INTERNATIONAL COMMITTEE OF THE RED CROSS

Weapons that may Cause Unnecessary Suffering or have Indiscriminate Effects

REPORT ON THE WORK OF EXPERTS

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CONTENTS

INTRODUCTION

1. At the second session, in 1972, of the Conference of Government Experts on the Reaffirmation and Development of International Humanitarian Law Applicable in Armed Conflicts, the experts of nineteen Governments submitted a written proposal suggesting that the ICRC should consult experts on the problem of the use of certain conventional weapons that may cause unnecessary suffering or have indiscriminate effects. In support of their proposal, the experts said, *inter alia,* that, in view of its importance and topical interest, this question had been the subject of sustained debate at the Conference meetings.

2. Within the last few years, several governmental and non-governmental bodies have been devoting their attention to an examination of the use of these weapons. At its XXth session held at Vienna in 1965, the International Conference of the Red Cross stated in its Resolution No. XXVIII that "...indiscriminate warfare constitutes a danger to the civilian population and the future of civilization" and that "the right of the parties to a conflict to adopt means of injuring the enemy is not unlimited".

3. Furthermore, the International Conference on Human Rights, held at Teheran in 1968, recognized the need "to ensure the better protection of civilians, prisoners and combatants in all armed conflicts" and "to prohibit or limit the use of certain methods and means of warfare".

4. The General Assembly of the United Nations also affirmed, in its Resolution 2444 (XXIII), the principles contained in the two above-mentioned Resolutions.

5. In its report on the reaffirmation and development of the laws and customs applicable in armed conflicts, which it submitted to the XXIst International Conference of the Red Cross (Istanbul, 1969), the ICRC referred, in connection with the different fields in which international humanitarian law should be developed, to the "prohibition of 'non-directed' weapons or weapons causing unnecessary suffering". The ICRC report came to the conclusion that "belligerents should refrain from using weapons:

— of a nature to cause unnecessary suffering;

— which, on account of their imprecision or their effects, harmed civilian populations and combatants without distinction;

— whose consequences escaped from the control of those employing them, in space or time."

The XXIst International Conference of the Red Cross requested the ICRC "on the basis of its report to pursue actively its efforts in this regard".

6. In the field of modern weapons, the United Nations has already carried out significant work. In its Resolution 2852 (XXVI), the General Assembly asked the Secretary-General to prepare, in accordance with paragraph 126 of his report on respect for human rights in armed conflicts (A/8052), a report on napalm and other incendiary weapons and all aspects of their possible use. The Secretary-General followed the mandate given to him by submitting to the General Assembly at its twenty-seventh session a detailed report on this matter (A/8803).

7. Shortly afterwards, a private body, the Stochkolm International Peace Research Institute (SIPRI), also published a report on napalm and other incendiary weapons. This report, which was released a few days after the UN Secretary-General's, was described as an "interim report", and it is understood that a final version is to be published at the end of 1973. Unlike the UN Secretary-General's report, the SIPRI interim report laid particular stress upon the legal and humanitarian aspects of the use of these weapons.

8. The present report, therefore, may be considered to form part of a series of studies undertaken by the United Nations and other institutions on the subject of weapons. The pressing nature of the problem itself and the fact that, at the present moment, it is not being considered by any international body, are among the reasons that have led the ICRC to carry out this particular study. The interest it arouses may be seen in the animated discussions and the numerous written proposals produced at the time when Article 30 (entitled "Means of combat") of the draft Additional Protocol to the four Geneva Conventions of August 12, 1949, submitted by the ICRC, came up for examination at the second session of the Conference of Government Experts.

9. With a view to drawing up the present report, the ICRC invited experts from those countries which had drafted the proposal referred to in paragraph 1 to meet at its Geneva headquarters. Some experts, nationals of other governments concerned, also took part. In addition, the ICRC invited the participation of the United Nations, the World Health Organization, the Special Committee on Disarmament of the Non-Governmental Organizations, and the

Stockholm International Peace Research Institute. This was the basis upon which it was possible to convene a well-qualified working group and, in naming its members below, the ICRC would like to express its gratitude to them. The members of the group were as follows:

Colonel Sumio Adachi Professor of Defence Academy Defence Agency Tokyo	(Japan)
Major Dr. Haidar Mustafa Al-Agha Medical Services Dept. Ministry of Defence Kuwait	(Kuwait)
Mr. Talal Al-Khudhairi Second Secretary Permanent Mission of the Republic of Iraq Geneva	(Iraq)
Colonel Abdul Wahab Al Qaraqly Director of the Legal Office Ministry of Defence of the Republic of Iraq Baghdad	(Iraq)
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Dr. Malvern Lumsden
Stockholm

It will be further recalled that, at its twenty-seventh session, the United Nations General Assembly, in Resolution 3032 requested the Secretary-General to prepare a survey of existing rules of international law concerning the prohibition or restriction of use of specific weapons. With a view to obtaining assistance in the preparation of this survey, the Secretary-General called upon Professor R.R. Baxter (USA) and Professor Igor P. Blishchenko (USSR) to undertake preliminary studies. On his return flight from New York, Professor Blishchenko kindly broke his journey in Geneva and took part on 13 and 14 June in the experts' deliberation. He was able, in particular, to give details of the work being undertaken in New York and thus to establish extremely useful links between the studies on two subjects that are closely connected.

10. The working group met in two sessions, the first during 26 February-2 March, 1973, and the second during 12-15 June. During the first session, drafting assignments for the individual chapters of the report were distributed among the experts. The drafts that were subsequently submitted were edited at the ICRC and then considered by the working group during the second session. The amendments and revisions recommended by the experts at the second session were subsequently incorporated by the ICRC during their editing of the final report. The ICRC wishes to express its appreciation to the World Health Organization for its assistance during the two editing processes.

11. The present report is purely documentary in character. It does not formulate any concrete proposals for the prohibition or limitation of the use of the weapons under consideration, although the ICRC and the experts alike hope that this may one day be possible.

12. The purpose of the report is to give a description of those weapons which might cause unnecessary suffering or have indiscriminate effects. The field of enquiry has therefore been circumscribed by these two criteria. Nuclear, chemical and biological weapons have not been considered to any substantial extent, for both the UN Secretary-General and the World Health Organization have published reports on chemical and biological weapons (see paragraphs 48 and 49), and the UN Secretary-General has also published one on nuclear weapons (see paragraph 47). Although the UN Secretary-General has also issued a report on incendiary weapons, as noted in paragraph 6, it was considered useful, in view of the recency of his report, to include an abstract of it.

13. The intention of the first two chapters of the report is to provide readers with a background to the subsequent chapters. Chapter I is devoted to a survey of the existing legal limitations regarding the use of specific weapons, and is intended to give readers an idea of the legal framework in which the problems are situated. The main provisions of conventional and customary international law, with special reference to those incorporated in the Hague Conventions of 1899 and 1907, are mentioned in this first chapter. Chapter II describes briefly all the major categories of weapon, and goes on to discuss, in broad terms, their military applications in relation to the concept of indiscriminateness. The chapter ends with an account of the medical and other problems involved in the measurement of degrees of suffering or injury.

14. The next five chapters constitute the main body of the report. In them, the relevant contemporary weapons and their effects on the human body are described. Chapter III deals with small-calibre single projectiles, such as those fired by rifles or machine-guns. Chapter IV describes explosive weapons of the blast and fragmentation types. Chapter V describes time-delay weapons, such as mines and booby-traps. Chapter VI deals with incendiary weapons, and is an abstract of the UN Secretary-General's report on this subject referred to in paragraph 6. Each of these four chapters ends with a summary of their salient features. Chapter VII speculates upon future weapon developments, and takes the laser as a specific example. The report closes with some brief "final remarks".

15. English was the principal working language of the group of experts, and although other languages were used, the English texts of the report were the ones that received the experts' most detailed scrutiny. In view of the highly technical character of parts of the report, it is possible that the French and Spanish versions—and the German translation by the experts of the Federal Republic of Germany—may contain certain inadequacies. Where uncertainties arise on this score, the reader is advised to consult the English version.

16. The ICRC expresses the hope that the present report will prove useful and stimulating. It is being distributed to all national Red Cross Societies, to all Governments parties to the Geneva Conventions, and to all interested non-governmental organizations. The report will also be available to anyone else wishing to consult it. It has been designed to contribute to the knowledge of all sections of the public, even those that are not particularly well-informed on the matters under consideration.

17. The ICRC, for its part, if the need were felt, would be prepared to continue inquiries and, for example, convene a conference of government experts in order to contribute to the promotion of relevant international humanitarian law.

CHAPTER I

Existing legal prohibitions or limitations regarding the use of specific weapons

1. General principles

18. At the outset of this report a brief discussion may be useful of the concepts upon which the employment of specific weapons has in the past been viewed as prohibited. The prohibition of use of specific weapons might, of course, be agreed upon between States regardless of the concepts and criteria that may be discerned behind prohibitions adopted in the past. Nevertheless these concepts and criteria retain their validity and still offer guidance.

19. The legal concepts discussed here are of direct relevance only to the questions of the use of particular weapons and of whether that use should be deemed permissible, or be subject to or be made the subject of prohibition. These concepts have no necessary bearing on measures of disarmament in the sense of elimination of development, production and stockpiling of particular weapons, though such measures may be deemed desirable as regards one or more of the weapons discussed in this report.

20. Any legal evaluation of problems related to the use of weapons in armed conflicts must proceed from the principle that the choice of means and methods of combat is not unlimited (cf. Hague Regulations concerning the Laws and Customs of War on Land, Art. 22). Rules which specify this general principle are those which explicitly or by implication seek to prevent the use of weapons causing unnecessary suffering, and indiscriminate weapons or methods of combat. In addition, the general maxim embodied in the Martens clause (Hague Convention No. IV, preamble para. 8) may be referred to here, namely that in cases not included in applicable conventions, civilians and combatants remain under the protection and the authority of the principles of international law, as they result from the principles of humanity and the dictates of public conscience. This underlines the applicability of international law even in such cases where prohibitions of specific weapons do not appear in existing international conventions.

(a) *Unnecessary suffering*

21. The principle that weapons causing unnecessary suffering must be avoided is set forth in the Hague Regulations, Art. 23, sub-para. (e). However, the authentic French version and the English translation of this Article differ in some respects: the French text provides that "il est ... interdit ... d'employer des armes, des projectiles ou des matières *propres à* causer des *maux* superflus", while the English version reads "it is forbidden... to employ arms, projectiles, or material *calculated to* cause *unnecessary suffering*" (emphases added). The English version would be the narrower if its contents were taken to add a subjective element to the original rule. In conformity with the authoritative French text, the principle must be stated to be that—irrespective of the belligerents' intentions—any means of combat are prohibited that are *apt* to cause unnecessary suffering or superfluous injury. While the authentic French text uses the term "superfluous injury" (maux superflus), the phrase "unnecessary suffering" used in the English translation has acquired a relevance of its own through the practice of States. Hence, both concepts are of importance for the assessment of whether particular weapons shall be deemed prohibited for use.

22. The principle referred to in the preceding paragraph is, indeed, found expressed already in the preamble of the St. Petersburg Declaration to the Effect of Prohibiting the Use of certain Projectiles in Wartime (29 November/ 11 December 1868), which states

> "...
>
> (2) that the only legitimate object which States should endeavour to accomplish during war is to weaken the military forces of the enemy;
>
> (3) that for this purpose it is sufficient to disable the greatest possible number of men;
>
> (4) that this object would be exceeded by the employment of arms which uselessly aggravate the sufferings of disabled men, or render their death inevitable;
>
> (5) that the employment of such arms would therefore be contrary to the laws of humanity."

The St. Petersburg Declaration imposes a ban on the employment of "any projectile of a weight below 400 grammes, which is either explosive or charged with fulminating or inflammable substances". The Hague Declaration concerning the Prohibition of Dum-Dum Bullets (1899), in pursuance of the same object of avoiding unnecessary suffering, prohibits the use of "bullets which expand or flatten easily in the human body, such as bullets with a hard envelope which does not entirely cover the core or is pierced with incisions".

23. What suffering must be deemed "unnecessary" or what injury must be deemed "superfluous" is not easy to define. Clearly the authors of the ban on dum-dum bullets felt that the hit of an ordinary rifle bullet was enough to put a man out of action and that infliction of a more severe wound by a bullet which flattened would be to cause "unnecessary suffering" or "superfluous injury". The circumstance that a more severe wound is likely to put a soldier out of action for a longer period was evidently not considered a justification for permitting the use of bullets achieving such results. The concepts discussed must be taken to cover at any rate all weapons that do not offer greater military advantages than other available weapons while causing greater suffering/injury. This interpretation is in line with the philosophy that if a combatant can be put out of action by taking him prisoner, he should not be injured; if he can be put out of action by injury, he should not be killed; and if he can be put out of action by light injury, grave injury should be avoided. In addition the concepts "unnecessary suffering" and "superfluous injury" would seem to call for weighing the military advantages of any given weapon against humanitarian considerations.

(b) *Indiscriminate effects*

24. The basic principle that the parties to an armed conflict shall confine their operations to defeating the military objectives of the adversary, and shall ensure that civilians and civilian objects are respected and protected, is embodied in international instruments, e.g. the St. Petersburg Declaration, preamble para. 2, and the Hague Regulations. It was often violated by methods of indiscriminate warfare, but is nevertheless firmly established in international law. The XXth International Conference of the Red Cross (Vienna 1965), in its Resolution XXVIII, confirmed "that distinction must be made at all times between persons taking part in the hostilities and members of the civilian population to the effect that the latter be spared as much as possible". The same text was included in Resolution 2444 (XXIII), of the UN General Assembly which was unanimously adopted on 19 December 1968.

25. It follows from this principle that weapons and other means of combat must never be directed against civilians or civilian objects. This principle has not been taken to mean a ban upon weapons and other means of combat which, though directed against military targets, entail the risk of incidental civilian casualties or damage to civilian objects in the vicinity of the targets. It does imply, however, that weapons which by their nature are incapable of being directed with any certainty to specific military targets, or which in their typical or normal use are not delivered with any certainty to such targets, are in violation of this principle.

26. Some international conventions prohibit the use of certain weapons because of their indiscriminate effects. The Hague Convention No. VIII concerning the Laying of Automatic Submarine Contact Mines prohibits "1st—to lay unanchored automatic contact mines, except when they are so constructed as to become harmless one hour at most after the person who laid them ceases to control them; 2nd—to lay anchored automatic contact mines which do not become harmless as soon as they have broken loose from their moorings; 3rd—to use torpedoes which do not become harmless when they have missed their mark". Likewise, the most significant instrument prohibiting the use of specified weapons, i.e. the Geneva Protocol of 1925 for the Prohibition of the Use in War of Asphyxiating, Poisonous and other Gases, and of Bacteriological Methods of Warfare, is at least in part based on the concept of preventing indiscriminate effects of combat.

