A PLAN FOR EQUIPPING UNITED STATES ARMY ENGINEER FORESTRY COMPANIES

by

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TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

Figure

A PLAN FOR EQUIPPING UNITED STATES ARMY ENGINEER FORESTRY COMPANIES

INTRODUCTION

This paper is presented in the interests of the Engineer Board of the War Department with the sole purpose of suggesting improvements to the major items of equipment which make it possible for an engineer forestry company to function efficiently as a self-sustained logging and sawmilling unit.

Out of the experiences of World War II have come many changes in ways of doing things, in types of tools and vehicles, and in the overall strategy of war itself. No single unit is immune from radical changes. So it is with the type of unit whose job it is to supply lumber to the nation's fighting forces. Criticisms and recommendations incorporated herein have come from men who have served in these units in every theater of war, who have used the equipment, and who are therefore reasonably reliable judges of its usefulness. Although it is not expected that complete agreement will be reached on each suggestion, it is felt that the weight of opinions from practical men cannot go entirely unheeded. Their judgment is certainly well ahead of the trial-and-error methods sometimes necessarily resorted to when reliable precedence is lacking.

References used in support of this treatise have their source in personal interviews and letters of officers and men of these units, in their articles in various trade and technical journals, in recent publications on logging and sawmilling equipment, in tables of organiza-

tion and equipment of the United States Army, and in army technical bulletins. Those who have directly or indirectly supplied this information are men who have had logging, sawmilling, and general forestry experience. The background of the writer, by way of qualifying his comments, includes the degree of Bachelor of Science in Forestry, a period of nearly five years as an officer in the United States Army, and a year of that time as commanding officer of an engineer forestry company in the United States and France.

Figure 1. The army sawmill on a Pacific island.(5)

THE ARMY FORESTERS

The Mission of an Engineer Forestry Company[5]

The mission of the engineer forestry company is to manufacture lumber for military requirements from woodlands in or near a theater of operations. This eliminates the necessity of allotting badly needed shipping space to this critical and bulky material of war.

The company is equipped and staffed to operate under various conditions and with timber of all sizes and species. It may set up and operate its own issued sawmill or mills, or it may take over and operate existing sawmills. It furnishes items of lumber required by all branches of the service. The unit can operate in stands of small-diameter softwoods or in the large-diameter hardwoods of the tropics, on fairly flat or rolling ground, in swamps, or in high, rough and broken terrain, and at sea levels or high altitudes in all climates. The lumber produced varies in size from large tactical and structural timbers for bridges and general construction to small one-inch boards for housing and crating.

History

World War I.[16]

Shortly after the American Expeditionary Forces arrived in France in the first world war, the enormous requirements for lumber in military operations became apparent. Shipping space was far from adequate, and lumber had to be acquired from French forests, so General John G.

Pershing cabled the War Department for a forestry regiment to supply the timber needs of the American Army.

This brought into being the 10th Engineer Regiment, which was later merged into the 20th Engineer Regiment. The unit was staffed by officers and men from forest industries and the United States Forest Service who had responded to the call from the War Department, and on October 9, 1917, the first contingent arrived in the interior of France, where their training was completed.

An excerpt of General Order Number Three of the 20th Engineers in which the commanding officer commends his troops, will give an idea of the work accomplished:

"General Order

No 3

Hq. 20th Engineers(For.)
U.S.M.P.O. 717
December, 1918

"To the Officers and Soldiers of the Twentieth Engineers and Attached Service Troops:

"On November 25, 1917, the first board was cut in France by American Forestry Troops at a little French mill in the Jura Mountains. At the same time, another detachment was getting out 50-foot piling in the Landes on escort wagons drawn by hand. The total cut during December, 1917, was 321,000 board feet of lumber and 12,000 railroad ties.

"When the armistice was signed on November 11, 1918, the 20th Engineers were operating 81 American Sawmills and producing 2,000,000 feet of lumber and round products every working day. Up to December 1, we have cut a total of 272,500,000 feet of lumber, including 2,728,000 railroad ties, together with 38,000 pieces of piling, 2,739,000 poles of all sizes and 892,000 steres of fuelwood.

"Recent reports from the various depots and construction projects of the A.E.F. show that the Army was, at the time of concluding the armistice, well supplied with lumber... Notwithstanding the difficulties in obtaining equipment and transportation, notwithstanding the enormous increase in the size of the A.E.F., and the work which it undertook over the original estimates, the Army has been given the lumber which it needed...This is an achievement in which every man in the Forestry Troops may well take pride, for every one of you have had a share in it...You have gotten more out of sawmills than had ever been dreamed of by mill operators at home. Time and again, in spite of difficulties such as lumbermen never contended with before, you have exceeded our expectations...

J. A. WOODRUFF
Colonel, Engineers"

This order implies that equipment and transportation were insufficient in the first war. In contrast to the present mechanized war, much of the work, such as hauling and loading, was by hand. The equipment, though up-to-date then, was largely horsepower and manpower.

World War II.

The recent war brought a more mechanized self-sufficient unit into existence. Separate battalions, separate companies, and self-sustaining platoons did away with the unwieldy regiment. The personnel trained as a unit before overseas shipment. These new organizations were flexible and could fit the proper number of men and pieces of equipment to any particular job. But there were still deficiencies in equipment, for in the present day there were many more changes in ways of doing things. In some branches of the service units left the United States with the most up-to-date equipment only to see it become

Figure 2. Turning a log.

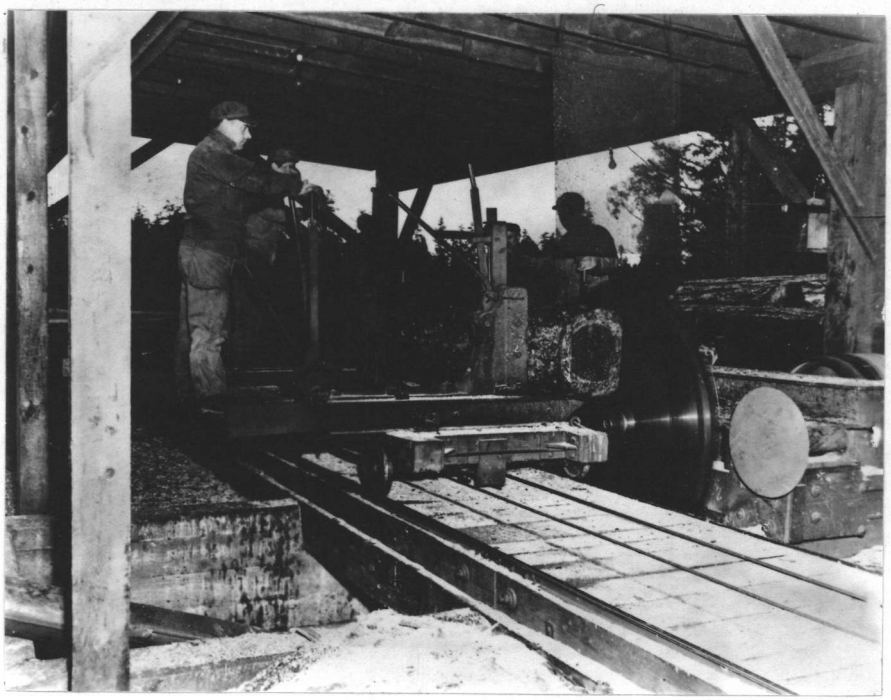

Figure 3. The headsaw.

obsolete before it had seen much service.

The need of forestry units in World War II was known well in advance, and activation and training was done early in the war at Camp Claiborne, Louisiana, first and at other camps later on. The result was that fully trained units went to every theater of war. Separate companies operated in Alaska, China, Europe, behind loosely-held Japanese lines in Burma, in the Phillipines, and on many of the smaller Pacific isles. Forestry companies were also activated at various overseas bases and trained on the job to replace units scheduled for departure.

So far, the amount of lumber and its products produced by these units has not been released, but figures from certain individual units indicate that production reached an enormous scale. For example, the 1065th Engineer Forestry Company[20] in ten weeks of supervising French mills, produced and shipped 7,500,000 board feet of lumber alone, to say nothing of cutting and shipping approximately 1,500 piling concurrently with this work. This was merely one unit of many whose job it was to keep the army supplied with one of the most critical materials of war.

Organization

General.

The company consists of a headquarters platoon, a manufacturing platoon, and a logging platoon[21] (Figure 4). To provide complete

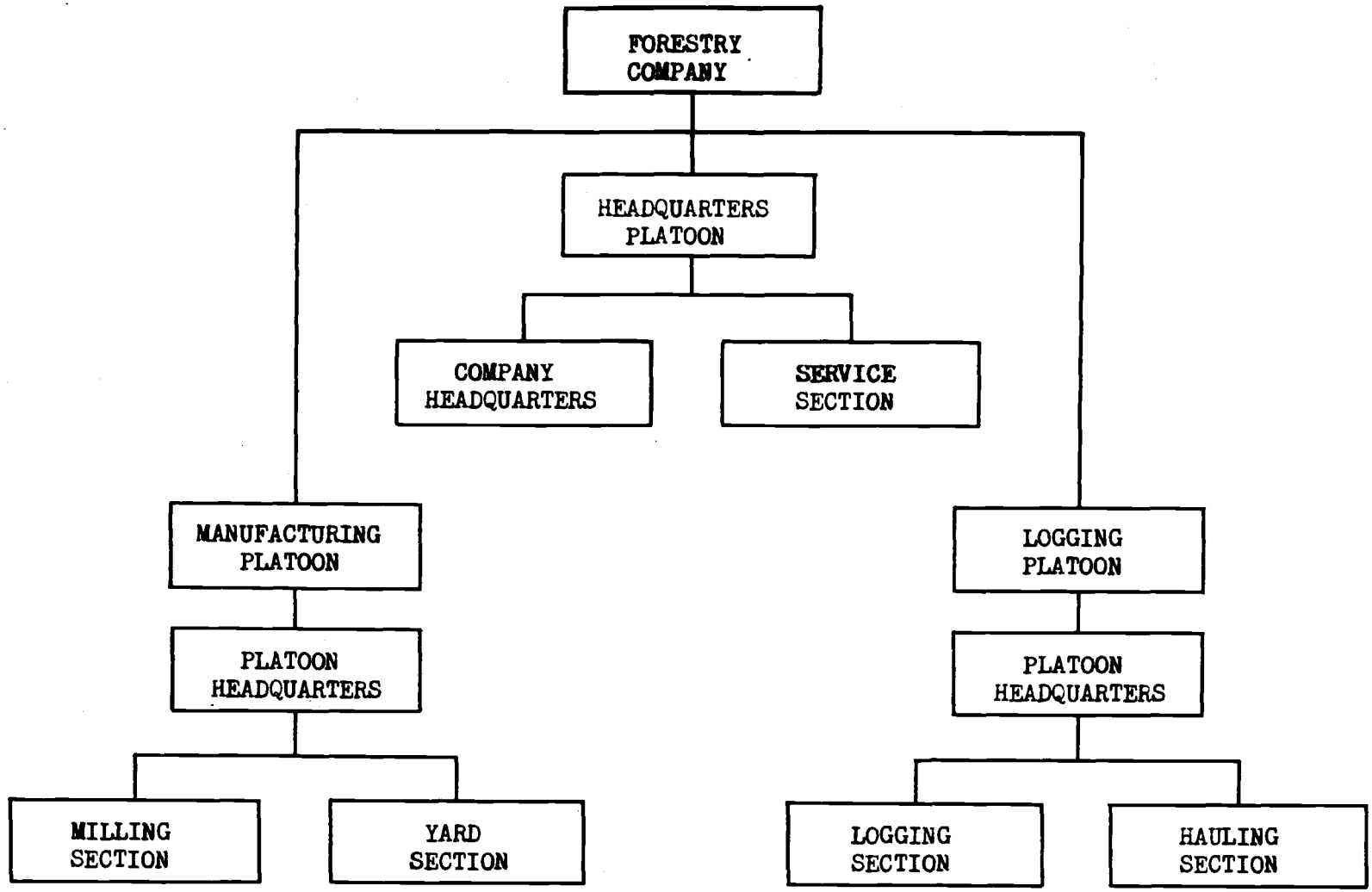

Figure 4. Organization chart of the engineer forestry company.[21]

flexibility, the individual platoons of the company are capable of independent operation. The headquarters platoon maintains a central supply point. The other two platoons are then able to establish themselves near their respective operations as separate self-sufficient units. From these two functional platoons the 1065th Engineer Forestry Company[20] organized three such units in order that three separate projects could be efficiently managed.

Personnel.[21]

The unit consists of five officers and 150 enlisted men. The company commander, a captain, is responsible for planning, organizing, and supervising operations of the various subdivisions of his company. His position corresponds to that of superintendent in civilian lumber enterprises. Within the company headquarters are a first lieutenant and a second lieutenant, as administrative officer and supply officer respectively. The latter commands the service section and is responsible for the maintenance of all equipment.

The manufacturing and logging platoons are each commanded by a first lieutenant, assisted by a technical sergeant as operations chief. The position of the logging platoon commander corresponds to logging engineer in civilian operations. That of the manufacturing platoon commander is comparable to a sawmill superintendent.

Figures 5, 6, and 7 indicate the distribution of personnel within the company.

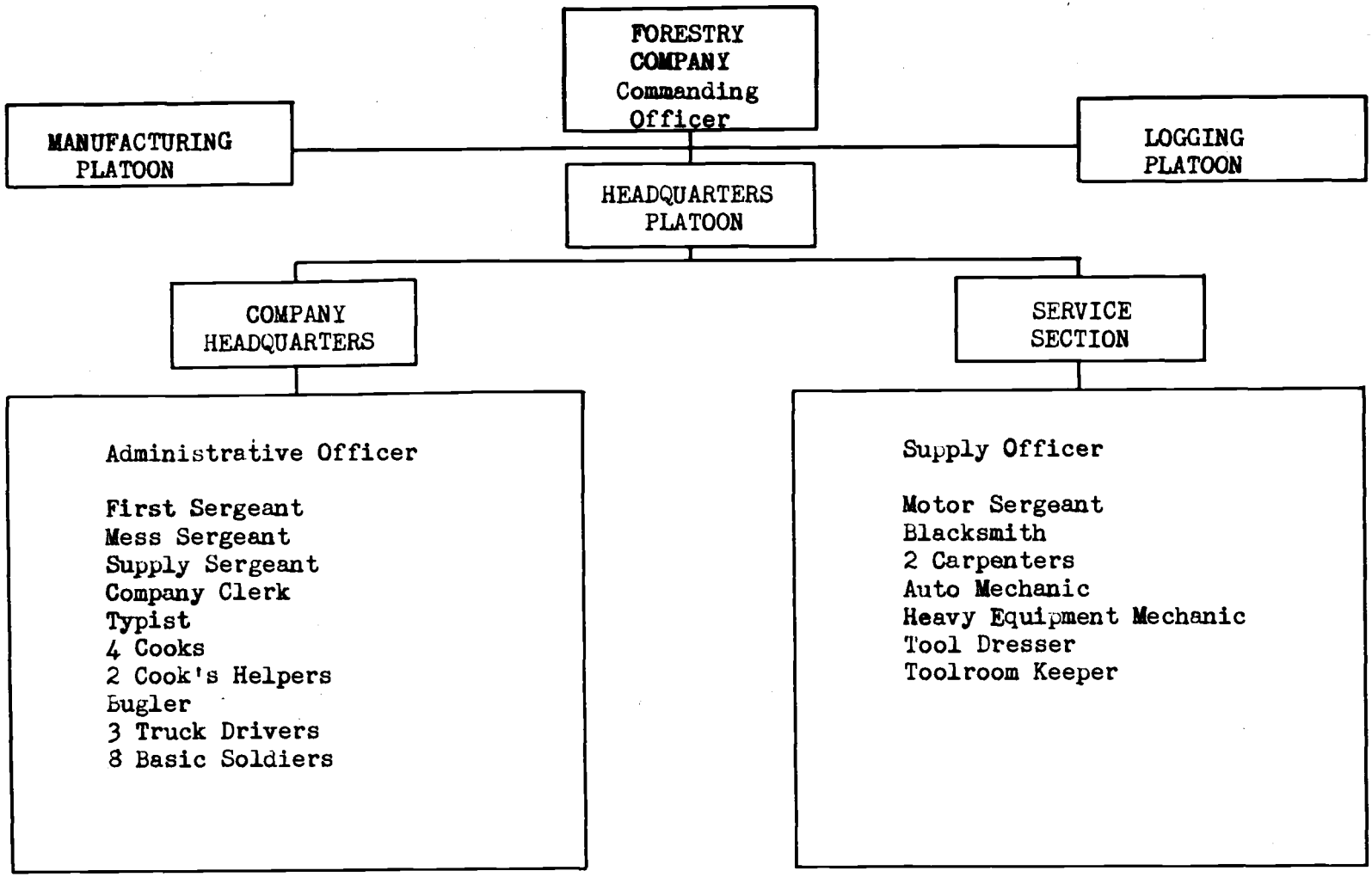

Figure 5. Personnel of Headquarters Platoon.[21]

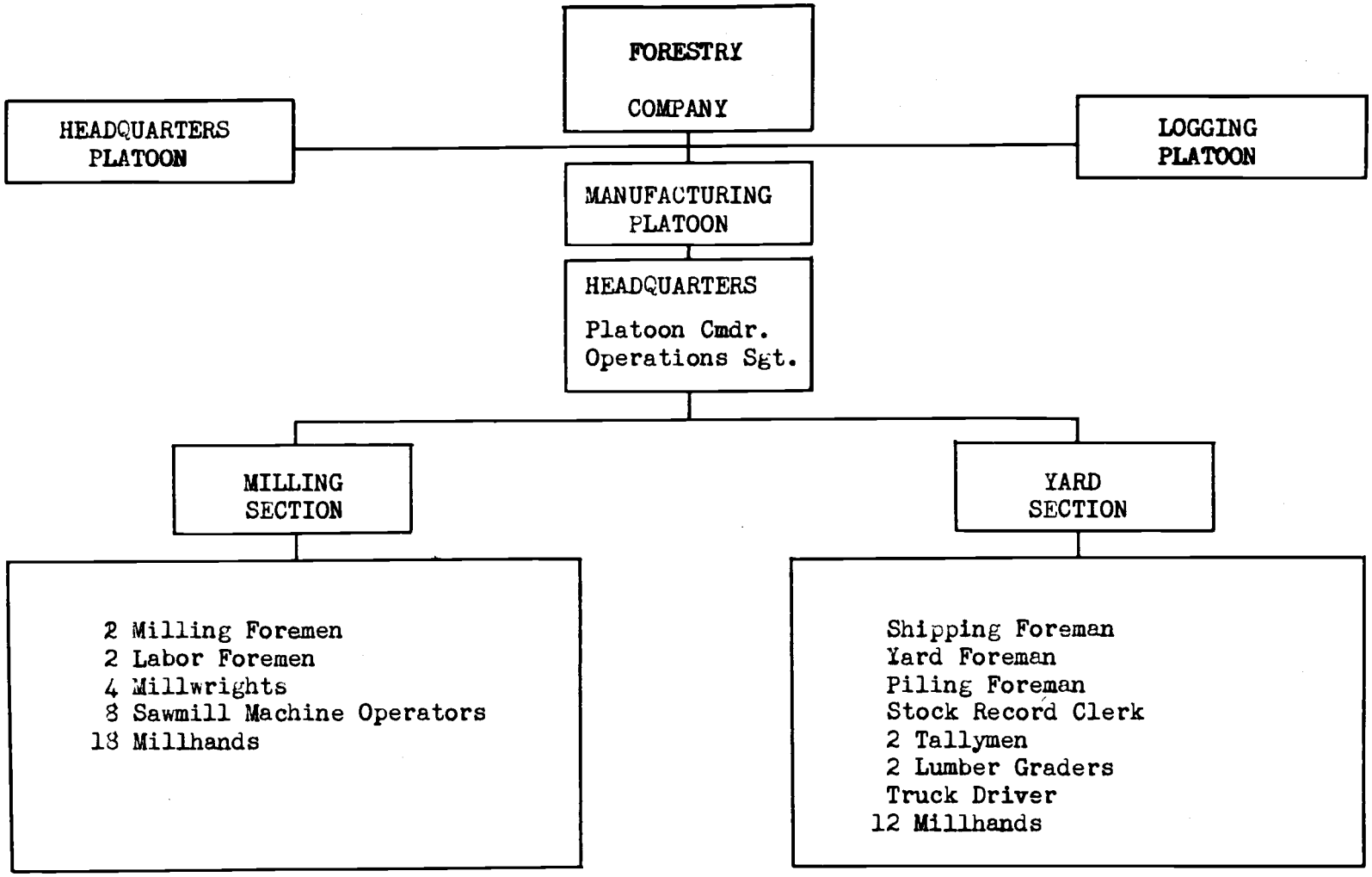

Figure 6. Personnel of the manufacturing platoon.[21]

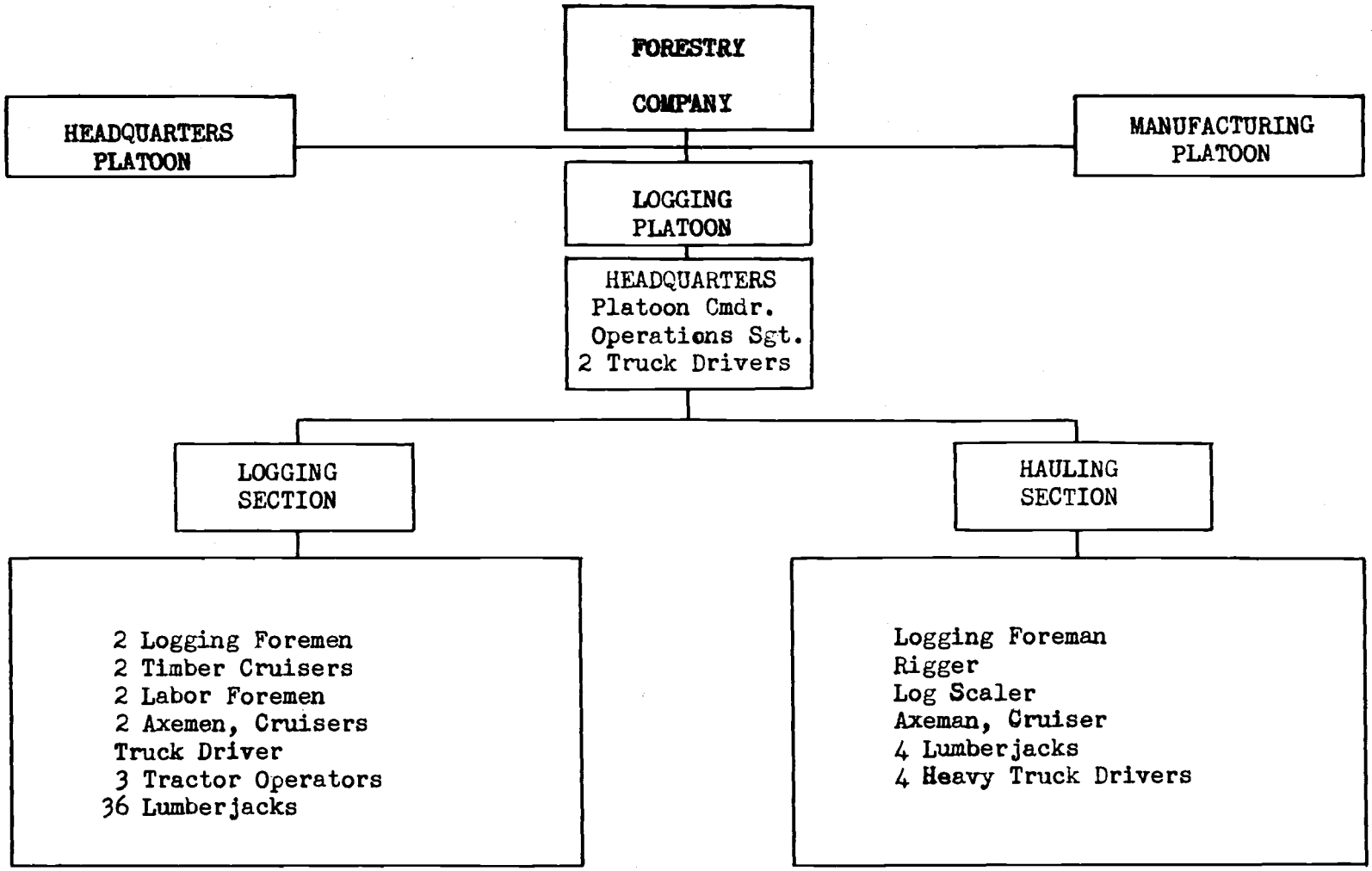

Figure 7. Personnel of the logging platoon.[21]

Armament.[21]

Since this type of unit must provide for its own security, every individual is equipped with the 30-caliber carbine. Two 50-caliber air-cooled Browning machine guns are supplied in addition, and two of the 2½-ton trucks have ring mounts installed on the cabs for these guns. All truck drivers are usually trained in the use of the machine gun.

Operational Equipment.

Equipment used by the company in the performance of its mission includes the basic engineer sets and the special tools, spare parts, and accessories required for sawmill and logging activities. These pieces of equipment are the basis of this study and will be itemized in a later section.

Housekeeping Equipment.

The company is supplied with the minimum necessary kitchen equipment to allow each platoon to operate a separate mess. Sufficient vehicles are available to permit normal administration, supply, and mess functions. In order that full use of these vehicles is obtained, they are also used in conjunction with the operational work, hauling crews to the job, for instance.

Tools and tool sets for maintenance are considered sufficient with one exception noted in a later section.

Training.(5)

When troops are assigned to an engineer forestry company, they have usually completed the eight-week period of basic training common to all engineer troops. They are then put through eight weeks of specialist training wherein they become proficient in the various skills required by this type of unit.

When this is done, the training is coordinated by at least a month of unit training. The objective of unit training is the development of a military organization capable of exploiting timbered areas and of conducting prolonged lumber operations in isolated areas, with all types of adverse conditions and under constant pressure to meet the tremendous demand created for lumber products in a theater of operations.

A great deal of teamwork and efficiency must be developed, because these units do not engage in combined training. Characteristic of such an organization is its ability to work independently and to perform its mission, normally without assistance from other engineer units.

When these three phases of training are completed, the company should be able to proficiently perform the following duties:

1. Reconnoiter forest resources by air, ground, or map.
2. Negotiate for acquisition of timber rights.
3. Execute timber land surveys.
4. Establish base camps at sawmill and logging sites.

5. Exploit standing timber by:

   a. Logging operations.

   b. Transportation of logs to sawmills.

   c. Manufacture of forest products at mill.

6. Supply lumber and timber in accordance with orders of the theater commander.

7. Maintain sawmill and equipment.

8. Provide for its own local security.

Figure 8. Army foresters in training at Fort Lewis, Washington.

PRESENTATION OF THE EQUIPMENT PROBLEM

General

The foregoing sections were presented in order that a foundation and background might be furnished to those unfamiliar with this type of unit and in order that the principal deficiencies in equipment and suggestions for their correction might be better understood.

Equipment is the fundamental consideration, and the training and selection of personnel will depend on the type of equipment used. It is the base upon which the others are founded, a constant which dictates the type of skilled personnel and the type of training to be furnished. Units may be well-trained and may have outstanding personnel for technical jobs, but if the equipment is inadequate, the efficiency of the unit is reduced. The tools should be of the highest caliber before personnel are assigned and training is initiated, they should also be reasonably priced. While cost is not a basic consideration in military operations, economy is always sound if the operation is not thereby hampered.

In the remaining part of this paper it will be shown that the engineer foresters lacked the best in equipment, and a plan will be advanced for correcting the faults. Criticisms presented will deal only with the major items of operational equipment. No attempt will be made to break sets down into component parts, for in general, the basic engineer sets and the supplemental forestry set[17] were complete and well chosen, planning of the latter showing excellent thought and

foresight.

Order of Presentation

Having acquainted the reader with the engineer forestry company, a discussion of materiél weaknesses and proposals for rectifying them will take the following order:

1. Operational and maintenance equipment tabulated.
2. Deficiencies listed.
3. Suggestions made for correction of deficiencies.
4. A proposed equipment plan advanced with recommendations.
5. Conclusions stated.

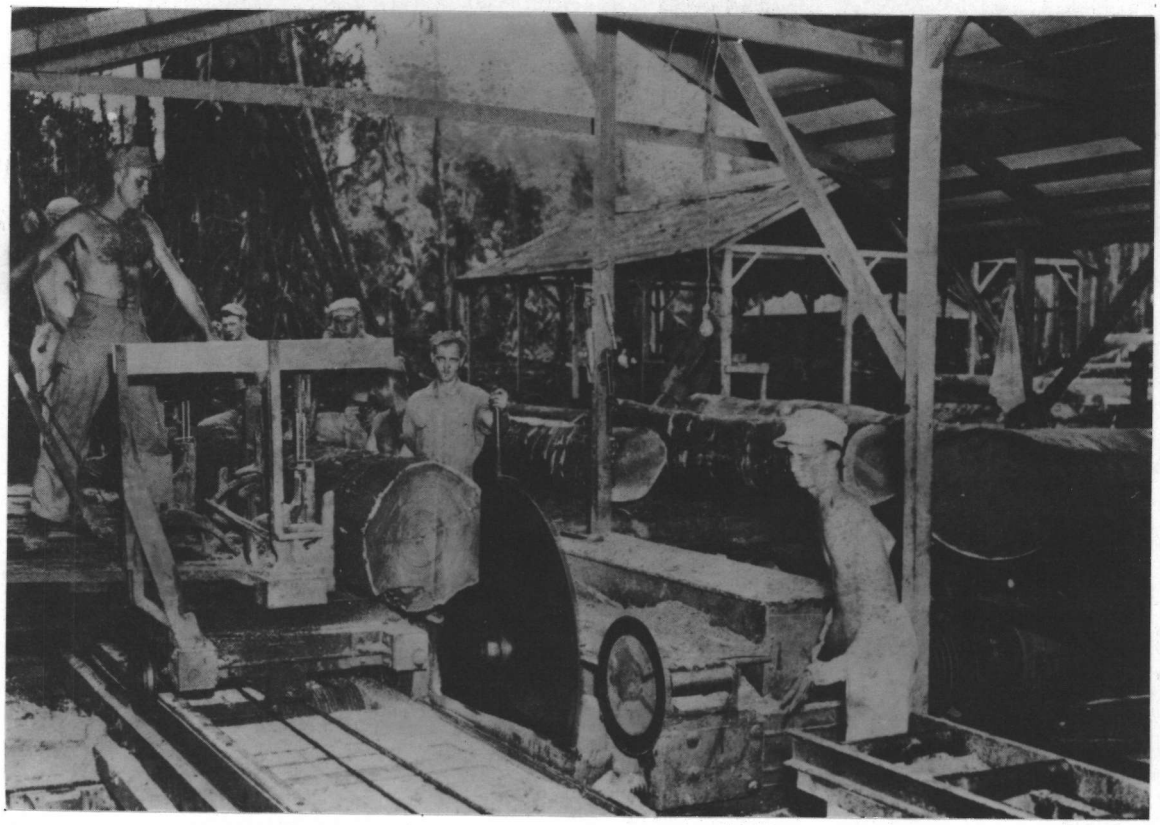

Figure 9. Sawing tropical hardwoods.(5)

ITEM	HDQTRS. PLATOON		MANUFACTURING PLATOON			LOGGING PLATOON				TOTAL FOR COMPANY
	COMPANY HDQTRS.	SERVICE SECTION	PLATOON HDQTRS.	MILLING SECTION	YARD SECTION	PLATOON HDQTRS.	LOGGING SECTION	HAULING SECTION		
Arch, logging, towed type, crawler mounted, with boom, 99" gauge	ADMINISTRATION & SUPPLY						1			1
Sawmill, portable, gasoline, head-block type, 4' x 7', 60" diam. saw				1						1
Semitrailer, front loading, 20-ton with 4-wheel tandem dolly								1		1
Tractor, crawler, 70-90 DBHP							3			3
Trailer, 4-wheel, special tandem, 7-14 ton, 4-DT								3		3
Truck, tractor, 4-ton, 4-DT, with cab protector and front-mounted winch								3		3
Trailer, 1-ton, 2-wheel cargo	1				1					2
Trailer, 1-ton, 2-wheel, 250-gallon water tank	1									1
Truck, $\frac{1}{4}$-ton	2									2
Truck, $1\frac{1}{2}$-ton cargo	1						1			2
Truck, $2\frac{1}{2}$-ton cargo, with winch	1				1	2				4
Truck, 6-ton prime mover with winch								1		1
Carbide and electric lighting sets				3						3
Blacksmith equipment, Set #1		1								1
Canvas worker's equipment, Set #1		1								1
Carpenter's equipment, Set #2, engineer platoon		1								1
Pioneer equipment, Set #2, eng. plt.		1								1
Saw, chain, portable, gasoline engine driven, 36" & sharpener							6			6
Supplementary equipment set #6, forestry company							1			1
Welding equipment, Set #2, oxyacetylene		1								1
Winch, tractor mounting, double drum with gypsy spool							1			1
Tool sets for vehicle maintenance: Carburetor and ignition		1								1
General mechanic's		2								2
Unit equipment, 2nd echelon Set #1 with spare parts cabinet		1								1
Grease dispensor, compressor, Set #6		1								1

Figure 10. Organizational and maintenance equipment.(21)

OPERATIONAL AND MAINTENANCE EQUIPMENT

Figure 10 tabulates the operational and maintenance equipment of the company as it exists in present army tables of organization.(21) Excepting vehicles, the housekeeping and security equipment is omitted, as it is reasonably sufficient and therefore does not reflect materially on the operations.

Figure 11. Crotch line loader using tractor power.

DEFICIENCIES IN EQUIPMENT

Manufacturing Platoon

The Power Unit.

The most consistent criticisms of equipment fell on the power unit of the sawmill. Every letter from former army sawmill operators

complained about its weaknesses. George Parsons,[14] graduate of Cornell with a BS and MF in Forestry, a one-time sawmill co-owner, and former commander of the manufacturing platoon of the 1065th Engineer Forestry Company, refers to the inadequacy of the unit as follows: "...deficient in power, short-lived, and top heavy causing undue difficulties in handling."

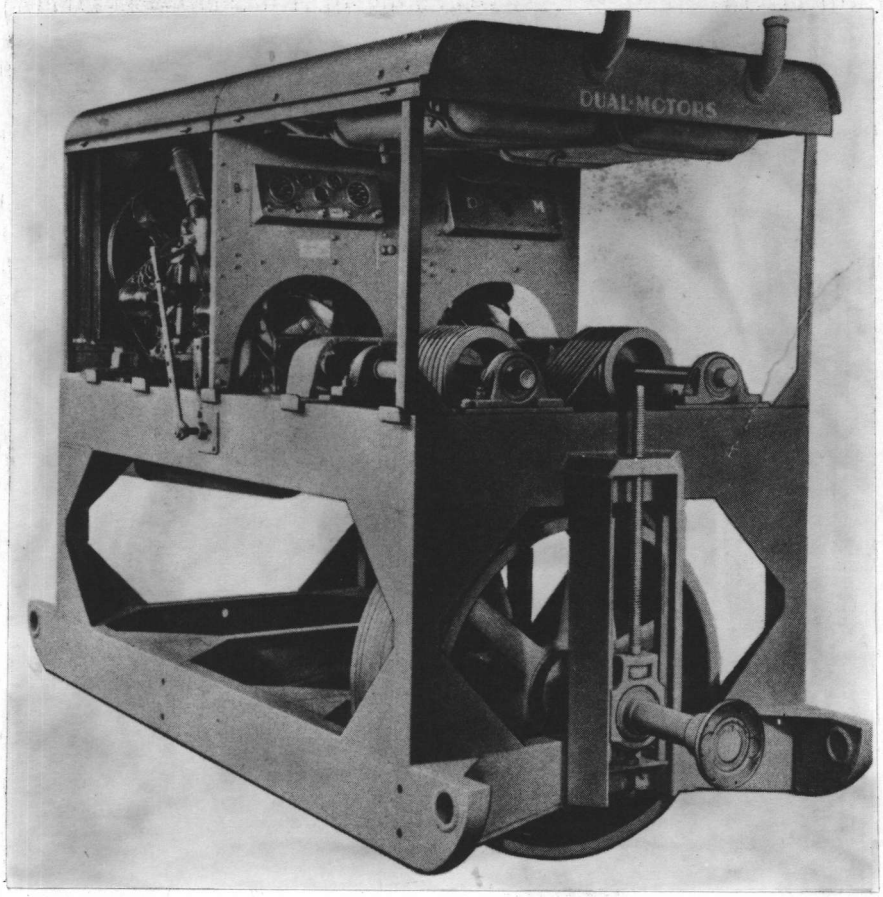

Figure 12. Twin engine power unit.[15]

Former commander of the 800th Engineer Forestry Company in Italy, recipient of the Legion of Merit for his lumber supply work there, and at present an assistant supervisor with the United States Forest Service, Horace C. Eriksson[6] is of the opinion that the high speed twin engine power unit (Figure 12), did not stand up for long periods of operation day in and day out. Furthermore, he raises the question, "...and when repairs were necessary, where did we get the parts?" There were none available to his knowledge in Italy.

Marvin S. Houston,[11] sawmill owner of Pitkin, Louisiana, and former sawmill platoon commander of the 797th Engineer Forestry Company on the Stillwell(Ledo) Road in Burma, substituted a slower but longer-lived and more powerful motor for his twin engine.

Sawmill platoon commander of the 1062nd Engineer Forestry Company in Europe and later in the Phillippines, Howard H. Frederick,[8] had so much trouble with the twin engine units on 20-hour per day production that he installed a D13000 Caterpillar engine and rigged up a new pully and belt system.

These typical views would then indicate that the present power unit is not the one for the job.

The Sawmill.

Criticizing the mill in general, Frederick[8] says: "The present mill is not a portable mill at all, but semi-permanent. It is too large, heavy, and bulky. It cannot be set down properly in a short

time (say two days maximum), as a truly portable mill should be. It is satisfactory for a rear area mill where time and ease of movement are not prime factors, but if it is attached to an army in action, it is worthless. We proved this when we tried to supply the First Army with bridge material for front-line use. They got so far away that logistics became a big problem. The same thing happened to the 1389th, 1390th, and 1391st (Engineer Forestry Companies)...The supply agencies yelled bloody murder and finally were compelled to raze buildings of all types for lumber."

He cites several specific weaknesses, chiefly that the carriage and edger have too many castings, that the oak timbers upon which track and carriage are mounted, warp easily and are too heavy, and that the trim saw exhaust pipe blows in the operator's face.

Partially contradicting Frederick's statement regarding the portable character of the mill, Parsons(14) opines that the mill was of too light construction which shortened its life. Apparently it is not the weight of the mill at which they are at odds, however, but the type of construction. He goes on to say that there were too many castings in which both he and Frederick agree. The argument then seems to be that a lighter mill would be feasible if forged members were substituted for the castings. Otherwise, these castings should be heavier or of steel to withstand the shock.

Parsons also finds fault with the sawdust blower, suggesting a sawdust chain instead. In this regard he is supported by Krissoff(12),

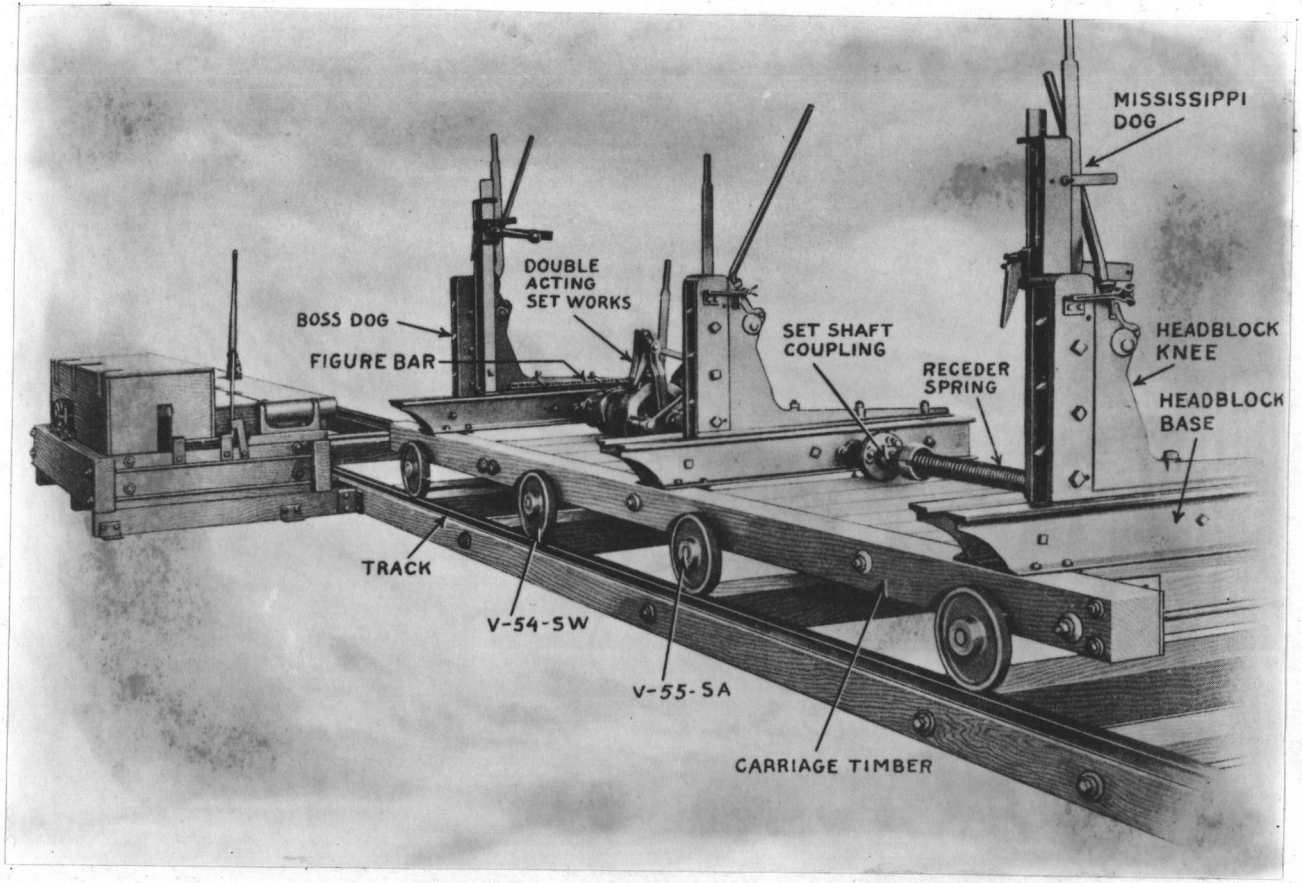

Figure 13. Carriage, track, and husk of the army sawmill.(4)

reporting activities of a sawmill unit on one of the Pacific Islands, who says: "The sawdust was wringing wet and clogged the blower..."

Krissoff added another point on cutting heavy, wet, tropical hardwoods, saying that the pins on the mandrel were sheared much too often.

Houston(11) states: "The biggest mistake regarding the sawmill itself in my opinion, was in designing it for manufacture. Any standard mill that I know of is a better mill than the one I used overseas. Actually all that is necessary is to go to any large portable mill producing about 2,500 board feet of lumber per hour and you will find the features desired..." He states further that the headblock was substandard, the mandrel was too short, the sawdust blower was unsatisfactory, and the saws themselves had too many teeth for the power and speed of the mill.

Eriksson(6) also criticizes the lack of standardization in the army mill. In his words: "The Corinth mill was of general poor workmanship, such as poor castings, alignment, and machine work throughout. This is no criticism of Corinth. They did the best they could, but why didn't the War Department insist on a standard commercial mill?"

Such comments as these are worthy of consideration when contemplating revision of the sawmill.

Figure 14. Navy Seabee Loggers with "homemade" loader.(9)

Logging Platoon

The Log Loader.

A portable log loader is the most notably lacking piece of equipment. It could have been used by both platoons, and besides facilitating the logging job, it would also have speeded up the moving operation. Most of the units built a loader with materials at hand.

McDowell,(13) following an interview with Capt. E. V. Roberts, now regional survey director of the Appalachian Forest Reserve

Experimental Station and formerly commanding officer of the Burma unit, reports the following: "...Here in a clearing beside the Ledo Road a G. I. was operating a crude derrick mechanism which was mounted on the body of a dilapidated truck...To my inexperienced eye it resembled a gin-pole on wheels.

"The Captain pointed to the machine. 'That,' he said, 'is the pride and joy of the outfit. It's a home-made jammer, designed and built by two of our men.'

"The Army T. O. (Table of Organization) for a forestry unit calls for the use of stiff legs in the loading of logs. Capt. Roberts' men, however, found the stiff legs to be awkward to handle in the dense Burmese jungles, so (two of his men) designed the jammer, patterning it after equipment they had used in civilian life.

"The resulting home-made rig was a conglomeration of...discarded equipment. Drums were taken from a shovel, gears were taken from TD-18 tractors, a motor was taken from a Dodge weapons carrier. The framework was formed with lengths of scrap steel welded together in the outfit's heavy equipment shop. A pole was fashioned from a log, and the whole contraption was mounted on a British-built motor truck...

"The jammer proved a lifesaver during those (rainy) days. 'We'd run the jammer as far as possible into the jungle,' Capt. Roberts said. 'Then we'd throw a block around a near-by tree with the light cable, or (haulback). In the meantime, the heavy cable and block would be extended as far as 500 feet farther into the jungle and hooked on a log. The log would then be dragged back through the swamp

to the jammer where our 'cats' could pull them out to the loading area. Without the jammer we never could have gotten those logs out to the road.'"

One of Roberts' lieutenants, Houston,[11] was also emphatic concerning the usefulness of such a vehicle, and the following comments are no less pertinent.

Eriksson:[6] "Every forestry company in the Pacific made its own loader. We used a shovel with a crane boom..."

Parsons:[14] "A truck or tractor mounted crane would have been of great value for loading logs, setting down mill, and moving equipment."

Blackerby:[2] "...but the most obvious neglect has been in loading facilities. Not only were logs frequently yarded by truck, but they were also loaded by truck. I have seen a truck kept in the woods for the prime purpose of parbuckling logs onto truck trailers..."

Krissoff:[12] "...a 20-foot 'A' frame built on a 10-ton prime mover is used to load logs in the woods..."

Figure 15. Portable loading rig designed by American soldiers of material captured from the Germans.[22]

Johnson[9] says that the Navy Construction Battalions with similar equipment built a crane on a tractor for loading logs (Figure 14), and Wright[22] describes an improvised log loader (Figure 15) used in the European Theater.

It is true that there are many ways and means of loading logs, and engineer troops were trained in rigging to devise such systems, which they usually did, but it cannot be denied that the mobility and efficiency of these units were impaired, wherever they operated, by the lack of a mobile loading unit.

Chain Saws.

Chain saws found limited use in the various units, apparently due to their weight and maintainence problems. While it is generally felt that they should be included in the equipment, it is also indicated that they should be improved.

Eriksson[6] gives a typical viewpoint in his letter: "...they (chain saws) are either still in the gadget classification or are too delicate for sustained operations in rough woods, long...distances from depot headquarters where parts and repair work can be secured. In Italy we did not use chain saws because they were too much of a nuisance to maintain. It was easier to hire civilians or to use prisoners on a cross-cut saw -- no maintenance problems in the latter instances."

Log Trucks.

There is a little disagreement as to what is desired in log trucks. It is well understood that there is usually insufficient transportation for many units in a military campaign. However, it is often permissible when supply forces have kept up with combat arms, for a unit to supplement its basic equipment with additional items. When this is possible, trucking is no problem, but too often it is impossible. So considering only the items allowed the unit, the problem is to strike a medium which will correct the most serious deficiencies, assuming that all cannot be entirely remedied.

Parsons[14] says that the present truck tractor with its trailer

is too slow and cumbersome for common use around a portable mill, although it was useful in hauling long piling.

Objecting to the truck and trailer combination for hauling logs on ex-cart roads in rough war-torn country, Houston[11] recommends extra-long wheelbase trucks. Capt. Roberts also found that the trailer was cumbersome and converted 2½-ton 6x6 cargo trucks to log trucks despite the overload on them. He is here again quoted by McDowell:[13] "Don't ever let anyone sell American equipment short. We've been using those 6x6's to haul our logs for months now. Each trip with a load averages between 5 and 10 miles, and a truck carries a 600 per cent overload. So far, we haven't had a single breakdown despite such punishment. Brother, that's performance."

The opinions of Eriksson[6] in this regard seem to coincide with the no-trailer-heavier-truck idea: "...The log trucks were too light. We found it too easy to overload the 4-ton Diamond T with the result that we were always having valve trouble and trunion blocks on truck chasses were breaking continually...Breakdown, lack of parts, and maintenance (constituted) the biggest headache while trying to do a job in a hurry."

A consolidation of opinions would indicate that the 4-ton log truck was too cumbersome with its trailer, lacking power if loaded completely, and too light for efficient loading if used without its trailer. Thus the maintenance problem was increased.

Tractors.

Here again diverse opinions are encountered depending upon the type of conditions in which the unit operated, and the problem is again one of striking an average for all types of areas.

Houston[11] says that two skidding tractors of the D-7 type are sufficient, and he thinks that the third tractor should be smaller and carry a boom for loading purposes.

While granting that the D-7 tractors were handy on a heavy pull, Parsons[14] feels that smaller machines would do the job as well in some cases and are easier to move. He feels that three D-7's have more power than is needed.

Eriksson[6] is of the opinion on the other hand that the D-7's are sufficient and recommends no other type.

Therefore, while no one has expressed dissatisfaction with the D-7 type tractor, some have indicated that a smaller type could be used to advantage in conjunction with the larger.

Logging Arches.

In some cases, units did not receive logging arches, though they could have been used. Units moved from Europe to the Pacific were required to leave their arches in Europe, and when they reached their destination, they had no replacements. Blackerby[2] says: "Our logging (in the Phillippines) would have been accelerated with the addition of an arch..."

Because the arch, boxed for shipment, is so cumbersome, many units abandoned them. In Europe they were seldom used and hauling them from place to place was not warranted. Perhaps a tractor and arch combined could be used to advantage here.

Service Section, Headquarters Platoon

While maintenance sets in the service section are considered adequate, very often a unit is so far from repair depots that it cannot get a heavy welding job done. The sawmill in its present form required occasional welding, and Parsons[14] found some work too heavy for oxyacetylene.

Summary of Deficiencies

Summarizing the weaknesses in equipment will facilitate their discussion in the following section:

A. Manufacturing platoon.

1. Power unit.
   a. Deficient in power
   b. Short life.
   c. Top heavy.
   d. Lack of spare parts in theater of operations.
2. Sawmill.
   a. Apparent lack of experience on part of manufacturer, producing substandard mill.

b. Reduced portability.

(1) Bulky units lend themselves poorly to rapid loading.

(2) Difficulty encountered in aligning units.

(3) Too heavy due to excess metal and exclusive use of oak timbers.

(4) Too much time required to assemble and disassemble in moving.

c. Too many castings on carriage and edger.

d. Exhaust pipe on trim saw motor in operator's face.

e. Sawdust blower ineffective.

f. Pins on mandrel too light.

g. Mandrel too short.

h. Too many teeth in saws with present type of power.

i. Track alignment poor, difficult to maintain, partly due to character of oak timbers upon which mounted.

B. Logging platoon.

1. Entire lack of log loader.

2. Chain saws.

a. Too heavy.

b. Difficult to maintain.

3. Log trucks.

a. Too unwieldy with trailer under combat conditions with accompanying poor roads.

b. Too light without trailer to carry a fair load.

c. Power lacking on grades.

4. Tractors sufficient but need for smaller one seen to supplement work of the D-7's. Three D-7's unnecessary.

5. Logging arches too cumbersome and often not worth hauling, although definitely required in some operations.

C. Service section, headquarters platoon. Oxyacetylene welding set not always adequate.

Figure 16. D13000 power plant as a substitute for the twin engine unit.(5)

SUGGESTIONS FOR CORRECTION OF DEFICIENCIES

General

Before proposing a plan for equipping these units, this entire section will project the various suggestions offered by several former army foresters as a result of their respective experiences. Perhaps their stimulating remarks will inspire new ideas to help make the forestry company into a truly mobile and efficient unit of the type required to support modern warfare.

A typical example of the ideas expressed regarding mobilization of the entire company is shown in this general statement by Frederick: (8) "With present strength, I know we could operate two mills, so why not supply each forestry unit with another small, truly portable mill so that they could do whatever is asked of them. 'Tailor' this small unit to fit a 20-ton trailer or something comparable; five man crews; no part over a ton; a twelve-foot carriage; no edger; no cut-off saw; power plant on trailer; one half-day maximum time to set mill down; and finally, a small streamlined logging set to go with mill." Actually such a mill as this would be handy for sawing bridge timbers from small logs, and could go quickly to the job wherever required.

True, no suggestion is made here as to how this unit is to be designed, but certainly such a unit, supplementing the main mill, could be used advantageously.

Manufacturing Platoon

The Power Unit.

Suggestions on the type of power to be employed are quite consistent. Eriksson[6] says: "A mill (of this general type) should be powered with a diesel motor of the same size as that of a D-7 or D-8 (tractor) to facilitate the parts problem, and it would have enough power to pull the head saw and edger when both are loaded...We know that the slow speed cat diesel engines can deliver the goods."

Houston:[11] "I would suggest a Caterpillar D13000, or its equivalent," (Figure 16).

Parsons:[14] "...Suggest 75 HP diesel and separate motor for the edger..."

Frederick:[8] "...I got a D13000 'Cat' engine for power and rigged up a new pulley system for the drive. I got what I wanted finally and that is constant headsaw speed, the dream of every good sawyer and mill man. But to do this, I had to sacrifice the weight factor. The D13000 tips the scales at about 11,000 pounds. It is a low speed engine (1000 rpm)...and practically foolproof. Consequently, very few shutdowns for repairs."

These men have all suggested a lower speed diesel power unit. The D-7 type and D13000 are similar in amount of power developed. The former is a tractor motor and the latter, an engine with power takeoff made for the job.

The suggestions offered would seem to eliminate the four chief criticisms of the power unit. In this type of motor, power is adequate; the motor is compact, not top-heavy; it is used by many military units, and the spare parts supply has usually been sufficient; and finally, it has been proven to be long-lived with a minimum of maintenance.

Before leaving the power unit, a further suggestion has been advanced. C. J. Budelier, forester for Pope and Talbot, Inc., in a personal interview, described a portable mill run from a generator, each unit in the mill being operated by a separate small electric motor. The advantages of the electric generator with separate motors are fairly obvious:

1. Each unit is capable of independent operation, can be temporarily shut off for repair or lack of material without effecting the other units.
2. No belts are required, a critical maintenance problem.
3. Exact alignment and precise leveling of the whole mill are not required thus reducing the unskilled manpower problem and saving time in setting up the mill.
4. The generator can be mounted on wheels, thus eliminating the space and weight required of other vehicles for the power unit.

Generators mounted on rubber tires are used in artillery units to operate fire control equipment, guns, searchlights, radar sets, and the Engineers Corps uses such trailer units for fire fighting equipment

and so on. Why not then bring the forestry units up to date as well? Whether the unit is an electric generator or a diesel motor, it could be towed behind a truck and release badly needed space for other equipment. The unit could also be equipped with screw-type jacks (outriggers) for leveling into operating position when necessary.

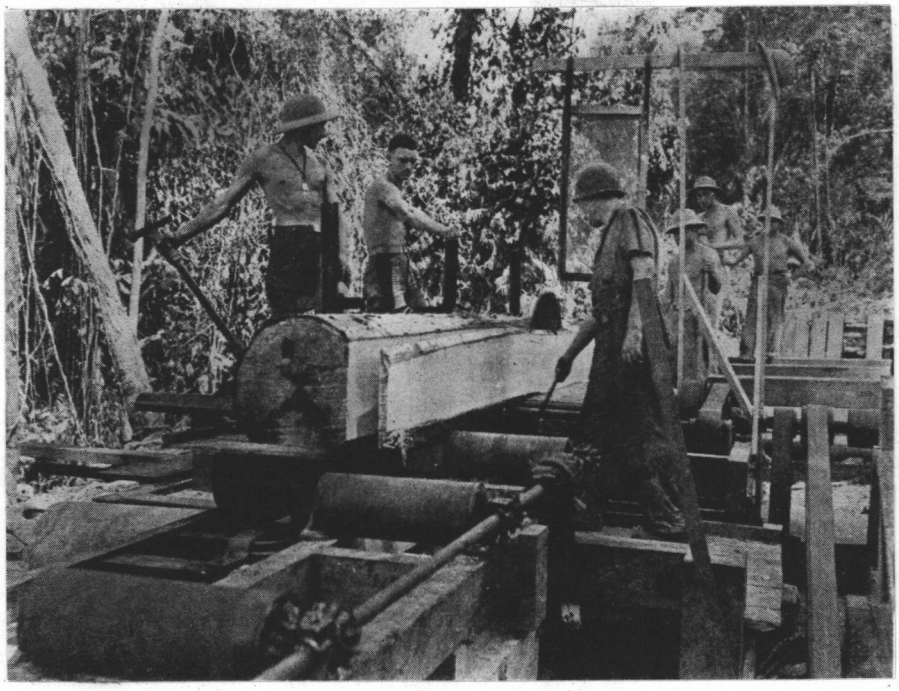

Figure 17. Seabees claim 12,000 board feet per shift with this sawmill.[9]

The Sawmill.

The key to the sawmill problem seems to lie in Eriksson's[6] statement: "Any future mills should be of standard popular commercial manufacture..." Parsons[14] names several standard makes, but it is

not the writer's purpose here to advertise various companies' products. Telford[18] in his report: "Operating Small Sawmills" gives a complete list of sources of equipment, and a study of the sawmills of companies listed therein would in most cases show a minimum of castings where the most strain and shock occur.

Houston[11] gives five suggestions for the sawmill unit:

"1. Ample power.

"2. Standard Type headblock carriage.

"3. Mandrel 10 feet or longer with three bearings to prevent shifting of husk frame and mandrel.

"4. Sawdust chain for moving sawdust. Overhead type preferred.

"5. For type of sawing done by the army, about 40 teeth per saw."

The last point would be eliminated if a powerful low speed diesel or electric power plant were substituted for the higher speed gasoline unit.

Frederick's[8] discussion shows how other difficulties were solved: "Personally, I like to use a 12-inch drive belt and keep the power unit about ten feet from the headsaw (toward the edger). Then, using the standard-length edger drive belt, this places the edger further away (by ten feet) from the headsaw. It is then easy for the edgerman to run 24-foot stuff through his machine.

"I found that an idler is unnecessary on either main drive belt, but the belts must be protected from rain and dampness to prevent stretching and contracting.

"Now, I believe that the mandrel is too light for an increase in power. It is possible that the sawyer may force the feed and cause the mandrel to break at the eye behind the main nut threads. It is a weak spot with too much power and should be 1/8 of an inch or more larger over all. This would necessitate a larger saw eye.

"Suggestions: put a headblock (without dogs) on front and rear of carriage to steady long logs...This would add very little weight to the carriage,..." Possibly better spacing of headblocks would steady the logs and eliminate the need of adding weight. Professor J. B. Grantham, School of Forestry, Oregon State College, recommends six feet between the first and second blocks and nine feet between the second and third, thus allowing adequate bracing for long or short logs.

Parsons[14] recommends a sawdust chain to eliminate the existing breakage and power loss of the blower, and he suggests a top saw be added, since it is advantageous in large timber.

From informal interviews with various former members of forestry companies and through personal experience, a few more suggestions are extended for consideration:

Major R. H. Bernardin at Fort Lewis and formerly a forestry battalion executive in Europe, suggests a double-drum hoist at each mill to aid in moving as well as loading timber, cants, and equipment.

Adoption of a mill modified somewhat like the Jackson Harvester might be a consideration. This mill is operated on the same trailer which moves it from location to location. With tubular steel construc-

tion and 52-inch saw, it can handle Douglas fir logs up to 36-inch diameters.

If the present unit were to be retained, it has been suggested that longer belting and additional lumber rolls be furnished to allow more room between the headsaw and the edger.

Professor Grantham, has suggested that two types of saw be included in the equipment: one for softwoods, and the other with more teeth and narrower kerf for hardwoods. This interchangeability would allow for uniform power.

Henry Disston and Sons[1] recommend twelve teeth to the inch of feed in hardwood and ten teeth to the inch of feed in softwood, power and carriage speed being uniform. In a situation where hardwood, softwood, or both are likely to be found, separate saws should be available as standard equipment to fit the job at hand.

Many suggestions have been received recommending a portable band mill, and while it has the advantage of less waste and thus a greater return on the investment, these are offset by its disadvantages as an army mill. It requires even more careful alignment than the circular mill, which takes valuable time, and there are less skilled band saw filers available to the army. All in all, the lack of skilled personnel prohibits the use of this type of mill. The conventional circular mill presents enough problems in this line without making it more complicated.

These suggestions taken individually would eliminate most of the afore-listed weaknesses of the present mill, and if all were well sifted and combined, certainly a more useful mill would result.

Logging Platoon

The Log Loader.

Army loggers used cross-haul and A-frame methods to load logs in World War I. World War II changed nothing in this respect. A mobile loader is necessary if the unit is to function properly in present day military campaigns. The number of suggestions received further emphasizes this need.

Parsons(14) suggests a truck or tractor mounted crane, as does Blackerby(2) who concludes with: "...I am of the opinion that a loader could be mounted on a truck similar to the (4-ton 6x6) logging trucks. Not only do I have in mind a definitely mobile unit, but one efficient enough to keep waiting of trucks at the loader at a minimum."

Houston(11) suggests two loaders: one "...of the type called 'jammer' in the Northwest mounted on a long wheelbase truck," and a medium size tractor with a boom to handle heavy machinery and to load logs or lumber.

Eriksson(6) seems to have hit the answer with this remark: "The final piece of must equipment should be a Lorain Moto Crane 6x6...a piece of equipment that a Forestry Company would use every day." (Figure 18)

Hicks(10) says that such a machine "...will lift 15 to 20 tons on approximately a 12-foot radius from the center pin...Some of these

machines have been used in the pine country to good advantage..."

Figure 18. One of the new Thew Lorain motor cranes, model 416, used as a log loader.

The type of crane mentioned by Eriksson and Hicks is comparable in size to a 3/4-yard shovel mounted on rubber tires. It has a separate motor with cab to facilitate its propulsion on highway at speeds of 20-40 miles an hour. It has front wheel drive for off-highway travel. It is equipped with front-end winch with tire guards on all wheels to keep from damaging the tires while handling commodities like logs. The machine is also equipped with power slack line puller, among the other features, which adapt it particularly well to logging

work. See Figure 18.

Such a machine with a trailer hitch could pull the sawmill power unit on a move and be available for setting up the mill. It could also be equipped with hydraulic outrigger jacks to be lowered when the loader is in use and thus give the crane more bearing and purchase on its load.

The 1065th Engineer Forestry Company in France used a Quickway Crane, a lighter, smaller machine but similar to the Lorain and constructed as described above. It encountered no difficulties with the size of timber found in the Jura Mountains (comparable to the Grand Fir of the Northwestern United States). However, because of its small size, it would not be effective in such timber as the Douglas Fir in the Northwestern United States nor in the heavy hardwoods of the tropics. Nevertheless, in France, this crane was never idle, and the motor sergeant kept a waiting list of the crews requesting its use, having to rotate it on jobs such as loading logs on trucks, loading piling and huge squared timbers on railroad cars, loading and unloading mill equipment, and even in aiding other vehicles which became mired off main roads. This vehicle was used more than any other single piece of equipment during actual operations of the unit.

Chain Saws.

Criticising the chain saws was easy, but very few of the foresters offered suggestions for their improvement. However, great

strides have been made in improving the performance of power saws. Not only the army loggers, but the logging industry in general has rebelled at the saws, saying that more time was wasted in maintenance than if the cross-cut saw had been used steadily in the first place.

At the annual meeting of the Truck Loggers Association of British Columbia, June 10,11, and 12, 1945, in Vancouver, B. C., Jack Challenger,(3) falling and bucking superintendent for Bloedel, Stewart, and Welch at Port Alberni, talked on recent power saw development. In his words: "There have been many new improvements, including reduction of weight and increase in power. Magnesium's use will reduce weight, and a satisfactory method of magnesium welding has recently been perfected...

"The advance made during the war developing 90 and 110 octane gasoline will make possible the use of smaller motors for power saws."

One manufacturer has produced a saw which decreases the weaknesses, some to the point of elimination. This is a one-man, gasoline-powered chain saw weighing only 38 pounds, about 1/3 of the weight of the present unit. It is durable, light, and easy maintenance is claimed.

Log Trucks.

The criticisms of the log trucks were twofold: (1) too unwieldy with trailer, (2) too light without. Suggestions made to improve this condition follow.

Parsons[14] suggests a long wheelbase truck, a trailer being used only when possibilities occur for long hauls on good highways. In Europe this was sometimes possible and necessary.

Houston[11] wants three extra-long wheelbase 2½-ton or 4-ton trucks to haul logs. The 2½-ton truck, though good for its purpose, is too light to haul logs, however. His contention is that a trailer is not needed, because the sawmill will not cut logs over 24 feet long, and if the mill is truly portable, no long haul with tree length logs is necessary. They can be bucked to saw-log length in the woods.

Eriksson[6], who claims that the alloted transportation was a joke, says: "The log trucks should be boosted to 6- or 7½-ton Whites or Macks and load them to capacity...In other words put a man on to do a man's job and eliminate maintenance." He used trucks to haul lumber long distances and added: "...there is a big difference between hauling 20 thousand board feet on a 7½-ton truck with 20-ton trailer behind and hauling 2 or 3 thousand feet on a 2½-ton truck."

At one time or another all of the units had to haul lumber as well as logs. Having one type of truck capable of hauling either logs or lumber, will increase the versatility of the unit.

The 1065th Engineer Forestry Company had to haul lumber with its log trucks, so a platform was built on the bunks with a cable truss support to prevent bowing in the middle (Figure 19). However, the load in this case was carried too high for complete safety. Frank McGraw, logging platoon commander of that company, suggested a 7½-ton truck and 20-ton trailer for each tractor. This would be three in

number, would eliminate the need for the 4-ton log trucks, and would allow sufficient space for the sawmill and logging equipment as well as personnel.

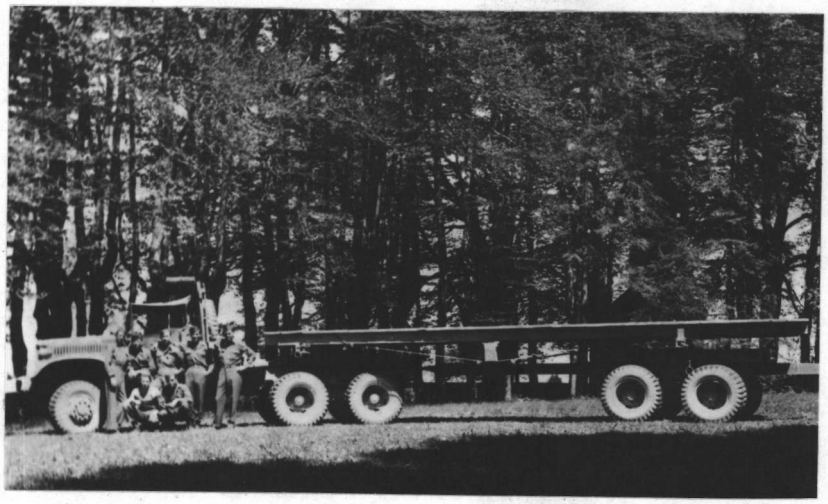

Figure 19. Log truck and trailer converted by the 1065th Engineer Forestry Company to lumber hauling unit, capable of carrying a load of 10,000 board feet, approximately 15 tons.

Tractors.

Eriksson(6) continues on tractors: "There is no doubt that the Caterpillar D-7 is the tractor to use. The (smaller) D-4 and -6 are too light, and the D-8 is too slow and cumbersome in rough woods. The (International) TD-18 is too fast and lacks pulling power." Where he operated, the D-7 was best, but others found use for a D-4, a small, but thoroughly reliable tractor. Houston(11) wants two D-7 tractors,

but a smaller one with a boom for utility loading at woods, mill, and railhead.

Parsons[14] on the other hand says that: "...D-7 Cats were handy on a heavy pull, but smaller machines would often have done the job and would have been easier to move. I suggest one D-7 and two D-4's.

A mean of all opinions, however, would overrule him and perhaps two D-7's and one D-4 would fulfill the needs for most jobs.

Logging Arches.

In answer to the question of logging arches being too unwieldy to move around with the present equipment, the United States Forest Service[7] has been experimenting with a combination that should in a small way revolutionize this phase of the industry, once the primary "bugs" are ironed out.

This is a combined tractor and arch, nicknamed the "Tomcat" (Figure 20). From the Forest Service report: "Departure from conventional track-type tractor begins with the tracks themselves. Track plates are 8x36 inches, so that two sets of sprockets and chains are provided for each truck. The track is given a sharp rake upward in front to facilitate climbing over obstructions, and a reverse slant at the rear to give the utmost support for the load being carried. The engine is mounted well forward on the frame, the drum somewhat more than half way to the rear and opposite the operator's seat, which is completely protected by a sturdy steel plate roof and steel grill.

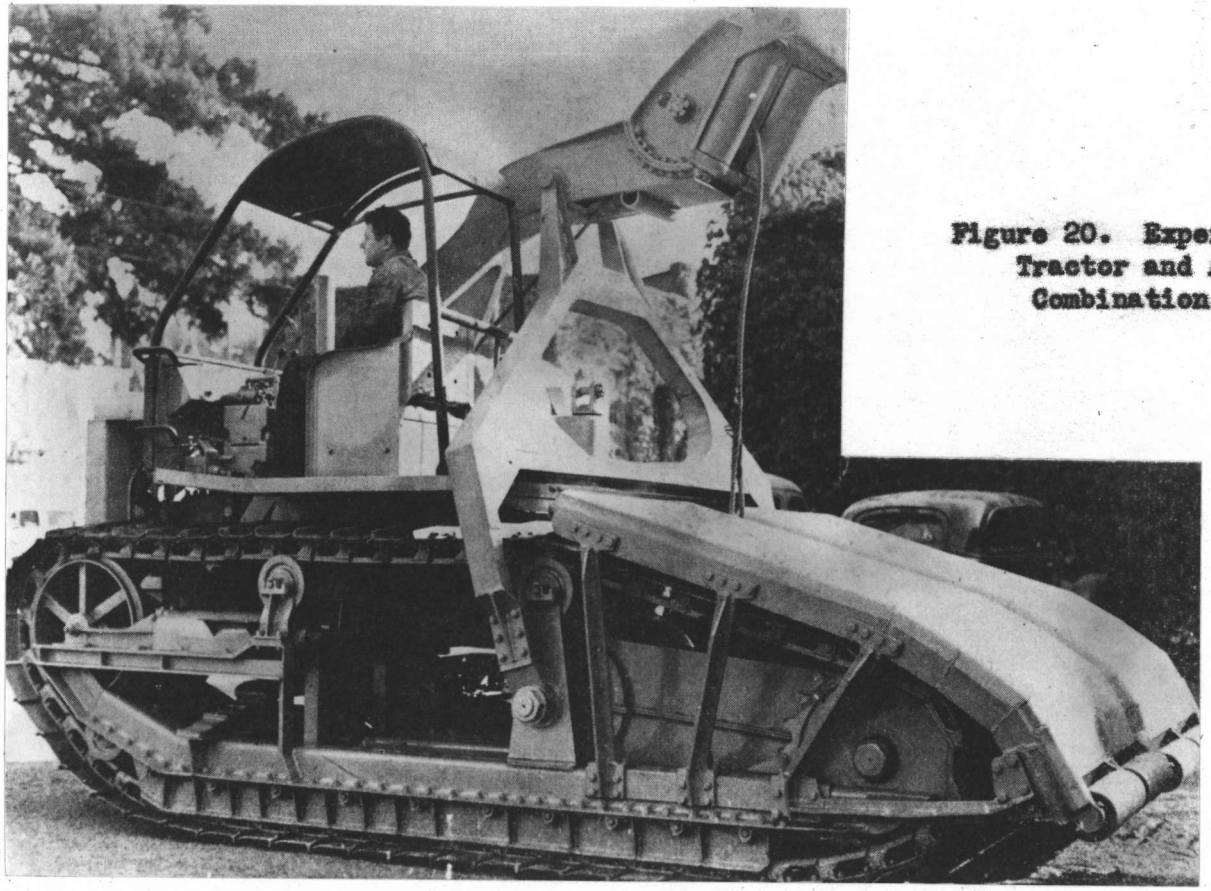

Figure 20. Experimental Tractor and Arch Combination.[7]

"The arch itself, rising from about midway of the frame, overhangs toward the rear sufficiently to bring the end of a log to rest on a heavy steel plate split apron, rolled at both outer edges and at the split to prevent hangups. The split permits use of a rear hitch built into the frame."

This vehicle with its wide tracks could be an excellent aid to tropical and swampy logging, and the army foresters would do well to replace one of the D-7 tractors on the present equipment list with a rig such as this. Mobility and efficiency are certainly not impaired, and the combination eliminates several tons requiring separate hauling.

Service Section, Headquarters Platoon

In answer to the statement that the oxyacetylene welder is inadequate for some of the work encountered, Parsons[14] suggests that a small electric welder be used in its place. If an electric generator was added to run the mill equipment, the electric welder would be operated off the generator, and the oxyacetylene equipment could then be eliminated.

Summary of Suggestions

Most of the proposals made would increase the usefulness of the unit if put into effect. However, some of them may tend to produce new problems. All of the recommendations will be summarized, however, and the less feasible ones will be eliminated in the final analysis.

A. Manufacturing platoon.

1. Power unit.

a. Equip with D-7 type tractor motor or D13000 type power unit.

b. Or determine the practicability of using a diesel electric generator set with separate motors mounted on each sawmill unit and with outlet for the lighting equipment.

c. Use any one of the above, mounted on wheels with trailer hitch and built-in jacks for leveling.

2. Sawmill.

a. Supply a separate small headsaw unit, mounted and operated on a trailer to cut timbers only, and including:

(1) Twelve-foot carriage.

(2) Small diesel power unit on trailer.

(3) Minimum essential logging equipment.

(4) No edger or trimmer.

b. Redesign main mill, streamlining it in general to reduce weight.

(1) Produce heavier 10-foot mandrel with three bearings to prevent shifting and breaking.

(2) Install overhead type sawdust chain.

(3) Substitute fir or pine for the oak beams.

(4) Replace cast-iron with cast-steel or machined forgings.

(5) Allow more distance between headsaw and edger with separate motors or more belting.

(6) Rearrange trim saw exhaust outlet.

(7) Design sections for accurate fitting to aid in alignment.

(8) Space headblocks to reduce play in long logs.

c. Equip platoon with two types of saws: for hardwoods and softwoods, respectively.

d. Supply more lumber rolls.

e. Furnish a double-drum hoist or a small tractor with boom for utility loading at the mill.

B. Logging platoon.

1. Log loader.

a. Supply rubber-tired, 6-wheel drive, motor crane equipped with trailer hitch and outriggers.

b. Mount a crane on a truck or a tractor.

c. Furnish unit with both: crane and tractor with boom.

2. Chain saws. Investigate new saws incorporating ruggedness with decreased weight and reduced maintenance.

3. Log trucks.

a. Furnish extra-long wheelbase 6- or 7½-ton trucks with 20-ton flatbed trailers to haul logs, lumber, or equipment and personnel.

b. Eliminate the 4-ton log truck tractors and their trailers.

c. Equip with long wheelbase trucks less trailer.

d. Equip with two types of truck: one for logs, one for lumber.

4. Tractors.

a. Eliminate one D-7 type tractor and replace with R-4 type with boom for utility work at mill, woods, or railhead.

b. Combine one D-7 type tractor with arch and dozer.

c. Furnish one D-7 tractor with an angle dozer for road work and the double-drum winch of the present listed equipment.

5. Logging arch. Adopt combination tractor and arch as referred to in B4b above.

C. Service section, headquarters platoon. Replace oxyacetalene welder with electric type.

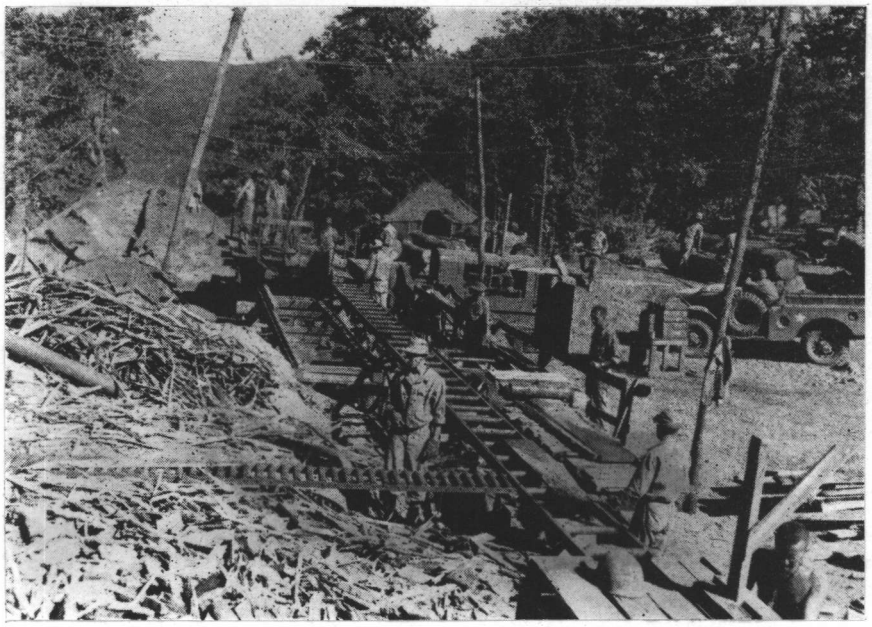

Figure 21. