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TECHNICAL REPORT

73-51-CE

# THE CARRYING OF LOADS WITHIN AN INFANTRY COMPANY

by

Dr. Stephen J. Kennedy

Dr. Ralph Goldman

Mr. John Slauta

May 1973

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UNITED STATES ARMY
NATICK LABORATORIES
Natick, Massachusetts 01760

U.S. ARMY MATERIEL COMMAND

Clothing & Personal Life Support Equipment Laboratory
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# THE CARRYING OF LOADS
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## FOREWORD

The "Load of the Soldier" has long been recognized as a major problem in all armies, and many actions have been taken to deal with it. The "LINCLOE" program has been one useful approach.

This report reflects consideration of the total problem of load carrying, taking into consideration the three basic aspects of the loads to be carried, the load carrying equipment and the impact upon the man himself. It has been prepared as a joint report between the Staff of the U.S. Army Natick Laboratories and the U.S. Army Research Institute of Environmental Medicine.

Dr. Ralph Goldman of the U.S. Army Research Institute of Environmental Medicine is recognized as one of the world's leading authorities on stress physiology. He has made many contributions to the study of the inter-action of the soldier and his clothing equipment system, and the environment in which he operates.

Dr. S. J. Kennedy has for thirty years been responsible for the development of the Army's uniforms, protective clothing and load carrying equipment. Mr. John Slauta, a military requirements analyst and clothing designer, has since World War II been concerned with utilization of the Army's clothing and equipment and the development of functional requirements based upon use experience.

Much of the progress in development of load carrying equipment in recent years has been the work of Mr. Eldon Metzger, a former instructor at the Mountain and Winter Warfare Training Center, Fort Carson, Colorado, and for the past twelve years a member of the research and development staff in Natick Laboratories. His contributions of design construction concepts include the development of the lightweight rucksack, the ARVN Rucksack, and the recently adopted medium and large field packs. In many ways, these developments have been the most significant contributions to efficiency to military load carrying which have been made up to this time.

Special recognition should be given for the contribution of Mr. Robert White, the Army's anthropometrist, for the contribution of data on variations in sizes of men. The data reported here are taken from his recent report, "The Body Size of Soldiers, US Army Anthropometry - 1966" — a report of the U.S. Army Natick Laboratories.

Much of the information of the load carried by Military Occupational Specialties in the Infantry Company was furnished by the Infantry Combat Developments Agency, Fort Benning, Georgia. Special credit should be given to Lt. Col. Larry S. Mickel, US Army Infantry Board, who arranged for the pictures illustrating these loads.

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# THE CARRYING OF LOADS IN THE INFANTRY COMPANY

## A. INTRODUCTION

The carrying of loads by the infantry involves four distinct problems:

a. The capacity of the load-carrying equipment, particularly in the pack, in relation to the requirements of various combat missions.

b. The weight of the load, in relation to the physiological limitations of the soldier himself.

c. The carrying of man-portable equipment assigned by the TO&E to various military occupational specialists in the infantry company, and other special items of organizational equipment.

d. How the load can best be distributed and carried.

This study has been intended to bring these problems into perspective, both in relation to what has been done in the past, and what is currently in progress, as well as to indicate some special aspects that should be of concern to designers of equipment intended to be man-portable.

## B. THE CAPACITY OF THE LOAD-CARRYING EQUIPMENT

In many studies of the problems of load carriage, the proper capacity of the pack has been subordinate to another critical problem, the weight of the load. Yet, in the actual development of load carrying equipment for the U. S. Army during and since World War II (and particularly during the Vietnam war) providing adequate capacity in the pack has been shown to be of at least equal importance to that of the weight ultimately carried.

At the outbreak of World War II, the load carrying equipment available for supply to troops was essentially that developed or modified during the interim period between the two wars. (Fig. 1)

Figure 1
Haversack, M-1928

The load carriage system consisted of the haversack (Haversack, M-1928 and Pack, Carrier), the field bag (Bag, Canvas, Field, O.D., M-1936) as an alternate item used principally by officers, the shoulder harness (Suspenders, Belt, M-1936), and the ammunition belt (Belt, Cartridge, .30 cal., Dismounted), to which were attached the canteen, bayonet, entrenching tool, and first aid pouch. The haversack with its pack carrier was quickly demonstrated to be inadequate for combat use in all theaters of operation, so three new packs were developed early in the war in an attempt to meet the actual needs of the troops:

(1) A rucksack (Rucksack, Cotton) for mountain and arctic troops (Figure 2) with an integral frame which gave the necessary stability to the load for climbing and skiing; this item was

Figure 2

Rucksack

essentially a large, commercial, civilian-type rucksack.

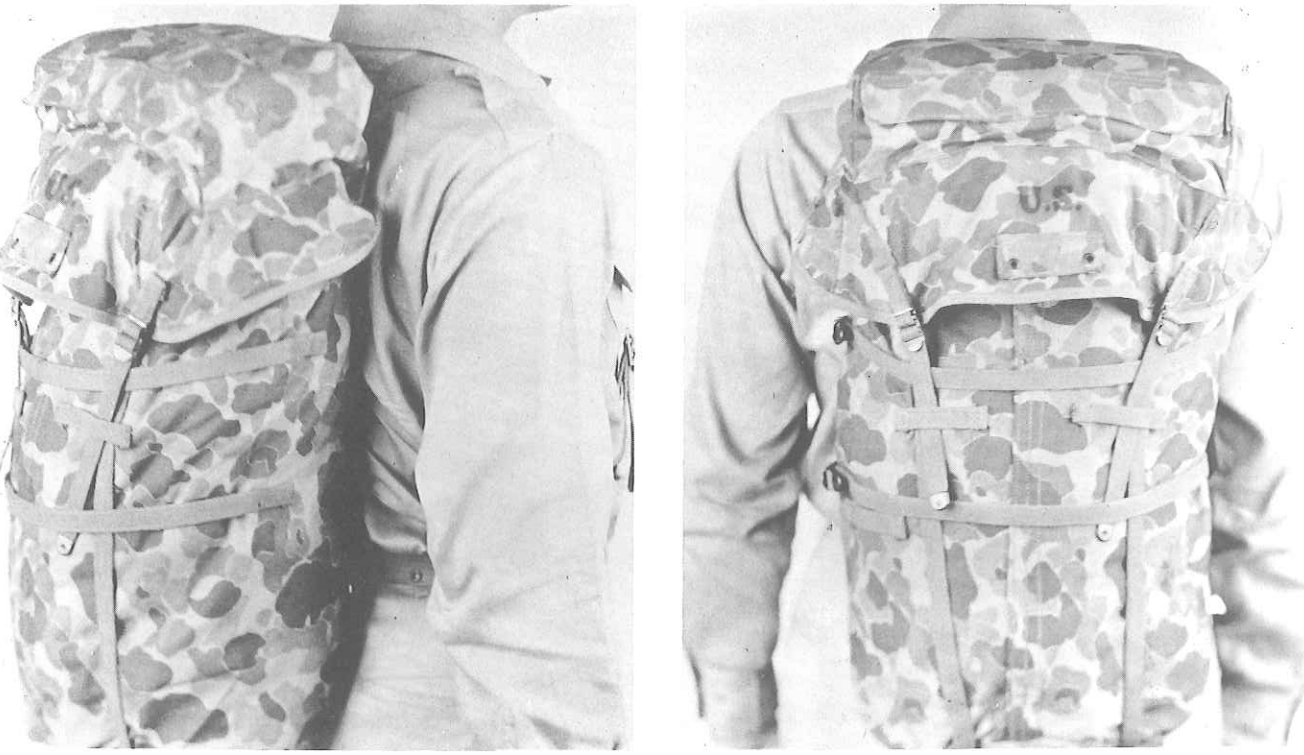
2) The new, basic pack was the field pack (Pack, Field); designed around the principle of flexibility in capacity (Figure 3). As designed, it was essentially a large wrap, with straps which permited adjusting its capacity to any size load.

3) A large jungle pack (Pack, Jungle), developed early in the war for troops in the Southwest Pacific, designed to be large enough for the man to be able to stow his gear without having to carefully fold it to fit snugly into the pack (as was necessary with the haversack); thus camp could be broken quickly in the event of a close-in enemy attack (Figure 4).

Figure 3
Pack, Field

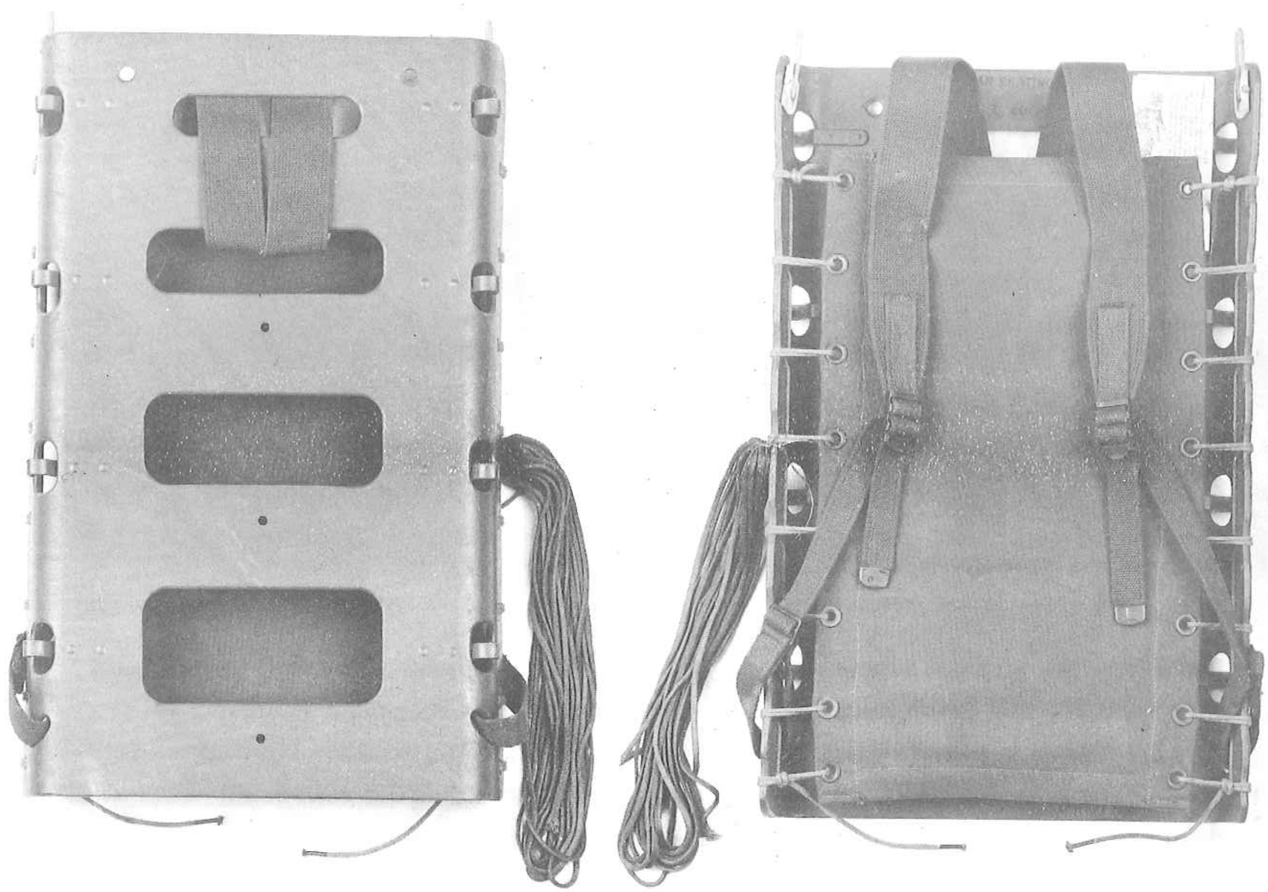
Figure 4

Pack, Jungle (Camouflage)




This family of packs was supplemented by a packboard (Packboard, Plywood) to carry such heavy objects as a five-gallon water can, an ammunition case, the base plate of the mortar, etc. (Figure 5). The rucksack and the packboard, while functionally satisfactory, were considered too heavy, and the other two packs proved unsatisfactory since the field pack could not hold loads of varied size securely and the jungle pack could not be well secured on the user's back.

Figure 5
Packboard, Plywood



As a result of this early experience there was a return to the concept of dividing the load into two components (as with the old haversack and pack carrier) and a new two-pack system was developed, the M-1945 equipment (Figure 6). This two-pack system consisted of a combat pack (Pack, Combat, M-1945) and a cargo pack (Pack, Cargo, M-1945). The combat pack was to be carried high on the man's back and was to contain the items considered essential at all times. It was planned that a horseshoe roll consisting of the shelter half, blankets and some extra equipment could be draped over the top and sides of the combat pack. The cargo pack was ultimately designed to have a dual purpose, (a) to hold military items not required in actual combat, and (b) to serve as a carrying case for a soldier's personal belongings

Figure 6
Pack, Field, Combat and Cargo M-1945


when he went on leave; as finally designed, the cargo pack could not be well secured on the soldier's back.

Although the M-1945 packs barely got into the supply system before World War II ended, use during the post-war period demonstrated the unsuitability of this design and in 1948, the authorization of one sleeping bag (Bag, Sleeping, Mountain) per individual in cold climates, required modification of this load carrying system to carry the sleeping bag as a normal part of the load.

A new approach to the design of load carrying equipment was started during the Korean War which eventually resulted in the adoption of a new set of equipment in 1956. Two particularly important changes in design concept were introduced in this equipment. One change was to discard the old ammunition belt in which the rifle ammunition had been carried in five-round clips; it was replaced by pouches (Pouch, Ammunition) worn on the pistol belt (Belt, Individual Equipment). These pouches were to carry two magazines each with 20 rounds of rifle ammunition ready for instant loading into the M-14 rifle.The pouches were attached to the belt with metal fasteners which allowed adjustment along the belt to the most comfortable or convenient position; while a large man could move them well to his sides, a smaller size man had to keep them almost directly in front. The second major change dealt with pack capacity, and a return to the small pack concept. The objective was to limit the

Figure 7

Pack, Field, Canvas (M-56)

soldier's load by providing a pack of just sufficient capacity to hold those things essential for combat. These included extra underwear, extra socks, a towel and toilet articles, and one third of a daily ration. By locating this pack low on the back, at the center of gravity of the body (Figure 7), there was room above it for carrying the sleeping bag and the poncho could be attached below it. Both could be dropped when not immediately needed.

This M-56 pack (Field Pack, Canvas) was the standard equipment at the time we became involved in Southeast Asia. Because of the nature of the missions in the early part of this war, particularly those of the Special Forces which involved several days continuously in the field, it quickly became evident that the capacity of the M-56 pack was too small; packs of

Figure 8
Rucksack, Lightweight

Figure 9
Frame, Lightweight, Rucksack
Used as Packboard

much greater capacity were needed, both for the U.S. forces and for the Vietnamese. Thus we had come full circle on the question of pack capacity, and were back where we had been at the start of World War II. However, two actions were taken which met the needs of our troops much better than we had been able to in World War II. The first was the adoption, by the Special Forces and later by all U.S. troops, of a new, 3 lb. rucksack (Rucksack, Lightweight), developed by Natick Laboratories for cold weather and mountain use as a replacement for the 7½ lb. World War II rucksack (Figure 8). This development had been completed by 1961, and the item was ready for procurement when the need in Southeast Asia developed. The aluminum rucksack frame gave the load stability on the wearer's back, and the nylon pack, with a capacity of 1.15 cubic feet was almost twice as large as the M-56 pack (.67 cu ft). Furthermore, a small demountable platform (Shelf, Cargo Support, Rucksack Frame) was provided which could be attached at the bottom of the frame; this shelf made it possible to carry items like a five-gallon water can, and thus served as a lightweight packboard (Fig. 9).

The other action was the development by Natick Laboratories, in 1963, of a tropical rucksack (Figure 10) for the ARVN, originally intended to be made on the local economy. This rucksack utilized a lightweight steel diagonal crossbar frame, and was dimensioned to fit the relatively short back waist length of the Vietnamese soldier. With its outside pockets, the bag of this rucksack had a considerably greater carrying capacity (1.0 cu ft) than either the M-44 or the M-56 U.S. packs previously provided to these troops. The design of this rucksack was so

Figure 10
ARVN Rucksack

well-liked that a version with a longer back and more capacity (1.15 cu ft) was made for U.S. troops (Rucksack, Tropical, Lightweight, Nylon), and came into wide use by U. S. troops in Vietnam.

Figure 11
Rucksack, Tropical, Lightweight, Nylon

The whole problem of load carrying had simultaneously been under re-study by the Infantry Combat Developments Agency, primarily from the standpoint of reducing the weight of the soldier's load. Two studies were carried out, the 1962 Study to Reduce the Load of the Combat Infantryman, and the 1964 Study to Conserve the Energy of the Combat Infantryman; both called for a major effort to reduce the weight of everything the soldier wore or carried under a program identified as LINCLOE — Lightweight INdividual CLOthing and Equipment. Specifically, with respect to the load carrying equipment, a LINCLOE QUALITATIVE MATERIEL REQUIREMENT established in 1965 called for the development of a set of load carrying equipment weighing no more than 3.3 pounds; this would include the belt, suspenders, pouches, pack and related items. To accomplish this LINCLOE objective, in 1967 the M-1956 load carrying equipment was converted entirely to nylon fabric, which reduced the weight from 5.15 to 3.3 pounds when dry, and by even more when wet, since the nylon material would not absorb water. The pack size, however, was left unchanged.

The study which Natick Laboratories had been giving to the whole matter of load carrying by the individual soldier during the war in Southeast Asia indicated that the only satisfactory solution was to achieve flexibility in the capacity of the pack by adopting more than one size pack, giving the local commander the option of using the size pack which his mission required. Accordingly, the project officer, Mr. Eldon Metzger, developed a five-component system of load carrying equipment consisting of the following:

(1) - Suspenders and belt to which would be attached two ammunition cases for the magazines for the rifle, with a pocket on each side for fragmentation grenades; a carrier cover for the one-quart plastic canteen, with a pocket on the side for water purification tablets; a molded plastic carrier for the entrenching tool; and a case for the first-aid packet or the compass.

(2) - A lightweight aluminum frame to which the packs could be attached, or which could be used separately for carrying existence or mission-type loads under all environments and tactical situations. With this frame went an aluminum shelf and cargo tie-down straps to assist in carrying such loads as the five-gallon water can (Figure 12), ammunition cases, or special items of equipment.

(3) - A large pack of rucksack design to be carried on the pack frame, with a capacity of 2.40 cu.ft. (Figure 13).

(4) - A medium size pack (Figure 14) of 1.15 cu.ft. capacity, also of rucksack design, which could be carried either independently with shoulder straps or attached to the frame.

(5) - A small size pack of 0.67 cu.ft. capacity.

It should be noted that the packs, as designed, were not attached to the suspenders and belt of the fighting load system, but had their own human-engineered (left and right) shoulder suspension to increase comfort by diminishing the tension points where the straps pass under the arms to attach in back.

The concept of this load carrying system, which was based upon meeting the needs of the soldier for adequate capacity and ready access to what he carried in the packs through the use of outside pockets, superseded the original LINCLOE primary concept of reducing weight. While the weight of every component was held to a minimum, it was anticipated that holding down the weight would be achieved by selecting the minimum size pack required to meet the needs of the particular mission.

This load carrying system, which was shown both to the Infantry Team and the Marine Corps in 1969, subsequently underwent numerous minor modifications during the course of final development and testing under a joint program conducted by Natick Laboratories in conjunction with the Infantry Team. In 1972, this new load carrying system, as modified but without the small pack, was adopted as standard.

The above review illustrates why the concept of flexibility in capacity has finally come to be adopted. Some further modifications to improve functionality, and some reductions in weight as new materials become available, may be practicable in the future. Hopefully, however, the advances present in this system with its packs of varied capacity, with or without the pack frame, and a shelf to simplify carrying heavy items, will receive extensive operational usage by troops before any future changes in this concept or design are attempted.

Figure 12

Frame, Pack, Used as Packboard

Figure 13

Field Pack, Large

Figure 14

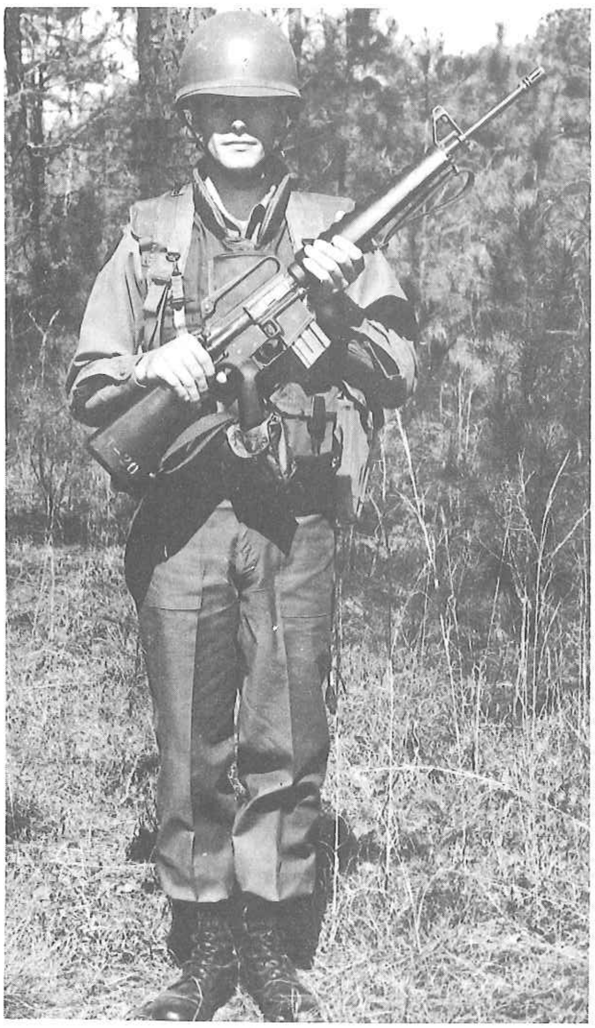
Field Pack, Medium

## C. THE INFANTRY RIFLEMAN'S LOAD

The basic problem with respect to reducing the weight of the soldier's load has been adequately covered in such studies as the 1964 Study to Conserve the Energy of the Combat Infantryman, conducted by the Combat Developments Command Infantry Agency. Numerous studies, conducted in support of the AMC Natick Laboratories' development programs by the U.S. Army Research Institute of Environmental Medicine (ARIEM), a Class II Agency of The Surgeon General, located at Natick Laboratories, have demonstrated the necessity and potential benefits of such weight reductions. The scope of this problem, however, can be clarified as follows:

The basic load of an infantry rifleman, generally taken as the representative soldier, for temperate hot weather areas, is a fighting load, without personnel armor, of 37.72 lbs. With personnel armor the weight totals 49.66 lbs. Adding CW protection and basic existence load items, the total weight is 61.12 lbs. as shown in Table I.

Figure 15 — Infantry Rifleman



| | | |
|---|---|---|
| Basic Fighting Load (w/armor) | | 49.66 Wt. (lbs.) |
| Existence Load | | 11.46 |
| | TOTAL | 61.12 |

TABLE I

The Load of the Infantry Rifleman *

(Warm Weather)

| | Weight in pounds | |
|---|---|---|
| Weapon | 8.89 | |
| (M-16 Rifle, with one magazine and 20 rounds; plus bayonet) | | |
| Ammunition | 10.52 | |
| (8 magazines, 20 rounds in each, in ammunition pouches; 2 hand grenades; 2 smoke grenades) | | |
| Personal Equipment | 10.19 | |
| (Load Carrying Equipment, plus attached items: 1 full canteen, entrenching tool, first aid pouch + 1/3 ration) | | |
| Clothing, Environmental Protective | 8.12 | |
| (Including boots and poncho) | | |
| Fighting Load w/o Body Armor | | 37.72 |
| Personnel Armor | 11.94 | |
| (Helmet w/liner; body armor vest) | | |
| Fighting Load w/Body Armor | | 49.66 |
| CW Protection | 6.75 | |
| (Mask and Protective Overgarment) | | |
| Existence Load, other items | 4.71 | |
| (Poncho liner; 1/3 ration; toilet articles, etc.) | | |
| TOTAL LOAD | | 61.12 lbs. |

NOTE: Magazines carrying 30 rounds are now replacing the 20-round magazines. The weight of the 30-round magazine, loaded, will be 1.01 pounds instead of 0.70 lbs for the 20-round magazine. However, the soldier will now carry 7 magazines of 30 rounds instead of 9 magazines of 20 rounds. This will result in a net addition to his load of 0.67 pounds.

* - Source: FM 21-15, "Care and Use of Individual Equipment," August 1972.

It will be obvious that the weight of some components of this load will be constant for all climatic zones. The weight of the weapon, of the basic load of ammunition, and of the personnel armor and CW protective items will remain the same in all climatic zones. However, in hot weather, more than one canteen is usually carried. Also, the substitution of cold climate clothing, and the addition of special gear for cold climates will both increase the weight of the load, and also create an encumbrance to movement. The added weight for cold climates, as shown in Table II, is 11.63 lbs. for cold-wet clothing (Table IIA), and another 8.21 lbs. added for extreme cold weather clothing (Table IIB), for a total additional clothing weight of 19.84 lbs. Adding the 23.19 lbs. for individual existence items for cold weather (Table IIC), the total added weight for extreme cold protection is 43.03 lbs. before adding the 9.75 lbs. for skiis or 4.6 lbs. for snowshoes as shown in Table IID.

Adding together the 61.12 pounds for the load of the infantry soldier in warm weather areas (shown in Table I), taking the figure for clothing for cold-wet areas (Table IIA) and eliminating from the equipment list (Table IIC) items for extreme cold, such as the inner sleeping bag and the snow camouflage cover for the rucksack, etc, gives a total weight of 90.59 pounds for a cold-wet area; if we use the total added clothing weight (Table IIB) plus the entire equipment list shown in Table IIC of 43.03 pounds for extreme cold weather areas, we arrive at a total load for the infantry rifleman (Figure 16) of 104.15 pounds, not counting the weight of oversnow equipment, if required.

While all of the items listed may not need to be carried by all soldiers all of the time, the items included in these Tables are those shown in current Field Manuals, as referenced. For purposes of this study, they should be considered to provide an approximate basic weight of what is considered "the soldier's load."

In summary, depending on the climatic zone being considered, this load as shown in the Field Manuals is as follows:

Basic Load of the Soldier

| | | Weight (lbs) |
|---|---|---|
| Hot weather clothing and equipment | | 61.12 |
| Added for cold-wet areas | | 28.41 |
| | Total cold-wet | 89.53 |
| Added for extreme cold | | 14.62 |
| | Total extreme cold- | 104.15 |
| Oversnow equipment: | skiis | 9.75 |
| | or snowshoes | or 4.60 |

## TABLE II

### Added Weight of the Load in Cold Climate Operations

| | Item | Weight of Cold Climate Item (in pounds) | Weight of Hot Climate Item (in pounds) | Added Weight (in pounds) |
|---|---|---|---|---|
| A) | Cold-Wet Clothing | | | |
| | Underwear and socks | 1.90 | .60 | 1.30 |
| | Suspenders | .25 | — | .25 |
| | Shirt, wool/nylon, OG | 1.50 | — | 1.50 |
| | Trousers, wool serge | 1.68 | — | 1.68 |
| | Trousers, cotton/nylon, wind resistant | 2.10) | 2.26 ) | 3.04 |
| | Coat, cotton/nylon, wind resistant | 3.20) | ) | |
| | Liner, coat, nylon quilted | .73 | — | .73 |
| | Cap, cold weather | .26 | — | .26 |
| | Muffler, wool | .38 | — | .38 |
| | Glove-shells, leather | .22 | — | .22 |
| | Glove-inserts, wool/nylon | .13 | — | .13 |
| | Poncho, lightweight | 1.70 | 1.70 | — |
| | Boots, Insulated | 5.50 | 3.36 | 2.14 |
| | | Total Added Weight for Cold Wet Areas: | | 11.63 |
| B) | * Extreme Cold Clothing (Cold-Dry) | | | |
| | Hood, winter | .96 | — | .96 |
| | Parka, cotton/nylon | 1.98 | — | 1.98 |
| | Liner, parka, nylon quilted | .95 | — | .95 |
| | Overwhite set: | | | |
| | Parka | 1.94 | — | 1.94 |
| | Trousers | 1.00 | — | 1.00 |
| | Liner, trousers, nylon quilted | .64 | — | .64 |
| | Mitten-inserts, trigger finger or | .22 | (replaces glove inserts) | .09 |
| | Mitten-shells, trigger finger | .43 | (replaces glove shells) | (-.21) |
| | Mitten Set, Arctic | 1.08 | (replaces mitten shells) | .65 |
| | | Total Additional Weight for Extreme Cold: | | 8.21 |
| | | Total Weight for Extreme Cold Areas: | | 19.84 |
| C) | Individual Equipment | | | |
| | Bag, Sleeping (Inner)Mountain | 7.06 ) | — | |
| | Bag, Sleeping (Outer) | 5.41 ) | 1.60 | 10.87 |
| | Mattress, pneumatic | 3.00 | — | 3.00 |
| | Case, water repellent | 2.25 | — | 2.25 |
| | Rucksack, lightweight | 3.00 | 1.00 (pack) | 2.00 |
| | Rucksack, snow camouflage cover | .75 | — | .75 |
| | Canteen, cold climate (2/3 filled) | 3.85 | 3.60 (full) | .25 |
| | Chapstick | .04 | — | .04 |

TABLE II (cont.)

| Item | Weight of Cold Climate Item (in pounds) | Weight of Hot Climate Item (in pounds) | Added Weight (in pounds) |
|---|---|---|---|
| Individual Equipment (Cont.) | | | |
| Thong, emergency | .12 | — | .12 |
| Glasses, sun, w/case | .30 | — | .30 |
| Sunburn preventive cream | .19 | — | .19 |
| Camouflage face paint, white/loam | .08 | — | .08 |
| Box, match, waterproof, w/matches | .15 | — | .15 |
| Starter, fire | .15 | — | .15 |
| Knife, pocket | .40 | — | .40 |
| Toilet articles and towel | 2.64 | — | 2.64 |
| | Total Added Weight for Individual Equipment : | | 23.19 |
| | Total Added Weight - clothing and personal equipment for extreme cold | | 43.03 |

D) Weight of Oversnow Equipment
(Added where occasion requires) :

| | | |
|---|---|---|
| Skis, all terrain, w/bindings & poles | 9.50 ) | = 9.75 |
| Ski wax (per box) | .25 ) | |
| or | | or |
| Snowshoes, Magnesium, w/bindings | 4.60 | 4.60 |

* - To be added to the cold-wet clothing system for extreme cold climate conditions.

Source:
FM 31-70, "Basic Cold Weather Manual," April 1968.

Figure 16
Infantry Rifleman — Extreme Cold Clothing and Equipment

In these listings, separation of the load into fighting and existence loads has not been attempted, except as shown in Table I for hot weather areas. The situation could vary greatly in cold weather areas because of diurnal and day-to-day variations in temperature, as to what would be needed under a particular situation since environmental survival is absolutely essential, and no firm figure can be readily arrived at.

It is evident that we are dealing with very heavy loads for any soldier to carry. Despite the continually increasing awareness of the impact of heavy loads on the soldier's mobility in any climate, and his susceptibility to heat exhaustion collapse in jungle or desert operations, current loads have reached very high levels. Therefore, the emphasis upon a continuing program that focuses on reducing the weight of the soldier's load is obviously fully justified.

Several aspects of the impact of heavy loads are addressed in the following sections.

## D. PHYSICAL WORK, LOAD WEIGHT AND TACTICAL MOBILITY

Typical military work demand levels range from about 100 kcal/hour for sentry duty, 150 kcal/hour for driving, and 175 kcal/hour for mine-clearing to perhaps 250 to 300 kcal/hour while patrolling, as a function of the terrain covered. An assault will require 425 kcal/hour $\pm$ 10% (at least in peacetime when the men are not under actual enemy fire), but infantrymen will seldom approach the maximum of a 600 kcal/hr (10 kcal/min) level which only allows an average soldier one hour of sustained work, or a 15 to 20 kcal/min level, which results in his exhaustion within 6 minutes.

Such energy cost levels are, of course, conditioned by the weight of load carried. A typical peacetime load table might show a combat rifleman carrying 44 lb. (20 kg), a machine gunner 70 lbs. (32 kg) and radio/telephone operators, mortar men or recoilless riflemen carrying loads greater than 77 lbs. (35 kg). Since it was recommended by a British Royal Commission in 1867, that a 45 lb. (20 kg) load is the maximum desirable for an approach march, with lower loads suggested for combat, even these peacetime loads are excessive. However, almost always throughout history, loads have increased during wartime operations, frequently doubling as shown in Figure 17. Reductions in weight in one part of the load tend to be offset by the addition of extra amounts of ammunition, grenades, flares, mines, etc. As shown in Figure 17, there appears to be a cycle in the load carried. Significant reductions in the load,achieved when a significant disadvantage is incurred by the greater mobility of the less-loaded enemy, may be replaced later by increases in the load carried to meet the real or imagined requirements of war.

Load carriage systems and load placement are important since hand-carried loads require almost twice as much energy as the equivalent weight carried on the torso, while the weight of heavy boots requires six times as much energy as the equivalent weight on the torso. In addition, bulkier clothing increases energy cost, with multiple-layer winter uniforms requiring 1.15 times as much energy as they should based on weight alone. Of course, varying terrain also alters energy costs; taking a black-top road at a fixed speed as a basis for comparison, with an efficiency factor *(m)* equal to 1.0, then, at the same speed, a dirt road would require 1.1, light brush 1.2, heavy brush or forest 1.5, and swamp 1.8 times as much work, with snow ranging from 1.6 for hard-packed snow to perhaps as much as a multiplier of 5 as a function of snow depth.