27. The prohibition of indiscriminate warfare relates more often to methods of warfare and methods of using weapons than to specific weapons *per se*. All weapons are capable of being used indiscriminately. This is not, of course, sufficient ground for prohibiting their use in armed conflicts, but a ground for prohibiting such types of use. However, in some cases weapons may be indiscriminate by their very nature. Moreover in some other cases the normal or typical use of the weapons may be one which has indiscriminate effects.

2. Military Manuals and Regulations

28. It is of considerable value to know in which way international law in force is reflected in some military manuals and regulations. Only a limited number of national service manuals were available for evaluation for the purpose of this report, and no manuals concerning rules of engagement have been available.[1] The manuals taken into consideration deal expressly with prohibitions of the use of weapons in armed conflicts. This permits some detailed comments touching on the implementation of the various legal principles in State practice.

29. In the light of the development which has taken place in the practice of States, confirmed by stands taken in their military manuals, the *St. Petersburg Declaration* continues to apply under present-day conditions to projectiles weighing considerably less than 400 grammes that are not capable of incapaci-

[1] *Austria:* Bundesministerium für Landesverteidigung: Grundsätze des Kriegsvölkerrechts, Anhang B der Truppenführung (TF), 1965 (pp. 253, 254);
France: Décret N° 66-749 du 1er octobre 1966 portant règlement de discipline générale dans les armées (Art. 34);

tating persons other than those who have received a direct hit, thus causing unnecessary suffering.

30. The *Hague Declaration concerning the Prohibition of Dum-Dum Bullets,* which was modelled on the lines of the St. Petersburg Declaration, did not raise much legal controversy, nor did it lead to difficulties in State practice. The British Government originally objected to an express prohibition of dum-dum bullets (named after a British arsenal near Calcutta) but ratified the Declaration in 1907. The United States was not a party to the Declaration; yet US Army Department pamphlet No. 27-161-2 (p. 45) points out that the U.S. delegation at the 1899 Peace Conference had pressed for the adoption of more stringent limitations; "The use of bullets inflicting wounds of useless cruelty, such as explosive bullets, and in general all kinds of bullets which exceed the limit necessary for placing a man *hors de combat* should be forbidden".[1] During the First World War, belligerent Parties accused each other in several instances of having used dum-dum bullets. There is, however, no reason to believe that the Declaration had not been implemented on the whole. Difficulties might arise from the somewhat uncertain definition of "bullets which expand or flatten easily in the human body". The examples given in the Declaration: "bullets with a hard envelope which does not entirely cover the core or is pierced with incisions" do not appear to be exhaustive. Hence the German ZDv 15/10 (para. 75) states that projectiles which produce the same effects by other means, e.g. hollow-point projectiles, are covered by the prohibition of the Declaration.

31. The prohibition of means causing unecessary suffering set forth in the *Hague Regulations,* Art. 23 sub-para. (e) is reflected in almost every military manual dealing with the subject of international law of war. The United States FM 27-10 (para. 34) states that the question as to what weapons cause "unnecessary

Federal Republic of Germany: Bundesministerium der Verteidigung *ZDv* 15/10, Kriegsvölkerrecht, Leitfaden für den Unterricht (Teil 7), Allgemeine Bestimmungen des Kriegführungsrechts und Landkriegsrechts, März 1961 (paras 64-90); *HDv* 100/1, Truppenführung, Oktober 1962, Anhang Teil III, Völkerrechtliche Grundsätze der Landkriegführung (paras 44-60), new edition in preparation;
Sweden: Jägerskiöld-Wulff, Handbok i fölkrätt under neutralitet och Krig, 1971, paras 99-104;
Switzerland: Eidgenössisches Militärdepartement, Handbuch über die Gesetze und Gebräuche des Krieges, Handbuch für die schweizerische Armee, 1963 (paras 18-24);
United States: Department of the Army Field Manual (FM) 27-10, 1956, The Law of Land Warfare, paras 33-38, Department of the Navy, Law of Naval Warfare (NWIP 10-2); Department of the Army, Pamphlet (DA PAM) 27-161-2, International Law, Vol. II, 1962, pp. 39-46;
United Kingdom: War Office, Code No. 12 333, The Law of War on Land being Part III of the Manual of Military Law, London 1958 (Chapter V).

[1] *Scott,* ed., The Proceedings of the Hague Peace Conference, The Conference of 1899 (1920), p. 80.

injury" can only be determined in the light of the practice of States in refraining from the use of a given weapon because it is believed to have that effect. Like the British manual (para. 110), the US manual stresses that this prohibition certainly does not extend to the use of explosives contained in artillery projectiles, mines, rockets or hand grenades. Both manuals give the same examples of means to which the prohibition of the Hague Regulations, Art. 23 sub-para. (e), would apply: lances with barbed heads, irregular shaped bullets, and projectiles filled with broken glass, the use of any substance on bullets that would tend unnecessarily to inflame a wound inflicted by them, and the scoring of the surface or the filing off of the ends of the hard cases of the bullets. The US DA PAM 27-161-2 (p. 45) adds that this amounts to an official prohibition of bullets which tear an unnecessarily large hole.

32. The use of *shotguns* during the First World War gave rise to legal controversy. In September 1918, the German Government lodged a protest with the United States against the use of shotguns by the US Army. The US Secretary of State replied in a note stating that in the opinion of the US Government the Hague Regulations Art. 23 sub-para. (e) did not forbid the use of shotguns, that in view of the history of the shotgun as a weapon of warfare, the well-known effects of its use, and a comparison of it with other weapons approved in warfare, the shotgun then in use could not be made the subject of legitimate and reasonable protest, and that the United States would not abandon its use.[1] The US DA PAM 27-161-2 (p. 45) quotes an opinion of the Office of the Judge Advocate General of 1961 stating that, while there is no conventional or customary rule of international law prohibiting the use of shotguns as such, international law does impose restrictions on the types of bullets that may be used in both smoothbore and rifled small arms. According to the author of DA PAM 27-161-2, the legality of the use of shotguns depends on the nature of the shot employed and its effect on a soft target: while the use of an unjacketed lead bullet is considered a violation of the laws of war, the use of shotgun projectiles sufficiently jacketed to prevent expansion or flattening upon penetration of a human body, and the employment of shot cartridges, with chilled shot regular in shape, is regarded as lawful. The German ZDv 15/10 (para. 76) regards shotguns as an illegal means of warfare which offers no real military advantage while causing unnecessary suffering.

33. The prohibition of *poison or poisoned weapons* contained in Art. 23 sub-para. (a) of the *Hague Regulations* has raised the question of whether the poisoning or contamination of water supplies from which the enemy may draw drinking water can be made lawful by posting up a notice informing the

[1] Cf. Hackworth, *Digest of International Law*, Vol. VI (1943) pp. 271-272.

enemy that the water has thus been polluted. The adoption of that practice by a commander of German troops in South-West Africa in 1915 led to a British protest which was rejected by the German Government. A former official American opinion which regarded it as legal to contaminate water by placing dead animals therein or by other means, provided that such contamination is evident or the enemy is informed thereof, was squarely in conflict with the British position (British manual, para. 112). The American FM 27-10 (para. 37) now refers to the prohibition of poison without qualifications, and so does the German ZDv 15/10 (para. 77).

34. The use of *flame throwers* and *napalm* has been a matter of dispute. The British manual (para. 110) regards these means as lawful only when directed against military targets, and states expressly that their use against personnel is contrary to the law of war in so far as it is calculated to cause unnecessary suffering. The US FM 27-10 (para. 36) states that it is not violative of international law to use weapons which employ fire, such as tracer ammunition, flame throwers, napalm and other incendiary agents, "against targets requiring their use". The US DA PAM 27-161-2 (p. 42) points out that these words have been inserted in order to preclude practices such as the wanton use of tracer ammunition against personnel when such use is not called for by a military necessity.

35. An express reference to *indiscriminate weapons* is contained in the German manuals. The HDv 100/1 Anhang Teil III (para. 607) states that flying bombs (e.g. rockets) must be designed in such a way that they can be launched against military objectives with sufficient accuracy. Accordingly, the ZDV 15/10 (para. 90) confirms that the use of such weapons would be illegal if their inaccuracy makes it likely for the civilian population to be hit with full power. Yet the ZDv adds that even inaccurate weapons may lawfully be employed against military targets if, due to the situation or extension of the target, there is but little danger that the civilian population will suffer disproportionately.

36. The use of *mines* is dealt with in a specific manner by the German manuals. The HDv 100/1 Anhang Teil III (para. 58) states that mines as such cannot be considered to be treacherous means, provided they are used in places where the enemy might reasonably suspect them. The HDv adds that the use of mines is forbidden in places that are exclusively used for peaceful purposes. The same rule is repeated in the ZDv 15/10 (para. 89).

37. *Delayed action weapons* and, more specifically, *booby-traps* should also be mentioned in this context. While the problems posed by their use relate apparently in the first place to methods rather than means of warfare, some weapons of this category might be considered as illegal means. The German

ZDv 15/10 (para. 70) describes as prohibited booby-traps that look like "peaceful objects", e.g. fountain pens, watches, or toys. The Austrian manual (para. 40), too, declares that booby-traps camouflaged as toys are illegal means of combat.

3. Implementation and international co-operation

38. The continuous development of new weapons and weapon systems necessitates an equally continuous assessment of such development in the light of the guiding principles of international law of armed conflicts, viz. the prohibition of use of means that cause unnecessary suffering/superfluous injury and the prohibition of indiscriminate warfare. These assessments must evidently take place in the first instance at the national level.

39. While there can be little doubt about the desirability for States to carry out negotiations and consultations with a view to determining whether the use of new weapons or weapon systems will be compatible with the laws of armed conflict, contemporary international co-operation in this field still calls for improvements. In the interest of international cooperation, topical problems touching on the employment of new weapons and weapon systems should be the object of periodical consideration among Governments, as was envisaged already in the St. Petersburg Declaration. The progressive development of international law in this field will enhance the protection of civilians against indiscriminate warfare and of combatants against means of combat that cause unnecessary suffering.

CHAPTER II

Principal categories of weapon, and the questions of indiscriminateness and degrees of suffering or injury

40. This chapter provides a brief introduction to the major types of weapon and their effects in order to place the subsequent discussion in perspective. It summarizes briefly the principal features, both of those weapons whose properties are described in detail in subsequent chapters, and of those other weapons forming part of present-day arsenals whose properties are not so described. The chapter goes on to discuss, in broad terms, some of the military applications of the different categories of weapon with particular reference to the concepts of indiscriminateness, unnecessary suffering and superfluous injury. The legal significance of these concepts has been described in Chapter I.

1. The principal categories of weapon

41. The major categories of weapon and their effects are summarized in Table II.1. Since this report is primarily concerned with the effects of weapons on people, and less with their effects on material, the focus is on the casualty-producing properties of the different categories.

42. *Explosive and penetrating weapons* cause a variety of different physical injuries. These may be grouped into injuries due to blast and injuries due to penetration of the human body by one or more missiles, such as projectiles or fragments. Penetrating weapons cause the latter type of injury, whereas explosive weapons may cause either or both types. As is described in Chapter IV, explosive weapons can be designed to maximize one or other of these two casualty effects, in which event they may be classified either as blast weapons or as fragmentation weapons.

43. Blast injuries sustained from the shock-waves created by explosive weapons result from the transmission of the shock-wave through the human body and its internal cavities. They vary in nature according to the medium (e.g. air, water or solid materials) through which the shock wave is transmitted to the body. They may be compounded by a variety of secondary effects, such as penetration by fragments, crush injuries from falling debris, and so forth.

44. As regards penetrating weapons, projectiles and fragments are responsible for the majority of injuries in modern conventional warfare. In recent conflicts they have caused 70-80 per cent of all battle injuries. Of this percentage, about three quarters of the injuries have resulted from fragments released by explosive weapons and about one quarter from single projectiles such as rifle or machine-gun bullets.

45. The wounds from penetrating weapons result from the transfer of kinetic energy during penetration of the human body by the projectile or fragment. This is described in more details in Chapter III. Death is particularly likely where vital organs are penetrated. Death may also result from loss of body fluids and shock, or subsequently from infection, particularly where there is the massive tissue destruction that may be caused by large projectiles, exploding projectiles, projectiles which flatten, expand or tumble on impact, or which enter the body with high velocity.

46. *Incendiary weapons* depend for their effects upon the action of incendiary agents. The latter have been defined by the UN Secretary-General as "substances which affect their target primarily through the action of flame and/or heat derived from self-supporting and/or self-propagating exothermic chemical reactions".[1] Against man, their casualty effects may sometimes also include asphyxiation and poisoning, for example by carbon monoxide generated during combustion, or by certain components of incendiaries such as white phosphorus. These burns are frequently difficult to treat, and death, due to a number of causes, may sometimes ensue several weeks after the initial injury. This is discussed in more detail in Chapter VI.

47. *Nuclear weapons* are, in effect, incendiary explosive weapons of great power. They are also radiological weapons because of the ionizing radiation released by the nuclear explosion, both immediately, and subsequently in the form of radioactive "fallout".[2] The dominant casualty effects are those of blast, thermal radiation and ionizing radiation. For the last of these, there may be an extended period of days, weeks or even years before symptoms of ill-health are displayed. Ionizing radiation may also delay the healing of other injuries, and affect the progress of certain diseases.

[1] *Napalm and other Incendiary Weapons and all Aspects of their Possible Use: Report of the Secretary-General.* United Nations: New York, 1973 (document A/8803/Rev. 1).

[2] For further information on the mode of action and effects of nuclear weapons, the reader is referred, in particular, to the report of the UN Secretary-General, *Effects of the Possible Use of Nuclear Weapons and the Security and Economic Implications for States of the Acquisition and Further Development of these Weapons,* United Nations: New York, 1968 (document A/6858).

48. *Biological weapons* depend for their effects upon biological-warfare agents. The latter have been defined by the UN Secretary-General as "living organisms, whatever their nature, or infective material derived from them, which are intended to cause disease or death in man, animals or plants, and which depend for their effects on their ability to multiply in the person, animal or plant attacked".[1] Against man, the weapons might be used, conceivably over very large areas, either to kill or to cause disablement lasting for days, weeks or months. One of the principal characteristics of the weapons is the incubation period that extends between the initial infection by the biological-warfare agent and the onset of disease; this may be of between a day and a month. Another characteristic is the poor degree of control, whether in space or in time, which the user of the weapons can exert over their effects. The agent may be carried far beyond the intended target area by natural processes of wind or drainage, or by living carriers of the agent or of the disease. In some cases also, the disease may be directly transmissible from man to man, thereby creating the risk of a spreading and persistent epidemic. These factors militate against the military utility of biological weapons.

