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76-61-AMEL

OPERATION OF MILITARY FIELD HEATING EQUIPMENT USING SOLID FUELS

March 1977

UNITED STATES ARMY
NATICK RESEARCH and DEVELOPMENT COMMAND
NATICK, MASSACHUSETTS 01760

Aero-Mechanical Engineering Laboratory

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report is the result of the US Army Natick Research & Development Command (NARADCOM) Production Engineering Program (Project 12, Task 19). In view of the present energy crisis and its impact on the use of liquid fuel, this project was undertaken to survey the present military heating equipment to determine their capabilities for burning solid fuels. This report describes standard military equipment and components for heating in field operations with solid fuel. Included in the report is a discussion of the handling and burning characteristics of solid fuels. The report concludes with twenty-two (22)

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20. Abstract (cont'd)

recommendations that should be considered. The increasing demand of liquid fuel needed for military combat equipment plus the uncertain supply of liquid fuel could result in a drastic reduction in the amount of liquid fuel available for field heating.

PREFACE

This report describes the present Standard Military Field Heating Equipment that is suitable for use with solid fuels. It also includes brief descriptions of coal and wood, their burning characteristics, storage problems, and their potential for use by the military for field heating. Recommendations relating to changes in present equipment and to the need for additional equipment are also included.

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OPERATION OF MILITARY FIELD HEATING EQUIPMENT USING SOLID FUELS

Introduction

The prescribed fuel[1] for US Army combat and tactical units is liquid fuel motor gasoline (MOGAS) and turbine engine fuel (JP-4). The possibility exists that the supply of liquid fuel for field heating could be greatly reduced or eliminated forcing the increased use of solid fuel (coal or wood).

If this condition occurs, vehicles, generators, and similar tactical equipment would have first priority in the use of the liquid fuel available. The fuel remaining and the fuel which has been declared unsuitable for its intended use would be available for heating. The present field heating equipment was designed to meet this potentiality, and at the same time be capable of operation without the use of external electrical power.

Field heaters presently in the military supply system will be discussed in Section IV. These heaters have been used with solid fuel for limited periods with moderate success. The term "field" is used throughout this report to describe military operations when tents and temporary shelters are used and where mobility is one of the main requirements.

Solid fuel for field heating will place a burden on our field Army because of the introduction of a form of energy which differs greatly from that presently used in the handling, storage, and final use. Use of solid fuel is not new to the Army, but as it was always considered an expedient, the handling was left to the ingenuity of the user.

Civilian use of coal for small space heaters is so limited that we cannot rely on past civilian experience to be of much help in the training of military personnel. Even the sight of coal is a new experience to most, let alone using it for heating. It is, therefore, important that procedures and equipment be available for military application in anticipation of a possible change of the Military Logistic Policy to use solid fuel field heating requirements.

[1] AMC Regulation No. 700-28 dtd 27 October 1971 Logistics Fuel Policy

Solid Fuel Characteristics

A. COALS

1. General:

A British Thermal Unit (Btu) is 1/180 of the amount of heat required to raise 1 lb. of water from 32° to 212°F. A calorie (cal) is 1/100 of the amount of heat required to raise one gram (g) of water from 0° to 100°C. 1-Btu = 252.0 calories = 1052 joules. For all practical purposes it is sufficiently accurate to regard a Btu as the amount of heat required to raise 1 lb. of water 1°F. One wooden match has the approximate heat value of one Btu.

Coal is a black, combustible, mineral solid resulting from the partial decomposition of vegetable matter away from air and under varying degrees of high temperatures and great pressure over a period of millions of years. Coal is found at varying depths of the earth, from the surface (open pit) to underground mines at depths of two miles. Except for the removal of impurities, drying and grading; coal is ready to burn when mined. Of all solid fuels, coal is by far the most important, being the cheapest and most abundant.

Coal contains inert matter in the form of ash and water, varying in amounts from 8% to 40%. The heating values range from about 37.22-MJ/kg (16,000-Btu per pound) for the better coals to about 26.75-MJ/kg (11,500-Btu per pound) for the poorer lignites. Dry coal consists of varying amounts of carbon, oxygen, hydrogen, sulfur, nitrogen, and ash.[2]

Coal may be classified in many ways. The classification of coal is more or less arbitrary, and the boundary lines are not too rigid, since the various types shade off into each other so gradually. To the general public it is either anthracite (hard) or bituminous (soft) coal. The American Society for Testing Materials has some fifty different standards applying to coal and its by-product coke.[3] This report assumes that the military could be forced to use all types and sizes in an emergency.

In general, it may be said that the degree of hardness of coal is a measure of the extent to which it has become pure carbon. The original vegetable matter from which coal was formed consisted of roughly 50% carbon, 43% oxygen, 6% hydrogen, and 1% nitorgen. During the process of formation,

[2]Haslam, Robert T., and Robert P. Russell, Fuels and Their Combustion, 1926, McGraw-Hill

[3]American Society for Testing & Materials, ASTM Part 19, Gaseous Fuels; Coal & Coke

the percentages of carbon increased and the percentages of the volatile constituents (oxygen, hydrogen, and nitrogen) decreased progressively until the material became anthracite coal. The final result consisted of approximately 95% carbon, 2.5% hydrogen, 2.5% oxygen, and only a trace of nitrogen. This progressive change from low-carbon high-volatile, to high-carbon low-volatile material, provides the basis for one of the principal scales for coal classification.[4]

TABLE I

STANDARD APPROVED CLASSIFICATION OF COAL[5]

Meta-anthracite	High Volatile B bituminous
Anthracite	High Volatile C bituminous
Semi-anthracite	Sub-bituminous A
Low Volatile Bituminous	Sub-bituminous B
Medium Volatile Bituminous	Sub-bituminous C
High Volatile A Bituminous	Lignite A

COMMON TERMS USED TO CLASSIFY COAL

Soft	Broken
Hard	Egg
Common banded	Stove
Splint	Chestnut
Cannel	Pea
Bog head	Buckwheat (1-5)
Slack	Peat
Briquets	Coke

2. Hard Coal - Anthracite:

Anthracite coal ignites slowly but its radiant heat is intense when in a state of incandescence. Its flame is short and of a yellowish-blue tinge, and it can be burned with practically no smoke. True anthracite is characterized by its few joints and clefts and their squareness; great relative hardness and density, high specific gravity ranging from 1.4 to 1.8; and semi-metallic luster.

[4]Faust & Kaufman, Handbook of Oil Burning, 1951, Oil-Heat Institute of America
[5]American Society for Testing & Materials, ASTM Part 19, Gaseous Fuels; Coal & Coke

3. Soft Coal - Bituminous:

In general, the bituminous coals are softer than the anthracites, contain more volatile matter, ignite more easily, and burn more rapidly. The distinctive characteristic of the bituminous coals is the emission of yellow flame and smoke when burning. The soft coals range in color from pitch black to dark brown, have a resinous luster in most compact specimens, and a silky luster in such specimens as show traces of vegetable fiber. Their specific gravity is about 1.3.

4. Powdered Coal:

One approach to coal burning, which had minor success during the early part of this century, was the powdered coal burner. All types of coal can be easily pulverized by means of rollers and grinders. When used in this manner, the powdered coal is injected into the combustion chamber, mixed with air, and burned in suspension. The resulting fire is similar to that of a liquid fuel burner, except that the ash must be removed from the flue gas and any accumulated powder or clinkers removed.

The advantage of burning powdered coal is that the firing rate can be modulated and intermittent firing is possible. It does, however, require power for blowers and metering mechanism.

This type of burning had some acceptance in the cement industry and in large power plants. Its use was short lived as automatic oil burning had the overall economic advantage. Of interest is the fact that Thomas Edison, in addition to his many other great discoveries, was granted a patent in 1904 for a powdered coal burner.[6]

5. Coke:

Coke, like charcoal, is the result of carbonization or distillation of coal by heat in the absence of air. The by-products of this process (coke, gas, tar, ammonia, and benxols) are widely used in industry. Coke, itself, is used primarily in the metallurgical industries in the production of metals. When coke is used for heating it has the advantages over regular coal of being cleaner to handle and providing almost smokeless combustion. Coke has a heat content of approximately 31.4-MJ/kg (13,500-BTU per lb) with a density approximately 30% less than coal.

[6]Herington, C. F., "Powdered Coal as a Fuel", 1918, D. Van Noslnand Co.