Combining all these factors, it is possible to predict the work demand as:

Energy cost $= m\,(W + L)\quad [2.3 + 0.32\,(V\text{-}2.5)^{1.65}]$ - where V is speed in km/hr, and weight (W) and load (L) are in kg. For example, at 5.6km/hr (3.5 mph) on a level, black-top road, each kilogram of load increases energy cost by 4.4 kcal/hr (i.e., 2 kcal/hr per pound of load). While it is thus possible to predict the physical work required as a function of body weight plus load and terrain *(m)* at any given speed, in the actual event what is important is not what the energy cost will be for a given speed, but rather what work rate the man will actually adopt.

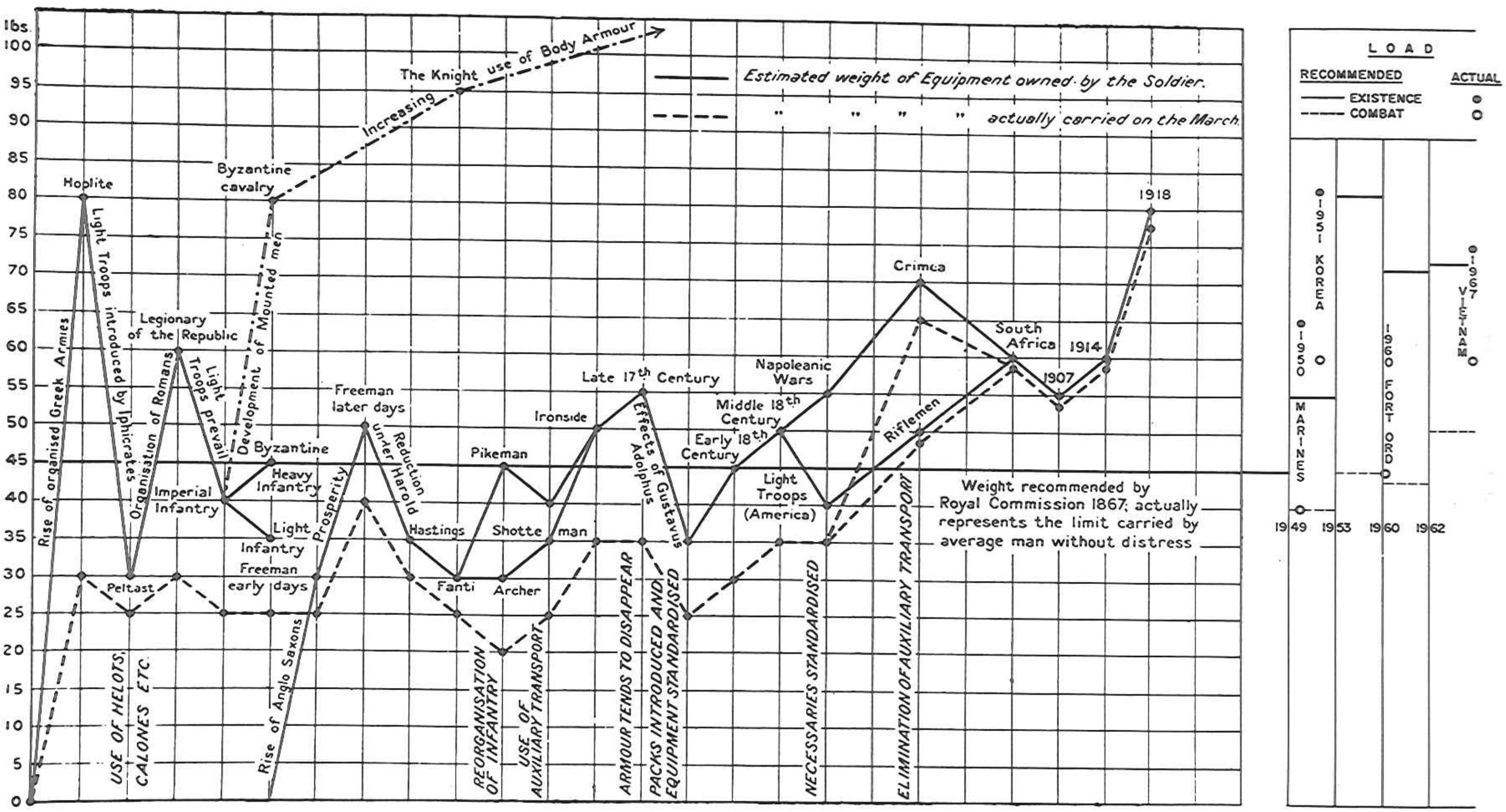



Figure 17

History of the Soldier's Load

Extensive review of limited combat studies and many laboratory studies has clearly suggested that reasonably fit, 18 to 30 year old, 70 kg, 172 cm soldiers, when working as hard as they are willing to, will work at a rate of 425 kcal/hr $\pm$ 10%, unconsciously adjusting their march rate as a function of load, terrain, etc. to achieve this level. This 425 kcal/hr level is relatively unaltered by sleep loss or temperature effects, and holds with minor adjustments even for loads up to 70 kg (154 lbs.), but is, of course, highly dependent upon motivation.

The adoption of this 425 kcal/hr self-paced work level is so reliable that substituting 425 for the energy cost in the above equation allows prediction of speed as a function of load and terrain. The validity of the speeds predicted by this approach has been demonstrated and, with an available adjustment for uphill instead of level terrains, summarises what needs to be said now and in future about the impact of load on the soldier, and on his mobility over a variety of terrains. The equation also serves to indicate endurance time, since he is not apt to exceed one hour of continuous work, when pressed to the 10 kcal/min level, or 6 minutes at 15 to 20 kcal/min. Whether elite troops will be appreciably better than other units in this regard is debatable, although their motivation to reach and sustain the 425 kcal/hr.level will certainly be helpful.

These energy cost relationships will be unchanged with increasing age, but since maximum work capacity decreases from perhaps 17.5 kcal/min at age 20 to 12.5 kcal/min at age 60, the older soldier will be working at a greater percentage of his maximum and the same work will seem harder. The impact of these generally unalterable physiological limits on present military operations is well-known.

With increasing use of armored personnel carriers and helicopters to deliver the combat infantryman into contact with the enemy, he may do less approach marching in the 1980-1990 time-frame and thereby lose the opportunity to learn, by necessity, to limit his load and discard nice but not really necessary items. Thus he may be brought into actual combat carrying the extra food, magazines, souvenirs, and the like which in older days he would have discarded during the approach march.

A 1980-1990 time-frame projected combat scenario will require greater mobility and endurance. Thus greater emphasis on load reduction, on auxiliary load transport, on improved re-supply and load rotation will be essential; these tactical alterations are required by human physiology since little can be done to increase the man's capacities. One load item whose weight will be a continuing problem, particularly in the heat, is water. Since the soldier can not do without it, a supply must be carried and resupply on the order of 25 lbs. (13 qts.) per man per day may be necessary.

Another factor that has not been addressed but that is significant now, and in the foreseeable future, is the interaction between fear, which draws on the man's physical resources, and physical work which draws on the same resources. Since this interaction with fear is almost always lacking in training and in peacetime maneuvers, loads can be carried (with little impact on the umpires or observers estimation of mission accomplishment) which could be extremely damaging in actual combat. As a result, it is easy to plan combat operations with loads and pace which can not be maintained under fear where the effects of heavy loads will be magnified. In actual combat the soldier's morale and the ability to sustain an engagement may be seriously degraded by failure to recognize the limits imposed by the interaction between fear and physical work. Training the individual with heavier loads than anticipated in combat is desirable to help offset the additional demands on physical resources imposed by fear during combat.

Selection of individuals with outstanding fitness can be accomplished, but it is unlikely that this can be done for other than elite units in the future. Individual variability in a given unit is generally not too great, but significant differences exist between elite units and others, with every man in an elite unit frequently able to run 3.2 km in 15 minutes or less. This is usually a result both of superb leadership, in which the officers also train to achieve this level, as well as of selection of individuals for these elite units, and these factors too are among the many that dictate the effects of loads on the soldier.

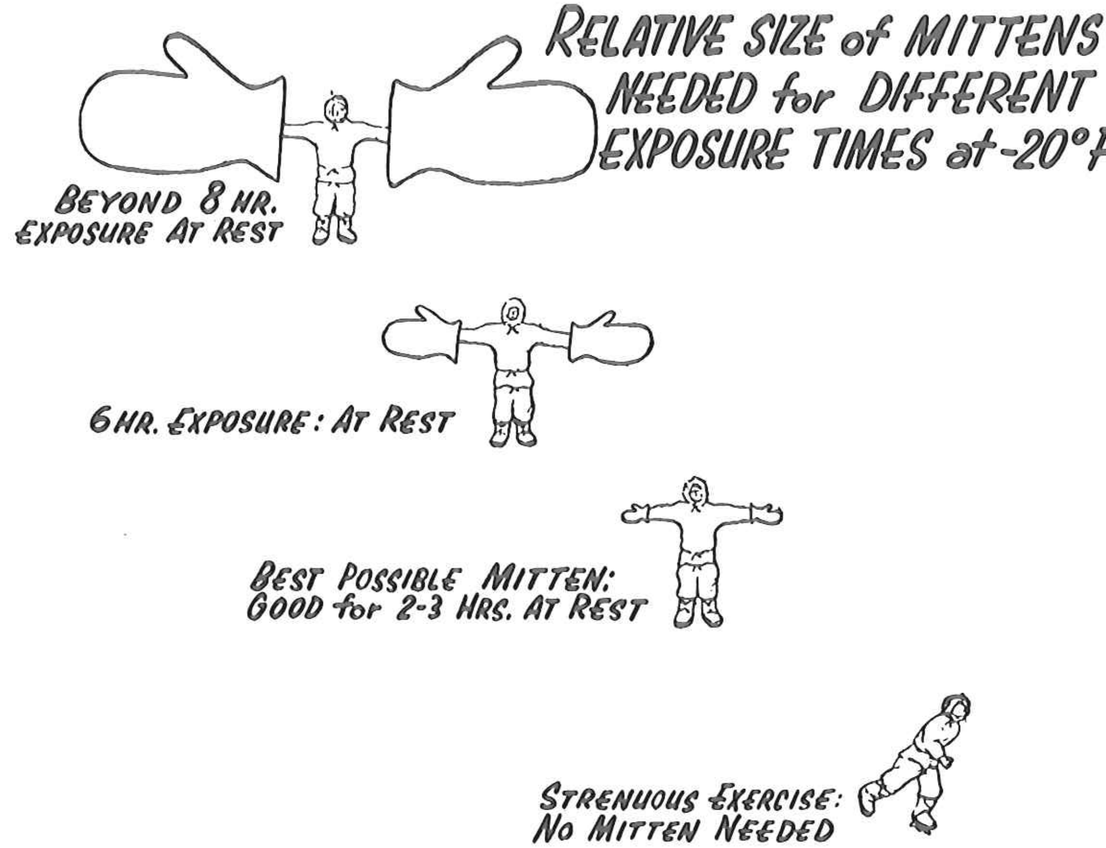
## E. LOAD WEIGHT, PHYSICAL WORK AND ENVIRONMENTAL EXTREMES

The impact of a heavy load becomes most serious at the two climatic extremes of hot climates and very cold climates. In the heat, the extra heat production demanded by the extra work load compounds the risk of heat exhaustion collapse. In the cold, the increased clothing weight (Table IIB) increases heat production, as predicted by the heat production equation given above, while adding the additional 15% increase associated with the difficulty of moving in such bulky, multi-layered clothing systems. As indicated above, these problems of heavy loads tend to be overlooked since most load carriage studies are conducted in comfortable environments. Thus, the physiological impact of a heavy load is underestimated when the soldier is committed to combat in extreme environments.

The extra heat production demanded by a heavy load increases the body's requirement for heat loss and results in increased sweat production. In jungle climates, or when armor or chemical/biological protective clothing is worn, the extra sweat frequently cannot be evaporated. The soldier gains no benefit from this wasted sweat production and his risk of heat exhaustion collapse, increased by the extra heat production, is further increased by the dehydration of the body by this excess sweat production. Furthermore, the increased sweat may drip into his eyes and soak his skin and make it more vulnerable to abrasion; increased skin infections and foot blisters are a common occurence under such conditions.

In the cold, it is essential to get rid of excess body heat without having excess perspiration absorbed into the clothing system, which would thereby reduce its insulating efficiency, leave the soldier exposed to the discomfort of after-exercise chill and increase his risk of cold injury. Through the front opening of the cold weather clothing system, which the man can open up when he is active in order to cool himself off, the use of vents at the wrists and neck, and the use of suspenders so that his trousers are not constricted at the waist, every available means is taken to assist the man to avoid over-heating. The relationship between body activity and the requirement for effective insulation for keeping warm is well shown in the classic illustration of the mittens. (Figure 18)

Figure 18




The amount of insulation required when the man is very active and generating up to 425 kcal/hr is quite small, as compared with what he requires when he is at rest or sleeping and generating no more than 60 kcal/hr. Thus the weight and bulk of protective clothing, added to the soldier's load, creates a problem that is quite different from that in a temperate area, and conclusions based upon the usual load carriage studies require substantial modification when the soldier is engaged in combat in cold climate areas.

## F. LOAD IN RELATION TO BODY SIZE

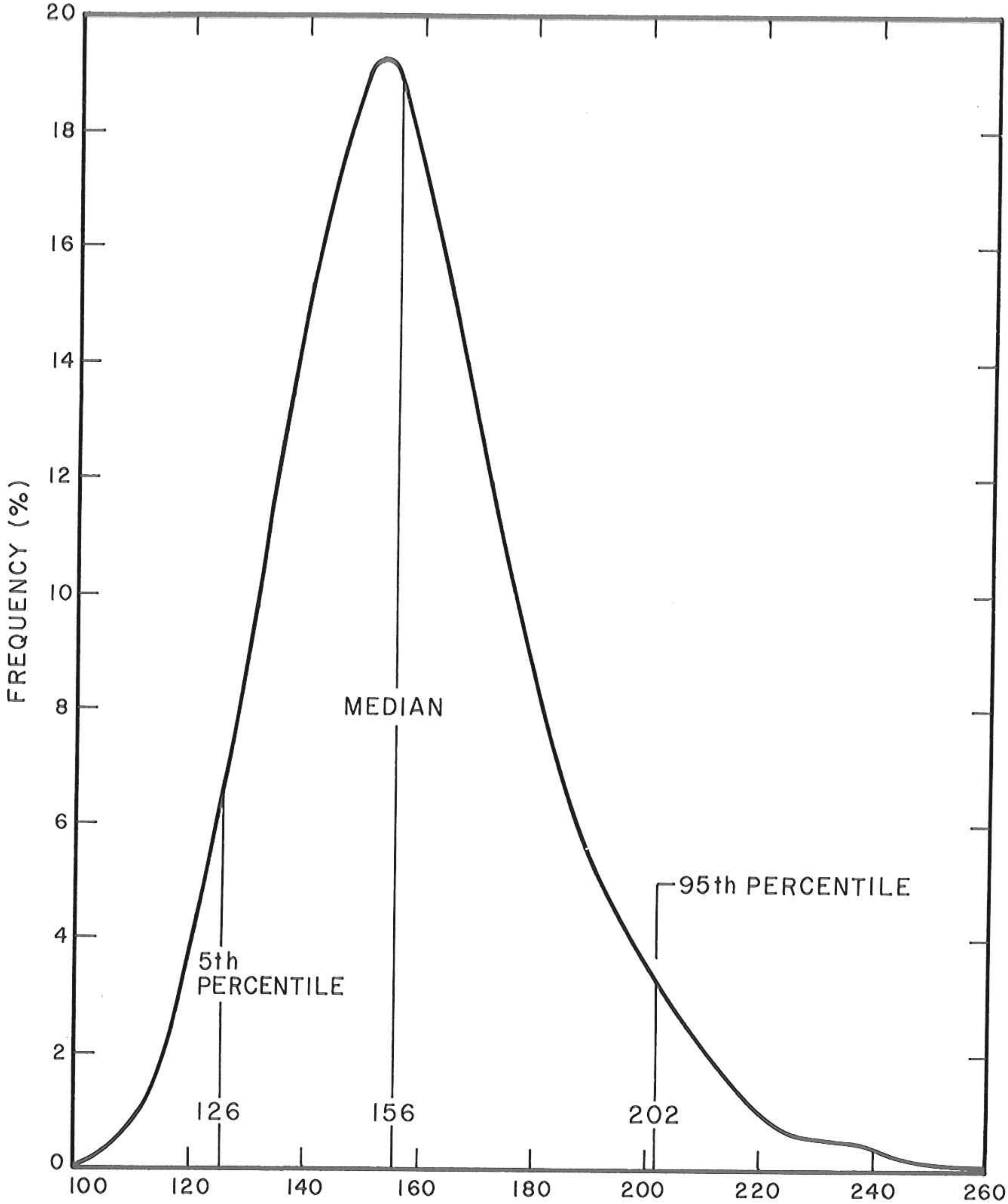
Another point which is significant from a physiological standpoint is the variation in the size of men in the total population. Discussions of the load carrying problem have referred to "the load of the soldier" as though it were sufficient to consider only the average man.

