damage to installations, stores and equipment will result from going underground.

The Cost-Effectiveness of Atomic Weapons.

In this brief review it will not be possible to carry out a complete analysis of the cost-effectiveness of atomic weapons. Furthermore, any valid conclusion would depend on authentic information of the design details and the manufacturing processes of atomic weapons. However, there are certain factors which bring light to bear on this problem, and it is proposed to discuss them here.

In considering the cost of an atomic weapon both the cost of the weapon itself and the cost of delivery must be taken into account. In fact, by doing this the lack of information on the actual cost of the weapons can to some extent be eliminated from the problem.

The basis for an estimation of cost of delivery of an atomic weapon is a comparative one. The most spectacular case is that of their strategic or tactical/strategic employment. It has been variously estimated that the effect of a single nominal bomb is comparable to that of a "thousand bomber" conventional raid. If this estimate is seriously in error, then it can readily be corrected by substituting a bigger bomb—up to say four times the power of a nominal bomb. On the basis of this equivalence there is little need to extend the argument further. A nominal or a 4 x N-bomb could be delivered by a single bomber. On the other hand, a thousand bomber raid represents a capital investment of something of the order of £500 million. Assuming a 5% loss of aircraft in such a raid, and a 15% maintenance and operating overhead, it would appear that such a raid would cost something of the order of £100 million. It would seem, therefore, to matter little if the atomic weapon itself cost £1,000,000 or £10,000,000.

A typical tactical comparison cannot be made in such general terms. In the case of troops deployed in the open there is some evidence to support the claim that 100,000 25-pdr. shells may produce the same order of casualties as a nominal bomb. However, unless they were delivered almost instantaneously (and that would require a prohibitive number of guns), the casualties would drop very rapidly as troops took cover. However, if it is further assumed that the artillery attack is spread over 10 minutes, then it would require something like 2000 field pieces to carry out the job. Such a number of 25-pdr. guns would represent a capital of £20,000,000. Such a concentration of artillery is roughly equivalent to the total resources of an Army. The total overhead associated with such a deployment (vehicles, fire control gear, personal equipment) would be of the order of £100 million. Assuming a figure of 20% for the maintenance and operating costs, then the cost of delivery is of the order of £20,000,000. Although this comparison is not so spectacular as the former, it does nevertheless draw attention to the fact that the cost of delivery is more important than the actual cost of the lethal part of the weapon.

It is not fair to leave this aspect of the discussion without mentioning that the mass fire support envisaged in this context is only one of the roles of artillery. In addition, an effective neutralising barrage of an area equivalent to that destroyed by a nominal bomb is often all that is required, and such fire support could be given by the normal resources of a divisional artillery.

The "effectiveness" factor in the cost-effectiveness equation has been implied in adopting the comparative method. In other words, to achieve a given result the relative costs of atomic and conventional fire power have been assessed. Furthermore the cost of the weapon—which is unknown—has been eliminated.

Before concluding this section mention is made, however, of the actual values that the effectiveness term may embrace. It was stated earlier that one atomic weapon (nominal) would be sufficient to destroy a major ordnance depot. The capital cost of such a depot (including its associated R.A.E.M.E. workshop installations) may be taken to be something in excess of £5,000,000. The stores contained in such a depot could have value of upwards of ten times this figure, i.e., £50,000,000.

From this brief and not too rigorous analysis, it would be safe to conclude that the cost-effectiveness of atomic weapons is likely to be high in comparison with standard weapons, especially against military installations and base facilities, such as ports and depots. So far as their use in the field is concerned, the situation is more obscure. If the discrimination of targets is adequate, a major tactical success may be achieved. However, to compare atomic and conventional artillery only in the case of "massed" fire support is not fair, as the conventional weapons have a wide variety of other functions.

Conclusion.

In setting down the conclusions resulting from the foregoing discussion it is important to emphasise that they are based on information which is in the main unclassified. Some of the "real" secrets may alter such conclusions drastically. However, even if they do, no real harm will have been done, for the main object of the paper has been to show how basic data on the effect of an atomic explosion may be applied to a military situation. If new data are supplied, new calculations may be carried out and fresh results obtained.

With this in mind, it is felt, then, that within the limitations of the available information the following conclusions may be warranted:—

(a) There is considerable literature available on the subject.

(b) The known effects of the nominal bomb and the scaling laws permit determination of the effects of atomic weapons of all sizes likely to be employed in military situations.

(c) Determination of casualties resulting from use of atomic weapons is difficult. It is, however, important that work should proceed on this task in order to provide quantitative data for new planning. Work on estimation of casualties already carried out reveals—

  (i) Casualties fall very rapidly as the passive defence measures are improved,

  (ii) Linear distributions of troops reduce casualties to a marked extent, and it appears that consideration should be given to the tactical and organizational problems involved in a "lattice" distribution of field forces,

  (iii) Casualties and damage in built-up and congested base areas, ports, L of C installations will be heavy.

(d) The pollution of large areas by residual radiations will influence large-scale tactical planning, and will introduce a whole series of administrative problems relating to contamination of personnel, food and equipment.

(e) Cost-effectiveness should be high, provided there is adequate discrimination of targets, and that accuracy of delivery is sufficiently high.

(f) It will be necessary to provide on the various formation headquarters a senior staff officer, who is basically qualified in physics and mathematics, and who has been trained and experienced in the many specialised problems relating to the employment of atomic weapons. Such an officer may require his own small staff of scientists at G.I. and G.II. level.

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Why I am an ★ ★ ★ Army Officer

An anonymous article published in the Military Review, U.S.A.