6. Storage Problems:

As coal is subject to spontaneous combustion, the storage of it must be given serious consideration. This characteristic is greatest among coals of lowest rank and increases as the coal size decreases. The absorption of oxygen or oxidation begins as soon as freshly broken coal is exposed to the air.[7]

The prevention of spontaneous heating in storage is a problem of preventing oxidation, as much as possible, and of dissipating any heat generated. Air may carry away heat but also brings oxygen to create more heat. Spontaneous heating can be prevented or lessened by:

a. Storing coal under water.

b. Compressing the pile in layers as with a rod roller to prevent access of air.

c. Storing large-size coal.

d. Preventing any segregation of sizes in the pile. (It is usually best to pile in layers.)

e. Storing in small piles.

f. Keeping storage pile height as low as possible. (The limit is 1.83-m (6-ft) for many coals.)

g. Storing away from any external sources of heat.

h. Avoiding any draft or air through the coal.

i. Using older portions at the storage first and avoiding accumulation of old coal in corners of storage areas.

It is desirable to watch the temperature of the pile. An iron pipe with a thermometer installed can be used when driven into the coal to reveal temperatures. When a temperature of 48.9°C (120°F) is reached, the coal should be moved. Using water to put out a coal fire, although effective for the moment, may only delay the necessity of moving the coal.[8]

[7] Marks, Lionel S., Mechanical Engineers Handbook, 1951, McGraw-Hill
[8] Bureau of Mines, The Storage of Coal IC 7235

B. WOOD

The approximate composition of moisture-free wood is 49% carbon, 6% hydrogen, 44% oxygen, and 1% ash. The average heat value of moisture and resin-free wood is 19.31-MJ/kg (8300-BTU per lb). Green wood contains approximately 50% moisture, and weighs between 641 to 1202-kg/m^3 (40 to 75-lb/cu ft). Air dried or seasoned wood contains 15 to 25% moisture and kiln-dried about 8%. A general assumption can be made that the heat content of a pound of coal is equal to about 0.91-kg (2-lbs) of wood and that a ton of coal has the approximate heat content of a cord of wood.[10] Wood is sold by the cord. The standard cord is 2.44-m (8-ft) long x 1.22-m (4-ft) wide x 1.22-m (4-ft) high, or 3.62-m^3 (128-cu ft). It should be noted that approximately 70% of a cord volume or 2.55-m^3 (90-cu ft) is wood. As wood is normally measured by the cord, consideration must be given to its value when it is measured by volume (cord).

The actual volume of cord will vary depending on the compactness of stacking wood due to the size and shape of the cut logs. Even if identical volumes are assumed, the heat content will vary depending on the type of wood. For example, a cord of bass wood contains 13290-MJ (12,600,000-BTU) while a cord of black locust will yield 27960-MJ (26,500,000-BTU). All dry, nonresinous woods give off practically the same amount of heat in burning. A pound of throughly dry wood will furnish under normal conditions, between 7.4-MJ and 9.5-MJ (7,000 to 9,000-BTU). A pound of good coal will furnish from 12.7 to 14.8-MJ (12,000 to 14,000-BTU). Therefore, the heat content of wood is approximately 57% of coal when measured by weight.[11]

Most woods split more readily when green or partly dry than when dry. Wood can be sufficiently dried for reasonably satisfactory burning within a few weeks of cutting. Wood dries faster when split, but the greatest amount of drying occurs at the cut ends. If possible, wood should be stored so that both ends are exposed to the air and protected from rain. For faster drying, stack wood off the ground and place strips of wood between the courses of logs to allow air circulation.

[9] Marks, Lionel S., Mechanical Engineers Handbook, 1951, McGraw-Hill
[10] Graves, Henry, The Use of Wood for Fuel, Bulletin No. 753, 10 Mar, 1919, US Dept of Agriculture
[11] Hale, J. D., Heating Value of Wood Fuel, Nov 1933, Dept of Mines & Resources, Forest Product Laboratories of Canada

TABLE II

BURNING CHARACTERISTICS OF WOOD

Species	Ease of Starting	Coaling Qualities	Sparks	Fragrance	Heating Class (I Best)
Apple	Poor	Excellent	Few	Excellent	I
Ash	Fair	Good	Few	Slight	II
Beech	Poor	Good	Few	Slight	II
Birch (white)	Good	Good	Moderate	Slight	II
Cherry	Poor	Excellent	Few	Excellent	II
Cedar	Excellent	Poor	Many	Good	III
Elm	Fair	Good	Very Few	Fair	II
Hemlock	Good	Low	Many	Good	III
Hickory	Fair	Excellent	Moderate	Slight	I
Locust (black)	Poor	Excellent	Very Few	Slight	I
Maple (sugar)	Poor	Excellent	Few	Good	I
Oak (red)	Poor	Excellent	Few	Fair	I
Pine (white)	Excellent	Poor	Moderate	Good	III

C. OTHER SOLID FUELS

1. Charcoal:

Charcoal is prepared by heating wood to the charring temperature in the absence of air. Wood loses 75% of its weight and 50% of its volume in charring with a resultant heat value of approximately 25.59 MJ/kg (11,000-BTU/lb).[12] Charcoal ignites and burns without smoke, It can be pulverized and, with the addition of a binder, pressed into any shape.

2. Paper:

Paper, a by-product of wood, has about the same heat value of wood. But, unless the ash from the burned paper is removed, air needed for combustion is restricted from reaching the unburnt paper, making combustion difficult. One solution is to soak the paper with water and press it into logs which when dried can be burned with fair results. If the log is made with a hole through the center allowing air to circulate, combustion is greatly improved.

3. Seaweed:

Kelp, a type of seaweed which grows up to two feet a day, is presently being investigated by California Institute of Technology as a source of energy. It can be used for food, fertilizers, natural gas, and as a fuel.

4. Manufactured Fireplace Logs:

A product gaining wide acceptance in the civilian market for use in fireplaces and outdoor grills, the logs are manufactured from sawdust, paper, and organics with hydrocarbons or wax added as a binder and to improve lighting.

5. Organics:

All organic material will burn when properly prepared. This class includes:

a. Wood Waste - Refuse material from lumber mills and paper mills, consisting of sawdust, shavings, bark, and chopped up trimmings.

[12] Graves, Henry, "The Use of Wood for Fuel", Bulletin No. 753, 10 Mar 1919, US Dept of Agriculture

b. Hogged Fuel - Sawmill refuse which when fed through a disintegrator or "hog" reduces the various sizes and forms to chips of uniform size. In this condition, it can be handled conveniently and fired with high efficiency.

c. Sawdust Briquets - Sawdust pressed into briquets is a convenient domestic fuel.

d. Tan Bark - Spent tan, an important waste fuel, is a fibrous portion of ground oak or hemlock bark used in tanning leather.

e. Bagasse - Sugar Cane from which the juice has been extracted by pressure between rollers of a mill.

f. Grain Shells - Included in this category are: cottonseed, straw, hay, etc.

g. Dung - Dried animal excrement.

Combustion

A. GENERAL

Regardless of the type of fuel under consideration, combustion results in the production of gaseous products. Many kinds of solid fuels contain minerals which cannot be burned and are left as a residue commonly called ash. Moreover, unless sufficiently high temperatures are employed and an ample supply of properly distributed oxygen is present, the combustible constituents of solid, liquid, and even gaseous fuels cannot be completely burned. Incomplete or partial combustion of all fuels produces toxic gases such as carbon monoxide, with smaller quantities of aldehydes, ketones, and other hydroxylated hydrocarbon compounds.

Combustion may be defined as a chemical combination of a substance with oxygen resulting in the generation of heat, and usually some light. The rate of combustion depends upon the rate of reaction of the substance with oxygen, the rate at which oxygen is supplied, and the temperature attained due to surrounding conditions. This is combustion in its simplest form. All solids, as well as liquids and even gaseous fuels, generally contain several combustible elements in combination with others which, depending on their nature, affect oxygen requirements and thus govern the combustion process. For continuous combustion, it is necessary to establish an effective balance between rates of removing heat and of supplying fuel and air (oxygen) to perpetuate the reaction.

Complete combustion is obtained when all combustible elements in the fuel are oxidized by all of the oxygen with which they will combine. In order for combustion to take place, Fuel, Heat, and Air are necessary in correct amounts.

B. COMBUSTION OF COAL

1. Coal Combustion:

When coal or wood is used in a batch type heater, the fuel is not admitted at a constant rate, resulting in a heat output (burning rate) that varies throughout the entire burn cycle. Constant attention must be given to replenishing the fuel, removing ashes and checking for over-firing.

When coal is burned, the oxygen in the primary air passes up through the grate uniting with carbon in the lower section of the grate forming carbon dioxide and water vapor. The lower section of the grate is, therefore, called the oxidation zone. The upper part of the grate is called the reduction zone where some of the carbon dioxide is reduced to carbon monoxide. This carbon monoxide is then mixed with the oxygen.

in the secondary air, which enters the upper portion of the grate and this results in carbon dioxide. When fresh coal is added, the moisture in the coal is converted to steam and expelled; the hydrocarbon gases are distilled, combined with oxygen, and burned in the area above the grated which is called the distillation zone.[13]

2. Firing Coal:

A small amount of crumpled paper is placed at the bottom of the grate, a few sticks of kindling wood are placed on top of the paper, coal is placed on top of the kindling, and paper is ignited. If kindling is not used, a greater amount of paper can be used so that the coal will be ignited.

Although this method of starting a coal fire is the safest, more expedient but dangerous methods are used. Simply pouring any liquid fuel (gasoline, fuel oil, etc) on top of a pile of coal will ignite the coal faster and with less effort, but under certain conditions with disastrous results. When poured over the coal or wood, the fuel is spread thinly over a large area making vaporization of the liquid rapid and complete. This condition is even more dangerous if heat is present in the form of smoldering ashes. The resulting fire could easily reach the explosive range as the gases are in a confined area. Although warnings of this danger are well known and stressed, it must be recognized that this method will be used by the military, access to liquid fuel and lack of fear (especially as an explosion does not occur each time this method is used) and the operators reluctance to follow a procedure if one of less effort is known is the reason.

The damper on any stove must be fully open when the fire is started. After a coal fire has been started, the damper in the flue and the air intake opening must be adjusted. The flue damper must never be entirely closed as long as there is any remaining fire as this would cause smoke and gases to enter the living quarters. It is for this reason that the present military standard flue damper has an opening that allows some of the gases to flow out the flue even when totally closed. As the burning progresses, a suitable bed of glowing coals is produced, which is overlaid with fresh coal as needed.

Glowing coals ignite volatile gases before they accummulate. But, if the bed of coals is allowed to become too cool and fresh coal is added, gases can accummulate before being ignited, resulting in a mild explosion and/or asphyxiation. Certain types of coal will fuse together when burned forming "clinkers". These, along with the ashes, must be removed to allow air to pass through the fire bed.

[13] Stone, W. R., Safe Use and Hazardous of Coal and Wood Stoves, May 74, Vol 68, No. 3, NFPA, Fire Journal

C. COMBUSTION OF WOOD

Wood combustion occurs in three basic stages:

a. The moisture in the wood is evaporated and expelled.

b. The volatile liquids are distilled and burned.

c. The fixed carbon (charcoal) is burned.

All three stages can occur at the same time, as when wood is added to glowing coals.

Because of its higher percentages of volatile liquids, wood burns with longer flames than coal. Therefore, the combustion space above wood fuel must be greater than for coal. And, unlike a coal fire where most of the air is introduced beneath the fuel, about 80% of the air must be supplied over and around the upper portion of a wood fire.

TABLE III

COMPARISON OF HEAT* CONTENT OF VARIOUS FUELS

Fuel	BTU Per Lb	MJ/kg	BTU per Common Sales Quantity
Coal	13,000	30.24	28,800,000 Per Ton
Wood	7,000	16.28	26,700,000 Per Cord
Charcoal	11,000	25.59	
Gasoline	20,500	47.68	127,000 Per Gal
#2 Diesel Oil	18,500	43.03	140,000 Per Gal
Gas (Propane)	21,500	50.01	
Electricity			3,412 Per KWH

*The BTU values used are averages. The correct BTU content must be made on each individual sample and the results will depend on the particular type or grade. Coal, for example, can vary between 6,500 to 14,700 BTU/lb and wood between 5,400 to 8,000 BTU/lb.

Military Field Heaters

There are only two heaters presently in the Military Supply System capable of burning solid fuel for the Army in the field.[14] The two heaters which will be fully described are:

a. Heater, Space, Radiant, M-41 (Type I)
   Specification MIL-H-13514
   NSN 4520-00-257-4877 (Referred to as M-41)

and

b. Heater, Space (YUKON M-50)
   Specification MIL-H-12340
   NSN 4520-00-287-3353 (Referred to as YUKON)

A. HEATER, SPACE, RADIANT, M-41, TYPE I

1. Background:

The original design of this heater, Fig 1, was first introduced to the Military 35 years ago in 1941. Except for structural changes, its original design has changed very little. Since its introduction, approximately 250,000 heaters have been procured. It is used primarily as a tent and field shelter heater. The basic heater consists of a base, adapter ring, top, and lid. No tools are required for assembly. The tapered shape of the base and top makes it possible to nest these parts, saving shipping space. The flat top surface is ideal for warming or cooking food, and the low silhouette and flat base give stability to the assembled heater. With normal care, and if not overfired, the heater should last at least two heating seasons. It has often been referred to as; M-41, Cannon Heater, the Beer Darrell Stove, Tent Heater, and the Pot Belly Stove. The orthodox shape and uncomplicated construction allows a wide interest of bidders and, consequently, a highly successful low cost item.

The basic heater, Fig 2, can be used with either solid or liquid fuel by interchanging some of the components. When used with solid fuel it is referred to as Type I, NSN 4520-00-257-4877 and when liquid fuel is used it is Type II, NSN 4520-00-927-4214.

[14] MIL-STD-1407, 16 July 75, Heater, Vehicle Compartments; Heaters, Coolant Engine; Heaters, Space

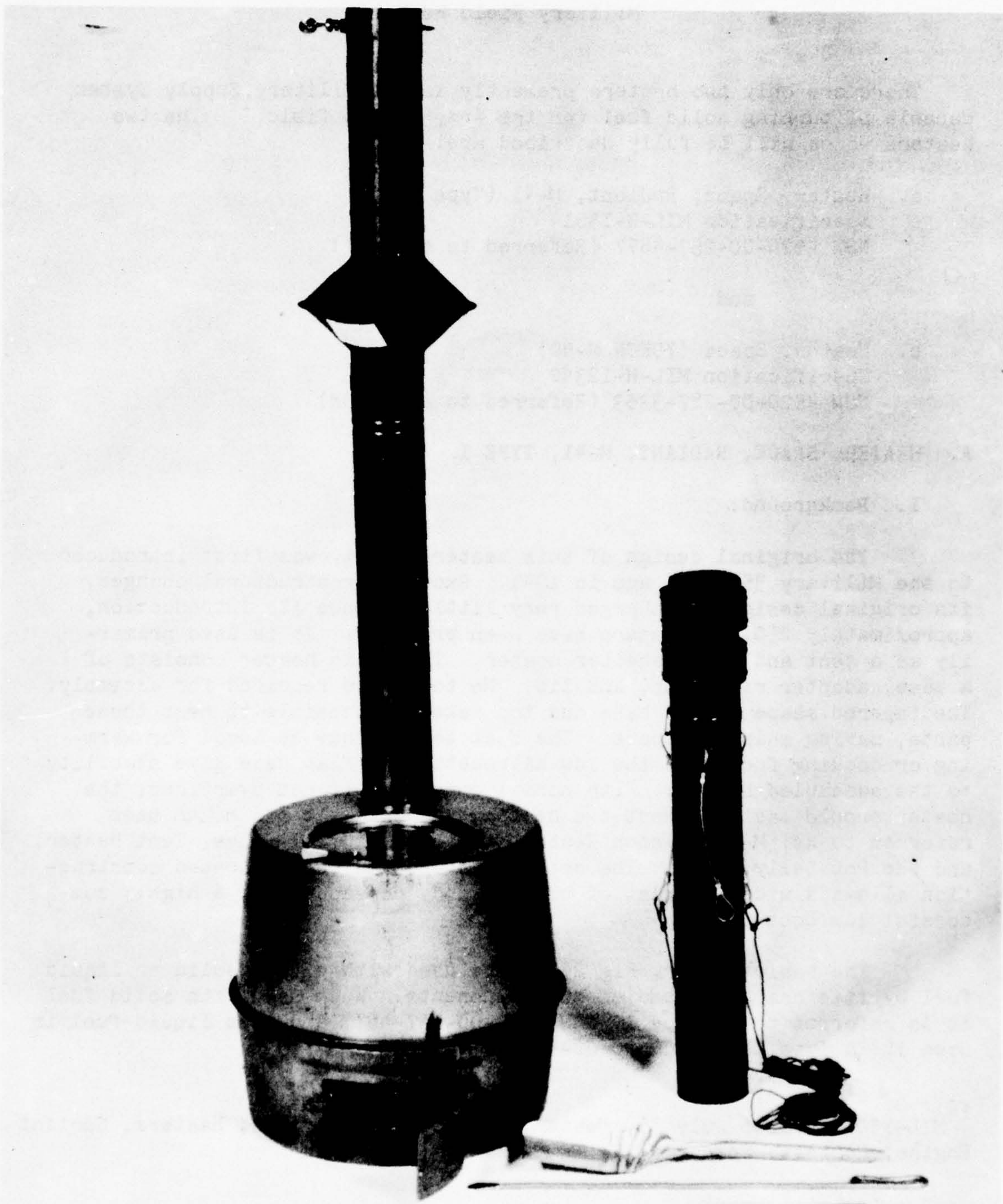

Fig. 1 Heater, Space, Radiant, M41 Type I

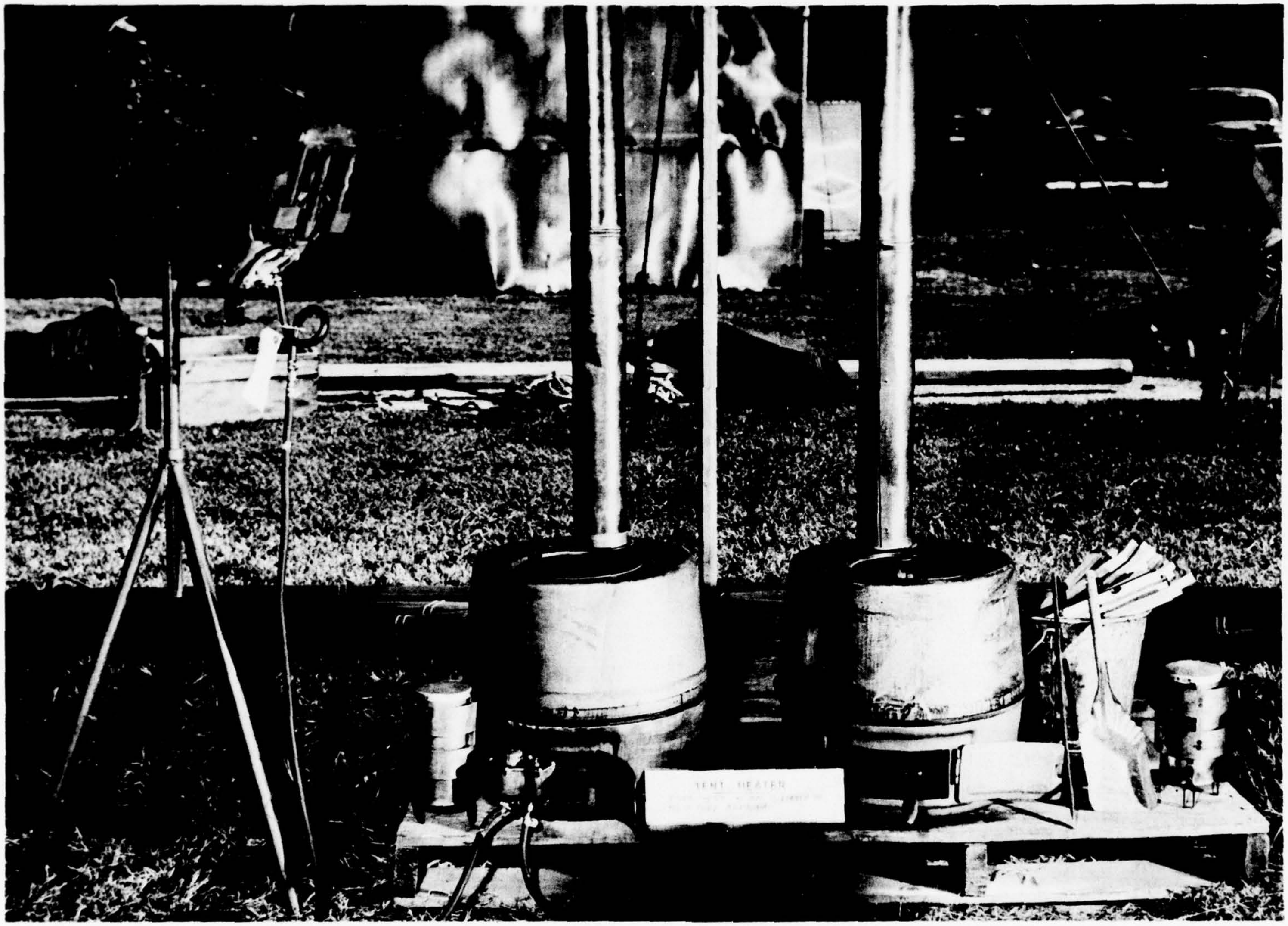

Fig. 2 Heater, M41, Type II(Liquid), Type I(Solid) Fuel Stand is not a standard item

TABLE IV

HEATER, SPACE, RADIANT TYPE PORTABLE (M-41) TYPE I

NSN 4520-00-257-4877

COMPONENTS

BASIC HEATER COMPONENTS

NSN	ITEM	SPECIFICATION
4520-00-555-0944	BASE	MIL-H-13514
4520-00-555-8539	TOP	MIL-H-13514
4520-00-555-8538	LID	MIL-H-13514
4520-00-555-8537	ADAPTER RING	MIL-H-13514
ADDITIONAL ITEMS NEEDED FOR SOLID BURNING TYPE I		
4520-00-153-4603	GRATE ASSEMBLY	MIL-H-13514
4520-00-555-8536	SHAKER	MIL-H-13514
5340-00-368-7439	POKER	MIL-P-584
4520-00-288-8650	DAMPER, FLUE 4 in.	MIL-D-1427
*4520-00-153-4616	ARRESTER, SPARK	MIL-A-54003
*4520-00-360-0098	CAP	MIL-C-10872
5120-00-293-0450	SHOVEL	MIL-S-1485 (Obsolete)
4520-00-277-8399	PIPE, AIR-CONDITIONING 4 in. diameter	MIL-P-551

*ITEMS presently not furnished as NSN 4520-00-257-4877

2. Description of Components - Basic Heater (Fig 3):

Base (Item 1 of Fig 3)

Constructed of 1.9-mm (.0747-in) 14 ga cold rolled steel by drawing. The base includes a 175.6-mm (6 7/8-in) x 88.9-mm (3 1/2-in) opening with a hinged door which completely covers the opening when closed by a latch for shipment. The base is 177.0-mm (7-in) high with a top diameter of 450.8-mm (17 3/4-in) and a bottom diameter of 425.4-mm (16 3/4-in).

Top (Item 2 of Fig 3)

Similar in construction to the base, the top includes a 228.6-mm (9-in) diameter hole for the stove lid and a 98.42-mm (3 7/8-in) diameter collar for the smoke pipe. The base is 247.6-mm (9 3/4-in) high and a top diameter of 409-mm (16 1/8-in) and a bottom diameter of 457-mm (18-in).

Stove Lid (Item 3 of Fig 3)

Constructed of 1.9-mm (.0747-in) 14 ga cold rolled steel pressed into shape to cover the opening in the stove top. The lid is held in place by inserting the small lip of the lid through a hole in the stove top. A small latch attached to the stove top keeps the lid closed if needed.

Adapter Ring (Item 4 of Fig 3)

Constructed of 1.9-mm (.0747-in) 14 ga cold rolled steel pressed into shape to fit both the stove base and top. It is not fastened to either part and is held in place by the weight of the stove top. An 285.75-mm (11 1/4-in) diameter hole located in the center, accommodated both the grate for solid fuel or the burner assembly when liquid fuel is used.

3. Description of Components - Solid Fuel:

The following additional components are necessary to burn solid fuel (Type I):

Grate Assembly (Item 5 of Fig 3)

Made of cast iron, the Grate Assembly consists of two interlocking parts held in place by a cotter pin. The Round Grate, which rests on the Adapter Ring and the Draw Grate, provides support for the fire bed and a means to remove the ashes from the fire bed to the ash pit below by "shanking".

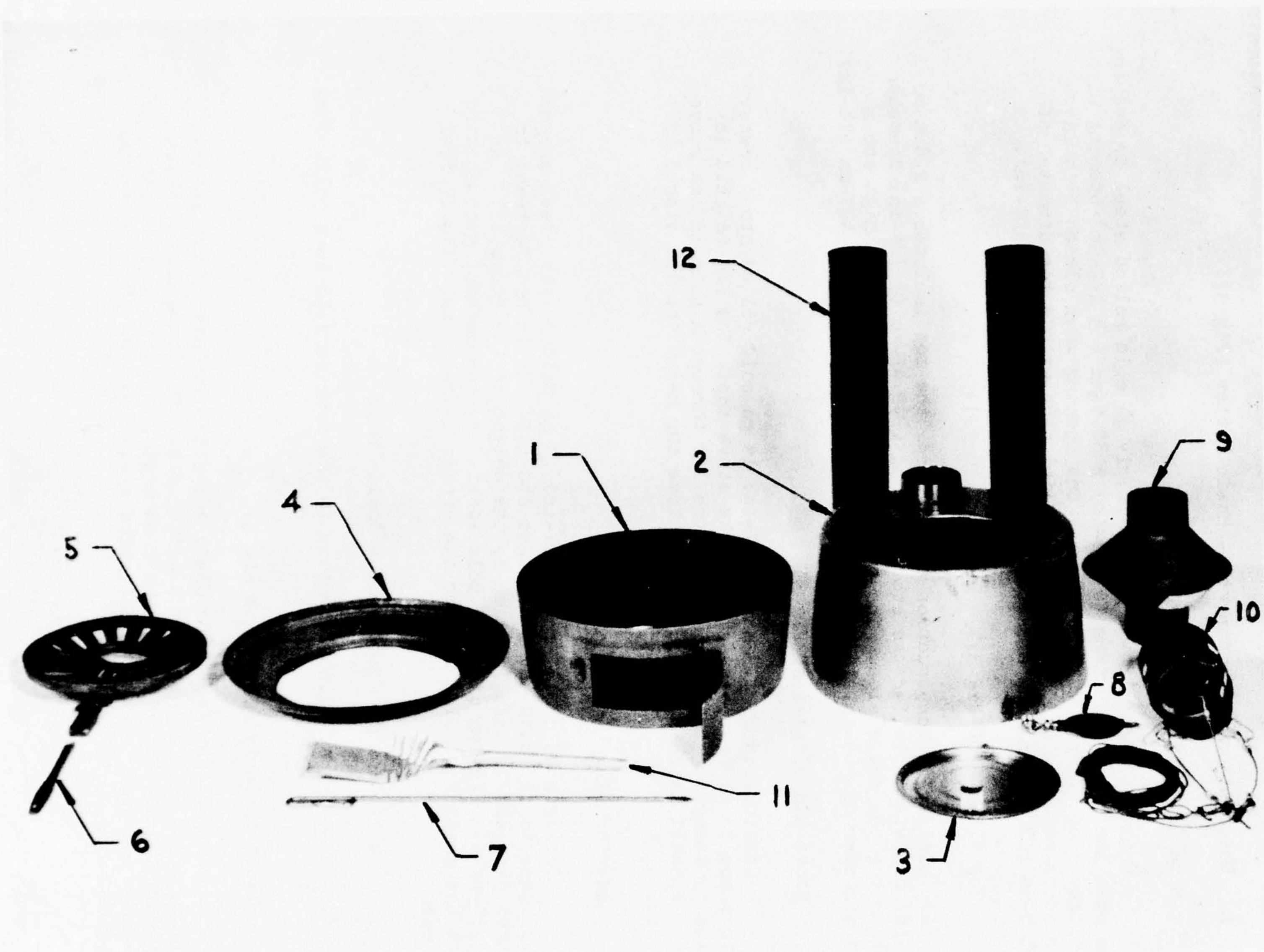

Fig 3 Heater, M41 Type I Components

Shaker (Item 6 of Fig 3)

A 254-mm (10-in) cast iron handle, which when inserted into the Draw Grate allows the Grate to be manipulated either to and fro or in a circular motion.

Poker (Item 7 of Fig 3)

A 9.54-mm (3/8-in) diameter steel rod, 610-mm (2-ft) long pointed on one end, and a handle on the other, used to improve burning by manually stirring the fire to allow air to come through the fire bed.

Damper (Item 8 of Fig 3)

A cast iron circular disk that is inserted inside the second section of the 101.6-mm (4-in) diameter smoke pipe without tools. Its function is to restrict the flue outlet thereby slowing down the combustion process.

Arrester (Item 9 of Fig 3)

A double conical sheet metal device that is installed between the first and second sections of stove pipe to reduce the flow of sparks out of the flue. It requires periodic removal of ash from the interior.

Cap Flue (Item 10 of Fig 3)

Also referred to as the Draft Diverter, it is made of blued steel .607-mm (.0239-in) 24 ga and is installed on the top of the last section of smoke pipe. Its function is to prevent down drafts caused by wind and to prevent rain or snow from entering the smoke pipe. Also included are 4-Tie ropes that are used to give stability.

Shovel (Item 11 of Fig 3)

Approximately .508-m (20-in) long with .089-m (3 1/2-in) scoop used to remove ashes and feed coal.

Pipe-Air Conditioning (Item 12 of Fig 3)

Normally referred to in industry as smoke pipe or stove pipe. Constructed of 0.378-mm (0.0149-in) 28 ga, 1009 blued steel. The pipe is shipped nested in the open condition and requires the locking of the edges for assembly. Rivets should be inserted through the hole provided to prevent any opening during handling. Sufficient lenghts of smoke pipe should be used so that the top of the last section is higher than any portion of the shelter.

TABLE V

HEATER SPACE M-41

GENERAL SPECIFICATIONS

Height	18 5/8-in	0.47-m
Diameter	18 5/8-in	0.47-m
Depth of firebox		
(Grate to stove top)	11-in	0.27-m
Weight	44-lbs	20-kg
Cube	7-cu ft	0.2-m^3
Output BTUH (Coal)	35,000 BTUH	10.3-kW^3
Smoke Pipe, Dia	4-in	0.10-m
Cost	$84.00	

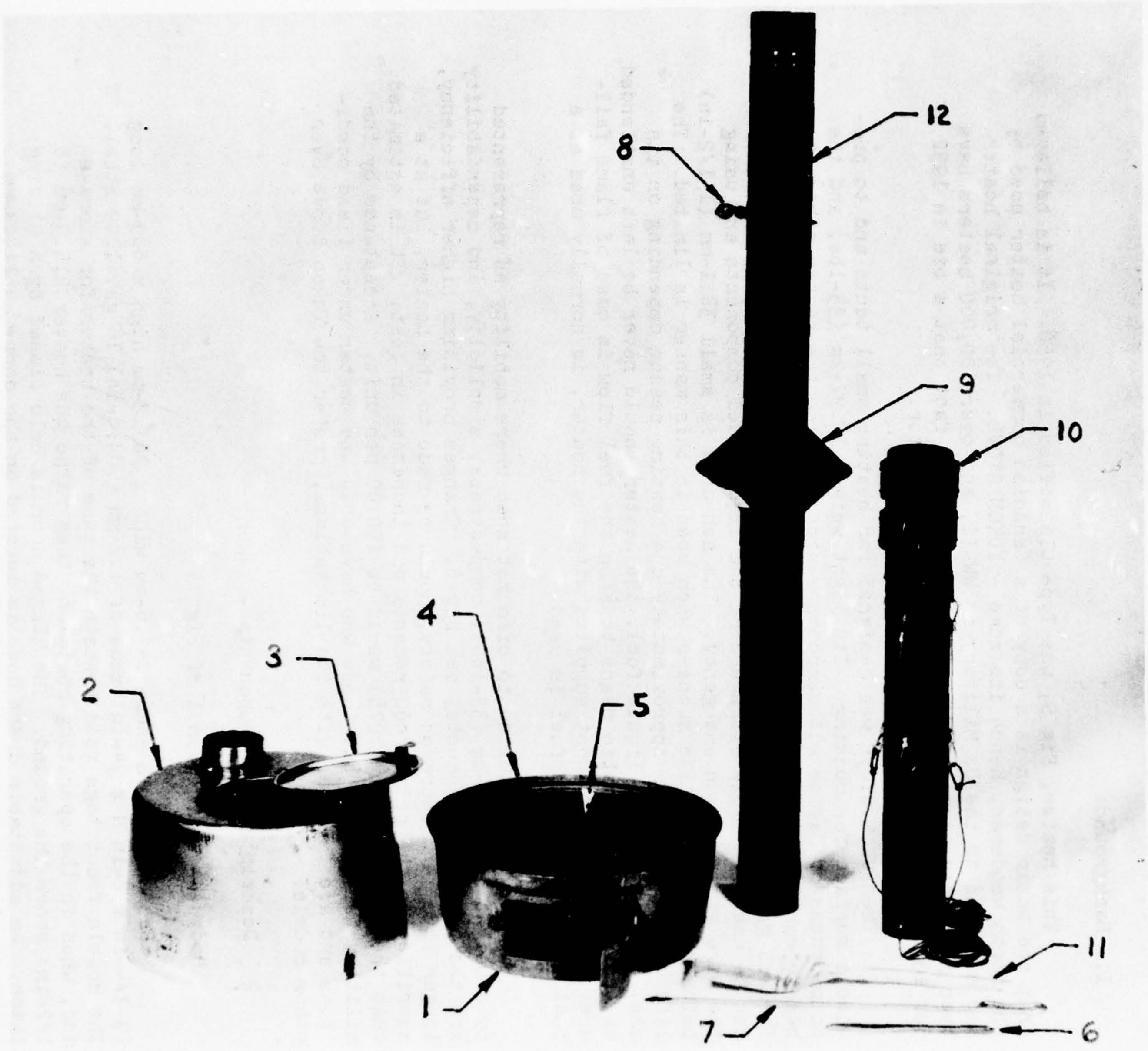

Fig. 4 Heater, M41 Type I Partially Assembled

B. HEATER, SPACE - YUKON

1. Background:

This heater, Fig 5, was Type Classified in 1950. It is believed that the basic design is a copy of a Canadian commercial heater used by the north woodsmen, hence its name - YUKON STOVE. The original heater was supplied to the US Military in WW II, and over 100,000 heaters have been purchased since 1952. Of interest is the fact that a bid in 1952 for 13,000 heaters was $13.25 per complete heater.

The YUKON STOVE was designed for heating small tents and to provide a surface for cooking. Its light weight 14.97-kg (33-lbs) and the compactness of having all components stored inside the heater makes it highly convenient and suitable for carrying on a pack board. Primary fuel is gasoline, and with less success, any liquid fuel. Solid fuel can be used by simply disregarding the liquid fuel components and using the wire grate, in an emergency. The ash area is small 38.1-mm (1 1/2-in) below the grate and its success when used in this manner is limited. The life of the heater is approximately one heating season depending on its use. When used with liquid fuel, the heater should never be left unattended as there is no automatic means to stop the fuel flow in case of flame failure. A 5 gal GI Can, not supplied with the heater, is normally used as a fuel tank when liquid fuel is used.

Its use is limited to circumstances where mobility as represented by a weight of 14.97-kg (33-lbs), compactness, simplicity, and dependability are the prime requirements, see Fig 6. Changes providing higher efficiency, longer life, and improved safety, could be made to the heater, but at a sacrifice to the prime requirements and increases in cost. It is estimated that the present cost (1975) would be $50.00 per unit. Acceptance by the military has varied, but those who have used the heater under field conditions and are familiar with its limitations, prefer the Yukon Stove over other models.

2. Description of Components - Yukon:

Body Assembly (Item 1 of Fig 7)

Rectangular in shape 247.6-mm wide x 203.2-mm high x 609-mm long (9 3/4-in x 8-in H x 24-in) made of 1.2-mm (.0478-in) 18 ga, 1009 steel. The double front legs fold beneath the base of the heater for storage and, when in the operating position, they raise the heater 215.9-mm (8 1/2-in) above the ground. The hinged door is held closed by a sliding latch. An adjustable draft door is located on the door. A 114.3-mm (4 1/2-in) diameter opening is located on the flat top for housing the burner when liquid fuel is used. The opening has a sliding cover which

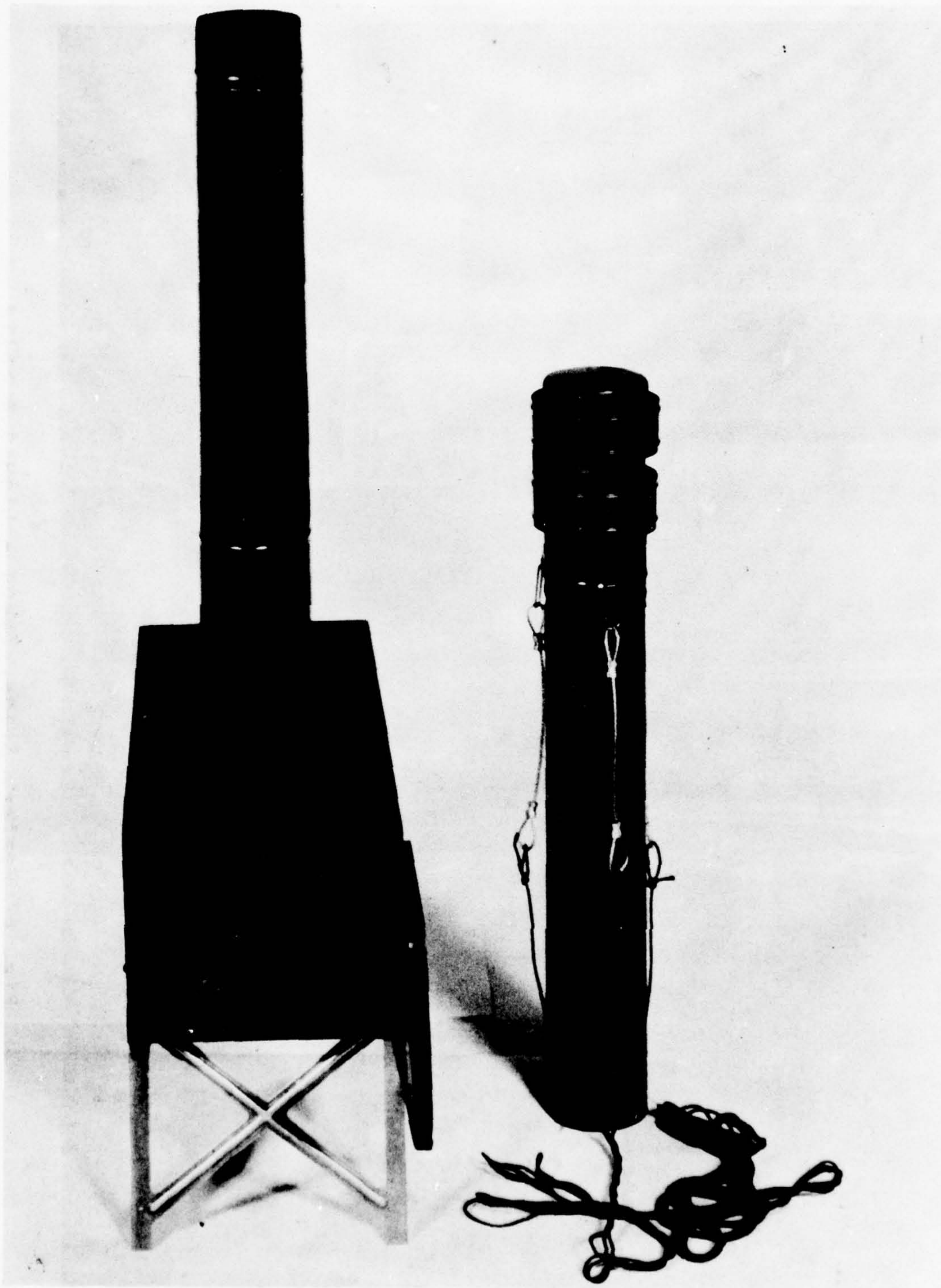

Fig. 5 Heater, Space Yukon

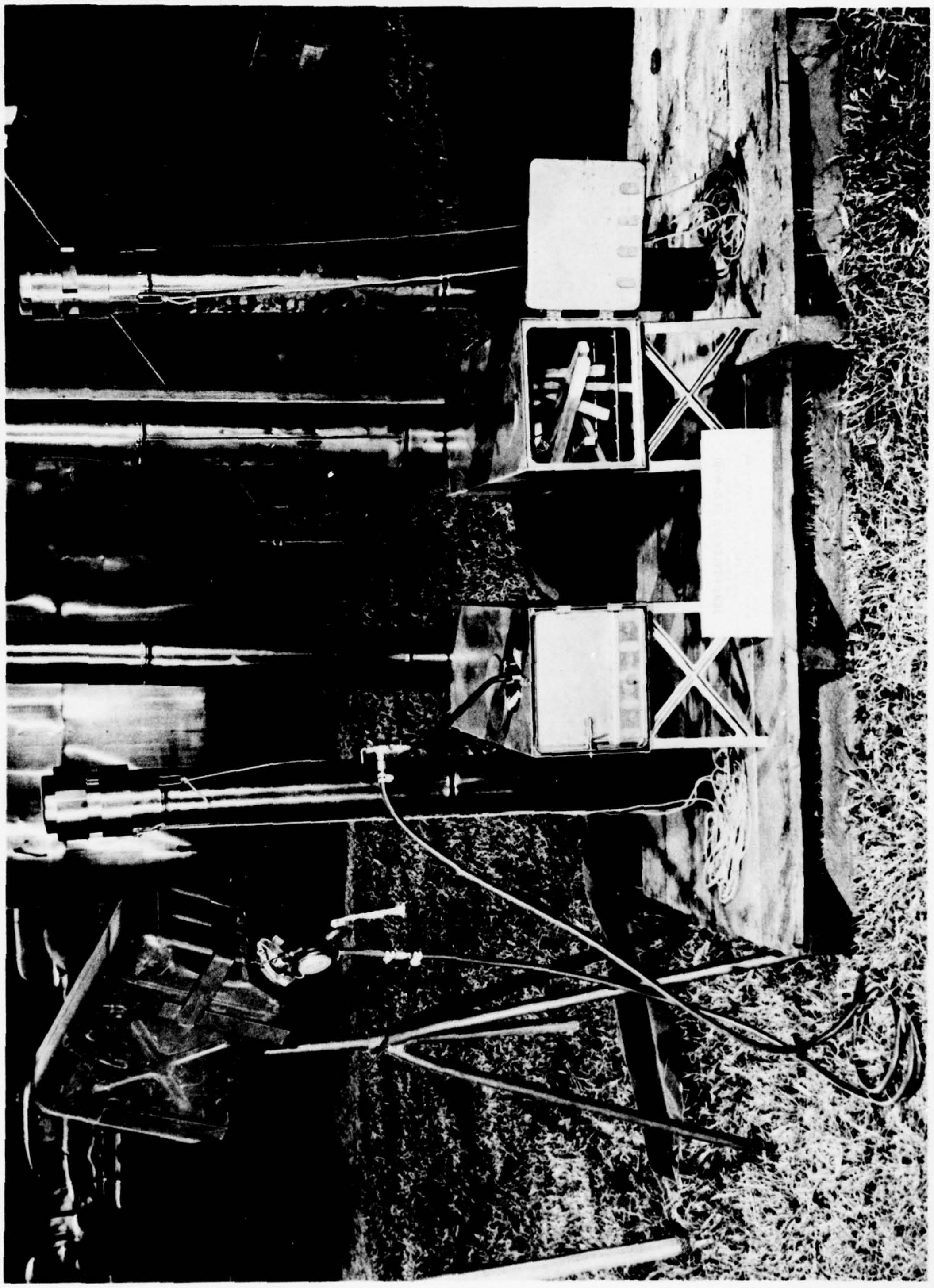

Fig. 6 Heater, Space, Yukon - Liquid & Solid

is kept closed when burning solid fuel and when stored. The flue is attached without tools to the rear of the heater by twisting the stack tee into three offset ear clasps. Approximately 90% of all steel used to construct the body is identical (1.21-mm (0.0478-in) 18 ga - 1009) resulting in a most economical method of fabrication.

Grate (Item 2 of Fig 7)

Constructed of 1010-1020 steel rod welded into a 241.3-mm x 558.8-mm (9 1/2-in x 22-in) frame. By inverting a 38.1-mm (1 1/2-in) ash space is provided. The frame is laid flat on the base for storage.

Pipe Air Conditioning (Item 3 of Fig 7)

Five (5), .378-mm (.0149-in), 28 ga, 1009 blued steel tapered sections make up the assembly. The tapered construction makes it possible for all five sections to be nested into the largest (No 1) section. The assembled sections, with Draft Diverter installed, gives an approximate stack height of 2.7-m (9-ft) from the floor of the assembled heater. The tapered construction has a tremendous savings in space but a disadvantage of having to replace the identical section if one becomes damaged.

Cap Flue (Item 4 of Fig 7)

This item is identical to that used with the M-41 and discussed in Section IV A-3.

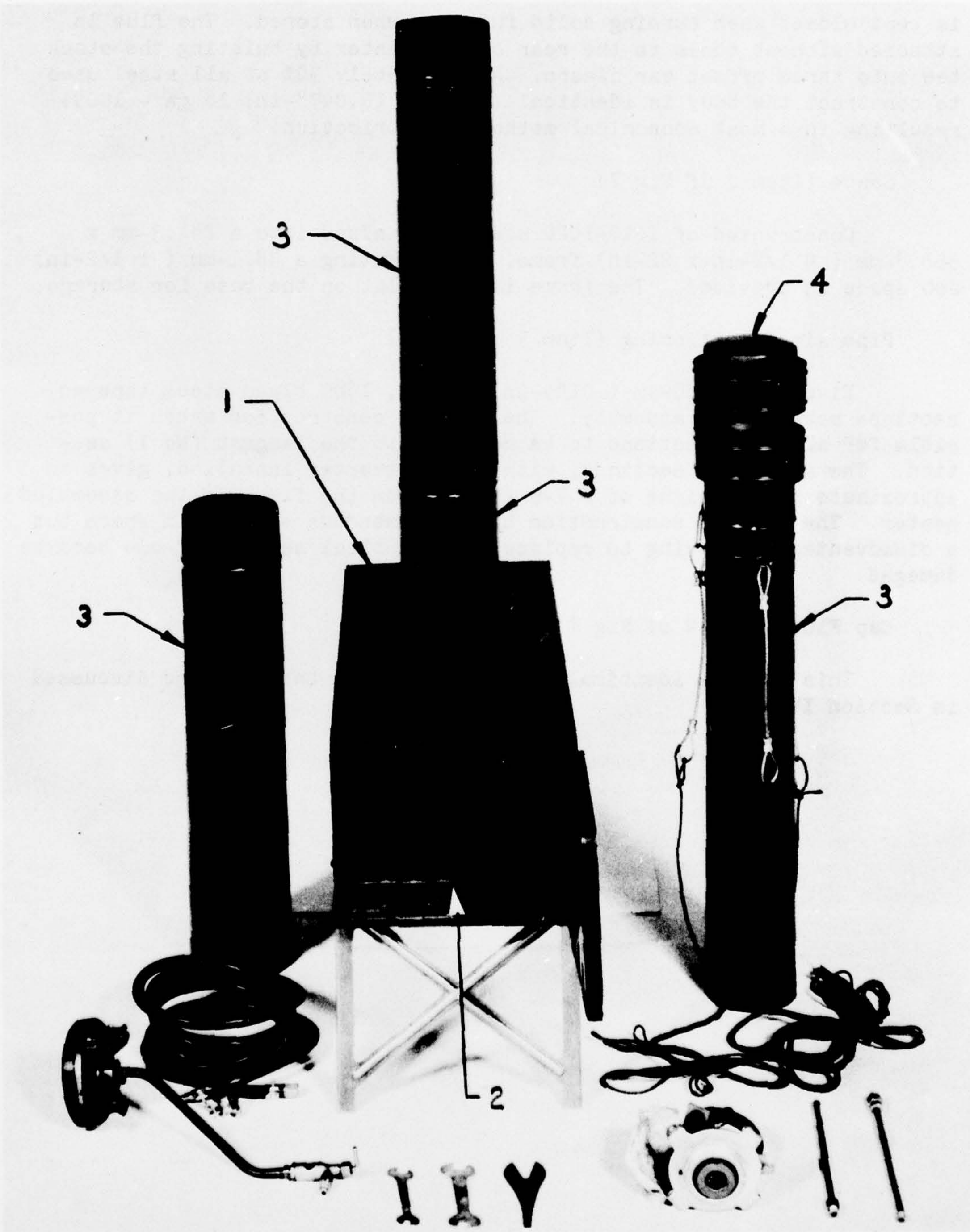

Fig. 7 Heater, Space Yukon, Components

TABLE VI

COMPONENTS - YUKON STOVE

NSN 4520-00-287-3353

NSN	ITEM	SPECIFICATION
4520-00-272-7692	BODY, ASSY	MIL-H-12340
4520-00-277-8342	GRATE	MIL-H-12340
4520-00-360-0098	PIPE-AIR CONDITIONING	MIL-H-12340
4520-00-233-6555	CAP, FLUE:	MIL-C-10872
	CORD, COTTON 1/8-12 ft lng	T-C-571

Items supplied with heater, but not used when heater is being operated with solid fuel.

7240-00-360-0094	ADAPTER KIT:	MIL-A-10957
5330-00-298-7165	GASKET, LARGE	MIL-G-432 Type III
7240-00-203-9735	VENT TUBE ASSY	MIL-A-10957
4720-00-303-4995	HOSE, ASSY 12"	MIL-H-10868
4520-00-540-6168	BURNER ASSY:	MIL-H-12340
7360-00-559-6874	VALVE DRIP	MIL-V-10908
5120-00-595-9029	WRENCH 3/8 x 9/16	MIL-W-10698
5120-00-293-2123	WRENCH 1/2 x 7/16	MIL-W-10698
5120-00-595-9193	WRENCH PIPE V	MIL-W-10698

Recent Field Exercise

On 23 Oct 74 and 16 Apr 75 military personnel used the M-41 Space Heater with solid fuel under field conditions during field exercises by the 39th Engineer Br., at Ft. Devens, MA. Because of the liquid fuel restriction, the use of solid fuel was prescribed in the form of bituminous coal from the base supply and wood from trees in the area.

Of interest, is the fact that many who had previously used the heater with liquid fuel preferred using coal. Their reasons were that coal burning was easier to control and caused less worry of a fire hazard when liquid fuel was used. In many cases the Cap, Flue, and/or the Damper, were not used. Rivets recommended to hold the Smoke Pipe together were not used in many instances. The spark arrester was used only 50% of the time, and when used, it was installed at any smoke pipe joint. Complaints were made about the necessity of frequent cleaning of the smoke pipe and the smoke and odors inside the shelter when the heaters were being used.

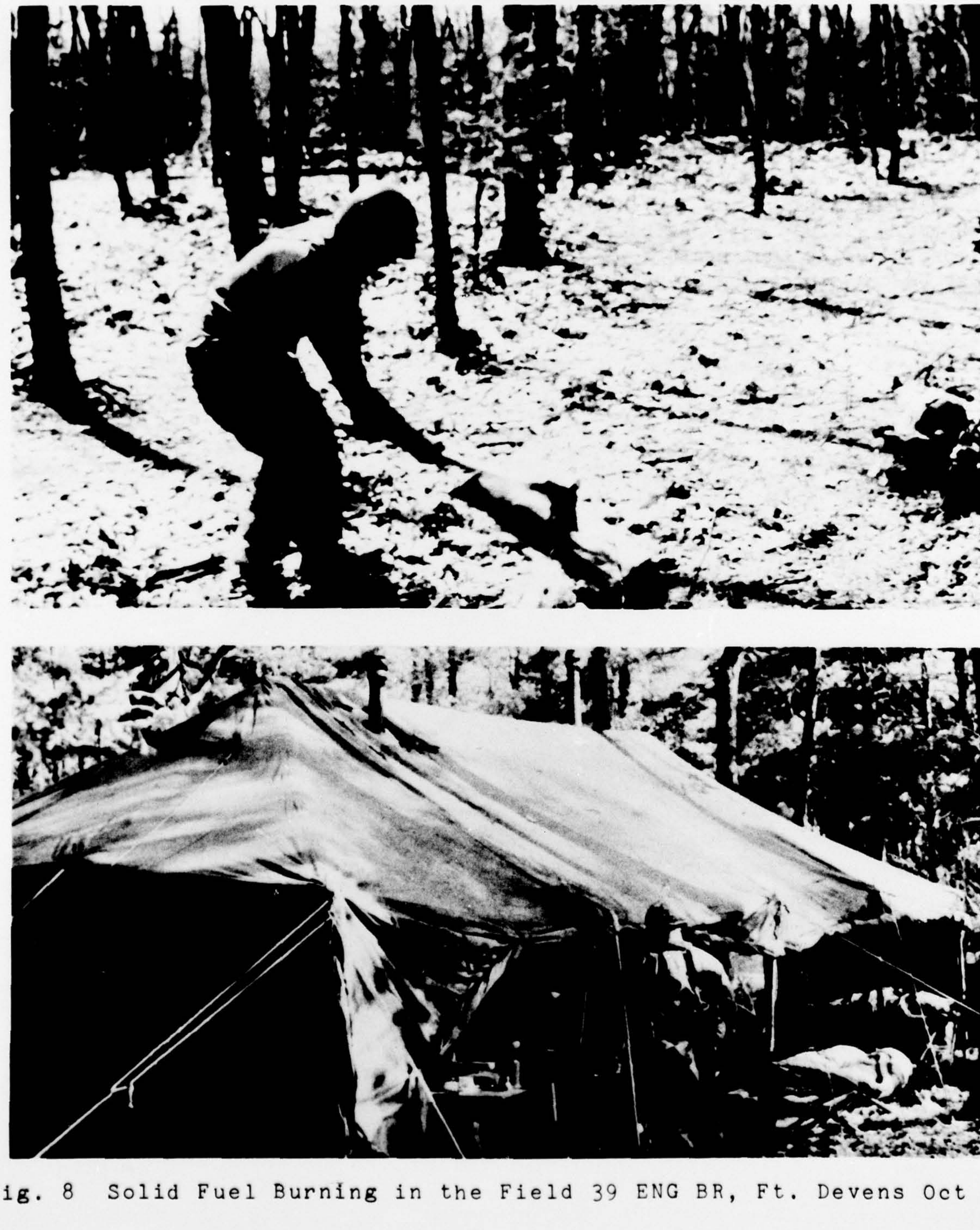

Fig. 8 Solid Fuel Burning in the Field 39 ENG BR, Ft. Devens Oct 74

Commercial Solid Fuel Heaters

It is possible that as the shortage of petroleum products increases the use of coal as a domestic fuel will increase. The technology of burning coal in large boilers and power plants is highly advanced; however, small heaters 14.6-kW (50,000-BTUH) presently available in the commercial market, are similar to those used at the beginning of this century. It can be expected that as the civilian market increases; improved solid fuel heaters will be available, however, this change may be too slow to be of value to military heating in the field.

Fig. 9 Historical Solid Fuel Burning Stoves

Recommendations

A. PRESENT MILITARY HEATING EQUIPMENT

1. The military nomeclature used to identify "PIPE, AIR-CONDITIONING" (MIL-P-551, NSN 4520-00-277-8339) should be changed to either "PIPE, SMOKE" or "PIPE, STOVE". Using a name common to both civilian practice and industry will eliminate the problems resulting from using terms which are unfamiliar to all concerned.

2. The SHAKER (NSN 4520-00-555-8536) should be part of, or attached to, the POKER (NSN 5340-00-368-7430). This change will greatly reduce the number of lost SHAKERS and also eliminate the need for a separate specification, POKER (MIL-P-584) from the supply system.

3. A metal tag should be attached to the surface of the Arrester, Spark (NSN 4520-00-153-4616) showing its correct location and also the location of the DAMPER 101.5-mm (4-in) (NSN 4520-00-288-8650).

4. The smoke pipe (PIPE, AIR CONDITIONING NSN 4520-00-277-8339 & 4520-00-277-8342) should be redesigned to increase its life and to improve the method of assembly. The present procedure of oxidizing to produce a dark blue color does reduce the glare but adds little protective properties.

5. Some type of pan or insulated mat should be provided to place the heater on in order to prevent fires. This same pan could be useful when liquid fuel is used as the same problem exists. The present prescribed method Par 2-7, a TM 10-4500-200-13 is to set the heater in a sandbox or on asbestos sheeting which, in many cases, is time consuming or impossible to locate.

6. An investigation should be conducted to determine whether one complete heater should be packed separately in a reusable container. A portion of this container could serve as Heater Pan (see 5 above). If this procedure is adopted, damage and loss of items will be greatly reduced, and having a complete ready-to-use heater would eliminate the present supply problem. However, the overall logistics cube would be increased.

7. TM 10-4500-200-13 should be revised to eliminate the discrepancies and to better describe use of the heaters when solid fuels are used.

8. The Yukon Stove (Heater Space Radiant NSN 4520-00-287-3353) should only use coal or wood as an emergency. Its life, when used with solid fuel is limited due to the thickness of metal, 18 ga 1.2-mm (0.0478-in).

9. The CAP, Flue, NSN 4520-00-360-0098, MIL-C-10872, and the ARRESTER, Spark, NSN 4520-00-153-4616, MIL-A-54003 should be included in the components of M-41, Type I, NSN 4520-00-277-4877.

10. The Wrench 6.35-mm x 11.1-mm (1/4-in x 7/16-in) (NSN 5120-00-293-2123), and the Wrench 9.5-mm x 14.3-mm (3/8-in x 9/16-in) (NSN 5120-00-595-9020) are not needed with the Yukon Stove as the Hose Assy MIL-H-10868 (NSN 4720-00-303-4995) includes coupling wrenches.

11. It is recommended that both the present standard heaters (M-41 & Yukon) be continued in the Army inventory until a better substitute is found. A need will always exist by the field Army for a heater of this type. Some type of heater must be available to heat tents and shelters that can operate without power and uses any fuel that is available.

12. Investigate the possibility of eliminating the shovel as a component and require the user to use his entrenching shovel.

B. FUTURE NEEDS

1. A prescribed method of storage, delivery, and the handling of coal must be detailed. The manual should include the recommended procedure for handling of coal from delivery of bulk coal to final use. Any needed support equipment should be developed and provided.

2. A study by logistic investigation should be made to determine whether bagging the coal at the coal storage area or delivery of the bulk coal to the tent areas and requiring the user to pick up the coal when needed is the preferred procedure.

3. A metal container, such as the old-fashioned coal hod or pail, should be type classified for handling of coal and ashes by the user. This container could serve the dual purpose of a shipping container for the shovel, poker, and spark arrester.

4. Extensive use of solid fuel will increase the possibility of sparks falling on the tents. Tent designers should be made aware of this danger.

5. A coal burning hot water heater should be developed, since the present Immersion Heater, NSN 4540-00-469-6593, is not adaptable to burning solid fuel.

6. Investigation should continue for the possible use of commercial solid fuel heaters.

7. A heater should be developed that uses solid fuel as its prime fuel for Military field use. The Heater should have a capacity of 17.6-kWH (60,000-BTUH) of approximately 3.6-kg (8-lbs) of coal per hour. The heater should be capable of using all types and sizes of coal, and wood up to lengths of 304.8-mm (12-in). The heater should have a cooking surface, be lightweight, operate without auxiliary power, and be capable of being mass produced.

8. Investigate the possibility of developing a coal burning steam driven electric generator. If successful, this unit would reduce the objectionable noise of the present gasoline driven generator.

9. An improved Flue Cap should be developed as the present configuration is extremely difficult to clean and readily plugs when solid fuel is used, it must be still capable of being stored inside the Yukon Stove.

10. The Energy Research & Development Administration (ERDA) is presently investigating the possibility of converting coal to liquid and gaseous fuels. The results of this project could have possible application for Army heating and, therefore, the findings should be evaluated.

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