The need for considering the range of body dimensions in the total population has been taken for granted with respect to clothing, footwear and other items worn by our troops, as being necessary for proper fit and comfort, as well as for achieving a suitable and uniform military appearance.

This concept of sizing for different sizes of men has been applied to only a very limited extent, if at all, in items of personal equipment and man-portable equipment made available to the infantry company. Except for the belt and suspenders of the load carrying system, which are designed to be adjustable for different size men, all other items of the load carrying system are of a single dimension and weight.

The physical work capacity of an individual soldier is largely established by his body size, with each added centimeter of height increasing maximum work production capacity by 0.2 kilocalorie/minute (kcal/min), and each kilogram (kg) increase in body-weight increasing maximum work capacity by 0.3 kcal/min. During a short (six minute or less) heavy assault, the maximum work capacity of the individual is relatively unimportant, but weight is important, and body weight becomes very important during sustained work, since it must be moved by the man. Thus a load which is appropriate for an average 70 kg (154 lb), 173 cm (5 ft 8 in.) man, could be increased by perhaps 50% for a 100 kg (220 lb.), 182 cm (6 foot) soldier and should be decreased by about 50% for a 50 kg (110 lb.), 162 cm (5 ft 4 in.) man. Failure to make such allowance means that the small man is working relatively much harder than the average, and the bigger man less, although it is a frequent observation that the smallest men may wind up carrying the heaviest items. In such a case, it would be unlikely that physiological and the usual work performance measures would show significant differences between a small and a large soldier, since the work would be identical if the weights of man plus load are identical. However, the smaller man will feel that the work is more difficult, and to the extent that it represents a greater percentage of his total work capacity, it will be harder for him and he will tire faster, and, in fact, lose his combat efficiency faster than a larger man. The extent of this problem will become apparent when one considers the range in size of the men in military service. The four accompanying charts, which are based upon, The Body Size of Soldiers — U.S. Army Anthropometry-1966 by Robert M. White and Edmund Churchill, show the range in size of our soldiers in four dimensions which are critical with respect to load carrying.

Figure 19




WEIGHT DISTRIBUTION OF U.S. ARMY MEN (1966)

Figure 19 shows the range in weight of soldiers. The average size man (median) weighs 156.3 pounds, and is generally the man who is thought of as "the soldier" when his capability in carrying a load is considered.

A practicable or desirable upper limit to the load for a man to carry, which will not unduly burden him, has been set by rule of thumb for many years at around a third of body weight; other studies merely recommend that the marching load not exceed 45 lbs. (cf. Fig. 17).

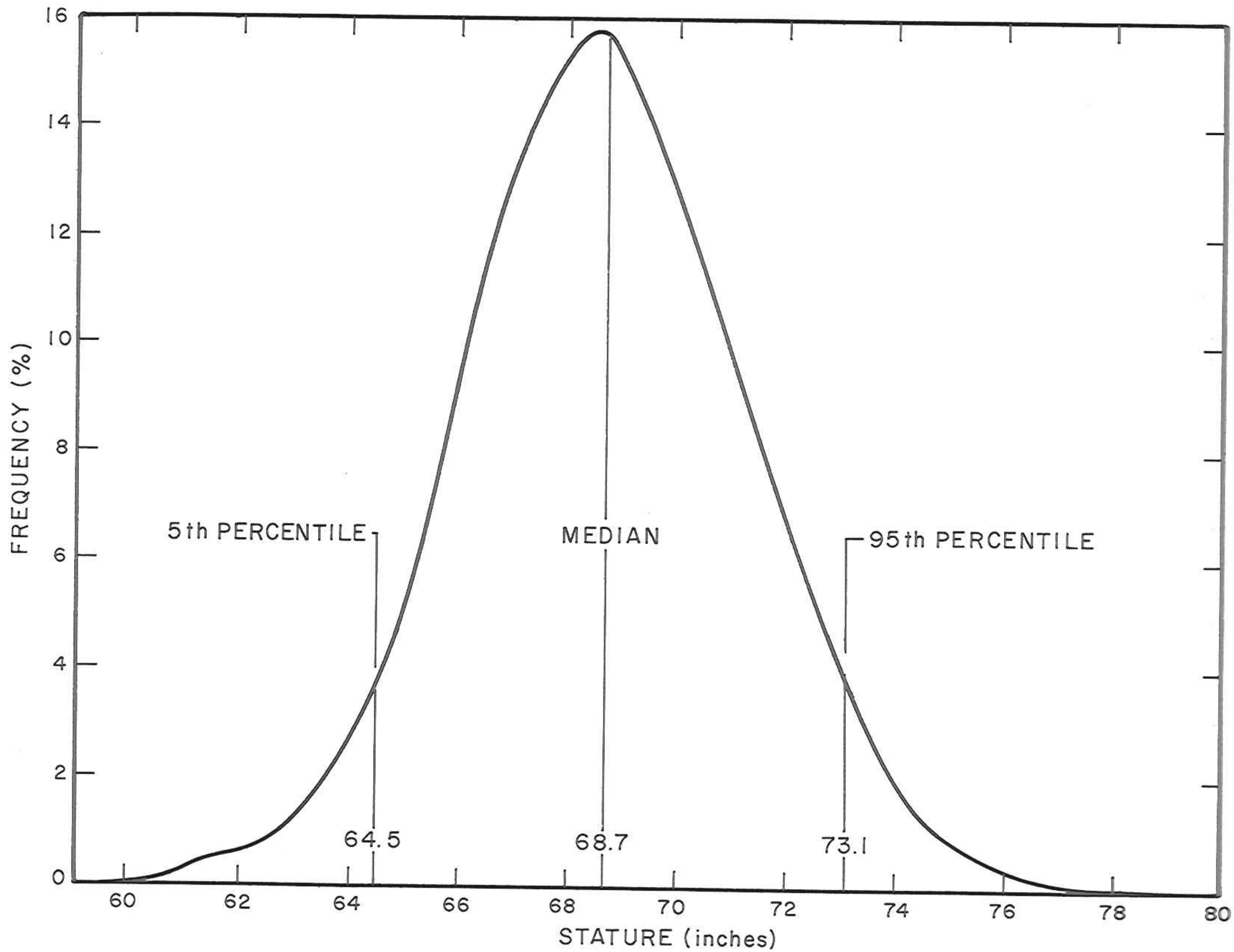
In short, the fifty percent of the infantry company who are smaller than the average are at a proportionately and significantly greater disadvantage in respect to their efficiency as load carriers to the extent that they come closer to the fifth (126.3 lbs.) or first (116.0 lbs.) percentile of men according to weight. On the basis of a third of body weight, the fifth percentile man, weighing thirty pounds less than the median, should carry a load ten pounds lighter than the median man; on the basis of relative maximum work capacities, the reduction in load should be about 23% for such an individual, on the basis of a 45 lb. load, again about 10 lbs. The above conclusion is to be tempered somewhat in respect to a balanced proportion between weight and height, i.e., that his weight is essentially muscle mass and not just fatty tissue. To the extent that this balance exists, height could be equally used as a criterion of the proportion of the smaller soldier's work capacity expended in carrying the same size load as a larger soldier, as discussed above. (Figure 20).

A further disadvantage of the small man is reflected in his waist circumference. While the dimensions shown in Figure 21 are for the nude man, by adding about 1½ inches, one can get the actual dimensions over the waist belt on fatigue trousers. The equipment which occupies space on the belt is of fixed dimension: the canteen, the entrenching tool, the bayonet, the ammunition pouches, and the space occupied by the pack in the back.

For the fifth percentile man, with a waist girth of only 27.4 inches (plus about 2 inches for his clothing), these items are crowded together on his belt, whereas for men in the upper half of the size range, there is ample space, and the ammunition pouches may be moved off to the side and away from the center of the body where they will be less cumbersome.

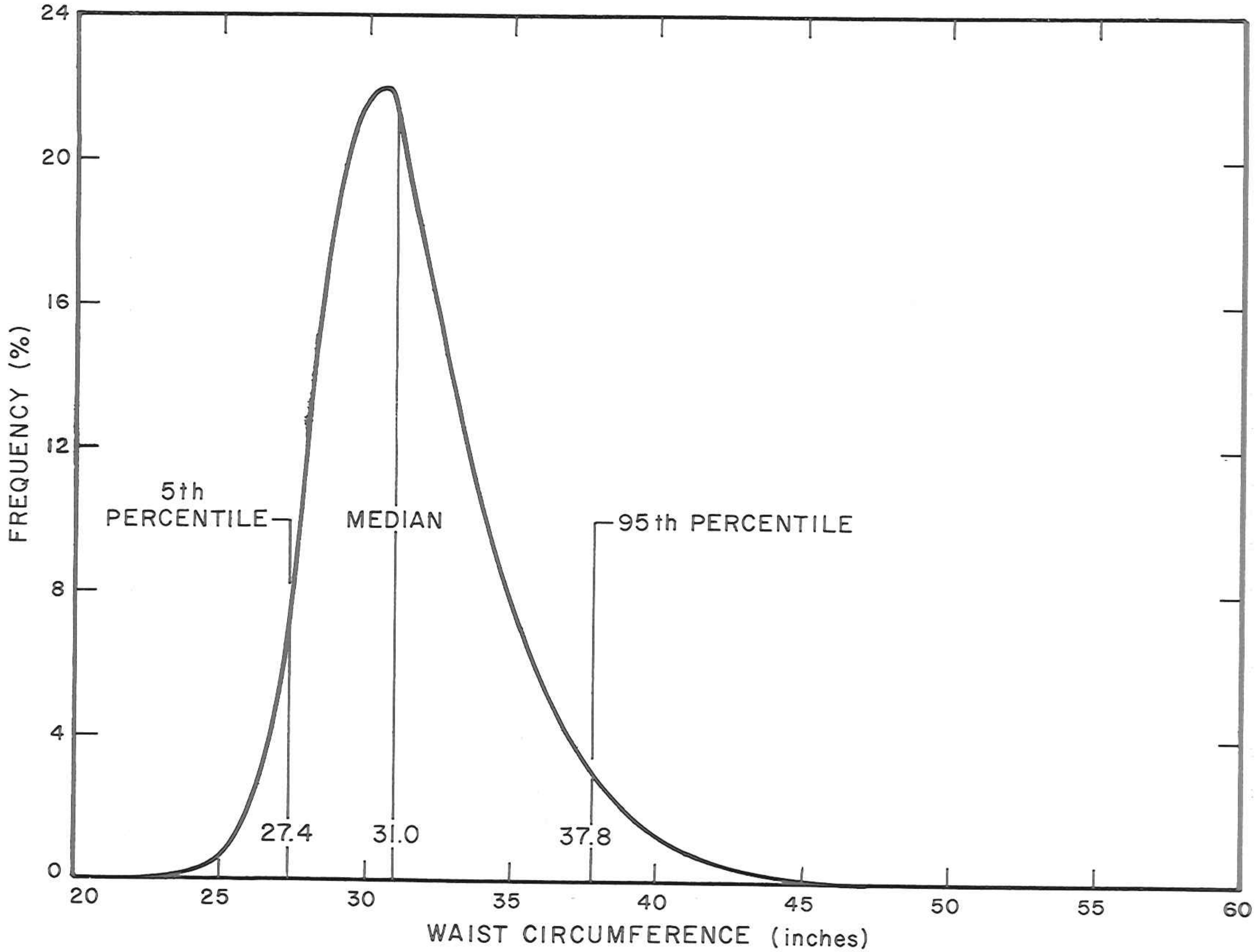
The same kind of problem exists for the man with a short back waist length (Figure 22). The correlation between stature and back waist length is not high, only .43, so we are not talking here necessarily about the difference between tall and short men. What matters in this respect to good load carrying is the space on the back above the buttocks for the positioning of a large load, whether a large pack or special items of man-portable equipment. It is also critical for a two-component load, such as a pack and sleeping bag attached separately to the load carrying harness, and to a packboard frame.

In short, the problem of load carrying cannot be reduced just to consideration of the average size man. While it is recognized that some items of equipment cannot be made in different sizes, the determination as to their effective man-portability should be weighed against the limitations of smaller sized men in the military service who may be called upon to carry them. This will apply both to weight and to the configuration of the equipment to be carried.



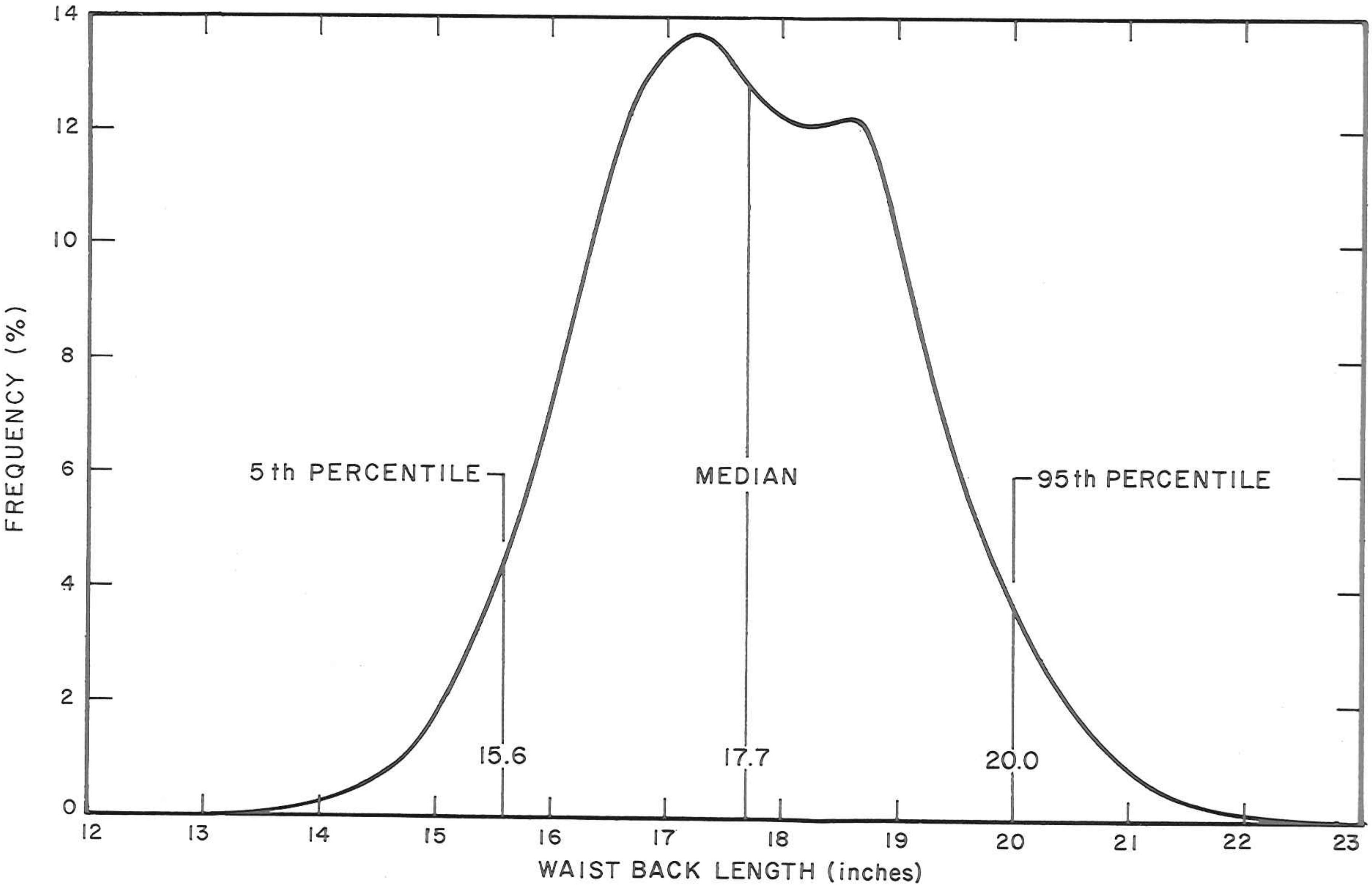

STATURE DISTRIBUTION OF U.S. ARMY MEN (1966)

Figure 20




WAIST CIRCUMFERENCE DISTRIBUTION OF U.S. ARMY MEN (1966)

Figure 21




WAIST BACK LENGTH DISTRIBUTION OF U.S. ARMY MEN (1966)

Figure 22

## G. THE CARRYING OF SPECIAL ITEMS OF MAN-PORTABLE EQUIPMENT

The items of equipment carried in the infantry company fall into three general categories:

a. Items comprising the basic load of the rifleman.

b. Items of TO&E equipment assigned to the various Military Occupational Specialties in the Infantry Company.

c. Items of special equipment which are mission-related, and which may be needed to be carried in a particular operation as required by the commanding officer.

The basic load of the rifleman, its separation into fighting and existence loads, and the additional items required for environmental protection of the soldier in cold climates have already been discussed; also some of the physiological problems associated with load carrying.

There is a fourth concern, however, with the additional load imposed on the various military occupational specialties (MOS) who must carry special equipment to perform their roles in the total integrated combat mission of the infantry company. The organization of the company is shown in Figure 23. Table IV lists 12 of 17 military occupational specialties organic to the 171 man infantry company, plus the normally attached aidman, all of whom have individual and somewhat unique load carrying requirements.