DURING the past five or six years many people have asked me why I am an Army officer. "Why," they ask, "do you remain in the Army? You have a good education. There are many opportunities in civilian life that would pay you as much or more than you are making now. Why do you subject yourself to the hardships of the service? Why do you live a life that separates you from your family, that entails constant moving and readjustment for your wife and child, that exposes you to the criticism which is always aimed at the professional soldier, that pays you a salary that makes the accumulation of wealth impossible, and that, at the end of 30 or 35 years, offers you an anonymous retirement, in which your former rank and authority will be forgotten except by a few?"

Usually I can answer these questions in three words which cannot be refuted. To simply say, "I like it" is enough to stop such questioning.

It is easy to say, "I like it," and thus end further discussion, but to myself this answer is not enough. To myself I must give the full answer, and as the years go by I find the reasons more convincing and more real.

I am an officer because, as such, I can best serve my country, my family, and myself. I am not driven by a desire to accumulate vast stores of this world's goods. My standard of living is adequate, and with good management I will never have to want. I am far more concerned that the security of our country is preserved, and that my son and his son can know the same way of life that has made this country great.

I am not driven by any false ideas of prestige. I am much more concerned with being a good leader and a judicious commander, so that I can carry out my obligation to the men who may serve under me. I am not afraid of anonymity. While it is true that throughout history many military men have become national figures, I do not delude myself with aspirations to fame. I am content, like thousands of others, to serve to the best of my ability, in any capacity whatsoever, to accomplish the assigned mission, and by so doing add whatever strength I have to the total strength of our nation.

I cannot agree with some of my civilian friends, who say that I am engaged in a non-productive endeavour, which has as its objective destruction rather than construction.

I feel that I am helping to produce the one commodity that is essential if our country is to progress. That priceless commodity is freedom, and if, by any act that I may perform in the course of my duties, I contribute to the preservation of that freedom, then I can say that I have produced far more than can ever be measured or weighed.

I will continue to say "I like it" to those who question me, but to myself I will always give the answers that mean more to me than these few words can express.

The dreadful experience of rushing under-strength units into action; of emergency recalls for combat veterans with family responsibilities; of long delays in training our citizen soldiers—all these stark deficiencies hold for us a solemn warning which we must not ignore. We must realise that our Army's Regular forces must be kept close to authorized strength, that we must support those forces with strong National Guard and strong Reserve Corps made up of both units and individuals. These individuals must be trained men who, after a short refresher period of training, can effectively fill the ranks of our divisions and other units, whether in combat or in training here in the United States.

—*General J. Lawton Collins, USA.*

THE SOUTH-EAST ASIAN COLLECTIVE DEFENCE TREATY

Lieutenant D. R. Little,
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(The term SEATO is an expression invented by the Press. In official writings the Treaty is usually called the Manila Pact.—Editor.)

SEATO, referring to the South-East Asian Treaty Organization, and pronounced as one feels inclined, was signed on 8 Sep., '54. For the pedantic, the true title of the treaty is the South East Asian Collective Defence Treaty, or the Manila Pact, and to call it anything else is therefore to give it a misnomer.

America was actually responsible for the inception of the treaty.

It was obvious to her—just as obvious as it was to the man in the street—that if events in South East Asia were allowed to continue in their present trend, slowly but surely each of the nations in this area (and this possibly includes Australia) would eventually be engulfed by the ever southward-spreading flow of Communist flood-waters, and the inundation of each nation would in turn jeopardise the security of the others.

The reason that this is possible—and all too probable if something like the Manila Pact were not formulated—is that no nation in South East Asia is capable of defending herself. The period of transition from domination by a foreign power to independence has been too swift and too complete for these new nations to be politically or economically sound. It must be remembered that ten years ago all the countries in South East Asia were ruled by a foreign power—all except Thailand. Today they are all free, except for Malaya and British Borneo, who are working towards independence, and while suffering the agonies of growing pains they present a magnificent target for Communist aggression.

That aggression will come is generally accepted, and will come in one of two forms: peaceful, political aggression or subversion, and if this fails then outright military aggression.

This, then, is the reason behind the treaty.

In order to understand why an alliance of collective security is so important to Australia, it is worth bearing in mind that Saigon, the southernmost foothold of Communism, is a mere eight hours' flying time by jet bomber from Melbourne, and that Singapore is a mere six.

Furthermore, it is generally admitted, and not without sound reason, that the defence of Australia rests with the defence of the countries to our north—countries which have been brought so close by virtue of the swift, far-reaching aircraft of today.

As has been stated, America was responsible for the inception of the treaty, and while the Foreign Ministers of Britain, France and the United States were in Geneva for the Indo-China talks they had the opportunity to discuss the situation.

It was decided that something decisive should be done, and done quickly, to stop the possibility of further Indo-Chinas in South East Asia. As a result, all the nations of South East Asia who were still free from the yoke of Communism were invited to attend a conference on collective security, to be held at Manila in the first week of September.

Mr. Casey led the Australian delegation, and as the talks opened on the fourth of the month the following countries were seen to be represented:—United States, United Kingdom, France, Australia, New Zealand, Pakistan, Thailand, the Philippines.

At the outset, Mr. Zafrullah Khan, the Foreign Minister for Pakistan, was wearing somewhat a detached air. He stated that his country was not interested in fighting the Chinese, and that he was there merely as an observer. But later it was apparent by the wholehearted manner in which he threw himself into the discussions, and possibly in the vehement manner in which he pounded the table, that he was there not as an observer but to do business.

The inclusion of Pakistan to the conference was regarded as somewhat a mixed blessing. On the one hand, Pakistan has a good, if small, army capable of very rapid expansion, a good air force, and a rapidly expanding navy. She is also getting military aid from the U.S.A., who is also building bases on Pakistani soil. On the other hand, Pakistan's acceptance helped to keep India away. This was not the sole reason for India's non-acceptance—she stayed away on principle—but it did help to cast the deciding vote.

The rejection of the talks by India was a decided loss to the treaty powers, firstly, because India has a huge war potential—vast reserves of manpower and raw materials. And secondly, since India has set herself up as the Voice of Independent Asia, giving the lead to the lesser Asian nations, and expecting their support on issues such as this, her rejection of the treaty talks gave the lead for other countries to do likewise.

Ceylon, who has suffered a reversal of foreign policy since the death of Mr. Senanayaka, took the lead from India, and refused to attend. During the former Prime Minister's time Ceylon had leanings towards the Western powers; now she supports herself very ably on the broad shoulders of her northern neighbour.

Burma rejected the treaty for two

very good reasons, each one of them conclusive: Firstly, she has a long-drawn-out border dispute with the Chinese, and secondly, she has had, and still has, the KMT rebels on her soil. Either of these two reasons could have served the Chinese with sufficient reason for an attack, but so far the Chinese have respected her sovereignty. Burma's attitude then was: "Why should I join the treaty powers and incur the displeasure or even the anger of the Chinese?"

It is significant, too, that Burma renounced American aid last year, possibly from pressure from across the border—either Chinese or Indian.

Indonesia's attitude to the talks was one of complete indifference, and for a time, like someone hard of hearing, pretended she couldn't hear what was being said, and made no comment whatsoever. When she finally did make an announcement it seemed as though she had not got the question right in the first place, and replied that she would join the treaty if Communist China were also invited.

Laos, Cambodia and South Vietnam could not, under the terms of the Geneva Truce, attend the talks even if they wanted to.

Thailand's representative was not hesitant about getting to the conference. Since the fall of Indo-China Thailand has been in a very precarious position. Significant, too, is the fact that Thailand's changes of Government have always been by *coups*.

The Philippines required no urging to attend the talks, having felt rather left out of Pan-Pacific policy since ANZUS.

As for the European countries, nothing need be said. It was to their interests, a fundamental which they all accepted.

At the discussions Thailand and the Philippines wanted a NATO-like treaty, but this suggestion was rejected by Mr. Foster Dulles, who explained that Congress would never ratify a NATO-like treaty in the Pacific. Britain also considered herself fully committed under NATO, and stated that the only troops she could deploy in support of the Manila Pact were those already in South East Asia.

The U.S.A. wanted aggression qualified by the word "Communist." But Pakistan, mindful of the Kashmir affair, asked that the word "Communist" be struck from the draft. Britain supported Pakistan on the grounds that if the treaty were directed specifically against Communist aggression, then the door would be closed against those other Asian nations who might later decide to come in, and whose attitude was sympathetic to the Chinese.

The discussion lasted four days, at the end of which time, on 8 Sep., '54, the Pacific Charter, 18 inches by 12 inches, and bound in dark blue leather, was signed. Each signatory was presented with a gold pen with which to enscrawl his name on behalf of the Government he represented. A tremendous ovation greeted the Foreign Minister for Pakistan as he mounted the rostrum to sign, as even up to this time it was not quite clear whether or not Zafrullah Khan was merely still observing.

The Pacific Charter, consisting of eight articles in all, was drawn up under the United Nations Charter, which permits regional defensive agreements.

The area delineated for the Pact is to be from West Pakistan east to the Philippines, and from Australia north to the parallel 21° 30′ North. This effectively cuts out Formosa and all points north.

Under the Charter, in the event of aggression against one of the signatories, the remainder will regard it as a threat endangering their own security, and will take steps to meet the common danger *in accordance with their constitutional processes.* This is the main difference between the Manila Pact and NATO, whose action to meet aggression is automatic. NATO has an international Headquarters, a composite army, navy and air force, a military machine in gear, and ready for immediate action, requiring only an act of aggression to release the clutch for it to become effective. Not so with the Manila Pact.

By a protocol, the U.S.A. will act only in the event of Communist aggression, not wishing to become embroiled in an issue such as Kashmir, but will take immediate action outside the treaty if either Thailand or the Philippines is attacked.

Laos, Cambodia and South Vietnam are *delegated* to invoke the treaty powers on their behalf. The treaty powers will act only by express invitation. Any other nation may be delegated by any member, and if acceptable to the remainder of the pact powers will be included under this protocol.

In the event of external subversion, the Pact Powers will meet to discuss what action should be taken.

Military planning is "permissive," and will be indulged in only by those members who so desire. Meetings will be held from time to time for planning at a date and place convenient to members.

Each nation pledges herself to improve her military and economic capacity to withstand military aggression and subversion. This will be done as far as possible by self-help, although those countries which are able to give aid will render economic and technical assistance outside the Colombo Plan.

From time to time the treaty members will meet to discuss the progress and further implementation of the treaty.

The Manila Pact is in force for thirty years, and any nation may resign after giving one year's notice. And any other nation acceptable to the present members may apply for membership.

The South East Asian Defence Treaty now rests in the various chancelleries of the member countries for ratification.

It remains to be seen now whether or not the treaty is a workable solution to the problems of South East Asia. In any case, if the treaty has laid a basis for mutual understanding among the countries of South East Asia then even this is a worthwhile result for Australia.

UNIFICATION—

Love Match or Marriage of Convenience

Lieutenant-Colonel A. Green,
Royal Australian Army Service Corps.

MAJOR Reginald Hargreaves, the doyen of British military essayists, has gone to great pains in his condemnation of outright amalgamation of the three Services. Like most sound, conventional military thinkers, he prefers the familiar devil he does know to the Frankenstein devil he doesn't know. The very ardour of his defence must raise our suspicions that there is, after all, a case for outright unification, rather than the federation of Services which Major Hargreaves seeks to perpetuate.