49. *Chemical weapons* depend for their effects upon chemical-warfare agents. The latter have been defined by the UN Secretary-General as "chemical substances, whether gaseous, liquid, or solid, which might be employed because of their direct toxic effects on man, animals, and plants".[2] Against man, the weapons may be used either to kill or to cause disablement for a period of between a few minutes and a few days. Chemical weapons have much in common with biological weapons, but a greater degree of control can be exerted over their effects, and the time-lag before their effects become manifest rarely exceeds a few hours. They are therefore considered to have greater military utility than biological weapons. The area of effectiveness of a single chemical

[1] *Chemical and Bacteriological (Biological) Weapons and the Effects of their Possible Use: Report of the Secretary-General.* United Nations: New York, 1969 (document A/7575/Rev.1). This definition was derived from a report prepared by the World Health Organization, subsequently published in revised form as *Health Aspects of Chemical and Biological Weapons.* WHO: Geneva, 1970. A broader definition of biological warfare agents is implicit in Article I of the Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxic Weapons and on their Destruction, which was opened for signature in April 1972. This Article refers to "Microbial or other biological agents, or toxins whatever their origin or method of production, of types and in quantities that have no justification for prophylactic, protective or other peaceful purposes."

[2] UN document A/7575/Rev.1, *supra* footnote 1. This definition also was derived from the WHO report. The Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or other Gases, and of Bacteriological Methods of Warfare, signed at Geneva on 17 June 1925, refers to "asphyxiating, poisonous or other gases, and of all analogous liquids, materials or devices".

Table II.1

THE PRINCIPAL CATEGORIES OF WEAPON AND THEIR EFFECTS

Category of weapon	*Principal casualty effects*
Explosive	blast, fragmentation, other secondary effects
Penetrating	penetration, high-velocity effects
Incendiary	burns, asphyxiation, toxic effects
Nuclear	burns, blast, ionizing radiation
Biological	disease
Chemical	toxic effects

weapon may range between a fraction of a hectare and several square kilometres.

2. Military classifications of weapons, and the question of indiscriminateness

50. The weapons described in the preceding paragraphs may also be classified according to certain of their military characteristics. In one widely used classification of this type, a distinction is made between "antipersonnel" and "antimatériel" weapons. Another convention is to distinguish between point targets and area targets and, as a corollary, between "point weapons" and "area weapons". Area weapons, whose effects are extended in space, have a further counterpart in "time-delay weapons", whose effects are extended in time. These distinctions are discussed further in the following paragraphs. They are of assistance in relating concepts of military necessity to such questions as the discriminateness, or otherwise, of particular weapon applications.

51. Antipersonnel weapons are those which are primarily directed towards killing or otherwise incapacitating people. The distinction between them and antimatériel weapons is not clear-cut, however, for in the interests of flexibility there is a military requirement for multifunctional weapons. Thus, many of the weapons that are commonly described as antipersonnel are also intended to be effective against light matériel, such as trucks. Likewise, antimatériel weapons for use against armoured targets may exert their principal effects by penetrating the armour and then killing or injuring the crewmen. A spectrum of target "hardnesses" may be envisaged that necessitates a range of weapons having different combinations of penetrating and destructive abilities. Antipersonnel weapons are those which lie at the "softer" end of the spectrum. Those lying at the "harder" end of the spectrum, the antimatériel weapons, are, generally speaking, considerably more powerful than antipersonnel weapons; their effects on the human body may therefore be correspondingly greater.

52. Chemical, biological and radiological weapons are examples of weapons that are primarily antipersonnel in their nature, for they have little or no effect upon inanimate objects. The human body is also vulnerable to thermal and mechanical stresses such as those created by incendiary or explosive weapons. Thus all the principal categories of weapon described in the previous section of this chapter may be used as antipersonnel weapons.

53. In distinguishing between point and area weapons, it is necessary also to distinguish between, on the one hand, the means of warfare, which are the

weapons available to field commanders, and, on the other hand, the methods of warfare, which are the ways in which the weapons are actually used.

54. Point targets are, by definition, well defined and usually small in size. Weapons for use against them, namely point weapons, are matched to the scale of the target and depend for their effectiveness upon accurate delivery. Point targets may, however, also be attacked with weapons whose area of effectiveness is substantially greater than the area of the target. This may be considered militarily necessary in cases where the target is moving, or where only its general location, not its precise location, is known.

55. Area targets are, by definition, large in size and present no specific aiming point to an attacker. Examples include enemy troops deployed over a wide area, or targets comprising many buildings or other fixed installations. These types of target may be attacked with a multiplicity of weapons that individually have so small an area of effectiveness as to be classifiable as point weapons. Artillery bombardment, or the use of high rate-of-fire machine guns, are illustrations of this. Alternatively, the targets may be attacked with a smaller number of weapons that, individually, are effective over a broad area; examples include large fragmentation or incendiary weapons, or poison gas.

56. Weapons which are effective over a broad area, whether they are used against point targets or area targets, are known as area weapons. Information on the areas of effectiveness of representative weapons having, *inter alia*, anti-personnel applications is given in Table II.2.

57. The area of effectiveness of a particular weapon is obviously a dominant factor in determining the discriminateness with regard to combatants and noncombatants with which the weapon may or may not be used. The closer the proximity between combatants and noncombatants, the smaller must be the area of effectiveness of the weapon in order for discriminate use of it to become possible. However, since there may be circumstances in which there is no proximity between combatants and noncombatants, it is not possible to define the degree of discriminateness of a weapon solely in terms of its area of effectiveness. All that can be said is that, in circumstances where combatants and noncombatants are sufficiently close to one another, area weapons will inevitably be less discriminate than point weapons, regardless either of the accuracy with which they are delivered or of the diligence of the user in attempting to avoid injury to noncombatants.

58. Proximity between combatant and noncombatant may be specified in terms not only of distance but also of time. The foregoing remarks about the

discriminateness of area weapons apply equally to time-delay weapons. These may either be of the type that are fitted with delayed-action fuses set to function after a predetermined or random time interval; or they may comprise target-activated devices such as sea-mines, landmines, or traps. Weapons of these types may remain active for hours, days or even years, and since the circumstances of war may change considerably during this period, the weapons may expose noncombatants to a grave and prolonged hazard.

3. Problems in measuring degrees of injury and suffering experienced from war wounds

59. Towards the end of the last century, a number of military and medical experts attempted to calculate lower limits for the amount of energy needed to kill a man or otherwise place him *hors de combat*. They were principally concerned with the design of new rifle bullets. By the beginning of the present century several different estimates were current in different countries. They ranged from 40 joules up to 240 joules.[1] While these figures still have some currency today, it is realized that attempts to set a precise value on the minimum energy needed to incapacitate a man require so many qualifications that the estimates have little practical value. Factors such as the velocity of the projectile, the position of the wound, and the strength and morale of the victim, strongly influence the degree of incapacitation caused, regardless of the energy of the projectile. These factors are discussed in subsequent chapters.

60. Similar difficulties attend the quantification of the degrees of suffering imposed by, or experienced from, the different types of weapon injury. This matter is discussed below in some detail from a medical point of view. There seem at first sight to be three main criteria with which levels of suffering might be assessed, namely degree of pain, degree of permanent disability or injury, and probability of death. As will be seen, however, none of these provide much more than the crudest guidance.

(a) *Degree of pain from wounds*

61. Pain may be conceived as the product of two components, one physiological and the other psychological. A man will experience pain only when

[1] The units of measurement given in this report are those of the recent internationally-agreed *Système International d'Unités* (SI units), now coming into use for all scientific purposes to replace both the c.g.s. and the f.p.s. systems. The joule (J) is the derived SI unit of work or energy; it corresponds to one newton-metre, which is to say about 0.1 kg-metre.

Table II.2

AREAS OF EFFECTIVENESS OF REPRESENTATIVE WEAPONS HAVING ANTIPERSONNEL USES

Type of weapon	*Category of area effectiveness* [a] *(hectares)*
Hand grenade, high-explosive or fragmentation 70 mm rocket, high-explosive 81 mm mortar projectile, high-explosive 105 mm shell, high-explosive	0.01-0.05
81 mm mortar projectile, fragmentation [b] 155 mm shell, high-explosive Antipersonnel mine, Claymore type 81 mm mortar projectile, white phosphorus	0.05-0.2
350 kg firebomb, napalm 70 mm rocket, multiple fléchette	0.2-1
155 mm shell, multiple fléchette 155 mm shell, chemical (sarin nerve-gas) 250 kg bomb, general purpose, high-explosive 250 kg cluster-bomb, fuel-air explosive 105 mm battalion fire, high-explosive shell [c]	1-10
350 kg cluster-bomb, fragmentation [d] 105 mm battalion fire, sarin shell [c]	10-100
7000 kg bomb, light case, high-explosive	100-500

[a] The range of areas that includes the area of effectiveness of the weapon concerned, "area of effectiveness" meaning the area within which an unprotected man standing in the open has at least a 50% probability of becoming a casualty. The figures are derived from a number of different military manuals and similar sources which refer specifically to the anti-personnel applications of the weapons (rather than antimatériel or smoke-screening applications.) Some of the figures are not strictly comparable, for, apart from operational considerations, there are differences in the severities of the casualties concerned.

[b] Notched-wire controlled fragmentation.

[c] A total of 72 rounds fired from six howitzers.

[d] Pre-fragmentation (pellet) bomblets.

two processes have occurred: the reception by the brain of a particular type of nerve signal, and the response of the brain to that signal. The signal will originate in the site of injury, and the response of the brain will be a consciousness of pain.

62. It follows at once from this that the degree of pain imposed by a particular weapon-injury will depend, not only on the amount of damage, but also on the psychology of the victim. It is this subjective element that is the principal obstacle to the quantification of pain.

63. Related to this matter is the commonly accepted view that certain types of physical injury are likely to cause particular psychological distress. Such injuries include those that might lead to permanent disability or deformity, especially facial disfigurement, loss of one or more of the senses, and impairment of reproductive capacity. This particular psychological component must obviously be included in any assessment of suffering, but, as it too is largely subjective, it cannot reasonably be quantified.

64. Setting aside these psychological questions, it is possible, and common practice, to speak of "physical pain". This is more accessible to quantification because it is determined in the first instance only by physical damage.

65. Pain arising at the time of injury may be severe, but it is frequently the case in war situations that little initial pain is in fact felt because of the state of excitement of the victim. This phenomenon has been observed many times (e.g. soldiers have walked long distances holding their intestines in their hands, or after having broken a leg have walked on the wounded leg without feeling pain). However, during the hours after wounding there is an increase of pain due to release of pain-producing substances and the onset of infection.

66. The intensity of the pain that ensues during the period after injury may become exceedingly great. It is determined by many factors, such as the situation and severity of the wound; the quality of first aid by dressing, splintage and drugs employed; the type, duration and circumstances of transport; and the time and availability of surgical treatment. Infection associated with complicated wounds necessitating prolonged treatment and many surgical interventions prolongs the duration of pain until healing has occurred. Scars are sensitive, and even painful, for many months. Residual infections and deformities may prolong pain for many years.

67. As a very general rule, the more tissue that is damaged the more painful will be the wound. (The factors described in paragraph 66 are of course also involved, to say nothing of the psychological element referred to in paragraph 62; according to circumstances, these may in fact be dominant.) Thus,

extensive fractures combined with crush injuries of the soft tissue will be particularly painful. So will multiple wounds caused by many fragments. The wound caused by a high-velocity missile, being large, will be more painful than the smaller wound caused by the same missile at low velocity.

(b) *Probability of death*

68. As a criterion of the degree of suffering or injury imposed by a particular weapon, the probability of death is no easier to predict or specify than the pain criterion. This is because the probability depends upon several factors that are only in part determined by the weapon itself or the manner in which it is used. They include:

(1) the localization of the wound in the body;

(2) the time lag between injury and treatment; and

(3) the state of physical resistance of the wounded person.

69. Different parts or organs of the body are important for life to varying degrees. Thus it is obvious that if a particular bullet penetrates the head of a person, it is likely to kill him, whereas if it penetrates the foot it will probably only put him out of action for a relatively short time.

70. A hit by a multiplicity of projectiles or fragments is more likely to injure a vital organ than a hit by a single projectile. This is self-evident, but the matter is complicated since two wounds that in themselves are not lethal, may together put such a stress on the body that the probability of death increases. The more organs that are injured the higher is the probability of death. If more than five different organs, for instance, are injured in the abdomen, death is statistically inevitable even if the victim survives the primary injury.

71. The time between wounding and adequate care will influence the prognosis of most war casualties. Good first aid and adequate surgical treatment will reduce the mortality rate among those surviving the primary injury. If the delay between wounding and surgical intervention is more than six hours, the mortality rises sharply.

72. With improvements in military medicine and surgery over the past decades, the mortality rate among the battle casualties of well-equipped armies has declined markedly. Thus, in the case of US battle casualties, the rate has fallen from 17% in World War I to around 2% in the Korean and Vietnam wars. Increasingly rapid transportation of the wounded has also been a prominent factor in this. Similar statistics relating to civilian war victims are not

available; their mortality has almost certainly been considerably higher. Civilian victims may be of all ages and both sexes. Children, old people, and pregnant women generally have a reduced resistance towards war injuries compared with the soldier. Resistance is seriously reduced among people exposed to famine, thirst, or cold climates. By way of illustration, it may be noted that mortality from abdominal injury among civilian people in Germany during World War II was 49% as compared with 35% among British soldiers; both groups received the same type of treatment.

(c) *Degree of disability after injury*

73. Generally speaking, the majority of weapon casualties brought in for medical or surgical care within a few hours will be cured, and their disability be only of short duration. It has usually been the case that more than 50 per cent of combatant battle casualties have been able to return to duty within a few weeks. When they occur, however, the disabilities succeeding weapons injuries may be of great variety. They may be due to the injury itself, or to complications developing after the injury.

74. Since so many different factors play an important role in determining the resulting disability, not even this criterion is at all precise for assessing the suffering imposed by a particular weapon. Typical disabilities include loss of one or more of the senses (e.g. sight or hearing); permanent or temporary damage to other parts of the nervous system; or damage to nonvital organs or to the extremities.

75. Injuries to the central nervous system (the brain and the spinal cord) frequently lead to especially severe disability. Here the disability is usually permanent. It may comprise partial or complete loss of mental capacity or of physical function. There may be loss of one or more of the senses (e.g. sight or hearing). Damage to the peripheral nervous system may lead to paralyses of various types and muscular atrophy. Modern techniques of neurosurgery and rehabilitation may considerably ameliorate these disabilities. Treatments of this type take a much longer time, however, than the treatment of most other weapons injuries; thus, even if the disability proves to be temporary rather than permanent, it will nevertheless be of prolonged duration.

76. During the rehabilitation and resocialization of a patient suffering from wound disabilities, it is necessary to take into account the psychological trauma to which he has been, and continues to be, subjected. The attendant psychological disability is very difficult to gauge. It may, for example, only develop after a substantial lapse of time, and it may well prove to be permanent, even though the original physical injury was relatively small.

CHAPTER III

Small-calibre projectiles

1. Historical background

77. For several centuries after the introduction of firearms, the existing state of the art of weapon manufacture restricted the design of the soldier's personal weapon to a simple muzzle-loading musket, typified by the British *Brown Bess*, which remained in service for well over a century. With such weapons it was usual to employ heavy spherical lead bullets of some 20 mm diameter. Fired in volleys, these were very effective at short ranges, but they were already grossly inaccurate at 200 m. In the middle of the 19th Century the muskets were rifled, and when fired with a solid lead bullet of the Minié type (calibre ca 14.7 mm) which were no longer spherical but elongated, with an expanding base to engage the rifling, they were quite effective and fairly accurate at 1,000 ft, despite the fact that they were still muzzle-loaders. The American Civil War, essentially a small arms war, was mainly fought with weapons of this type on both sides.