Figure 23

(TOE 7-18H)

RIFLE COMPANY, INFANTRY BATTALION, INFANTRY DIVISION OR SEPARATE INFANTRY BRIGADE

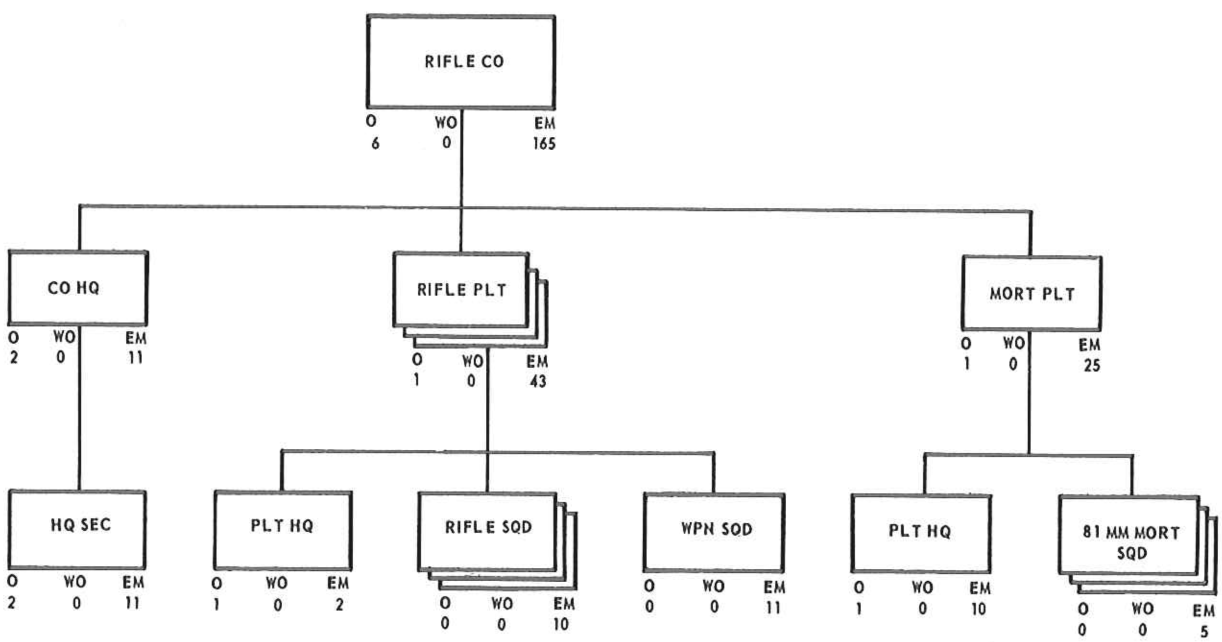


TABLE IV

## MILITARY OCCUPATIONAL SPECIALTIES IN THE INFANTRY COMPANY

| | MOS |
|---|---|
| **Company HQ Section:** | |
| C.O. — Captain | 01542 |
| Communications Chief — E-5 | 31G40 |
| Radio Mechanic — E-4 | 31B20 |
| Field Wireman — E-3 | 36K20 |
| Radio/Telephone Operator — E-3 | 11B10 |
| **Rifle Platoon HQ:** | |
| Platoon Leader - LT. | 01542 |
| Platoon Sgt. E-7 | 11B40 |
| Radio/Telephone Operator·E-3 | 11B10 |
| **Rifle Squad:** | |
| Squad Leader - E-6 | 11B40 |
| Team Leader - E-5 | 11B40 |
| Grenadier - E-4 | 11B20 |
| Automatic Rifleman - E-4 | 11B20 |
| Rifleman - E-3 | 11B10 |
| **Weapons Squad:** | |
| Squad Leader - E-6 | 11B40 |
| Gunner 90 MM | 11H20 |
| Asst. Gunner 90 MM | 11H10 |
| Machine Gunner | 11B20 |
| Asst. Machine Gunner | 11B10 |
| Ammunition Bearer | 11B10 |
| **Mortar Platoon HQ:** | |
| Platoon Leader - LT. | 01542 |
| Platoon Sgt. - E-7 | 11C40 |
| Forward Observer - E-5 | 11C40 |
| Fire Direction Computer - E-5 | 11C20 |
| Radio/Telephone Operator | 11C10 |
| **81 MM Mortar Squad:** | |
| Squad Leader - E-5 | 11C40 |
| Gunner - E-4 | 11C20 |
| Asst. Gunner - E-3 | 11C10 |
| Ammunition Bearer - E-3 | 11C10 |
| **Attached From HQ & HQ Co. Inf Bn:** | |
| Company Aidman - E-5 | 91B20 |

The special TO&E equipment which presents the biggest problem with respect to load carrying includes the communications equipment and the weapons and ammunition of the grenadier, the weapons squads and the mortar squads. Actually, all members of the infantry company, other than the rifleman, have some special equipment which they must carry. However, the major problems arise where either this equipment adds significantly to the weight of the load or where its configuration creates a difficult problem of carrying.

The principal items of communications equipment consist of the AN/PRC-77 radio, weighing 24.05 pounds with batteries, of which there are ten in the infantry company, and the AN/PRC-88 radio, weighing 3.0 pounds, of which there are eighteen in the infantry company. There is also ancillary equipment, such as the telephone switchboard, SB-993/6T, weighing 2.25 pounds.

The radio-telephone operators (Figure 24), located in the company headquarters section and in each platoon, are required to carry 28.55 pounds in addition to their fighting load, or a total weight of 78.21 pounds. (It is to be noted that the exact location of the radio-telephone on the suspenders as shown in the illustrations in this report is optional to the individual soldier.) The most effective integration of this equipment with the rest of the soldier's equipment system could well be made the subject of a specific study, both from the standpoint of configuration and location as well as to prevent detection of the radio operator by an enemy.

Other personnel in the communications network section include the field wiremen (2), in the company headquarters section who also carry the PRC-77 radio and spare battery. However, in addition, they must be prepared to carry the wire reels, and to string the wire. The field wireman with the W/MX-306 Wire Dispenser is shown in Figure 25, and with the W/DR-8RL-39 Reel with wire is shown in Figure 26. The wire dispenser adds and extra 26.0 pounds to the wireman's load, so that with his fighting load, his radio and the wire dispenser, he would be carrying 100.71 pounds in his hot weather clothing/equipment system. When carrying the reel with wire, which weighs 17.29 pounds, his total load would be 92.0 pounds.

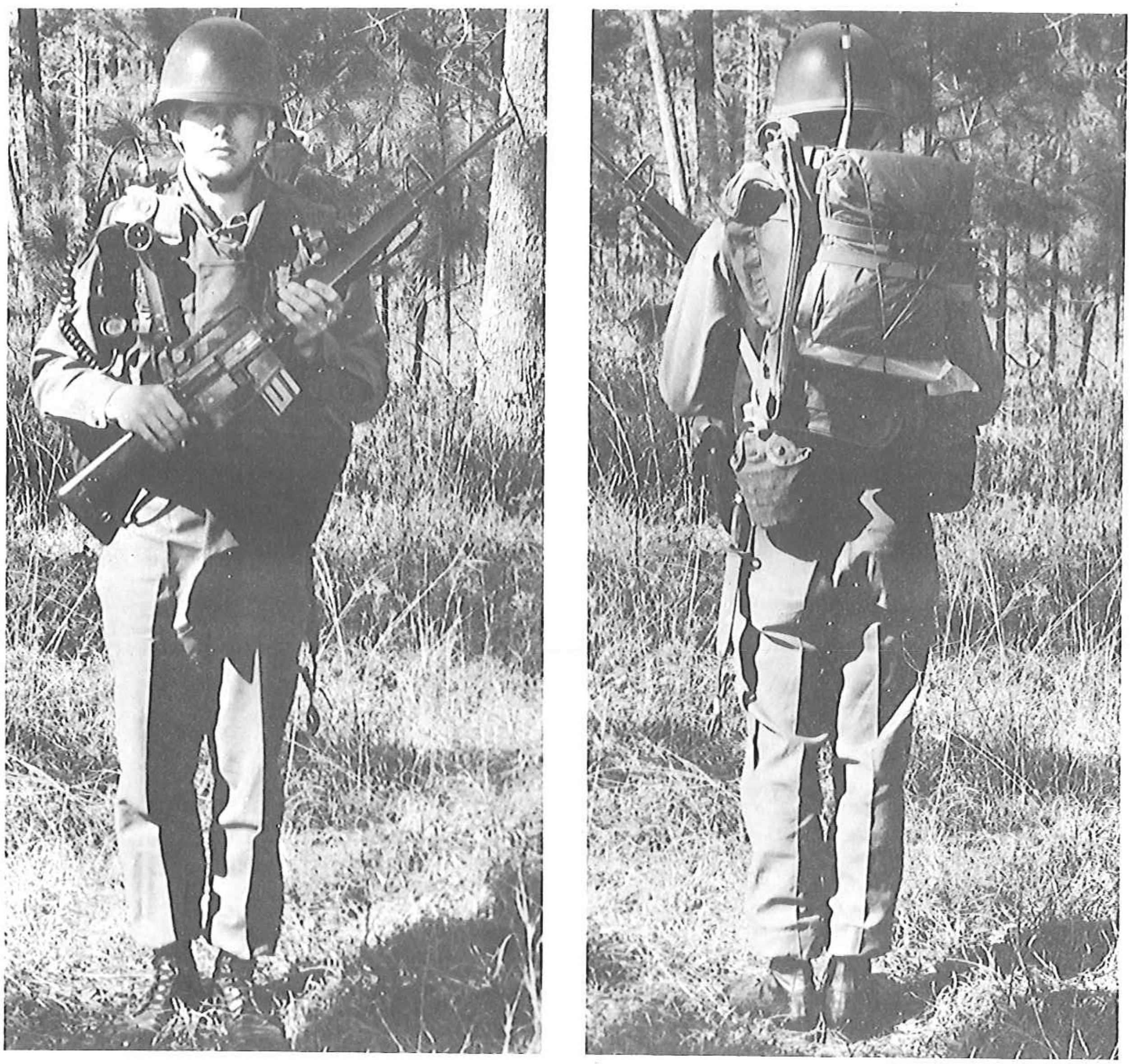
In addition, there is the RC-292 Antenna, weighing 47.0 pounds, which is both bulky and difficult to integrate with the rest of the items of the soldier's load. If the radio/telephone operator attempted to carry this item (Figure 27), plus his radio and other special equipment, plus his fighting load, his total load would be 125.21 pounds.

Here then is the list of the TO&E loads of personnel in the communications network:

| | Weight<br>Hot Weather Areas |
|---|---|
| Rifle Platoon Sergeant | 57.77 |
| Radio Telephone Operators | 78.82 |
| Field Wireman, carrying X/MX-306 Wire Dispenser | 100.71 |
| Field Wireman, carrying W/DR-8/RL39 Reel w/wire | 92.00 |
| RTO, carrying the RC292 Antenna | 125.21 |

Figure 24

RADIO-TELEPHONE OPERATOR



| | Weight (lbs.) |
|---|---|
| Basic Fighting Load (w/armor) | 49.66 |
| Marking Panels | .40 |
| Flashlight | .82 |
| Compass, Magnetic w/case | .43 |
| Radio, AN/PRC-77 w/batteries | 24.05 |
| Spare Battery, AN/PRC-77 | 2.85 |
| Total Load | 78.21 |

Figure 25

FIELD WIREMAN

Carrying the W/MX-306 Wire Dispenser on Pack Frame


| | Weight (lbs) |
|---|---|
| Basic Fighting Load | 49.66 |
| Radio AN/PRC-77 w/batteries | 24.05 |
| TE-33 Tool Kit | 1.00 |
| W/MX-306 Wire Dispenser | 26.00 |
| Total Load | 100.71 |

Figure 26

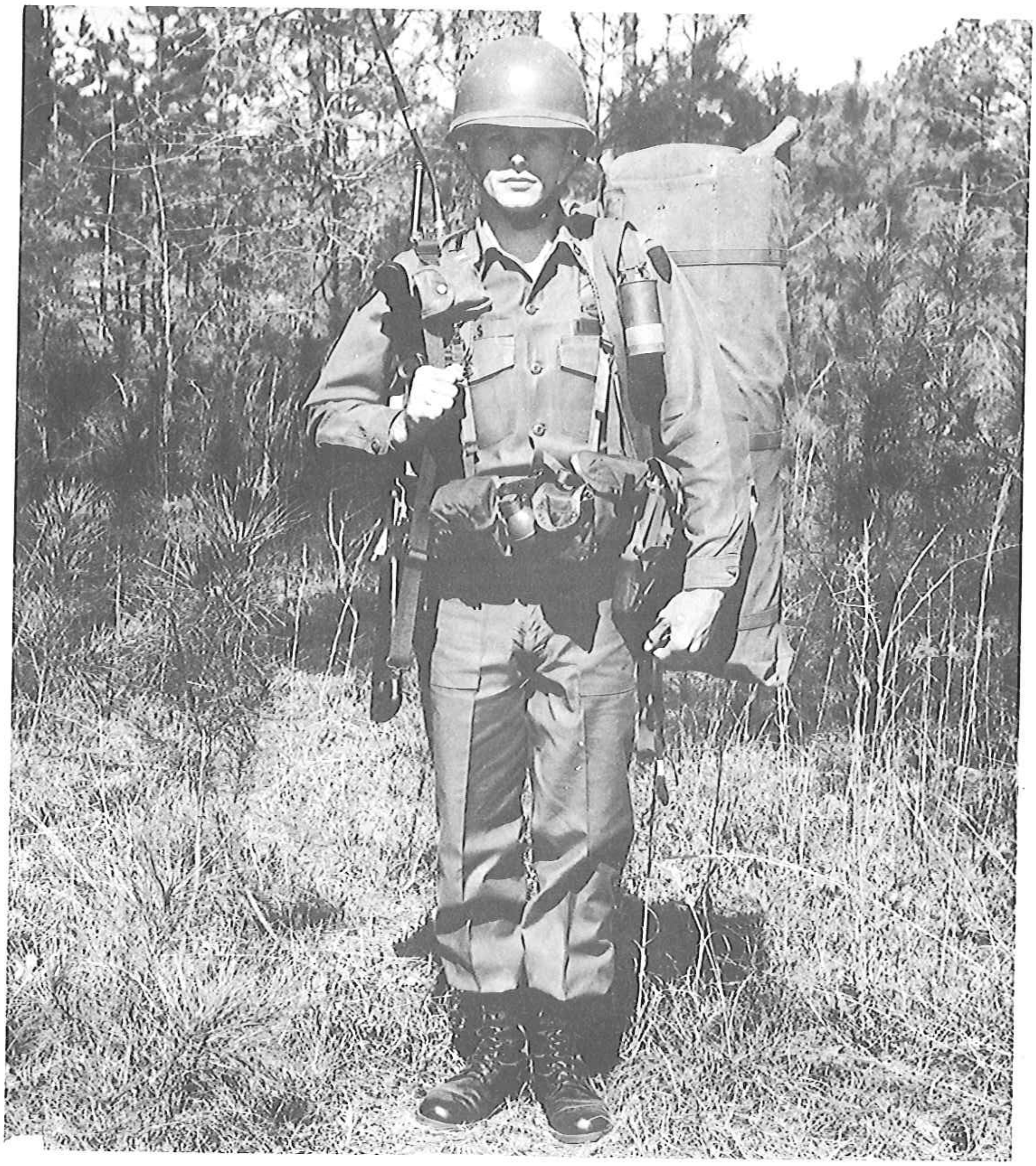
FIELD WIREMAN

Carrying the W/DR-8/RL Reel with Wire

| | Weight (lbs.) |
|---|---|
| Basic Fighting Load | 49.66 |
| Radio AN/PRC-77, w/batteries | 24.05 |
| TE-33 Tool Kit | 1.00 |
| W/DR-8/RL-39 Reel w/wire | 17.29 |
| Total Load | 92.00 |