The Concept.

During the past one hundred and fifty years there has been a progressive conversion of the world to political federalism and reduced local sovereignty. Our own Commonwealth is a fairly recent convert to this form of government, and some philosophers, notably Bertrand Russell, foresee that the only cure for the ills of unbridled sovereignty, exemplified in modern Europe, lies in wholesale federation. Now, during the past ten years, there have been unmistakable trends towards military federalism, in an inter-Service synthesis, which will reconcile the three fighting services to the minimum of essential co-ordination consistent with their independent existences. Such an adaptation of political formulae to the military system is not necessarily logical, efficient or secure; since it leads to dichotomy in thought and action.

Origin of Services—Human or Divine?

There is an implied concept abroad that the Services, in the conventional forms with which we are familiar, of Navy, Army, and Air Force, partake of the quality of philosophical Universals. They are regarded as basic indestructible entities, of the very fabric of life itself. Probably only a very pacific Quaker would contest this common fallacy, although the words Air Force themselves have only a currency of about a quarter of a century. This concept of autonomous armed forces is based on the axiom that the elements of land, sea and air so differ in their military requirements and effects that each requires a wholly separate force to defend the national interest.

The historical growth of separate Services was determined by geographical and national characteristics. Generally there has been a distinct divergence between the genius of land and sea powers. Neither the Romans nor the Greeks, despite Salamis, were conspicuously apt sailors; Russia has never, until very recent times, posed a naval threat to the world. Genghiz Khan, Napoleon and Hitler alike were as notable for their lack of nautical prowess as for their success on land. The Norse, the Polynesians, the Japanese (admittedly an amphibious nation), expanded primarily in their natural element, the sea. It is not surprising, therefore, that the simplification of military power into sea, land and air forces finds a ready and tolerant acceptance.

This belief in turn derives support from the fundamental differences between ships, land transport and aircraft. For centuries it remained valid. The doctrine of each service supreme and self-sufficient in its own element could not, however, survive when the range, speed and armament of aircraft obtruded permanently into the spheres of the Navy and the Army.

At this stage, according to their various traditions and tasks, the major powers began to experiment. The British, accustomed to independent sea power, at first freed their air power; then led the naval aviation captive to it, in an astonishing volte face. The great European land powers, Russia and Germany, created air arms which, although nominally independent, were closely allied to their armies, and not modelled on pure air power. In the U.S.A. powerful air auxiliaries of the Navy and Army eventually gave place to an independent U.S.A.F., with a strong, independent naval aviation, and a small army aviation branch. This has been a transitional period of compromise and innovation, in which the substantial shadows of independent Services have been preserved, and the shadowy substance of unification has been sought, often in vain.

Conservative Virtues.

The traditional autonomous service has possessed indisputable virtues, some of which it retains, while others are outmoded. The primary virtue is absolute specialisation within a narrow field. This exclusive virtue connotes the vice of narrowness, inflexibility and the perpetuation of self-interest, often at the expense of other services. Nevertheless, the merits of such specialist forces as Nelson's fleet, the pure, independent air power of the Battle of Britain, the "blue water" navy of the United States in the Pacific campaigns are plain for all to see. This specialisation was strategic, tactical and technical.

In the moral field there are the commensurate virtues of service, loyalty, tradition and the competitive spirit which they breed. The ideal of military esprit de corps, embodied in regimental pride or devotion to one's own service, has been a convenient national device for the fostering of blind devotion and courageous service. It can lead to a blind arrogance, and to an emotional contempt for others, based on an overweening self-esteem. In a primitive society, such as Cetewayo's Zulu nation, esprit de corps was stimulated by permitting whole regiments to marry only after proving themselves in battle. Modern convention prohibits such an obvious incentive, but relies on vari-coloured uniforms, service and regimental distinctions, and Public Relations budgets to spread the myth of this service's omnipotence or that unit's irresistible elan. These stimuli are somewhat oblique in effect, since they often ignore the broader, deeper ideals of service to the nation. Nevertheless, so long as men remain tribal in instinct they have a proper place in the lower organisational levels. It is when they infect the higher levels with emotional partisanship, where logical thought is a necessity, that they endanger the very security which they effect to serve.

Modern Vices.

The proven virtues of the independent services do not outweigh their vices, when we consider the requirements of total war. Modern war is strategically, technically and geographically comprehensive. The services have been rendered wholly, mutually, interdependent. This interdependence originates in the common industrial field from which they procure their weapons, is continued in the logistical channels through which they draw their support, and is consummated in triphibious warfare. Failure on the part of one service causes failure for the others. The failure of the Luftwaffe to supply Stalingrad precipitated the collapse of the German Eastern offensive; the failure of the Italian navy in the Mediterranean led to the loss of the battle of Egypt for Rommel; and the Battle of Britain denied victory in the West to the Wehrmacht. The fortunes of the separate services were admittedly closely inter-related before the atomic age, but never before so intimately. The inherent defect in the individual or independent service concept lies in its narrow, unrealistic application to total war. War, like Litvinov's peace, is indivisible.

Military Federation in War and Peace.

This fact of indivisibility was grudgingly admitted by most of the warring powers in World War II, but the ensuing deduction, that the armed forces ought therefore to be undivided, was not followed to its logical conclusion. The Allies evolved Joint Chiefs of Staff, at the national and allied levels. The Germans created a Supreme Command, which functioned in parallel with the General Staff in actual practice. These joint organisations were created to unify and co-ordinate the strategic planning and execution of war; and thus to get each service into correct role and perspective.

Under strong political leadership, and inspired by the mutual danger without, the Allied expedients in unification, by integration of the services, succeeded in winning the war. Since that war ended there has been further technological progress, rendering the totality of war more absolute, and reducing the time available for trial and error methods of evolution. When World

War II ended it seemed that a new era in unified military thought had begun. Provision was made for mutual consultation at the higher levels; the Joint Services Staff College was founded, Land/Air Warfare doctrine was instituted as a fundamental co-ordinated system. (N.B.: The School of Land/Air Warfare is now the only all-service institution in Australia.) After nearly ten years of cold war it is quite apparent that the separate services have lapsed into their old conservative egocentricity and imaginary self-sufficiency.

If that is doubted, every staff officer should examine his conscience, likewise every commander. If they are satisfied that they, subconsciously and instinctively, consult the other services in administrative and training matters of mutual interest, and, more subtle tell-tale, that they seek and enjoy the society of the other services off duty, then they may go free. In practice it is clear that the expedients of joint education and consultation are paid lip service only. Interservice understanding is so important that the lack of it must constitute a bar to the employment of any officer in high and responsible office. As Eisenhower expelled those staff officers who lacked Anglo-American accord, so should each service dispose of its incurably partisan die-hards. While devotion to one's own service remains an excellent thing and is recognised, the frequently complementary quality of inability to co-operate with other services is often ignored in our officers, and goes unpunished.

It should not be supposed that the obstructionists to unification act from malice aforethought. Far from it. They are often men who have devoted their lives to their Services, risking all for the reputation of these services and in the national defence. Gradually the prestige of those services has become inseparable from their own. However sincere they are, they have acquired hidden, vested interests. This naturally increases their antagonism to change. The suggestion that their own service should, for the common good, merge its identity with the others, amounts to blasphemy, aggravated by an apprehension of personal injustice. Whatever the motives, such an attitude incapacitates the affected person for higher military rank in any service.

Never were the inherent defects of organisation and spirit more clearly revealed in the system than in the budgetary manoeuvres of the services, here and abroad. In peace or cold war, the fiscal question is paramount to the health of a service. Manpower, equipment, training—all depend upon the vote. The single-service chief who stood back from the scrummage around the Treasurer at this annual match would be guilty of gross disloyalty to his own charge. By the same token, any disparagement or unfair advantage of the other services becomes an act of grace. Consequently the lobbying, the Press pronunciamentos, the pre-budgetary emotion engendered, are all to the detriment of logical and constructive planning for war.

Despite the claims of self-sufficiency made by each service, there are always anomalies which illustrate the degree of overlap between these forces. These are such hybrids as Marines; R.A.F. Regiment; R.A.S.C. Fleet, Glider Pilot Regiment; Seebees; the Luftwaffe A.A.

and parachute formations. These expedients are part of the existing inter-service patchwork quilt, which must persist so long as the services remain sovereign.

We are therefore in the process of creating federal armed services. Functions of overall strategy and logistics are co-ordinated and integrated as far as possible, while the residual powers of technical and tactical employment are left to the three services. Such compromises may be good in constitutional matters, but they have no place in the dynamics of Total War in the Atomic Age. This is happening because of the inherent conservatism of military thought and tradition, and unreasoning fear of the radical reforms which the system requires.

In certain countries there have already been strenuous efforts to unify the fighting services. In the U.S.A. this question has been most ardently debated by the protagonists and their political advocates. Legislation was initially introduced after World War II whereby the services would be progressively unified within the National Military Establishment. This did not imply actual merging of the fighting forces, but overall co-ordination and integration. Within a few months the efforts of the Joint Chiefs of Staff to get their major weapon programme into correct perspective were dragged before the bar of public opinion, with all the blaring publicity of a cause celebre.

Unification in the U.S.A. was confronted by two intractable and partisan services: a bellicose navy on the defensive and a young, aggressive, independent air force. As a result, the famous B36 controversy, and the carrier programme controversy, were used to sabotage well-planned efforts at unification. These controversies did slow up the rate of unification, and caused Congress to take stock of the overall defence mechanism. The present policy appears to be a canny one of "gradual inevitability." However, Congress wisely forbade the over-ruling of specialist service chiefs within their own narrow fields, but reasserted the power of the Joint Chiefs of Staff to co-ordinate the broader issues of strategy and planning. Undoubtedly the unification programme in U.S.A. was well-intentioned but badly timed. It is noteworthy that argument largely centred on the question of whether one service, the air force, using one weapon, the atomic bomb, could guarantee victory. It is equally interesting that this somewhat undignified fracas was characterised by the usual emotional and partisan polemics which have become inseparable from inter-service squabbles. Probably the most convincing argument for unification in the U.S.A. was, in fact, the B36 controversy, and the mental attitudes it revealed in the autonomous services.

Within the British Commonwealth there has been no declared policy of unification, although there are frequent protestations of fraternal affection. Immediately prior to World War II there was a burning controversy, discreetly camouflaged, on the ownership of the Fleet Air Arm. During and since that war there has arisen the whole facade of inter-service committees and joint organisations upon which we rely to correct and realign the idiosyncrasies of the independent services. These often lead to a form of Dutch auction—in which one service makes mutual arrangements with a competing service to sponsor one another's bids. Even the annual hustings for finance are preferable to this.

Advantages of Unification.

It is appropriate at this stage to examine the advantages of complete service unification. These may be summarised as:—

(a) Unity of doctrine, leading to effective, concentrated prosecution of war, under unified command.

(b) Elimination of irrelevant single-service vested interests inseparable from the autonomous services, thus leading to clear operational doctrine, and to economy of effort.

(c) Wholly co-ordinated approach to procurement of manpower and material.

(d) Rationalisation of logistical systems and methods, leading to economy and efficiency, whereas the present triplicate system is manifestly wasteful and unnecessary.