78. The appearance of the breech loader as the general infantry weapon was sign-posted by the mid-century Chassepot and Dreyse rifles, but the production of the modern type to manually-operated rifle had to wait another decade or so before the development of the brass cartridge case (itself an intricate multi-stage operation) and the introduction of smokeless powder, based on nitro-cellulose. With these developments the manufacture of rifles and ammunition that were lighter and yet more powerful became possible.

79. These more powerful weapons had calibres which tended to lie between 7.5 and 8 mm, and had muzzle velocities of around 700 m/s. To meet these conditions it became necessary to coat the lead bullet with a jacket of a harder metal such as a cupro-nickel alloy. Such bullets were usually of a blunt-nosed, gently tapering, cylindrical shape, and were fairly stable in flight. Not infrequently they passed right through the body without causing extensive damage around their path, giving up to the body only some 20% of their kinetic energy.

80. Doubts then arose as to whether such a bullet had adequate stopping power, either for big game or for a charging enemy. This led to the introduction

of bullets in which the hard metal jacket was cut in such a way as to allow the lead core to flow out on impact, thereby transferring more of the kinetic energy of the bullet and thus increasing the severity of the wound. Bullets of this type have been made in many forms, generically known as "dum-dum" bullets. However, the exceptionally severe wounds which they could cause excited general horror, and their use in war was internationally banned in the Hague Declaration of 1899.

81. Early in the 20th Century, a pointed bullet was introduced into the German service, and soon afterwards in most other countries. These were found on occasion to produce very severe wounding, and so came under suspicion of acting like dum-dum bullets. This was disproved, and it was found that these bullets sometimes tended to "tumble" on impact, thereby transferring as much as three-quarters or more of their kinetic energy, and greatly enlarging the wound. One of the principal reasons for this occasional behaviour was, as is described in more detail below, the higher velocity of the bullet (around 750-800 m/s at the muzzle).

82. Over the years since then, 7.62 mm calibre projectiles have become the most common standard ammunition for rifles and machine guns. Since the early sixties weapons of 5.56 mm calibre, whose projectiles have a very high muzzle velocity (over 950 m/s), have also begun to come into use.

83. More recently still, research and development work has begun to provide techniques for firing fléchette ammunition from infantry weapons. A fléchette is a miniature dart commonly weighing in its steel version less than a gram (there is a heavier version made of depleted uranium). A typical one is about 30 mm long and resembles a wire nail with miniature fins at its tail; it was originally designed to be fired singly from special rifles with a very high velocity (over 1250 m/s). Because of its favourable ballistic shape, it can retain a high velocity even after 400 m or so of travel, but except at short ranges its accuracy is poor. As a way of increasing the hit probability of rifle-fired fléchettes, particularly against moving targets, a rifle round is being developed that comprises a small package of fléchettes. A smooth-bore shot-gun cartridge containing 20 fléchettes is also in use. This kind of ammunition is intended for close combat.

2. Weapons for firing small-calibre projectiles

84. There are many different types of small-calibre weapon for single projectiles. Their casualty effects, however, depend less on their differences in construction than on the types of ammunition which they use. They may be

classified into the following groups: pistols and other hand-guns; submachine guns; rifles and assault rifles; and machine guns.

85. Hand-guns usually only fire ammunition of relatively small kinetic energy, so that their effects are relatively weak when compared with other types of firearm. Modern military service weapons are nearly all of 7.5 or 9 mm calibre, and few if any have a muzzle velocity much in excess of 425 m/s. Consequently, although the bullet frequently remains in the body, it does not cause wounds as severe as those of high-velocity rifle bullets.

86. Submachine-guns generally use normal pistol ammunition (e.g. 9 mm) or other such ammunition whose kinetic energy is smaller than that of rifle or machine-gun ammunution.

87. Rifles and assault-rifles constitute the basic infantry weapon of most armies. As noted earlier, the most common ones have a 7.62 mm calibre (e.g. the current M-14 and AK-47 assault rifles). The M-16 5.56 mm rifle may be mentioned as one example of the new generation of smaller calibre weapons which are beginning to replace the older, larger calibre ones.

88. Machine-guns usually fire standard rifle ammunition. There are heavier ones, e.g. of 12.7 mm calibre, but they are used primarily against vehicles or helicopters. They have high muzzle-velocities.

89. There are also certain types of lighter machine-gun that have been developed with the specific aim of delivering so many projectiles over an area that the hit-probability against personnel increases greatly. This is mainly achieved by a very high rate of fire secured, for example, through the multi-barrelled Gatling-gun mechanism. Such weapons may fire at a rate of 4,000-10,000 rounds per minute.

3. Military requirements and the design of small-calibre projectiles

90. In the design and development of new, small-calibre projectiles, the principal military requirements are for smaller weight, and increased hit-probability, but without decrease in the kill- (or incapacitation-)probability of each projectile.

91. During World War II, many armies tried to develop lighter infantry weapons, coming to realize that for most infantry combat functions good ballistic properties were not necessary at ranges exceeding 400 m (90% of all engagements taking place within that range). It was considered more important for soldiers to be mobile, and for infantry to have light and handy weapons.

In particular, a reduction in the weight of ammunition was considered essential. This is still the case, and has been one of the main reasons for the development of the 5.56 mm calibre weapons referred to earlier. These weapons fire a projectile weighing less than four grams (as compared with the 9-10 grams of 7.62 mm projectiles) at a muzzle velocity exceeding 950 m/s.

92. Other things being equal, hit-probability generally increases with increasing velocity, since the trajectory of the bullet will be flatter and the time of flight shorter. High-velocity small-calibre projectiles show excellent ballistic properties at the beginning of their trajectory, but projectile velocity and energy decrease sharply with increasing range. This has not been considered a serious disadvantage, however, since at 400 m the earlier type of projectile, such as the M-14 7.62 mm round, had some 20 times the energy considered necessary to incapacitate a man, and indeed about twice as much as required to defeat body armour (about 700 joules). The M-16 (Armalite) rifle round loses velocity more rapidly than the 7.62 mm round, as would be expected of its light weight, but at 400 m it still has more than enough residual energy to incapacitate an unprotected man, and perhaps just enough to defeat body armour. The fall-off in velocity and kinetic energy with distance is illustrated for representative projectiles in Table III.1.

93. It is instructive to consider the case of two bullets that have the same kinetic energy but different calibres. The bullet of smaller calibre has the smaller weight, so that if its kinetic energy is to equal that of the larger bullet it must be projected at a higher velocity, for its kinetic energy is proportional to the product of its weight and the square of its velocity. However, the velocity of the smaller bullet will decline more rapidly as it proceeds along its trajectory so that, even if the initial kinetic energy of the smaller bullet is equal to that of the larger one, this equality will not be maintained, and its energy will fall below that of the larger bullet. If, therefore, the user wishes to secure the advantages of lighter ammunition and lighter weapons, he must endow the lighter bullets with a greater initial velocity (though the consequence of the square law relating velocity and kinetic energy is that this increase need not be very large). This increase in velocity tends to increase markedly the severity of the wounds inflicted by the lighter bullets.

94. When the projectile is not sufficiently stabilized by the spin imparted by rifling, the tumbling effect referred to in paragraph 81 may also be observed, the projectile turning end-over-end when it hits the human body. Wounds involving this effect are particularly serious since the tumbling results in a more complete energy-transfer during the moment of impact.

95. It is difficult to specify the criteria that determine whether a projectile penetrating into the human body remains stable. A projectile may show stable

Table III.1

BALLISTIC FEATURES OF REPRESENTATIVE PROJECTILES AND FRAGMENTS

Type of missile	*Mass of missile (grams)*	*Missile at point of release*		*Missile after travelling 100 m*		*Missile after travelling 400 m*	
		Velocity (m/sec)	*Kinetic energy (joules)*	*Velocity (m/sec)*	*Kinetic energy (joules)*	*Velocity (m/sec)*	*Kinetic energy (joules)*
7.62 mm bullet as for the M-14 rifle	9.7	870	3,800	800	3,200	600	1,700
7.62 mm bullet as for the AK-47 rifle	7.9	720	2,100	630	1,600	390	610
5.56 mm bullet as for the M-16 Armalite rifle	3.6	980	1,700	830	1,300	490	440
Fragment from high-explosive shell	(1-100)	1,250	780		1	0	0
Fragment from controlled-fragmentation (notched wire) grenade		1,000				0	0
Pellet from prefragmented bomblet	1.0	1,250	780		50		

flight in the air, and then overturn when penetrating into another medium. This depends on the velocity, spin, length and shape of the projectile.

96. The present high level of technology in the field of weapons and ammunition undoubtedly means that the high-velocity and tumbling effects could be used to design very light weapons of extremely high destructive power.

4. Medical effects of small-calibre projectiles

97. The greater medical effect of high-velocity weapons is partly due to the energy resulting from the high velocity. It is also due to the fact that, compared with lower-velocity projectiles, a higher proportion of the energy of the projectile is transferred to the tissue upon impact. The energy-transfer is more efficient in part because the high-velocity projectile tends to tumble or break up in the wound, and in part because of the more intense hydrodynamic shock-waves which it creates.

98. As noted earlier, a rifle bullet with a velocity of less than about 800 m/sec., fully jacketed and of conventional shape, transfers, in a typical case, about 20 per cent of its kinetic energy upon penetration of human tissue. The amount of energy transferred can be increased if the projectile is provided with a soft point which deforms on impact with the body. By this means, as much as 80 per cent of the energy of the bullet can be transferred. This is a characteristic of the dum-dum bullet.

99. Projectiles of high velocity and of a high length-to-calibre ratio are unstable when passing from air to a denser medium such as human tissue. The spin imparted by rifling is not sufficient to stabilize the projectile under these conditions. As the projectile will rarely strike the target at right angles, it will start to tumble immediately. The bullet will thus transfer its energy to the surrounding tissue at a high rate even if it does not deform on impact like a dum-dum bullet. If the jacket of the bullet is thin, it may break under the enormous forces acting on the projectile as it tumbles; the bullet will then exhibit a true dum-dum effect even though it was not primarily designed to do so.

100. A projectile which strikes a bone can transfer energy to bone fragments, which may then act as secondary projectiles. These can cause further tissue damage, or if they strike abdominal organs, greatly complicate treatment. High-velocity projectiles have a great capacity for producing secondary projectiles in the human body. Low-velocity projectiles seldom produce them.

101. The wound caused by a low-velocity projectile in human tissue is localized. As in the case of a knife wound, it is only the tissue in direct contact with the

projectile which is affected. Little energy is transferred to tissues in the vicinity, and the wound, practically speaking, is localized.

102. The situation is very different when a high-velocity projectile strikes tissue. A temporary cavity is formed behind the projectile because the tissue is thrown out at high speed radially from the projectile by the hydrodynamic shock wave. The force with which the tissue is slung apart depends on the energy the projectile imparts as it passes along its path. The temporary cavity reaches its maximum size about two milliseconds after the strike, and pulsates with declining amplitude, soon shrinking to a smaller, permanent cavity. As the projectile passes, it sets up a strong shock wave in the surrounding tissue. This can damage blood vessels and nerves which are at a considerable distance from the path of the projectile. Even bones at some distance can be fractured. The shock waves sent out as the cavity pulsates are not so strong, but may cause some increase of the damage. The high radial force to which the tissue is subjected when the temporary cavity is formed is the main cause of the damage produced by high velocity projectiles.

103. The density and elasticity of the tissues struck by a projectile, or which are involved in the temporary cavity, make a great difference to the degree of damage done. Muscle is particularly vulnerable on account of its relatively high homogeneous density. The lungs, with their spongy texture and high air content, absorb less energy, and have less tendency to form temporary cavities. Other things being equal, therefore, damage to lung tissue will be less than damage to muscle.

104. The entrance opening of a through-and-through wound caused by a projectile with high impact energy is only very slightly larger than the size and appearance of the bullet at the point of impact. But, on account of the formation of the temporary cavity, the exit hole often becomes much larger. At the exit of the projectile an explosive effect is observable. There are often large tears in the skin caused by the action of the pressure wave on the tissue around the exit. The elastic skin is fairly resistant to the pressure wave but is torn apart in the same way that fabric tears.[1]

105. During the formation, pulsation, and contraction of the temporary cavity, alternating positive and negative pressures arise. These create a suction effect into the missile track of a through-and-through wound, with the conse-

[1] The medical literature contains many photographs that illustrate very clearly the difference in kind between the wounds caused by low velocity projectiles and those caused by high-velocity ones. A set of photographs of this type is contained in the report by the Stockholm Working Group on Inhumane Weapons, that was released in June 1973 by the Government Minister responsible *(Conventional Weapons: Their Deployment and Effects from a Humanitarian Aspect)*.

quence that bacteria are drawn in from the surrounding skin surfaces. Following the passage of a high-velocity bullet, the missile track is surrounded by a quantity of necrotic or damaged tissue with poor blood circulation. The bacteria which have been sucked in are thus provided with an excellent growth medium. The large amount of tissue destroyed at a distance from the actual missile track, the presence of secondary projectiles, and the certainty of infection of devitalized tissues, are the main features distinguishing wounds of this type from most other injuries occurring in peacetime.

106. The effects described above are typically found in wounds of the extremities caused by high-velocity missiles. The temporary cavity produced by high velocity missiles hitting the abdomen is somewhat different. Its pulsating movements are not so pronounced, but the movements of the abdominal wall are larger. The formation of the cavity presses the viscera against the abdominal wall. It is probable that the intestinal perforations often seen far from the actual missile track are caused by expansion of local gas bubbles in contact with the intestinal wall. The liver is very vulnerable. If it is hit directly with a high-velocity projectile the density of the organ enables the kinetic energy to be widely transmitted within it.

107. The thoracic cavity is surrounded by the comparatively rigid, ribbed thoracic wall. A temporary cavity is formed, but, as mentioned earlier, it is of a comparatively small size. However, the change in pressure may produce heart arrest or disturbance of the blood circulation.

108. The rigid bone structures enclosing the brain exacerbate the injury when the head is hit by a high velocity missile. The temporary cavity that is formed literally pushes the brain through the *foramen magnum*, thus causing lesions of the brain stem, with impairment of the regulation of breathing and of blood pressure. Depending on the speed and impact energy of the missile, varying amounts of brain tissue and of the bone structure of the skull are destroyed. Probably the primary cause of death is damage to the brain stem.

109. If the bone structure of the spine is hit, much of the energy of the missile is transferred to the spinal cord, producing relatively severe lesions. Depending on the height of the lesion, varying neurological effects may result. If the wound involves both intestines and the spinal cord, the mortality risk is extremely high.