Figure 27

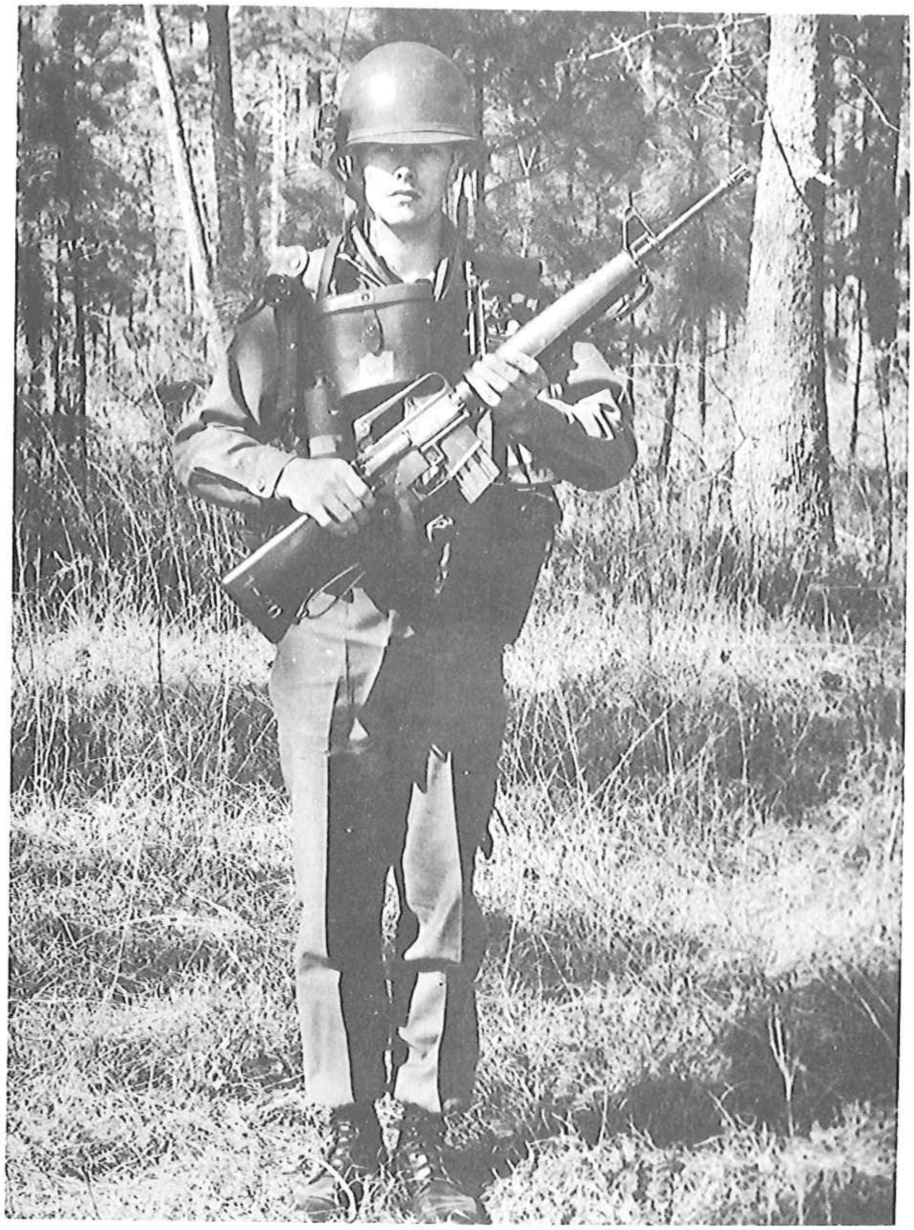
RADIO-TELEPHONE OPERATOR
Carrying the RC/292 Antenna



| | Weight (lbs.) |
|---|---|
| Basic Fighting Load (w/armor) | 49.66 |
| Special TO&E Equipment | 28.55 |
| RC/292 Antenna | 47.00 |
| Total Load | 125.21 |

Figure 28

RIFLE PLATOON SERGEANT



| | Weight (lbs.) |
|---|---|
| Basic Fighting Load (w/armor) | 49.66 |
| Flashlight | .82 |
| Map and Case | 1.00 |
| Compass, Magnetic w/case | .43 |
| Binoculars w/case | 2.86 |
| Radio AN/PRC-88 w/battery | 3.00 |
| Total Load | 57.77 |

In addition, the AN/PRC-88 radio, with the receiver mounted on the helmet (Figure 28), is supplied to the platoon sergeant, and the squad leaders of the rifle and weapon squads. This item consists of two components: the receiver, with its own battery and weighing 8½ oz. may be mounted on the helmet; the transmitter may be hand-held. The total weight of this radio is 3.0 pounds. These personnel also carry the flashlight and compass, plus the map and case, and binoculars. The weight of their special items amounts to 8.11 pounds.

The grenadier (Figure 29) in the rifle squad is another MOS with a heavy special load. He is expected to carry the grenade launcher (3.00 lbs.), the ammunition vest (1.10 lbs.) and 24 rounds of 40mm ammunition (12 lbs.). If it is assumed that he also carries his normal load of rifle ammunition, then the weights of the above are in addition, and his fighting load for hot weather areas would weigh 65.66 pounds (46.61 lbs. plus 19.05).

The weapons squad has some heavy loads of TO&E equipment. The gunner (90MM, Figure 30) must carry the 90 mm recoilless rifle (35.0 lbs.) plus binoculars (2.86 lbs.). The usual method of carrying, over one shoulder, requires the use of both of his hands. In place of the rifle and rifle ammunition, he carries a pistol with 21 rounds of pistol ammunition. The difference in weight (19.41 lbs. minus 4.59), 14.82 pounds, means that his added weight of load is 23.04 pounds, thus his total hot weather area load is 72.70 pounds.

The assistant gunner 90 MM, carrying four rounds of ammunition, weighing 26 pounds, is shown in Figure 31. His load is slightly less than that of the gunner, but it would be expected that he would be making numerous trips to bring up ammunition, so that his total work expenditure could be considerable.

The machine gunner and assistant machine gunner similarly have pistols in place of rifles, but they have loads consisting of the machine gun plus 100 rounds for the machine gunner, (Figure 32) and a spare barrel plus 100 rounds for the assistant gunner (Figure 33). The weapons squad ammunition bearer (Figure 34) carries a rifle so that what ammunition he may carry will be in addition to his normal fighting load.

In the mortar platoon, the mortar squad leader (Figure 35) would normally carry the 81MM mortar sights. This would give him a total load of 60.44 pounds.

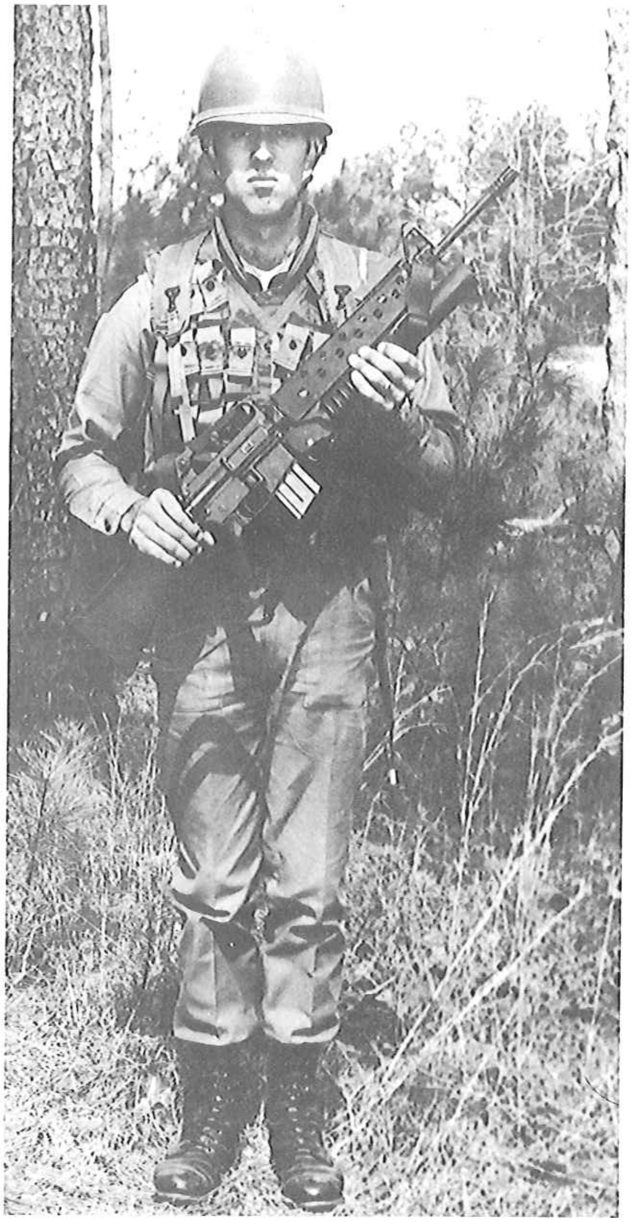
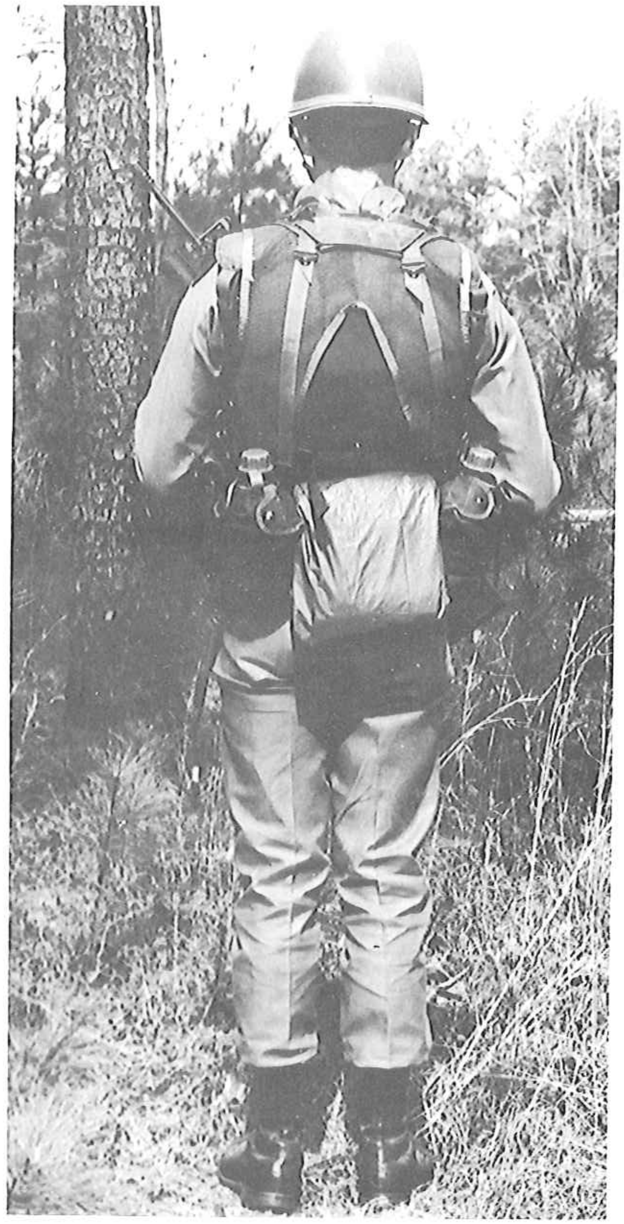
Heavy loads are carried by the 81MM mortar gunner (Figure 36) who carries the tube, (27.80 lbs.); the assistant gunner (Figure 37) who carries the bipod, (31.0 lbs.), and the ammunition bearers, one of whom (Figure 38) carries the base plate and aiming stakes (35.87 lbs.), or four rounds of ammunition (Figure 39) weighing 46.68 pounds. The mortar platoon fire direction computer (Figure 40) also carries a heavy total load of 89.30 pounds.

In summary, the total loads of the above personnel, wearing the hot weather clothing system, are shown in the following table:

| | Weight Hot Weather Areas |
|---|---|
| Weapons Squad | |
| 90 MM Gunner | 72.56 |
| 90 MM Assistant Gunner | 60.70 |
| Machine Gunner | 67.81 |
| Assistant Machine Gunner | 62.53 |
| Ammunition Bearer | 82.66 |
| Mortar Platoon | |
| Fire Direction Computer | 89.30 |
| Mortar Squad | |
| Leader | 60.44 |
| Gunner | 63.32 |
| Assistant Gunner | 66.13 |
| Ammunition Bearer / Base Plate | 85.53 |
| Ammunition Bearer (4 rounds) | 96.34 |

Figure 29

GRENADIER

| | Weight (lbs) |
|---|---|
| Basic Fighting Load (w/armor) | 49.66 |
| Grenade Launcher, M-203 or M-79 | 5.95 |
| Vest, Ammunition, 40mm | 1.10 |
| Ammunition, 40mm (24 rounds) | 12.00 |
| Total Load | 68.71 |

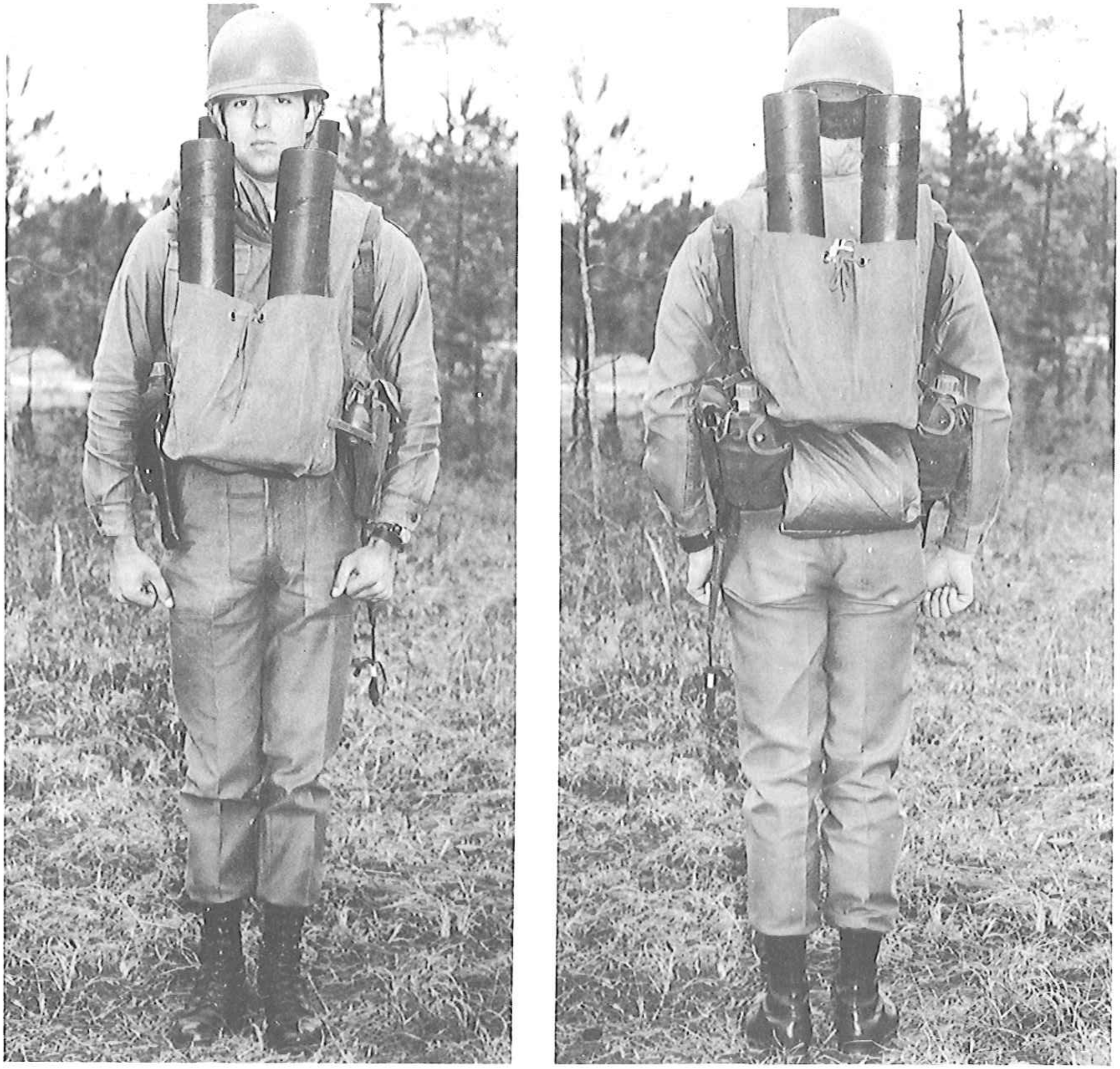
Figure 30

WEAPONS SQUAD GUNNER (90 MM)

| | Weight (lbs.) |
|---|---|
| Basic Fighting Load (w/armor) (Pistol instead of Rifle, etc.) | 34.70 |
| 90 MM Recoilless Rifle | 35.00 |
| Binoculars w/case | 2.86 |
| Total Load | 72.56 |

Figure 31

WEAPONS SQUAD ASSISTANT GUNNER (90 MM)



| | Weight (lbs.) |
|---|---|
| Basic Fighting Load (w/armor) (Pistol instead of rifle, etc.) | 34.70 |
| Ammunition 90 MM (4 rounds) w/bag | 26.00 |
| Total Load | 60.70 |

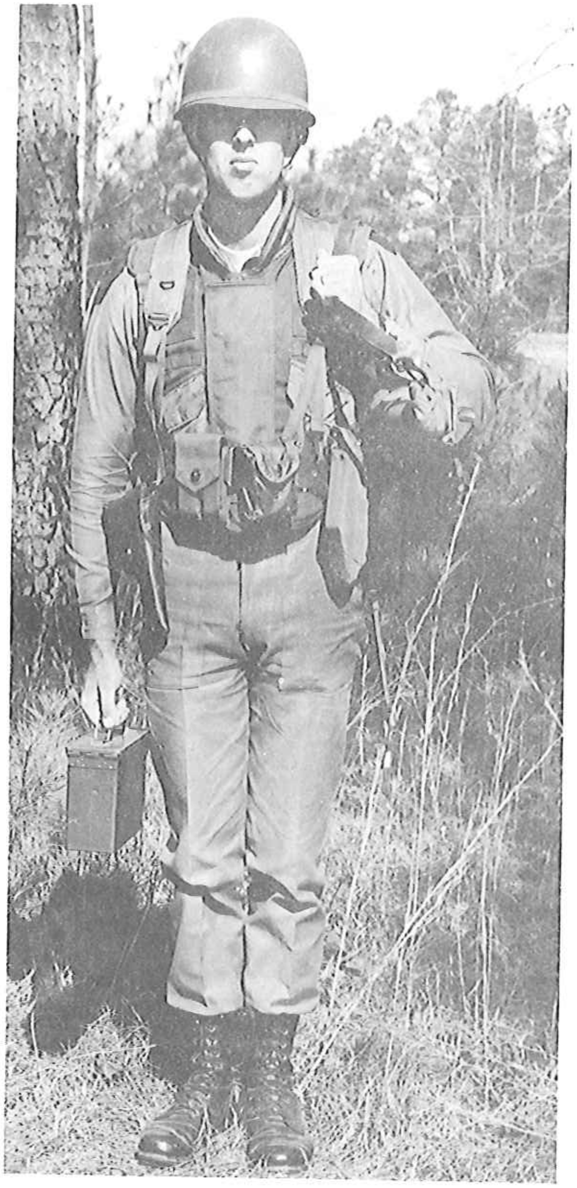
Figure 32

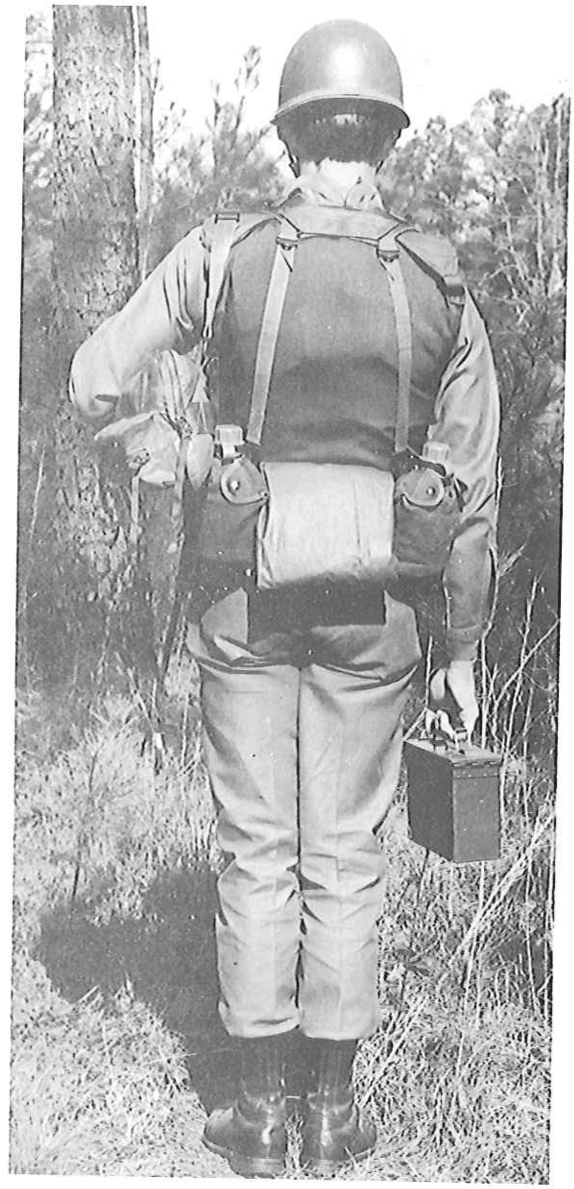
MACHINE GUNNER (M-60)

| | Weight (lbs.) |
|---|---|
| Basic Fighting Load (w/armor) (Pistol instead of rifle, etc.) | 34.70 |
| Machine Gun, 7.62 mm | 23.25 |
| Binoculars w/case | 2.86 |
| Ammunition, machine gun (100 rounds) | 7.00 |
| Total Load | 67.81 |

Figure 33

WEAPONS SQUAD ASSISTANT MACHINE GUNNER





| | Weight (lbs.) |
|---|---|
| Basic Fighting Load (w/armor) (Pistol instead of rifle, etc.) | 34.70 |
| Spare Barrel, Machine Gun, w/case | 20.83 |
| Ammunition, machine gun (100 rounds) | 7.00 |
| Total Load | 62.53 |

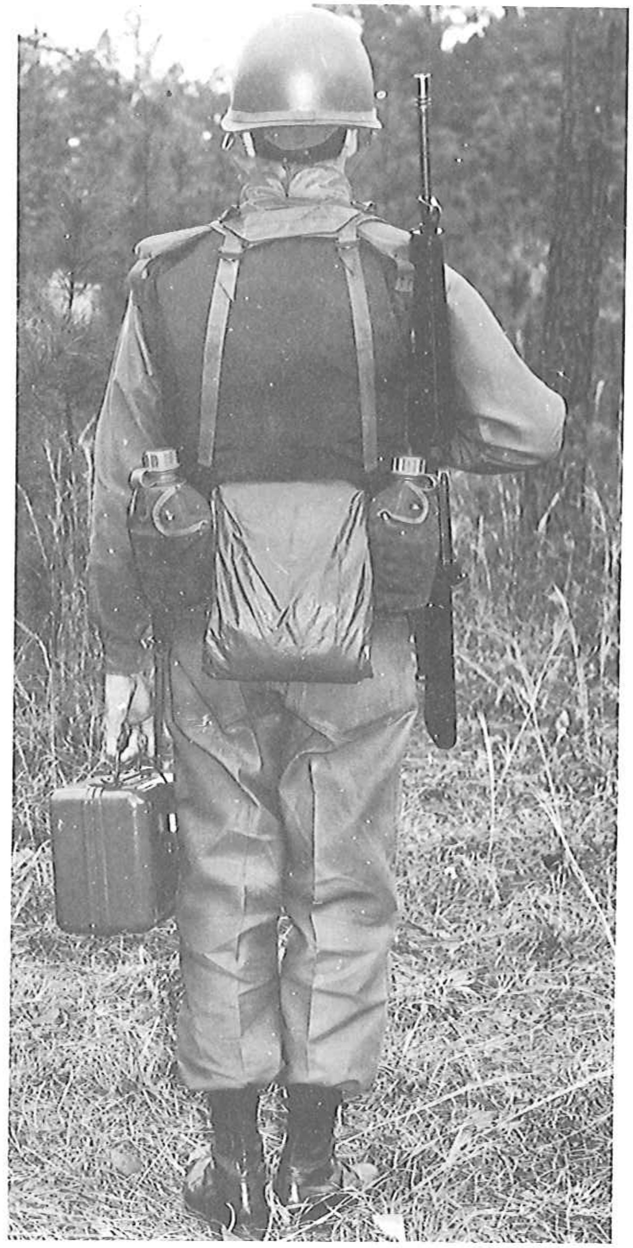
Figure 34

WEAPONS SQUAD AMMUNITION BEARER

| | Weight (lbs.) |
|---|---|
| Basic Fighting Load (w/armor) | 49.66 |
| Ammunition, Machine Gun (100 rounds) | 7.00 |
| Ammunition, 90 MM (4 rounds) w/bag | 26.00 |
| Total Load | 82.66 |

Figure 35

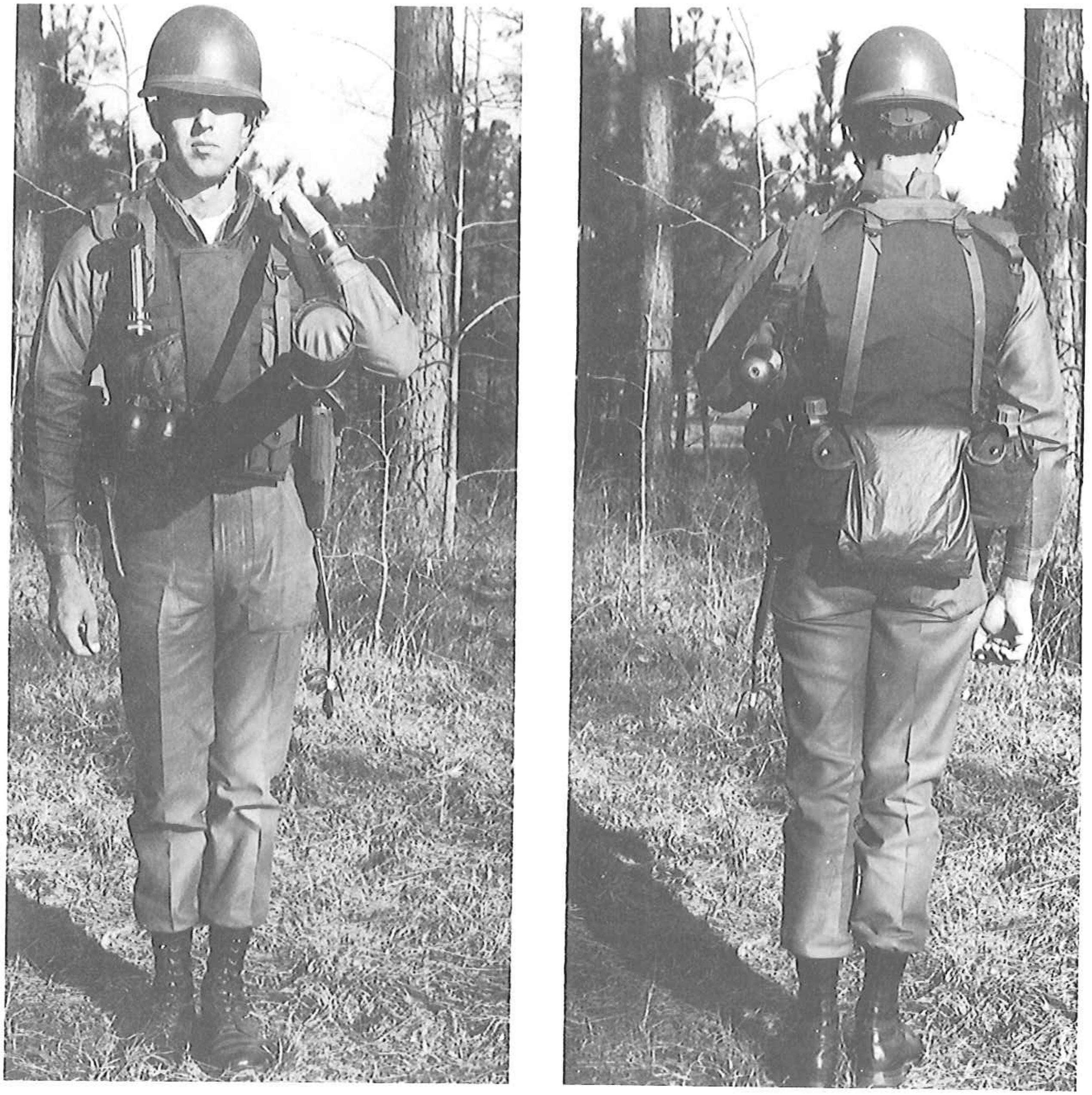
81 MM MORTAR SQUAD LEADER



| | Weight (lbs.) |
|---|---|
| Basic Fighting Load (w/armor) | 49.66 |
| Flashlight | .82 |
| Map and case | .43 |
| Sights, 81 MM Mortar | 9.53 |
| Total Load | 60.44 |

Figure 36

81-MM MORTAR GUNNER



| | Weight (lbs.) |
|---|---|
| Basic Fighting Load (w/armor) (Pistol instead of rifle, etc.) | 34.70 |
| Flashlight | .82 |
| Tube, 81 MM Mortar | 27.80 |
| Total Load | 63.32 |

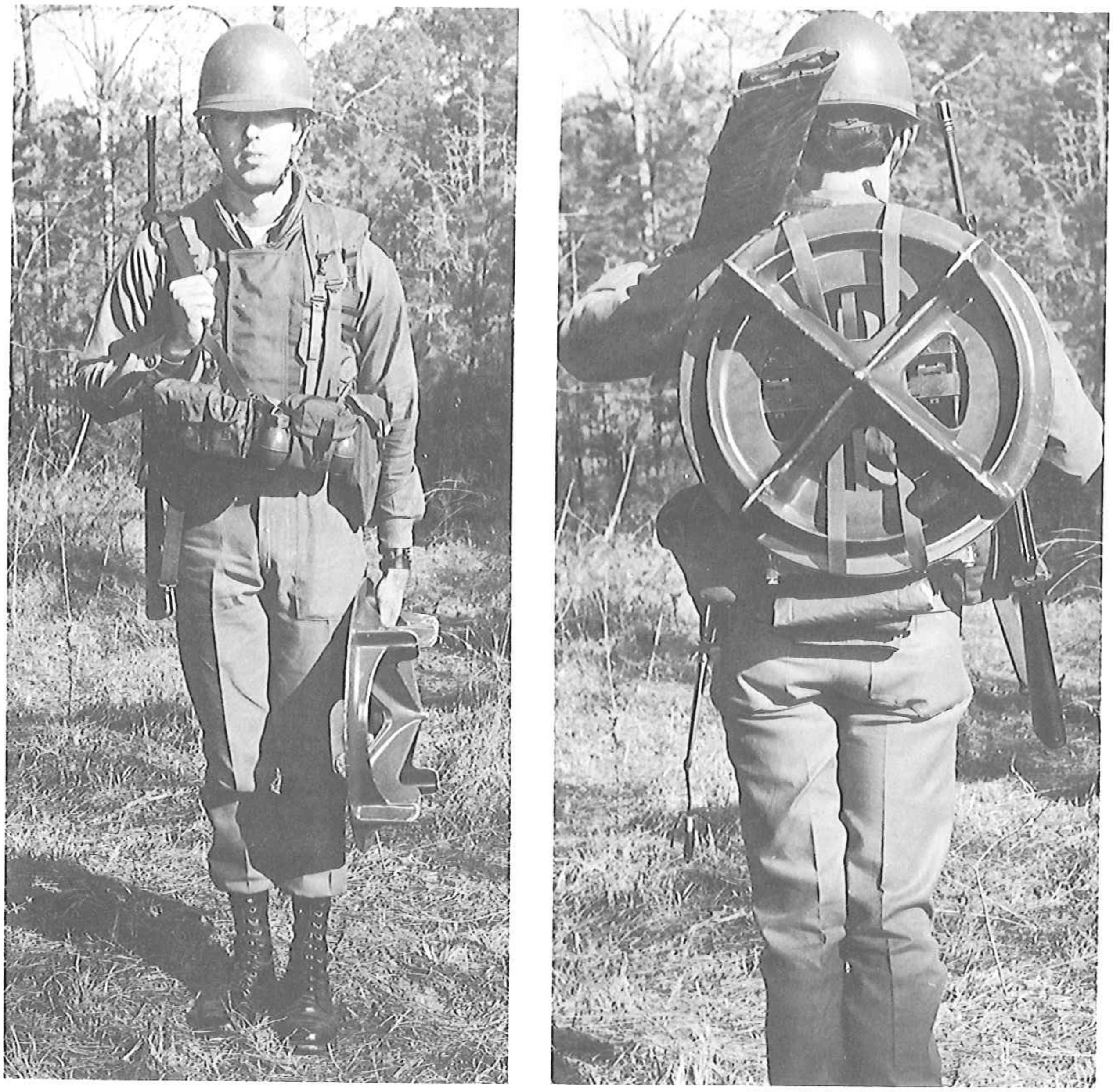
Figure 37

81 -MM ASSISTANT GUNNER

| | Weight (lbs.) |
|---|---|
| Basic Fighting Load (w/armor) (Pistol instead of rifle, etc.) | 34.70 |
| Bipod, 81 mm Mortar | 31.00 |
| Compass, Magnetic, w/case | .43 |
| Total Load | 66.13 |

Figure 38

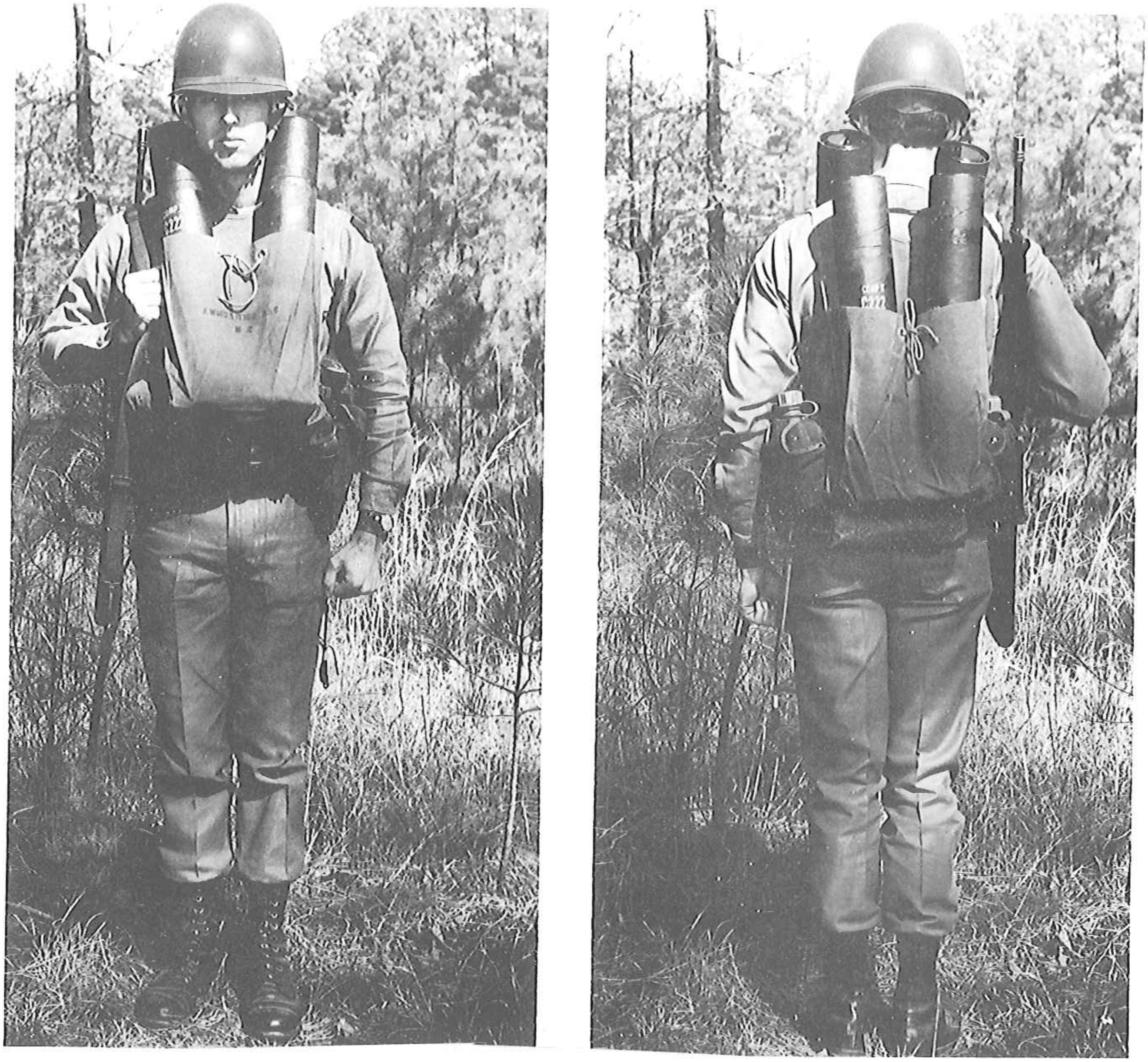
81-MM AMMUNITION BEARER, W/BASE PLATE



| | Weight (lbs.) |
|---|---|
| Basic Fighting Load (w/armor) | 49.66 |
| 81 mm Base Plate | 24.27 |
| Aiming Stakes | 11.60 |
| Total Load | 85.53 |

Figure 39

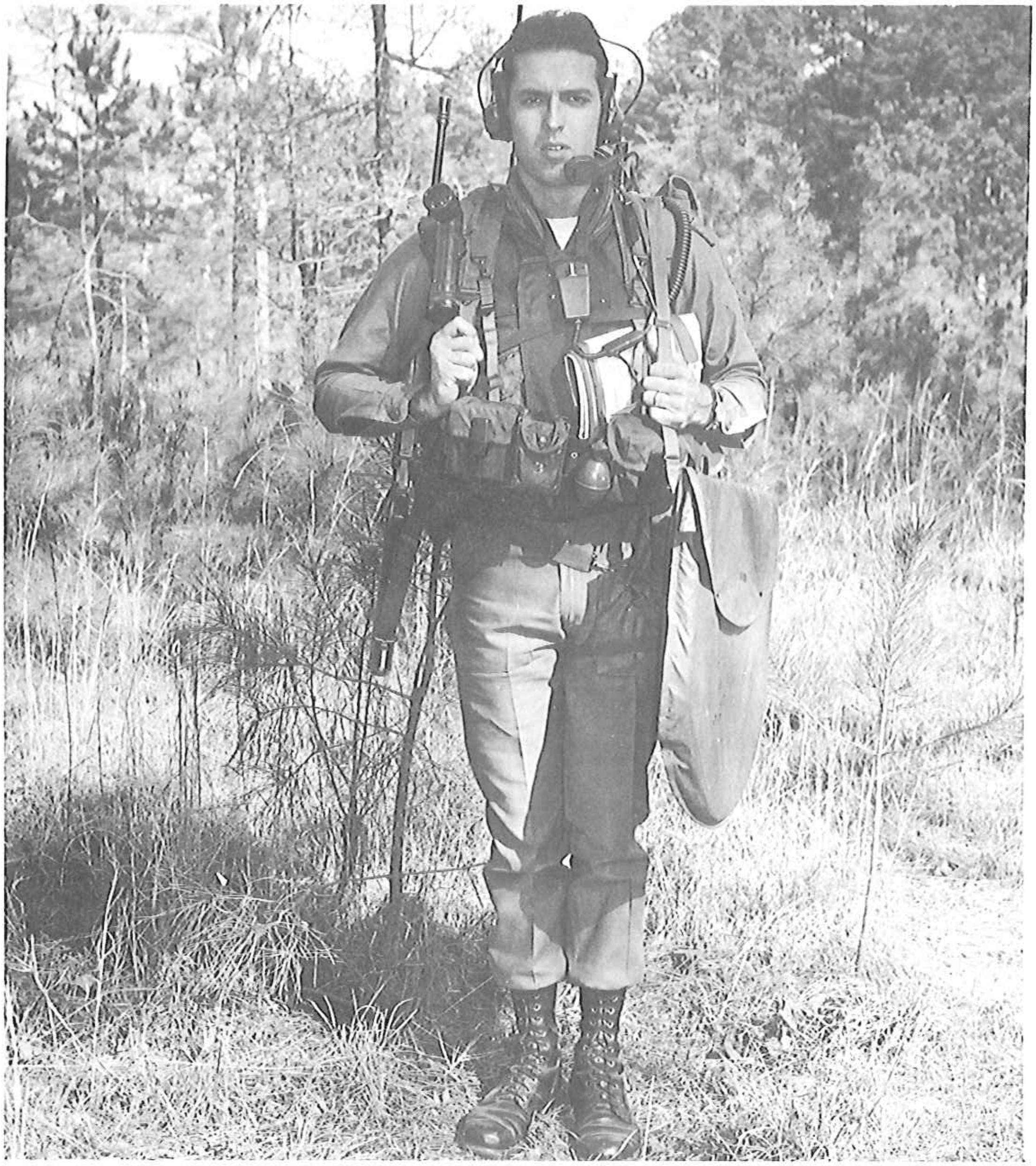
81-MM AMMUNITION BEARER



| | Weight (lbs.) |
|---|---|
| Basic Fighting Load (w/armor) | 49.66 |
| 81 mm Ammunition (4 rounds) | 46.68 |
| Total Load | 96.34 |

Figure 40

MORTAR PLATOON FIRE DIRECTION COMPUTER



| | Weight (lbs.) |
|---|---|
| Basic Fighting Load (w/armor) | 49.66 |
| Flashlight | .82 |
| Map and case | 1.00 |
| Plotting Board MO-16 | 6.17 |
| Radio AN/PRC-77 w/battery | 24.05 |
| Spare Battery, w/headset microphone | 5.35 |
| Aiming Circle, 81 mm Mortar w/tripod | 2.25 |
| Total Load | 89.30 |

If we were to add to the above weight the extra weight of cold weather clothing and equipment of 43.24 pounds as listed in Table II, it would give total weights over 100 pounds for all of these MOS'. Even if the extra weight of the cold weather clothing and equipment were cut to a bare minimum, by elimination of some of the items, by leaving them for separate distribution or sled carry, it is clear that efficient operation of these personnel in cold or extreme cold climates would be quite limited, simply from the standpoint of weight of the loads to be carried, quite aside from other considerations of the severity of the climate, difficulty of the terrain, etc.

One further person with a special load is the aid man (Figure 41) assigned to headquarters company, but normally attached to the infantry company. His kit of medical equipment, weighing only 9.50 pounds, is not excessive. The litter, however, would be his concern.

In addition to the TO&E equipment which has been listed above, there are numerous other items of organizational equipment as well as munitions available to the infantry company which are considered as man-portable, or which must be carried into position for use. Following is a partial list:

| | Weight (lbs) |
|---|---|
| Night Vision Sight, AN/PVS-2 mounted w/case | 7.01 (16.27) |
| M18A1 Claymore Antipersonnel Mine | 3.00 |
| (Kit Carrier and Mine) | 6.00 |
| M3 Riot Control Agent Disperser | 35.00 |
| M9 Portable Flame Thrower | 50.00 |
| XM47, Surface Attack Guided Missile, Dragon | 31.87 |
| Rope | 2.00 |
| Trip Flares | 1.50 |
| XM 191 Flash w/clip | 25.00 |

NOTE: The above list is based upon TOE-7-18H, which may be consulted for a full listing.

The carrying of the special items of TO&E equipment assigned to the military occupational specialties in the infantry company, and the special organizational items of equipment, in addition to the soldier's normal load, involves four important considerations:

- The distances over which they may have to be man-carried in the deployment of the infantry company in offensive and defensive combat.
- The decreased mobility which the carrying of heavy loads induces, as discussed above.
- The most efficient way to carry them, so as to integrate them effectively with the rest of the soldier's load.
- The configuration of the equipment design, so that it will integrate with the rest of the soldier's load and permit the greatest ease of carrying, so as to create the least interference with the soldier's effectiveness as a combat soldier.

Figure 41

COMPANY AID MAN

| | Weight (lbs.) |
|---|---|
| Basic Fighting Load (w/armor) (Pistol instead of rifle, etc.) | 34.70 |
| Medical Instruments, w/supply set and case | 9.50 |
| Flashlight, plastic, right angle | .82 |
| Total Load | 45.02 |

The field manuals do not fully clarify what is expected as to distance with respect to man-portable items. For example, The Rifle Company, Platoons, and Squads, dated April 1970, in discussing the employment of the Mortar Platoon (3-18) states:

> "The mortar position is normally well forward during the attack because of greater accuracy at shorter ranges, and so that fires may be provided as long as possible prior to displacement. . . . . Routes of supply should be short, covered, and concealed, and they should permit vehicular movement into the firing position if possible."

The implication of the above is that under some conditions, the mortar would need to be sited near a road net, but that under other conditions, it could well be located at considerable distance away.

This same general problem appears in FM 31-70, Basic Cold Weather Manual, dated April 1968, where it is stated (5-5 f.(1)):

> "When track-laying vehicles and cargo sleds cannot be used any further due to the tactical situation, the crew-served weapons, ammunition and warming tents must be moved to the units in man-drawn sleds."

Here, the implication is that sleds will permit deployment of the heavy equipment at some distance from the road net. Where the use of sleds may not be practicable, it would appear that the equipment would need to be man-carried.

When one turns to the problem of man-carrying in mountain situations, it is clear that the need for man-carrying of this heavy equipment is recognized. In FM 31-72, Mountain Operations, Chapter 3, Section VIII, Transportation, 128.b., it states:

> "Motor transportation in mountainous terrain is usually drastically reduced. Only those vehicles carrying loads which cannot be packed should be allowed beyond a previously designated truck-head."

It is further implied, however, that supply in mountain operations will be effected by helicopter, Chapter 3, Section IV, 103.b, states:

> "The helicopter's ability to use the landing sites available in mountains enable it to quickly move personnel and equipment into locations which otherwise could not be reached except after the elapse of considerable periods of time."

In the absence of clear indications of the conditions, particularly the distances, for man-carrying of such equipment under combat conditions, it must be assumed that, under extreme conditions, which necessarily define the limits of the problem, distances could be considerable, and the terrain difficult. In fact, it would appear that where vehicles cannot go, and where the use of airlift could betray the location of a position, resort must be made to hand-carrying. In other words, the terrain which will create the greatest strain on the man carrying the equipment (which can be predicted using the mobility cost equation given previously) is the very condition where the greatest dependence will be placed upon man-portability.

Since it is likely to be under extreme conditions of terrain and physiological stress that the carrying of these items of heavy equipment will be most important from a tactical standpoint, their configuration is of the greatest importance. It must be such that they can be effectively integrated into the total load carried by the soldier.

Field testing of this equipment should be made by soldiers carrying their full load plus body armor; and the final configuration and the way in which the equipment is to be carried should be established prior to final determination of the design of the item. Particular consideration should be given to the possibility of carrying such items on the packboard frame which is an integral part of the newly designed load carrying system.

Specific doctrine as to the way an item can be most effectively carried should be worked out during the process of evaluation of design or the testing of the equipment and should be incorporated into the manual of instruction for its use.

## H. CONCLUSIONS

1. The dichotomy between capacity requirements of the load carrying equipment, particularly the pack, and the weight of the load presents a problem to which there is no solution. The availability of packs of more than one size to accommodate the different requirements of different tactical and combat situations through the application of the concept of flexibility in capacity in the load carrying equipment, affords one partial solution. An aggressive, continuing development program to apply advances in materials and design technology to reduce the weight of all items carried by the soldier will also contribute toward a solution.

2. The present load of the soldier, including his basic fighting load, plus the special clothing and equipment required for cold climates, and the special equipment carried by many of the MOS' in the infantry company, exceeds tolerable limits, if the loads are to be carried for significant distances. The price to be paid in expenditure of energy may reduce the combat efficiency of the soldier beyond acceptable limits.

3. Soldiers who are below the average in size pay a significantly higher price in proportionate physiological cost. For missions requiring the carrying of extra heavy loads, men of above average size should be selected; e.g., RTO's and personnel of the weapons and mortar squads.

4. The configuration of special items of equipment should be carefully studied from the standpoint of the way they are to be carried in respect to the rest of the soldier's clothing/equipment system. The method of carrying should be established during the process of design. The preferred method of carrying should be identified in the instructions for use of the equipment during its evaluation by troops.

5. The new frame for the pack, developed for use also as a packboard as an integral component of the M-73 load carrying system, affords a ready means for efficient carrying of heavy equipment having a configuration that is adapted to being attached to this item.

6. Testing of load carrying systems should be carried out across a full environmental range of clothing, temperature and terrain conditions. Guidance in the design, and if necessary, support in the conduct of such studies, should be obtained from the U.S. Army Surgeon General's Research Institute of Environmental Medicine, located at the Army Natick Laboratories, Natick, Massachusetts.

7. In summary, the whole area of load carrying within the infantry company presents numerous problems to which there are no fully satisfactory solutions. A systems approach, which would include all items which are expected to be man-carried, is required at all stages of their development to make sure the problems of carrying are adequately defined and maximum effort made to reach optimum decisions as to configuration, weight and utilization.

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| | |
|---|---|
| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Natick Laboratories<br>Natick, Mass. 01760 | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP<br>NA |

3. REPORT TITLE

THE CARRYING OF LOADS WITHIN AN INFANTRY COMPANY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

Dr. Stephen J. Kennedy, Dr. Ralph Goldman, and Mr. John Slauta

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
|---|---|---|
| May 1973 | - | - |

| | |
|---|---|
| 8a. CONTRACT OR GRANT NO. | 9a. ORIGINATOR'S REPORT NUMBER(S)<br>TR-73-51-CE |
| b. PROJECT NO.<br>c. 1J764713DL40<br>d. | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) |

10. DISTRIBUTION STATEMENT

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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13. ABSTRACT


The carrying of loads by the infantry involves three distinct problems:

a. The capacity of the load-carrying equipment, particularly the pack, in relation to the requirements of various combat missions.

b. The weight of the load, in relation to the physiological limitations of the soldier himself.

c. The carrying of man-portable equipment assigned by the TO&E to various military occupational specialists in the infantry company, and other special items of organizational equipment.

This study brings these problems into perspective, both in relation to what has been done in the past, and what is currently in progress. It also indicates some special aspects that should be of concern to designers of equipment intended to be man-portable.


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|---|---|---|---|---|---|---|
| | ROLE | WT | ROLE | WT | ROLE | WT |
| PACKS (Carrying) | 8 | | | | | |
| BACK PACKS | 8 | | | | | |
| LOAD CARRYING | 8 | | | | | |
| LOAD CARRYING EQUIPMENT | 8 | | | | | |
| MILITARY PERSONNEL | 4 | | 9 | | | |
| INFANTRY | 4 | | 9 | | | |
| WEIGHT | | | 6 | | | |
| PORTABLE EQUIPMENT | 9 | | 6 | | | |
| EQUIPMENT | 9 | | 6 | | | |
| MAN-PORTABLE | 0 | | 0 | | | |
| EFFICIENCY | | | 7 | | | |
| ANTHROPOMETRY | | | 6 | | | |
| TACTICAL WARFARE | | | 7 | | | |
| MOBILITY (MILITARY) | | | 7 | | | |