(e) Creation of central responsibility in planning, training, and particularly in fiscal matters, instead of the existing unnatural, unwieldy machinery which thrives on compromise rather than on dynamic progress. Simultaneously it would correct the distorted perspective in which fiscal matters now appear.

Effects of Unification.

One typical example of the interplay of service interests and budgetary demands is that of transport aircraft. In war the Army is the principal user of air transport, in tactical and strategic roles. Nevertheless, since the transport aircraft is simply a different type of aircraft, requiring similar pilot and maintenance techniques, and maintenance facilities, to the combat aircraft, it is the responsibility of the Air Force. Airmen of the air transport forces are, in fact, second to none, and do all in their power to comply with Army needs.

It is in the budgetary provision of transport aircraft that the system breaks down. Air Forces look to combat aircraft as their major responsibility. The funds available are rarely enough to equip the Air Force in bombers and fighters. Consequently the Army has to accept inferior transport aircraft in insufficient numbers. The types of transport aircraft now serving the British and Australian armies are clear proof of this fact.

Under a unified service there would be a broader perspective among the budget drafters. The decision on whether new bombers or new transport aircraft should be bought would be viewed more dispassionately and decided in relation to an overall plan, not in accordance with the limited scope and finance vote of a single service.

Australian Background to Unification.

The Commonwealth armed forces are among the younger, albeit well-proven, military organisations of the world. They have inherited many of the traditional habits and themes of their British counterparts, generally adapted to suit Australian conditions. For many years the portfolios of the navy and army were united under one head; subsequently air and navy were joined, and now, again, one Minister is responsible for the navy and the army. In such young services it should be easier to achieve true unification than in older countries such as the United Kingdom. On the other hand, as we have seen in the case of the U.S.A.F., vigorous young services can be the most violent in defence of their separate identity. (It is interesting to see how adamant is the U.S.A.F. in assuming all functions about its own airfields, to the total exclusion of the U.S. Army *wherever feasible.)* Nevertheless, in Australia it should be relatively simple to proceed with unification, since the forces involved are smaller, and are already linked in some functions, such as recruiting. Unified Australian forces need not become a "Frankenstein Monster."

In day-to-day activities there are certain matters which are already dealt with on a unified or part-unified basis. The Treasury deals with many questions of pay and allowances on a common footing, also reserving to itself the right to profit from inter-service discord when occasion offers. Clothing is procured centrally. In war the supply of rations and petroleum for the Air Force and the Army is vested in one service. These are, of course, only *minor examples of a trend.* In planning at the higher level, the National Defence Council, the Department of Defence, the Joint Chiefs of Staff, the Joint Planning Committee and the Joint Administrative Planning Committee are all evidence of that trend; but they are mainly federal, makeshift devices to obtain co-ordination between organisms which are not naturally unified in thought or action. The military climate of Australia is more congenial to the growth of unification, and the services and the public better prepared, than anywhere else in the English-speaking world.

Unification by Easy Stages.

It would be folly to embark pre*cipitately on wholesale and complete* unification. The fighting forces are sensitive, although powerful, instruments. This is the fact which has hitherto precluded a direct approach to unification here, and rebuffed the unifiers in the U.S.A. Unification, being inevitable, may either be achieved now, in a time and manner of our own choosing, or later, in the emergent and inconvenient necessity of war. It must be accomplished in such a manner that the confidence of the public and the services is retained; that the technical effectiveness of the arms and services are not prejudiced. It must be logical, gradual and complete.

Education.

One of the most effective steps in unification, and less painful than *most, is to unify the basic education* of officers, now conducted separately in the Service Colleges. Of the four years' courses, some two years of this most formative period are spent in perfecting the academic backgrounds of potential officers. If this were done in a single college, the future leaders, growing up together, would accept unification and implement it more readily and effectively. This is not a difficult step. Many senior R.A.A.F. commanders were trained at R.M.C., Duntroon; already in India the three services train their young officers in a common college; and in Canada, at Royal Roads, R.C.N. and R.C.A.F. officer candidates study together. This step, of unifying the cadet colleges, could be enforced at an early stage in unification, and would be an effective point at which to influence the services as a whole.

Logistical Unity.

After combining officer cadet education, probably the most fruitful field for integration lies among the various ancillary departments of the three services. One service which has frequently been suggested before is the medical service. Despite the legitimate claims of a minority of specialists in aviation medicine, and who could still be earmarked and trained in this important field, there seems scant justification for the retention of three separate medical services. For many years in India, where a sizable air force and navy were retained, all services were given hospitalization by the Army Medical Service. A unified medical service would offer combined facilities, better equipped, yet more economical, than three independent medical organisations. In addition, such a service would increase the career prospects of officers, and improve the present notoriously unfavourable recruiting situation in the medical field.

The provision and distribution of supplies, transport and petroleum products are similarly processes which could effectively be discharged by a single agency, and the change could be made within a comparatively short time. In war, the R.A.A.S.C. assumes certain of these functions for other Australian services in the overseas theatre. Unification in peace would facilitate the changeover.

The provision and distribution of ships, vehicles, aircraft and heavy war material generally are not susceptible to immediate and outright unification. Common user stores, such as clothing and small arms, could be centralised, and the remaining responsibilities gradually absorbed into common agencies. Procurement of these materials is already co-ordinated at the highest level by the Supply Department.