110. The treatment of high-velocity wounds depends upon the part of the body that has been hit, and on the medical facilities available. In all high-velocity wounds there is massive destruction of tissue. The damaged tissue is invariably contaminated with bacteria, as described in paragraph 105. To avoid severe infection, the damaged tissue must be removed. Thereafter, in most parts of

the body the wound should be left open for some time and, if circumstances permit, closed later. This surgical procedure must be performed, for there is no other safe way of treating high-velocity wounds. Antibiotic treatment cannot substitute for the surgical procedure.

111. Since high-velocity wounds very seldom occur in peace-time, most surgeons are not familiar with their specific treatment. This often leads to prolonged healing periods and a high risk of mortality and disability.

5. Salient features of the chapter

112. In recent years, certain military requirements, notably for lighter, more convenient personal weapons for the individual soldier, have led to the development of small-calibre projectiles that are fired at considerably greater velocity than hitherto. Wounds from projectiles that strike the body at more than about 800 m/sec differ both in degree and in kind from wounds caused by lower-velocity projectiles. Because of the tendency of high-velocity projectiles to tumble and become deformed in the body, and to set up especially intense hydrodynamic shock-waves, the wounds which they cause may resemble those of dum-dum bullets.

CHAPTER IV

Blast and fragmentation weapons

113. This chapter describes weapons which act through blast and fragmentation. These effects are displayed to varying degrees by all explosive munitions. A spectrum may be envisaged extending between weapons that maximize blast, such as the fuel-air explosive devices, and weapons that maximize fragmentation, such as the multiple-fléchette projectiles. Near the middle of the spectrum are such weapons as the "general-purpose" aircraft bomb which can inflict major damage both through blast and through fragmentation.

114. In the sense that the effects of an explosive burst, whether they are blast or fragmentation, may extend through a large volume of space, no explosive weapon can strictly be classified as a point weapon. Some such weapons may employ so small an explosive charge, however, that it would be inappropriate to classify them as area weapons. Examples would include small-calibre high-explosive projectiles, such as those designed for 20 mm aircraft cannon; they might also include artillery projectiles and the smaller aircraft bombs. Equally, it is important to note that certain weapons which dispense individual small-calibre projectiles may be directed effectively against area targets. This requires that the target be swept by a sufficiently large number of projectiles fired in rapid succession. Machine-guns, particularly those of very high firing-rate, are cases in point. Weapons of this type have much in common, therefore, with fragmentation weapons which dispense a large number of missiles over an area in a single burst.

115. The individual missiles released by fragmentation weapons are subject to the same ballistic considerations as the small-calibre projectiles described in the previous chapter. For this reason, much of what is said in that chapter, both as regards the design criteria for weapons and as regards medical effects, is also relevant to the discussion below of fragmentation weapons.

1. Blast weapons

116. Blast weapons are those whose principal effects result from the shock waves released when a high-explosive charge detonates. Blast effects are primarily sought from munitions which are to detonate in water or inside more

or less enclosed spaces. In the case of munitions such as massive aircraft bombs, blast effects may be important even if the munitions burst in the open air. Munitions can also be constructed in such a way that their effects are concentrated in specific directions; this may be needed for such purposes as the rapid clearance of helicopter landing zones or for action against hard targets. If the munition first penetrates into a medium such as earth or water before it bursts, it is usually said to have a mine effect, and the shock waves passing through the medium play a major role in obtaining the desired results. Most blast munitions also exert fragmentation effects through rupture of their casings. These effects can be minimized, and blast maximized, by using lightweight casings. Such a possibility is not available for gun-launched projectiles because these must be robustly constructed in order to withstand the setback forces.

117. Examples of blast munitions include light-case massive bombs for aircraft, certain missile warheads, certain antipersonnel mines, anti-tank mines, naval mines and torpedoes.

118. The important factor in the construction of blast munitions is the total volume of gas released by the detonating explosive. Special high-explosives have therefore been developed for blast munitions. These are usually produced by compounding a normal military high-explosive with varying proportions of a metal that has a strong exothermic reaction with oxygen. The metal, often aluminium, is usually introduced in the form of powder or fine flakes. This mixture may also give a significant incendiary power to the exhaust gases from the explosion.

119. The purest blast munitions are the new fuel-air explosive (FAE) devices. They consist of a special container filled with a combustible, volatile liquid, such as ethylene oxide. This liquid is forcibly sprayed out into the air above the target area. After a delay of up to a few seconds, the air-diluted cloud of liquid fuel becomes explosive, and at this point a detonating device is functioned. A blast wave effective over a wide area results from the explosion. At present, this type of munition is primarily intended for the clearance of mine fields containing pressure-sensitive mines: a charge of about 30 kg of ethylene oxide is enough to set off most if not all mines within a circle of 15 meters diameter. Some FAE bombs contain as much as 500 kg of fuel. FAE weapons have also been used as antipersonnel weapons.

2. Fragmentation weapons

120. Explosive munitions maximizing fragmentation effects have been developed for most of the existing weapon-delivery systems. Within this category,

artillery shells, aircraft bombs and bomblets, rocket warheads, land mines, hand grenades, rifle grenades and mortar projectiles have all been developed, and many of them extensively used. Although they may also have significant blast effects, they may be referred to generically as fragmentation munitions.

121. Fragmentation munitions act by ejecting a large number of fragments at a high velocity, usually in a symmetrical pattern around the bursting munition. They can also be constructed so that the fragments are concentrated along a linear trajectory, as in certain antipersonnel mines. The size of the fragments may range from hundreds of grams down to fractions of a gram.

122. It is possible to distinguish between two main types of fragment: those obtained by spontaneous fragmentation and those by prefragmentation. In between these two types there are various methods for optimizing fragmentation patterns, a technique known as controlled fragmentation. All these approaches seek to achieve the optimal balance between the number of fragments released and the energy which each of them contains, that is to say between hit-probability and kill- or incapacitation-probability.

123. The size of fragments from spontaneously fragmenting munitions depends on the type of explosive used and on the material within which the explosive is encased. Technology has now made it possible to predetermine, within certain limits, the shape and size of fragments by suitable construction of the munition.

124. As regards the design of antipersonnel fragmentation munitions, there is a trend towards smaller and smaller fragments. It has been found that, at fragment velocities attainable with the newer types of explosive, even a fragment weighing a fraction of a gram may put a person out of action. If this degree of fragmentation can be achieved with a munition, both its hit-probability and its kill- or incapacitation-probability will be increased. There will, however, be an increased likelihood of several fragments hitting the same target if this is in the proximity of the burst. A typical 15.5 cm artillery shell of conventional design, for example, usually ejects about 3,000 fragments weighing more than 0.5 grams; in contrast, a typical modern fragmentation shell of the same calibre yields about 15,000 fragments weighing less than 0.5 grams.

125. In order to secure the greatest military benefit from fragmentation effects, the spread of fragments must be as even as possible over the area within which, by virtue of their velocity, the fragments retain a high incapacitation- or kill-probability. It would be a waste of available fragment material to make the fragments too large, but if they were made too small, they would lose too much of their energy through retardation before hitting the target. A compromise approach that has been exploited since the time of World War II is the use of clusters of small fragmentation munitions. Here, the available fragment

material is divided between a number of small bombs ("bomblets") which are scattered over the target area prior to burst. This achieves a shorter fragment trajectory to the target, and therefore permits a finer fragmentation than if the same fragment mass were ejected from a single munition. Another consequence of the division into bomblets is that it becomes possible to obtain a more even distribution of fragments over the target area. The influence of protection provided by the landscape is thereby reduced.

126. One example of an extensively used fragmentation cluster-bomb contains nearly 700 bomblets each weighing about 0.5 kilograms; in outward appearance the munition resembles a massive bomb of 350-kg rating. A person standing 15 metres from one of the bomblets when it explodes will probably be hit by at least five fragments, each weighing about half a gram.

127. The types of target against which fragmentation cluster weapons are mainly used are large-area targets with a relatively low protection level (e.g. combatants in the open), and important point targets where it is necessary to obtain a direct hit for attaining a sufficiently high kill-probability. Cluster weapons may also dispense bomblets such as the shaped-charge ones used against such targets as tanks and armoured personnel carriers.

128. A particularly characteristic feature of modern fragmentation munitions is the high initial velocity of the fragments which they dispense: 1,000-2,000 m/s is common. Small fragments retard rapidly in their trajectory, however, especially if they are irregularly shaped; figures illustrating this are included in Table III.1. Impact velocities of over 1,000 m/s may nonetheless occur, and such fragments may have the severe and characteristic medical consequences that have been described in the previous chapter. In addition, non-spherical fragments have a greater tendency than small-calibre projectiles to roll in their trajectory, or to align their larger surface across the trajectory; this increases their ability to transfer energy to the human tissue that they penetrate.

129. Fragments from spontaneously-fragmenting munitions tend to have sharp edges and irregular shapes. The casing that yields the fragments is manufactured from steel or from some other heavy metal. The older high-explosive shells usually had a long cylindrical body which tended to fragment into long, thin splinters. Nowadays shell-casings are usually shorter with a curved inner surface; this, in combination with the use of more highly fragmenting casing alloys, causes each fragment to be more in the shape of a cube or a sphere. Fragments of this type are more efficient from the point of view of air drag, a factor which increases their effectiveness against the harder types of targets. In general, though, fragments from normal fragmentation munitions are not particularly effective against armour, so that such targets as

armoured personnel carriers need direct hits. For use against this category of target, however, there are special types of fragmentation munition that yield large, heavy, high-velocity fragments.

130. Concerning controlled fragmentation, one of the objectives is to produce parallelepiped or cube-shaped fragments. It is usually impossible to eliminate completely some spontaneous fragmentation of the casing material, and this means that controlled-fragmentation munitions nearly always generate a spectrum of fragment sizes.

131. In the case of pre-fragmented munitions, the fragments are usually of a spherical shape for reasons of aerodynamics, penetration and manufacture. The number of these pellets can be very large. Each bomblet in the cluster-bomb described in paragraph 126 contains about 300 pellets, so that the whole munition can dispense about 200,000 pellets.

132. A more recent type of pre-fragmentation munition dispenses fléchettes of the type referred to in paragraph 83. At present fléchettes cannot be accelerated with high explosive, but have to be fired with a powder charge from a special shell, usually of the head-ejection type like the classical shrapnel. These are the so-called "beehive" weapons. A 15.5 cm beehive artillery shell may contain several thousand fléchettes. The velocity of the fléchettes released from beehive ammunition does not usually exceed about 900 m/s unless the motion of the munition itself can augment significantly the velocities imparted by the powder charge. This may be the case with beehive warheads for high-velocity air-to-ground rockets. If the fléchettes strike the body at impact velocities exceeding 900 m/s, they may tumble in the wound, giving rise to particularly serious medical consequences. Because of their great aerodynamic stability, they do not usually tumble at lower velocities.

133. It is possible to heighten the effects of pre-fragmentation munitions by making the fragments from particularly hard or dense materials (such as tungsten carbide and sintered tungsten, or depleted uranium). By increasing the density of the fragment, air retardation is lowered and the fragments may thus have a higher impact velocity at the target. Munitions using fragments of these special materials may, however, be very costly, and the benefits are appreciable only against targets with a high level of protection. When used against unprotected people there is little to be gained.

134. Generally speaking, controlled fragmentation or pre-fragmentation munitions are militarily more efficacious than spontaneously fragmenting munitions. The drawbacks of pre-fragmentation, and to a lesser degree of controlled fragmentation, include higher production costs and the reduced strength of the casing, which is an important factor for gun-fired munitions.

If optimal effects are to be obtained from such munitions they must, however, be designed for specific targets. This means that particular fragmentation munitions are often only of tactical value against particular types of target; their effects on other targets with, for example, only a slightly higher degree of protection, may be slight. Munitions constructed for use against people may have little or no effect on matériel. The human body is, however, among the most vulnerable of all potential military targets, so that munitions designed for less vulnerable targets may have a devastating effect upon it. Munitions primarily intended to be used against light matériel (e.g., non-armoured vehicles) may in particular be used with great effectiveness as antipersonnel weapons.

3. Military applications of blast and fragmentation weapons

135. Blast and fragmentation weapons have many antimatériel applications. The following paragraphs, however, deal only with their antipersonnel uses.

136. A common military requirement is for weapons to incapacitate military personnel dispersed over a large area. This may arise both in conventional and in antiguerrilla warfare. In some cases the primary objective may be to eliminate the crews of anti-aircraft or field-artillery units. Fragmentation cluster-bombs of the type referred to in paragraph 126 were originally designed for these purposes. They are used from ground-strike aircraft, and are constructed to give the appropriate area coverage. Tests carried out show that fragmentation cluster-bombs are several times more effective than conventional bombs and shells when directed against "soft" targets.

137. A single 350-kg fragmentation cluster-bomb may effectively cover an area of about 300 × 900 m. A fighter bomber can carry at least four weapons of this type, and a larger aircraft many times more. Although heavy bombers usually carry antimatériel weapons, these may have antipersonnel effects over an area of several square kilometres per aircraft.

138. Beehive warheads delivered from salvoes of air-to-ground rockets have an area-effectiveness comparable to cluster-bombs. A typical 70 mm beehive rocket warhead may dispense its fléchettes over an area of 200 m × 40 m. A fighter-bomber may carry several dozen of these weapons in addition to other armament.

139. Large area effects may also be obtained from artillery weapons although, unless they are used in large numbers, their area-effectiveness will be smaller than that of ground-support aircraft. Beehive projectiles have provided a major increase in the capacity of artillery for engaging area targets.

140. Fragmentation warheads are being developed for surface-to-surface rockets, both small and large. These also will increase the antipersonnel area-coverage capabilities of ground forces.

4. Medical effects of blast and fragmentation weapons

(a) *Blast effects*

141. The medical effects of shock waves transmitted through air depend on the duration of the waves. An explosion which produces shock-waves with more than a certain minimum duration, and of short wave-length, is very likely to damage the viscera or other internal organs. At longer wave-lengths, the risk of rupture of internal organs is less.

142. The eardrum ruptures when exposed to an overpressure of about 35 kilopascal.[1] With this one exception, the human body can resist an overpressure of up to 250 kPa if the shock wave is short. This, however, presupposes that the person is not in contact with any solid objects. A shock wave which is transmitted to the body directly from solid materials can produce severe injury even when the overpressure is considerably lower than the figures given above. Injuries can also be inflicted at lower overpressures if the victim is in the vicinity of an object which reflects the shock wave, but in this case the maximum overpressure must be a good deal higher.

143. Shock waves are transmitted more rapidly in water than in air, and because their retardation is less, they are effective at greater distances from the explosion. The human body has approximately the same density as water, and the shock wave is transmitted through firm media (such as bone) without significantly disturbing them. However, if the shock wave passes through gas-filled cavities such as the lungs or the intestines, severe local injury may be caused. Consequently, shock waves from underwater explosions mainly result in injury to abdominal organs and the thorax of anyone in the water at the time of the explosion.

144. Shock waves transmitted through hard objects, such as ship decks or the sides of tanks can, without damaging the hard material, be transmitted to people who are in contact with that material. Multiple fractures, injuries to major blood vessels or to internal organs far from the contact surface may result.

[1] The pascal (Pa) is the derived SI unit of pressure. 100 kilopascal (kPa) corresponds to about 1 kg/cm^2.

(b) *Fragmentation effects*

145. As noted in paragraph 44, the greater proportion of battlefield injuries in modern conventional warfare are caused by fragments from bombs and shells. Although the quantitative ballistics of fragments and bullets may differ greatly, they have, in principle, comparable effects on the human body. This is because each fragment acts as a single projectile when it hits a target. Its effects will depend upon its weight, size, shape and velocity. Much of what is said in the medical section of the previous chapter applies here also, and will not be repeated. The main difference is that with fragmentation weapons, the hit probability is higher and there is greater likelihood of multiple injuries.

146. As regards mortality rate, the predominant factor in multiple injuries to an individual is the number of organs affected. From data collected from the records of World War II, it was found that with adequate medical care within 7 hours of the injuries being inflicted, the risk of fatality rose by 15% for each additional abdominal organ injured. If more than five abdominal organs were injured in the same patient, the probability of death was practically 100%. This is illustrated in Table IV.1.

147. Other things being equal, therefore, it might be said that casualties from fragmentation weapons are more likely to die than casualties from other types of conventional weapon. Moreover, the greater danger to which they are exposed of injury to vital organs seriously complicates treatment and worsens the prognosis.

148. In addition to the increased mortality risk, the degree of non-fatal incapacitation is also increased by multiple injuries. So also may the degree of pain experienced. These factors are discussed in general terms in Chapter II, paragraphs 59-76.

149. The treatment of multiple wounds raises special problems. Most of the cases will require surgical attention to more than one injury at the same time. This could be necessary to save the life of the patient, to limit the time of exposure to anaesthesia, to stop haemorrhage, to save a particular organ or to prevent complications. In recent armed conflicts where medical services of a very high professional standard were available, it was almost a rule that several surgical teams would work on the same patient. This resulted in reduction of fatalities and more effective medical care. Different specialists were represented, e.g. neurosurgeons, eye surgeons, orthopaedic surgeons and general surgeons. Since such resources are seldom available to the average country, patients with multiple wounds will rarely receive adequate attention.

Table IV.1

FATALITY RISK IN ABDOMINAL INJURY

The patient received adequate medical care within 7 hours of wounding. Fatality risk expressed in relation to the number of abdominal organs injured. Zero-injured abdominal organs indicates that the patient was wounded in the abdominal cavity but that no abdominal organs were involved.
(According to experience of the Second USA Auxiliary Surgical Group, 1942-1945).

Patients in the sample	*Number of abdominal organs injured*	*Percentage of fatalities*
98	0	5
496	1	10
402	2	24
132	3	42
41	4	54
13	5	92
3	6	100

Cited in Whelan, T.J., Burkhalter, W.E., and Gomez A., "Management of War Wounds", in Claude E. Welch (ed.), *Advances in Surgery*, Vol. 3, Chicago Year Book Medical Publisher, 1968.

5. Salient features of the chapter

150. Blast and fragmentation weapons are widely used for antimatériel purposes but they also have antipersonnel applications. Fragmentation weapons are the more commonly used for antipersonnel purposes, and there have been a number of developments, in response to military requirements, aimed at increasing their area coverage in this role, for example through the use of multiple-fléchette and other prefragmentation techniques. The same is true for certain recent trends in blast weapons, notably the development of the fuel-air explosive devices which may be used either for mine-clearing or for antipersonnel purposes. It is now possible for a single fighter-bomber aircraft armed with fragmentation or blast weapons to expose an area measurable in square kilometres to high-intensity antipersonnel effects. As is noted in Chapter II, paragraphs 53-57, area weapons have an obvious and uncontrollable tendency towards indiscriminateness, although in this regard much, but not all, depends upon the manner and circumstances in which the weapons are used.

151. Fragmentation weapons are capable of discharging fragments that can sometimes produce wounds of the high-velocity type described in Chapter III. More commonly, they inflict upon their victims a multiplicity of less severe injuries. Multiple injuries of this type have a cumulative effect that increases the mortality risk, the pain experienced by the victim, and, assuming medical facilities are available, the probability of prolonged and difficult treatment.

CHAPTER V

Time-delay weapons

1. TECHNICAL CHARACTERISTICS OF TIME-DELAY WEAPONS

152. The time-delay weapons described in this chapter are time-fused or target-activated explosive devices. There is also a discussion of traps of the non-explosive type, for these may be regarded as target-activated time-delay weapons. There are various other categories of time-delay weapon, notably certain chemical and biological weapons, but they lie outside the scope of the present report.

153. *Landmines* are the most familiar example of time-delay weapons. They are primarily designed as counter-mobility devices, usually being implanted below the surface of the ground in patterns that restrict possible enemy movement. Landmines to counter armoured or other vehicles depend on blast, most frequently making use of "shaped" or channelled explosive force to disable targets. Anti-vehicle landmines cannot normally be detonated by dismounted troops because most such mines are activated by higher pressures than a man can exert, or by acoustic or magnetic-induction fuses that discriminate between humans and vehicles.

154. Antipersonnel landmines are also in wide use, and most depend on fragmentation to produce casualties. Usually, they are detonated by pressure-sensitive contact fuses, but may also be activated by vibration sensors, trip-wires or other such devices. As a rule, antivehicle and antipersonnel mines are used together in a minefield. Some antipersonnel mines, when triggered, pop up out of the ground before exploding, thus optimizing horizontal fragmentation effects.

155. Most mines use metal casings and fuse components so that under favourable conditions they can be located by electromagnetic sensors. In World War II and since, large quantities of wooden and plastic-cased antivehicle and antipersonnel mines have been in general use. Still other materials have been used, less commonly, for landmine construction: glass, clay and concrete. In respect to anti-vehicle mines, non-metallic casings are just as effective as steel ones since the shape and size of the explosive charge is decisive, not fragmentation.

156. Sonic and soil-disturbance sensors and like devices have been proposed for non-metallic mine detection, but the surest method remains the tedious probing of the ground with a sharp object. Even for metallic mines, rapid detection is not possible, and this is the main reason why minefields continue to serve a counter-mobility function. From a military point of view, however, battlefield use of non-metallic mines may be as troublesome to friendly troops as it is to the enemy, especially under fluid combat conditions. For this reason, mines are often used that explode or render themselves harmless after a predetermined period of time.

157. *Aircraft, artillery and naval gun-delivered mines* are, like the landmine, employed for interfering with free movement in areas distant or close to the zone of combat. They are, however, not easily marked or charted, as is usual practice with extensive landmine fields. As a rule, air-delivered mines are modified aerial bombs, 250-500 kg in weight, that are time-fused or metal-activated. Such mines are generally used in conjunction with numerous anti-personnel bomblets that are target-activated and generally fitted with trip-wire detonators. The bomblets prevent troops from de-activating the anti-vehicle mines, and the anti-vehicle mines prevent tanks or trucks from clearing the bomblets. Air-dropped antipersonnel mines sometimes consist merely of small bags of pressure-sensitive explosive; several thousand may be scattered by a single aircraft.

158. Several nations have in service, or are developing, gun or rocket-propelled mine-laying systems. These can place on the surface strings or strips of mines to counter advancing enemy troops and vehicles.

159. Although *booby traps* sometimes have an anti-vehicle purpose, they are primarily used as antipersonnel devices, designed both to slow movement and to cause casualties. Activation of explosive-type booby traps may be by pressure, pull, tension-release, pressure-release or electrical means, and the explosive charge can be any size blast or fragmentation device available. For example, hand grenades, aerial bombs, shot-gun cartridges or blocks of explosive can be rigged as mines for ambush or other purposes. Construction of explosive-trap mines does not require specialized military training or equipment, and for this reason the use of booby traps can be expected in any war.

160. Examples have been noted of wiring dead bodies, or even wounded, so that their movement will explode munitions, but this use is uncommon. Innocent-appearing objects, such as valuable items, doors of houses, floor-boards or furniture can be rigged to trip fuses. Further, trails can be randomly mined, or ambush positions planted in remote areas where troops might patrol.

Yet other booby traps might serve to alert friendly troops of hostile soldiers in the vicinity.

161. Non-explosive booby traps, also serving to restrict enemy movement and cause casualties, are relatively simple devices. Armed forces have encountered them in all wars, and no recent developments have improved on old methods. Sometimes the trap is a pit in the ground along a trail in which pointed sticks are placed and the hole camouflaged. Also, trip wires can fire arrows or release spring-loaded weights or spiked devices. Infective or toxic substances have occasionally been smeared on the spikes.

162. All of the explosive devices noted above can be equipped with fuses that are set to explode the charge at a pre-set time. Some landmines, for example, are designed to self-activate hours or days after emplacement, allowing temporary safe passage of friendly and even some enemy forces. Landmines have been equipped with counters that permit safe passage of a predetermined number of vehicles before exploding.

163. More often than landmines, air-delivered weapons have time-delay fuses, sometimes short ones to allow escape of the aircraft before explosion occurs, and sometimes to impede the clearance of, for example, a bombed airstrip. Time-delay aerial bombs have also been mixed with incendiaries in raids on built-up areas to prevent fire-fighting crews from containing the flames. Such use can also prevent medical teams from aiding the wounded.

164. Generally, large time-delay aerial bombs used for mining are easily detected and avoided, and, since that is their main purpose, do not generally cause large numbers of casualties. In contrast, however, small bomblets fused to explode immediately may be mixed with others that are equipped with time-delay fuses and then spread over a wide area; casualties produced by the initial attack may, because of the time-delay bomblets, be isolated for days from medical assistance, being exposed to further hazards during the interval.

165. Most air-delivered time-delay explosives, in particular bomblets, are usually set to self-destruct within a few days. This is an important feature if friendly forces are soon to cross the area, or if the area is a populated one, or if the enemy is to be denied the bombs for his own use. However, self-destruct mechanisms of this type are frequently unreliable.

2. Military applications

166. Time-delay weapons used in land warfare are like sea mines in that their primary purpose is to counter enemy mobility.

167. Before hostilities commence, target-activated weapons can be used along border areas as barriers against the movement of potentially hostile forces. Barrier minefields may serve to channel attacks towards areas that can be better defended. Once hostilities have begun, such barriers perhaps have less usefulness, but they can be employed to isolate sections of the battlefield, to deny terrain, and otherwise to hinder enemy activities.

168. Similar to barrier minefields are other forms of tactical minefield intended to restrict movement of hostile forces in the area of friendly positions, and to protect fixed defensive points in the combat zone. Minefields used in such ways are generally marked or fenced to prevent injury to friendly forces, civilians and livestock.

169. Barrier, denial, tactical and protective minefields containing antivehicle and antipersonnel mines usually produce relatively few casualties among enemy troops. Since the minefields will usually be under friendly surveillance, explosion of one mine will alert the defenders. Attacking forces are likewise alerted to the presence of a minefield, are made more cautious, and may be forced to find alternative approach routes. The military purpose of time-delay weapons is to keep the enemy at tactical arm's length.

170. While most tactical uses of mines in forward combat areas are controlled, other antipersonnel or antivehicle minefields in the same areas might be more haphazardly placed. The use of aircraft, helicopters or artillery to scatter time-delay weapons, or booby-trapping a zone, is militarily beneficial, not to produce large numbers of casualties, but rather for nuisance purposes to slow movement. Uncontrolled combat-zone mining is frequently as much of an annoyance to friendly forces, who might enter areas earlier mined by themselves, as it is to the enemy, to say nothing of the local inhabitants.

171. Nuisance minefields can be employed in areas distant from combat zones along lines of communication such as railways, highways and inland waterways. Poorly trafficable terrain raises potential mine effectiveness, and perhaps allows for effective route blocking. However in view of the haphazard accuracy with which time-delay weapons are usually scattered from aircraft, distant mining serves more to slow than to stop movement.

172. Distant blocking, nuisance, and communications attacks are collectively called "interdiction", a campaign against the enemy's logistical organization. In the case of interdiction at great distances from the combat zone, the distinction between tactical and strategic use becomes unclear. In any event, the military advantages of interdiction are difficult to measure, becoming more uncertain the further from the front lines it is applied.

173. A further application of air-delivered time-delay weapons is the use of bomblets to suppress anti-aircraft fire prior to a bombing attack. Time-delay bomblets tend to neutralize defences until the defenders consider that all the bomblets have exploded. The question is open as to how much delay is militarily necessary under normal circumstances, and how much is designed to continue harassment for an indefinite period.

174. Booby traps are useful solely as nuisance devices. Rapid mobility of combatants lessens their utility.

3. Medical effects

175. In conventional warfare, casualties from mines and booby traps have normally been quite low in proportion to casualties from other weapons. This applies to both combatants and noncombatants.

176. With the exception of non-explosive booby traps and such things as chemical or incendiary mines, time-delay weapons always produce their effects by fragmentation or blast. Broadly speaking, therefore, the medical characteristics of the injuries which they cause do not differ greatly from those described in the preceding chapters.

177. Mines of the explosive type generally injure the lower half of the body. As a rule, the injury is mainly due to blast. The result is more or less pronounced tissue destruction and shattered skeleton parts. The extent of the injury is proportional to the weight of the charge. The amount of explosive needed to cause amputation of a foot and thereby incapacitate a soldier is around 30 g. An increase of the explosive charge may cause the following additional injuries: loss of limbs, damage to the anal-genital area and injuries to the lower half of the body including the abdomen. The traumatic amputation of a leg or a thigh was the typical wound produced by mines during World War II. The particularly extensive damage to tissue, the forcing of dirt, etc., into the stump by the explosion, the serious shock condition sustained as a result of haemorrhage and later infection, are the cause of the relatively high mortality rate as compared with other injuries to the extremities.

178. Fragmentation-type mines very often cause injuries of the high-velocity type, since the victim is usually in direct contact with, or very close to, the point of burst.

4. Salient features of the chapter

179. The principal military use of time-delay weapons is to impede enemy mobility, and for this purpose they may be designed either as anti-vehicle

weapons or as antipersonnel weapons. In the latter case, they may act either through blast or through fragmentation, so that their effects on the human body are broadly similar to those described in Chapter IV. In the case of explosive antipersonnel mines, however, the close proximity between the exploding weapon and its victim may lead to extremely severe injury. Thus, the wounds from fragmentation mines may both be multiple and be of the high-velocity type.

180. In the case of blast antipersonnel mines, it is possible to specify rather precisely the minimum size needed to put a man out of action, for it is known that less than 30 grams of explosive may suffice to destroy a man's foot. When larger amounts of explosive are used, there may be amputation of the legs, damage to the reproductive organs and grave abdominal injury.

181. In that proximity between combatants and noncombatants may be defined in terms of time as well as distance, time-delay weapons have a tendency towards indiscriminateness. This is discussed in Chapter II, paragraph 58. It is, however, possible to incorporate into many types of time-delay weapon special devices that can render the weapon harmless after a predetermined time interval. Devices of this type have been developed to meet such military requirements as the need to avoid obstructing friendly forces; but they could also serve to mitigate the indiscriminate tendencies of time-delay weapons.