It becomes obvious that a unified logistical system will greatly reduce the administrative overheads of the services. Rarely a week passes without some national military figure releasing a statement, in the nature of a pious hope, that the administrative tail will be shortened, that the services must be streamlined in the interests of mobility and of increased fighting effectiveness. Nevertheless, every schoolboy knows that the tail, far from diminishing, is actually growing fatter and longer. This becomes abundantly clear when the public goes to Central Station, and can judge, from the evidence of separate Naval, Army and Air Force R.T.O.'s, each in their own little cells, that separate services triple the administrative overhead. If further evidence is required, it might well be sought in the field of dentistry. Are three dental corps really necessary? In unification lies a sure way of reducing these overheads, and the administrative tail, without loss of efficiency and at a slight cost in amour propre. Any reform which promises to reduce the manpower commitment of an underpopulated Australia in this manner surely cannot long be ignored.

Joint Staff.

There are already an Imperial Defence College, a Joint Services Staff

College, and the School of Land/ Air Warfare; all teaching common doctrines of strategy and integrated operational procedure. There are also Joint Planning Staffs in the operational and administrative fields. It would be a logical step to create from these sources a Joint Staff Corps. This would be en elite, drawn from the existing services, selected for all-round adaptability to three-dimensional warfare, and for ability to co-operate. They would form the new great general staff of Generalists, who would direct the efforts of the Specialists in the sea, land and air arms of the unifying services. From this cadre would ultimately be drawn the leaders of the unified Defence Force.

At an appropriate time it would also be necessary to appoint a Supreme Commander or, in peace, a Supreme Chief of Staff. This proposal has already been given serious consideration by the Australian Parliament and Press. Since in war this is a proven necessity, it appears a regression to ignore it in peace. Indeed, we may well inquire how supreme commanders of triphibious forces are expected to gain worthwhile experience in our existing organisations, save by secondhand methods in theoretical discussions at the joint colleges. In a simpler era soldiers like Don John of Austria and General (Admiral) Monk were able to convert themselves into commanders at sea, but the future Don Johns and Monks will need to be thoroughly trained and experienced. Under a unified system they will be educated and trained and conditioned, in peace, to command a single Defence Force in war. It is of interest that the only truly unified Defence Force in the world today is that of one of the youngest military powers, Burma, which started without the vested interests from which we suffer.

Unification of Fighting Arms.

The integration of the fighting elements into the single Defence Force need entail no loss of the essential characteristics of each arm. These would be retained, in the same way that artillery and infantry, or cruisers and submarine services, have kept their own identity in the past. The difference would be that those characteristics would be employed directly by the sole staff and force responsible for conducting operations of war. Guided ground/air AA missiles would not be an "Aunt Sally," disputed between the Army and the Air Force; they would constitute the A.A. arm of the national unified Defence Force.

In order to assess the operational effects of this unification, the application of tactical aviation to the land battle may well be taken as a classical example. There are at present separate air and land forces, each with its own procedures, staff system, nomenclature, even differing in their service abbreviations for the same words. In order to ensure co-ordination an elaborate, artificial fabric has to be constructed, which serves not only to direct the combined effort effectively but also to police the inevitable misunderstandings which occur when autonomous services try to co-operate. An integral air arm would be able to assume supporting functions to a division with as little preliminary as the divisional artillery.

In maritime operations the naval arm would benefit, particularly in this air age when air cover is indispensable to successful warfare at sea. The claims of the navy could not be ignored, because the responbibility for its safe and effective operation would be that of the unified staff, under the supreme commander. Moreover, the air and sea arms would work together from habit and not from sheer necessity.

An excellent start in operational unification might be made in the setting up of new, unified directorates to deal with the most modern aspects of war. Single directorates to deal with atomic warfare and guided missiles should be readily accepted. It is noteworthy that progressive New Zealand has already raised an inter-service Defence Scientific Corps. This is a project which Australia might well emulate.

Implementing Unity.

The process of unification should be gradual, and might be spread over five to ten years. As each arm or service was merged, it would assume the common ranks and uniform of the new Defence Force. There would inevitably be a transitional stage, in which some dislocation would have to be accepted. As the implementation of the process would be directed by the Supreme Chief of Staff and his Joint Staff Corps, this dislocation would be minimised.

The growth of the spirit of the new Defence Force, which would be a most important factor, would need to be carefully watched and fostered. Non-co-operative diehards would have to be ruthlessly eliminated, and there would be a small number of these in each service, because the present system tends to breed them; although, happily, they are less numerous in the senior ranks of the Australian services than they are in many other nations' services. Gradually the conviction of the benefit of increased efficiency as an instrument of war, greater economy, and better career prospects would assert itself, and the reformed Defence Force would stand as a coordinated entity, in place of the ramshackle devices of federal compromise which preceded it.

In total war, true balance of forces will only be achieved in a unified military machine, and victory will accrue to the balanced forces. In our organisational problems we may be compared with the dissident Christians before the fall of Constantinople. Either we unite for victory, or we pursue our internal dissensions to end in defeat, or, at best, in costly victory.

BOOK REVIEWS

THE FIRST COMMONWEALTH DIVISION. By Brigadier C. N. Barclay, C.B.E., D.S.O. (Gale and Polden Ltd., Aldershot, England).

AT THE end of the First World War in 1918 the statesmen of the civilised world, appalled by the slaughter, destruction and economic waste of the catastrophe through which they had passed, established the League of Nations as an agency for settling international disputes without recourse to arms. Subsequent events proved that nations, despite the lessons of the war, were not yet ready to submit their differences to international arbitration. Aggression again raised its ugly head, and when Mussolini attacked Abyssinia the League failed to meet the challenge to its authority. That failure, for all practical purposes, led to the collapse of the League of Nations.

In World War II the allied statesmen took a more resolute and realistic view when they established the United Nations to perform similar but broader functions to the old League. This time they created machinery for meeting aggression with force of arms. That machinery was put to its first test when the North Koreans committed an act of flagrant aggression against South Korea.

The indecisive result of the campaign in Korea undertaken by the United Nations has tended to obscure the all-important fact that the anti-aggression machine of the Charter did work. It may not have worked very smoothly or efficiently, but it did work. Critics of the campaign, both in the political and military spheres, should bear in mind that this was the first occasion in modern times when nations banded together to meet aggression with force, to protect the victim and to fight for justice. That in itself was a notable achievement, and it may well be that history will rank the Korean campaign as the most important war in modern times, perhaps as the turning point in international relations.

For soldiers of the British Commonwealth the campaign holds a particular interest, for it was the first occasion on which troops from many of our member nations fought together in an integrated formation for any length of time. It was to be hoped that someone would tell the story of that significant occurrence before the campaign had receded too far into history. These hopes have not been disappointed, for in "The First Commonwealth Division"

Brigadier C. N. Barclay has told the story of the Commonwealth's military effort in Korea.

In writing his story Brigadier Barclay, unlike a great many military historians, has been at some pains to sketch the political background against which the military operations took place. Although brief, this aspect of the story is clear and sufficient. In his accounts of operations he has also been careful to place the actions of the Commonwealth troops in proper relation to the actions of the United Nations' forces as a whole. Indeed, it may be said that the book is an account of the Korean campaign, with emphasis on the operations of the Commonwealth troops.

After sketching in his background, Brigadier Barclay begins his story with the arrival of the first Commonwealth troops in Korea. In the early part of the story, when the number of units was small and operations highly mobile, he gives details of actions down to company level. Later, when the number of units increased, and the Division was formed, he deals with operations on a battalion basis.

Brigadier Barclay's description of operations is lucid and entertaining, while his enthusiastic account of the manner in which a division comprising troops from different countries and cultures fought together harmoniously and efficiently should give great encouragement to those who have worked so hard for the ideal of integrated Commonwealth forces.

Unlike many books of this sort, this one contains excellent maps, which enable the reader to follow the narrative with ease. In addition, the text is illustrated with numerous "Diagrammatic Sketch Maps," which military writers might well take as a model.

To anyone concerned with the mechanics of integration the book would have been more valuable had the author given some details of the administrative machinery. Brigadier Barclay several times refers to the importance of administration, but he does not give us a clear picture of how this more than usually complicated machine worked. Even at the expense of making the book a little longer, this would have been well worth while.

The book has a particular interest to Australians, for it describes the first campaign in which major units of our regular army fought overseas. To the soldiers who participated it is a valuable record of their services in what will undoubtedly become an historic campaign.

INTERNATIONAL RELATIONS IN THE MODERN WORLD. A study course in nine chapters, compiled by the Australian Army Educational Corps.

Any person of average intelligence, wishing to be informed of any subject from beekeeping to nuclear physics, selects his sources of information with care, and follows an organised course of study. The only exception seems to be in the realm of international affairs. Influenced by such headline phrases as "The bees are swarming" or "Lower Slobovia must be atomised," nine people out of ten will speak with the utmost authority on any given subject that comes into the news.

Ask them some basic questions, and it is palpable they have only the haziest conception of what it is all about. Unfortunately few people are asked any questions. Army officers are.

Since Current Affairs is a subject for promotion examinations, it is of great importance to provide a comprehensive course of background study. Normally this might involve close reading of a dozen books and reference to a hundred more. Is it possible to present all the basic elements in one book? In producing "International Relations in the Modern World" the Australian Army Educational Corps has accepted the challenge, and presented such a basic course with appropriate bibliography to each of its nine chapters, directing attention to wider fields of study.

The plan of the book follows that of "Australia in the Modern World," reviewed in Australian Army Journal, No. 60, of May, 1954. Questions are posed at the end of each chapter, which facilitate the use of the material for lecture/discussion purposes, although the course is also intended for individual study.

It is by no means "easy reading." *Indeed, some passages require con*centrated effort and compel the thought that a little simplification would be an improvement. However, this fault is perhaps inherent in what is, after all, a text book and not a series of popular articles. On this point the Introduction itself is worth quoting—". . . the course may not prove as exciting as the pages of current magazines, but it comes closer to the facts which lead to understanding."

An initial chapter undertakes the somewhat ambitious task of summarising the history of the past 500 years on the principle that the first essential is to know how things came to be the way they are. The prospects of co-existence, the difficulties of international organization, the influence and interplay of modern ideologies, economic factors, the impact of pressure groups, ethnical and regional considerations and other general factors which comprise the vast and troubled background of every-day world affairs, are discussed and argued objectively. Here again the reader will perhaps grow a little impatient at times, having the thought of the present reviewer: "Doesn't this writer ever get excited about anything?" The writer would doubtless reply that "excitement is not his business; for that you must turn to the pages of the illustrated magazines or to the widascope screen.

The careful analysis of the problem of effective international organization in the face of the "sovereign rights" of individual member States, the discussion of the problem of finding a permanent basis for cooperation between East and West, and the survey of the growth and influence of modern ideologies are the main highlights of the book.

Surprisingly enough, no reference is made to the development of nuclear fission and thermo-nuclear fusion, and their impact on international relations. This startling conditioner of all other factors in international relations which has, in Sir Winston Churchill's words left humanity " . . . roaming and peering round on the rim of hell," should provide material for a volume on its own account, and it was probably decided to let well alone.

There is one bright spot in all this objective realism—the account of the evolution of the British Commonwealth of Nations in the final chapter. That this loose organisation of self-governing and non-self-governing States should endure through every kind of difficulty and trial is a tribute to the established British virtues of liberalism, justice and tolerance. These are the virtues which may well rescue mankind from "roaming and peering round on the rim of hell," and set him on the road to effective international organization and the rule of law.