CHAPTER VI

Incendiary weapons

182. This chapter is an abstract of the report of the United Nations Secretary-General entitled *Napalm and other incendiary weapons and all aspects of their possible use* which was transmitted to the General Assembly in October 1972.[1] Reference should be made to that report for further information.[2] Categories of weapon other than the incendiaries may also have an incendiary action—as, for example, in the case of nuclear weapons—but this chapter is concerned only with those where incendiary effects are the ones primarily sought.[3] Incendiary weapons may, however, have damaging effects in addition to those of heat or flame: some incendiary agents are poisons, for example, and some produce toxic or asphyxiating effects when they burn.

1. The different types of incendiary weapon

183. There are three principal components to an incendiary weapon system: the incendiary agent; munitions for dispensing the agent in the target area; and a delivery system for conveying the munitions to the target. Incendiary munitions have been developed for most of the weapon delivery systems possessed by present-day armed services, including artillery, naval ordnance, aircraft, armoured fighting vehicles and the individual soldier.

(a) *Incendiary agents*

184. Targets vary in their vulnerability towards heat. The human body, for example, and inflammable materials such as wood or dry vegetation, are more

[1] UN General Assembly document A/8803, 9 October 1972. The report has since been published by the United Nations in a printed version incorporating minor revisions: see paragraph 46, footnote 1.

[2] The Stockholm International Peace Research Institute (SIPRI) is also publishing a detailed study of incendiary weapons. An interim report, entitled *Napalm and incendiary weapons* was released by SIPRI in October 1972.

[3] Fuel-air explosive devices, which are primarily blast weapons but which also produce a fireball, are described in Chapter IV, paragraph 119. Chapter VII includes speculation upon the military possibilities presented by laser devices causing thermal damage.

vulnerable than structures composed predominantly of concrete or metal. For this and other reasons a range of different incendiary agents has been developed. These can be grouped into four broad categories according to their chemical characteristics: metal incendiaries, pyrotechnic incendiaries, pyrophoric incendiaries, and oil-based incendiaries.

185. Incendiary agents may also be grouped according to their operational characteristics. One important distinction is between "intensive-type" agents, which are designed for use against materials of low combustibility, and "scatter-type" agents, for use against readily combustible targets or as direct casualty agents against people. Intensive-type agents, which are usually metal or pyrotechnic incendiaries, must burn at a very high temperature and hold their fire in a compact mass. In contrast, scatter-type agents, which are usually pyrophoric or oil-based incendiaries, do not need to produce so intense an effect, and may be scattered in relatively low density over their targets.

186. The two most heavily used intensive-type incendiary agents have been magnesium metal and the pyrotechnic composition known as "thermate", of which there are many varieties. A number of other intensive-type agents have also been developed at one time or another.

187. The two most extensively used groups of scatter-type incendiaries are the white phosphorus pyrophoric formulations, and the oil-based incendiaries, of which napalm is an example. A third group is starting to come into prominence, namely the "thickened pyrophoric agents" (TPA); these have already begun to supplant napalm in certain battlefield roles.

188. When exposed to air, white phosphorus soon bursts into flame spontaneously, generating a dense cloud of white smoke. For this reason white phosphorus has been used since World War I both as an incendiary agent and for creating smoke screens or smoke signals. Plasticized formulations have been developed to increase the adhesiveness of the agent and the efficiency with which it may be scattered. Lumps of burning phosphorus are difficult to extinguish with water, and even if water is effective the lumps re-ignite when they are dry.

189. Oil-based incendiaries have been in use since ancient times. Per unit weight, petroleum hydrocarbons generate considerably more heat than any of the intensive-type agents mentioned above. A great increase in their effectiveness came during World War II with the development of the first of the napalms. These comprise a light petroleum hydrocarbon, such as gasoline, to which a thickening agent, such as rubber, aluminium soap or synthetic polymer, has been added. In addition, a wide range of materials have been used as additives for napalm to enhance its aggressive properties. "Loaded" napalms

of this type include the so-called "pyrogels", which lie midway between the scatter type and the intensive-type of incendiary agent.

190. The thickened pyrophoric agents are based on certain metal alkyls. The one that is coming into increasing use, as a filling for projectiles of various types, is triethyl aluminium; it is thickened with a synthetic polymer to provide the requisite dispersal characteristics and adhesiveness.

(b) *Incendiary munitions*

191. Intensive-type incendiary agents are mainly used in munitions for aircraft delivery. A typical munition comprises a cluster-bomb unit containing several tens or hundreds of small bomblets each weighing up to five kilograms or so. The cluster unit is designed to open some way above the target to distribute the bomblets over a rather wide impact area, in the same manner as fragmentation cluster-bombs.

192. Intensive-type agents are sometimes included, often with high-explosive charges as well, in the payloads of projectiles for aircraft cannon, artillery and certain infantry weapons. They provide a means for setting fire to the vulnerable interiors or fuel tanks of vehicles, etc., into which the projectiles have penetrated.

193. As regards scatter-type agents, napalm is mainly used either in massive aircraft bombs or in flamethrowers. A typical napalm bomb comprises a large thin-walled container shaped like an auxiliary fuel tank. A current version holds about 400 litres of the agent. When it strikes the ground, the napalm is splattered over an elliptical area about 120 metres long and 25 metres wide. In this design, the napalm is ignited by a 0.6 kg charge of white phosphorus and generates a large, intensely hot, fireball that lasts for about five seconds. This then subsides, but the napalm continues to burn on the ground for about five minutes. A single ground-support aircraft can carry several of these weapons, known as "fire-bombs", under its wings.

194. For high-altitude bombing, more solidly constructed munitions are used. These have usually been smaller than the firebomb described above, and are typically of 50 kg rating. Cluster units of small bomblets have also found extensive application. Munitions of these types have been loaded with napalm, pyrogel or white phosphorus.

195. Flamethrowers are of two principal types: the man-portable and the mechanized. The former, which a soldier can carry on his back, comprises a tank of napalm, a tank of compressed air (or some other propellant device),

and a nozzle/igniter system through which the napalm is ejected. A typical present-day model weighs about 25 kg and holds about 15 litres of napalm. This it can throw to a distance of 50 metres in a single 8-second burst or in a succession of shorter bursts. Mechanized flamethrowers are larger devices with longer ranges that are used either as auxiliary, or as main, armament on armoured fighting vehicles. A typical mechanized main-armament flamethrower has a napalm capacity of about 1300 litres, which it can eject in about a minute over a range of 200 metres.

196. Other ground munitions for napalm include land mines and various other emplaced booby-trap devices or fougasses.

197. White phosphorus formulations, in addition to their use in aircraft bombs referred to above, have been extensively employed in artillery and mortar projectiles of small and medium calibre, and in air-to-ground rocket warheads. They have also been used in landmines and hand- and rifle-grenades.

198. Thickened pyrophoric agents have been used in small-calibre rockets fired from man-portable multibarrelled launchers. Their tactical functions are similar to those of the portable flamethrower, but they have a considerably longer range (around 200 metres with accuracy) and are simpler to use. Larger TPA projectiles are being developed for artillery and air-to-ground rocket launchers.

2. Tactical applications

199. The principal military attractions of incendiary weapons lie in their area effectiveness. This may stem from the self-propagating character of the fire that the incendiary may initiate in suitable surroundings. Or, in the case of scatter-type incendiaries, it may stem from their capacity for distributing burning incendiary agent in a broad area around the points of burst. Against many types of target, the napalm distributed by a firebomb, for example, may spread over an area substantially greater than that which would be damaged by the blast from an equivalent high-explosive bomb, and it may initiate a secondary fire that spreads still further. However, incendiaries are rarely as effective as high explosive bombs against trained and well-equipped military personnel.

200. In the choice between incendiaries and the other types of area weapon described in previous chapters, incendiaries have one other militarily important feature, namely their psychological effect. Man seems to have an intense inbred fear of fire, and incendiary weapons, particularly those based on scatter-type

agents, may unnerve him to an extent that other forms of attack may not. There are several recorded instances where troops seasoned to heavy artillery bombardment have broken and fled when attacked with napalm, and it is said that more prisoners tend to be taken in operations where it is used. Instances are also recorded where soldiers facing advancing flamethrowers have committed suicide inside their bunkers.

201. Battlefield incendiary weapons have generally been based on scatter-type agents, although intensive-type agents have on occasions been employed against tactical targets, such as fixed installations in the battle area or convoys of vehicles moving through densely forested areas. The most heavily used battlefield incendiaries have been napalm firebombs. Employment of white phosphorus projectiles has also been common, either for incendiary purposes or for smoke-screening or smoke-marking. The flamethrower has found extensive applications only in particular types of combat environment.

202. The firebomb originally gained much of its reputation among field commanders as an antimatériel weapon, particularly against tanks and heavily dug-in emplacements. The napalm may penetrate inside structures, and its intense heat may buckle or melt non-inflammable materials such as weapon components or other machinery, and may cause failure of internal combustion engines and critical electronic equipments. In recent years, however, it seems that the firebomb has begun to give way to new developments in explosive weaponry. The cluster unit of shaped-charge bomblets, for example, is becoming an increasingly favoured antitank weapon.

203. The firebomb is also an antipersonnel weapon, and because of its area effectiveness and its psychological impact it has proved exceedingly efficient.

204. Ground-support aircraft are becoming the dominant weapon in operations against isolated units operating in remote areas. In one much-used technique, ground patrols in an area withdraw as soon as they locate enemy units, and call in ground-support aircraft to saturate the area with antipersonnel munitions. The firebomb is often preferred for the purpose. In another type of operation, the ground units are dispensed with altogether and strike aircraft laden with firebombs or similar ordnance rove over territory believed to contain enemy personnel, searching for "targets of opportunity".

205. Flamethrowers, both portable and mechanized, are primarily special-purpose assault weapons for the destruction of enemy soldiers holding positions that are protected against explosives, bullets or shrapnel. They can project lethal streams of flame over obstacles, around corners, and into narrow openings. They can sometimes be used on rugged terrain and have, in the past, proved efficacious where other weapons have failed in dislodging defenders

from tenaciously held positions, such as pill-boxes and certain types of cave defence. In these roles, however, the flamethrower, with its many limitations, is giving way to new designs of shaped-charge and TPA projectile.

3. The use of incendiary weapons against strategic targets

206. Many illustrations of the large-scale use of incendiary weapons against strategic targets (such as population centres) may be drawn from World War II. Germany and Japan suffered particularly heavily. Around 100,000 tons of bombs were dropped on 60 Japanese towns and cities, practically all of them incendiaries. Eighty per cent by weight of the incendiaries were napalm bombs, the remainder being magnesium or thermate. The air-raids killed 260,000 people and injured another 412,000. Nearly two and a quarter million homes were destroyed and 9.2 million people left homeless. In Germany, 1.35 million tons of bombs were dropped on population centres. Although less than a quarter of the bomb tonnage was incendiary more than three quarters of the resultant civilian air-raid casualties were due to fire.

207. After the war it was calculated on the basis of observations made in Germany that, as regards material damage from large-scale attacks, one ton of incendiaries was equivalent to 4.8 tons of high-explosive bombs. Likewise, in Japan it was found that incendiaries had been 12 times as destructive as high-explosive bombs against readily combustible targets, and 1.5 times as effective against fire-resistant targets.

208. The air raids that caused the greatest destruction in German cities were those directed against Hamburg in the summer of 1943 and against Dresden in February 1945. Both involved large tonnages of incendiary weapons together with high-explosive weapons, and both created fire-storms.[1] Hamburg was hit by 4400 tons of high-explosive bombs, 2700 tons of magnesium/thermite incendiaries and 1900 tons of thickened-gasoline bombs. Some 3000 bomber-aircraft missions were flown over the city, with 100,000 people mobilized to supply and conduct them. Most of the attacks were delivered under perfect bombing conditions against an enemy whose radar alert system had been

[1] Firestorms are rare phenomena even during intensive incendiary warfare. They occur only under particular weather conditions and in certain types of surrounding. They require a large number of nearly simultaneous ignitions in proximity to one another. When a conflagration takes hold under these circumstances, a chimney effect may be created in which the induced inrush wind velocity exceeds that of the prevailing wind, thus preventing any significant spread outside the periphery of the fire, and causing the conflagration to burn so intensely that it dies down only when everything combustible has been consumed.

jammed beforehand and whose ground and air defences proved unusually ineffective. The intensity and co-ordination of the attack on the night of 27/28 July were sufficient to build up a huge conflagration that in turn developed into a cyclone-like firestorm. About half of the town dwellings were totally destroyed, and only 20 per cent of the remainder were left undamaged. The area of destruction stretched over about 35 km^2 of the town centre, and left 40 million tons of rubble to be cleared away. Probably 43,000 or more people were killed, and it took more than two months to dig their corpses out of the debris.

209. The most destructive air raid against Japan was directed against Tokyo during March 1945. In terms of the number of dead, it exceeded in destructiveness either of the subsequent atomic bomb attacks. It was conducted entirely with incendiaries, 1665 tons of napalm bombs, most of them clusters of small munitions, being dropped from 279 heavy bombers. Within half an hour, fire had taken hold of the readily inflammable city centre and, fanned by a high wind, this built up into a huge conflagration that eventually destroyed or seriously damaged about 60 km^2 of Tokyo. Some of the inhabitants were able to escape through the wide fire-lanes, but many others were encircled by the flames and died of suffocation and burns. Those who fled to the city canals faced death from the scalding water or from the stampeding mob crowding in and crushing on top of them. It is estimated that 83,800 people died and 41,000 more were injured. More than a million were left homeless.

4. Medical effects of incendiaries

210. In describing the medical effects of incendiaries, it is useful to deal first with those general features of burns that are common to all types of thermal injury, whether or not they are caused by incendiaries, and then to describe the additional casualty effects that are characteristic of particular incendiary agents.

211. It is common practice to classify burns according to the degree of damage produced in the various layers of the skin or underlying tissues. The chances of survival of patients with deep burns depends on the depth, extent and localization of the burn, and on the quality and accessibility of medical treatment. People with burns covering 40 per cent of their body have a fair chance of survival if they are given adequate medical treatment in general hospitals. If more than 60 per cent of the body surface is burned, the patient usually dies unless he is given specialized treatment in a modern burn hospital. The chances of survival are less for children and elderly people, or if the resistance of the patient is lowered for any reason.

212. Burns that cover more than 5 per cent of the body surface tend to demand more medical resources than equivalent wounds caused by other weapons. The treatment is generally difficult, prolonged and painful. After healing, deep burns commonly result in scars, contractures and other types of deformity which are a major physical and societal burden on the victim.

213. Deep burns that cover more than 15% of the body surface affect the entire organism. The patient can go into a state of shock characterized by serious and often fatal metabolic changes. What is called "hypovolemic" shock may develop where the volume of blood is reduced by loss of blood or plasma from a wound or a burn. In a state of severe shock the supply of oxygen to the brain, heart, liver and kidneys diminishes, causing serious damage. In cases of severe burns, hypovolemic shock may set in within 2-10 hours. Severe shock can only be treated by replenishing the volume of blood. In addition to losses of blood and plasma, a toxic condition can develop as the poisons generated in the burnt area enter the blood circulation. Particularly with scatter-type incendiary agents adhering to the skin, the pain and the fright may induce a "neurogenic" type of shock. This condition, which is primarily psychological, can worsen the effect of the hypovolemic shock (which is primarily physiological).

214. The skin is a natural barrier against infection. In burns, the body is open to infection from the burnt surface; moreover, the damaged tissue provides a medium that favours the growth of bacteria. The bacteria and their toxins may enter the blood and produce septicaemia and toxaemia which may lead to death.

215. Inhaled combustion products can damage the mucous membrane of the respiratory tract so that it swells and impedes the breathing process. If the damage penetrates as far down as to the alveoli or air sacs, there may be destruction of the tissues which replenish the blood with oxygen from inspired air, and this may be a further cause of death. Inhaled gases may also have toxic effects. Respiratory burns, as these forms of respiratory damage are commonly known, are one of the principal causes of the deaths that occur rapidly during large fires.

216. As regards napalm and related scatter-type incendiaries, it is difficult to provide concrete information about their specific medical effects. Napalm burns inflicted on an unprotected population are generally a combination of deep and multiple burns. Because napalm weapons usually scatter large gobbets of the agent, they tend to cause extensive injuries. Untrained people may try to scrape the napalm off their skin or burning clothing, and in this way the napalm may often be spread on to other parts of the body, particularly the hands.

217. Large quantities of burning napalm consume correspondingly large quantities of oxygen from the surrounding air and tend to generate substantial amounts of carbon monoxide. Both these factors can cause severe or mortal injury to persons in the vicinity of the fire. Carbon monoxide in a concentration of 5000 mg/cubic metre is lethal if inhaled for more than a minute or two. Sub-lethal dosages of carbon monoxide may produce permanent injury to the central nervous system and the heart as a result of oxygen deprivation. It has been reported that 5 per cent of those who recover from napalm burns continue to suffer from the secondary effects of carbon monoxide poisoning.

218. When white phosphorus burns on skin, it commonly causes deep burns. Usually the phosphorus is scattered in small adhesive lumps, which result in a great number of fairly small but deep burns. If the burning phosphorus particles remain unextinguished, muscles and other deep tissues may be damaged, resulting in permanent loss of motor function.

219. Phosphorus is a powerful protoplasmic poison. If it is allowed to lie embedded in tissue it may produce systemic damage as a result of its toxic action. Potentially lethal damage of the liver, heart, kidneys and blood-generating organs may follow. Whether or not these effects become clinically manifest depends on the degree of absorption of the phosphorus. Little is known about the factors influencing this absorption.

220. Intensive-type agents present relatively few specific medical problems. The injuries which they cause usually result from the conflagrations which they can initiate rather than from actual contact with the agent.

5. Salient features of the chapter

221. The military attractions of incendiary weapons reside in their area effectiveness and in their utility both against personnel and against many types of matériel. When these properties were exploited on a large scale against enemy cities during World War II, they caused immense devastation and loss of life. At a tactical level, incendiaries have several important military applications, although in armed services that have access to the latest weapons technologies they are being supplanted by new types of fragmentation and shaped-charge weapon.

222. In that incendiaries are area weapons, they have the tendency towards indiscriminateness that is described in Chapter II, paragraphs 53-57. In this regard, however, much though not all, depends upon the manner and the circumstances in which they are used.

223. The injuries caused by incendiary weapons are much the same as any other burn wound, which is to say that they are exceptionally frightening and painful, difficult to treat, and likely to result in permanent deformities and disabilities. In addition, some incendiary agents superimpose their own characteristic effects upon the burn injuries. The asphyxiating and toxic properties of burning napalm and other such agents are examples of this.

CHAPTER VII

Potential weapon developments

1. General trends

224. Very substantial resources are currently devoted by many States to research and development in the field of military technology. Much of this is directed towards the improvement of existing weapons and the exploration of new weapon concepts. In the laboratories, therefore, there must be many potential weapon developments that are of direct relevance to the present report.

225. For a variety of reasons, among them the secrecy which is customarily maintained by States around their military affairs, speculation as to which of these new developments will come, as it were, to fruition, can only be uncertain. One thing which is certainly true, however, and which should be noted at the outset of this chapter, is that there will always be many novel weapon concepts which appear militarily attractive at first sight, but whose attractions do not survive the detailed scrutiny of what would actually be entailed if the concept were reduced to practice. Considerations of control, logistics, maintenance, user-competence, and so forth, impose severe constraints on the introduction of new weapons.

226. Be that as it may, the rapid progress of armaments technology in recent years, and the extraordinary rapidity with which new weapons of increased destructiveness have been entering service, undermine any grounds there may be for complacency. Whole areas of science, which hitherto had made little contribution to weapons technology, now have a relevance which few would have predicted in earlier decades. Yet it would be over-pessimistic to suggest that these trends are inexorable. Apart from anything else, they are subject to budgetary constraints which are under political control.

227. Some indication of the direction of current trends in the development of specific types of weapon has been included in each of the four preceding chapters. The following paragraphs present a broader overview.

228. Increases in fire-power—the paramount example of which has been the development of nuclear weapons—will continue to stimulate increases in the mobility of ground forces. They will also lead to improved, and more wide-

spread, use of armour, and to weapons better able to penetrate this armour. Such weapons will probably be even more destructive than present ones if used for antipersonnel purposes. The use of antimobility devices, including antipersonnel/antimatériel minefields laid by rockets, artillery or aircraft, will continue to grow in importance.

229. The increasing mobility will bring with it an increasing requirement for weapons that can be brought to bear on targets with greater rapidity, and launched against them with greater accuracy. This will mean a continuing and growing emphasis on target-acquisition radars, particularly equipment for small units, and of terminal guidance and target-homing devices for rockets, projectiles and bombs. In the latter connection, there have been dramatic increases recently in the use and effectiveness of infra-red, laser and other electro-optical homing devices for the larger munitions, particularly aircraft bombs and missiles; these may well be extended to artillery projectiles and the smaller rockets. Greatly extended effective range will be sought from artillery, for example by the use of rocket-assisted projectiles.

230. Increasing mobility will also call for area weapons that can be brought to bear rapidly on an area through which enemy forces are moving. Such weapons will also be necessitated as a countermeasure against the more widely scattered troop dispositions that field commanders must adopt in the face of increased firepower. This will mean the development of improved fragmentation munitions and related devices giving an increased area effectiveness to all types of weapon system. New flame weapons may continue to appear alongside the TPA projectiles referred to in paragraph 198; they might exploit some of the newer fluorine-based incendiary agents. Infantry men will be provided with automatic portable weapons capable of greatly increased rates of fire, and with high rate-of-fire grenade launchers firing fragmentation grenades. Multi-barrelled rocket launchers capable of blanketing several hectares in single salvoes with fragmentation or blast effects will come into wider service. Strike aircraft will acquire improved all-weather and low-altitude capabilities, and will be equipped with modular, multipurpose weapons systems that will increase their ability to engage targets of widely differing types at short notice.

231. The increased power and area-effectiveness of weapons will increase the vulnerability of the individual soldier. In addition to increasing the importance of armoured personnel-carriers, this may mean the increasing use of body armour made from lighter-weight materials. These can provide greatly increased protection against fragmentation weapons and, in some forms, against incendiary weapons. In particular, they may provide an effective countermeasure against the lighter, higher-velocity projectiles that are coming into use for small arms. This in turn may generate still more powerful antipersonnel

weapons, or an increasing reliance upon antimatériel weapons used in an antipersonnel mode.

232. Apart from an increasing reliance upon armour, the increasing vulnerability of the individual soldier may lead to new techniques of warfare in which he plays a less direct role, giving way to the use of longer-range weapons, unmanned weapon systems (e.g., remotely-piloted vehicles such as ordnance-carrying drones directed to their targets by remote control) or combinations of emplaced ground sensors linked electronically to automated fire-control devices that can direct weapons against targets indicated by the sensors. The growing possibilities for miniaturizing computers, and for producing them more cheaply, will expedite these trends.

233. Increasing dependence upon electronic and electro-optical systems for communications, target acquisition and guidance will bring with it an increase in the use of electronic and electro-optical countermeasures, including jamming, deception, and the use of antiradiation weapons. The substitution of human control over the targeting of weapons by electronic controls that are vulnerable to countermeasures of these types may have deleterious consequences for the discriminateness with which weapons can be used. These may countervail the precision attainable with the novel target-homing devices referred to in paragraph 229.

234. It may be useful to single out one particular area of military technology to exemplify certain of the trends referred to above. The example chosen is that of the laser.

2. Lasers

235. Laser range-finding and target-spotting has been found to be an inexpensive method of improving the accuracy of weapons delivery, especially aerial bombs. Although they have rather low power-outputs, the lasers used for such purposes are capable of damaging the human eye at ranges of up to some thousands of metres.

236. Laser devices having considerably greater power-outputs might eventually be used, perhaps in the next several years, as thermal weapons. Continuous wave (CW) power-output, once measured in tens of watts, has in a decade been increased ten thousand fold. Now, hundreds of kilowatts are being achieved with some high-energy laser devices.

237. Three basic types of high-energy laser are being developed:

(a) *Gas-dynamic lasers* are the most advanced at present, with 200 kilowatts or more of CW power-output at a wavelength of 10.6 microns. The operative gas is carbon dioxide which is heated to high temperatures, expanded, and cooled by supersonic passage through nozzles, with the resultant high energy being discharged through a mirror cavity. Gas-dynamic lasers are relatively inefficient because of problems in heating the working gas. Their most likely applications are in ground-based weapons or aboard ships. Aircraft use is possible, but only aboard large bombers.

(b) *Electric-discharge lasers* use high-voltage power supplies to excite carbon dioxide gas, and attain CW power-outputs of about 100 kilowatts. Pulsed-type electrical lasers may also have military applications since an output of 2,000 joules of energy in 20 microsecond pulses has been demonstrated with them. This corresponds to 100 megawatts of peak power. Electric-discharge lasers have shipboard application possibilities and, if airborne generators and capacitors are improved, probably can be used aboard aircraft.

(c) *Chemical lasers* use chemical reactions to achieve power-outputs and are in early stages of development, thus far achieving discharges of 10 kilowatts. They have much military interest because little outside energy is required, so that chemical lasers may eventually be small and light. Furthermore, they operate at shorter wavelengths (2.6 to 5 microns), a technical feature that reduces atmospheric attenuation and increases thermal damage effects. Chemical lasers may have the most potential for multipurpose military use.

238. As regard military applications, CW or pulsed-type high-energy lasers have several potential uses as weapons at the power levels already achieved experimentally, provided equipment can be designed for operational conditions. Current maximum power-output appears to be much lower than the theoretical limit, so that in the future there may be a broadening of potential weapon applications. The advantage of lasers is that they can burn holes in targets or their radiation can destroy the optical sensors of attacking weapons. Laser beams have essentially a zero time of flight, have no mass requiring compensation for inertia, and can be pointed rapidly from target to target. Since a laser depends on thermal heating, many problems arise. Energy decreases as the square of the distance to target, the atmosphere absorbing energy, and the heated air may distort or block the beam. Highly accurate target-tracking devices are required because the laser beam must remain on the same spot to cause the necessary damage.

239. High-energy lasers may initially be useful as defensive weapons against aircraft and missiles. Perhaps the first uses will be land- and sea-based, followed by installations on large bomber aircraft. Still later, in possibly 10 years, fighter-interceptor aircraft may have laser guns, and progress may have been made in laser defence systems against intercontinental ballistic missiles.

240. Use of lasers as anti-personnel devices is unlikely due to low cost-effectiveness for this purpose. Lasers could, of course, have antipersonnel effects in addition to primary antimatériel purposes.

241. As regards the action of lasers on the human body, laser light may give rise to several damaging effects, including heat, pressure, possible shock waves (both acoustical and ultrasonic) and protein generation in the blood plasma. At the present level of understanding, the most important effects on human tissue seem to be heat and pressure. Tissue ionization, chemical transformations and disturbances of the blood circulation may also occur at the impact site.

242. The eye is the most vulnerable part of the body to the laser. In the ultraviolet part of the spectrum, radiation is absorbed by the various nucleic acids and proteins of the ocular media. Exposure to this radiation can thus lead to corneal damage. In the visible and near infra-red parts of spectrum, the retina of the eye is the most vulnerable. This is due to the transparency of the ocular media and to the inherent focussing properties of the eye. Due to this infraction, the radiant energy per unit area in a laser beam incident upon the cornea may be increased by a factor of more than 100,000 at the retina. This may culminate in retinal burns and perhaps total destruction of the eye for anyone looking straight into a laser beam (note that if he is looking through binoculars, the intensity of the beam that strikes the eye will be increased by a factor of the square of the magnifying power). Elsewhere in the body, incident laser light will not receive so high a degree of concentration. Skin damage is unlikely to occur except with high-energy lasers.

FINAL REMARKS

243. The purpose of the present report has not been to present proposals for the prohibition or restriction of the use of any of the weapons or weapon systems discussed. The purpose has rather been to compile facts—legal, military and medical—relevant to any discussion to that end, which governments, intergovernmental organizations and other international bodies may undertake. Some final remarks are nevertheless called for.

244. It is clear from the preceding chapters that several categories of weapon tend to cause excessive suffering and particularly severe injuries or may, either by their nature or because of the way in which they are commonly used, strike civilians and combatants indiscriminately.

245. One example is provided by high-velocity ammunition for small arms. Although the use of the presently known projectiles in this category appears to offer some military advantages, these must be weighed against the fact —of which there is insufficient awareness—that they typically cause injuries much in excess of what is needed to put a combatant out of action.

246. Another example is provided by the fragmentation weapons. Weapons of this category cause the greatest number of casualties in modern armed conflicts. Hence evolution in this area of weaponry is of especial importance. It is obvious that the trend towards weapons which fragment into vast numbers of small fragments, and are susceptible of covering large areas, increases the risk of multiple injuries and the possibility that civilians will be affected.

247. Mention should next be made of incendiary weapons with the suffering they entail and the massive destruction they have sometimes brought about. Certain uses of antipersonnel mines and other time-delayed action weapons likewise can lead to indiscriminate effects and injuries far in excess of what is required to put combatants out of action.

248. The facts compiled in the report in regard to these and other weapons speak for themselves and call for intergovernmental review and action. Such action might be justified particularly in respect of two types of weapon apart from incendiaries, namely, high-velocity small arms ammunition and certain fragmentation weapons. The risks involved in their rapid proliferation and use would seem to constitute good reasons for intergovernmental discussions concerning these weapons with a view to possible restrictions upon their

operational use or even prohibition. It is appreciated that the technical difficulties involved in such discussion are considerable. Nevertheless, even in this regard, it would appear that several approaches to the solution of these problems may be open.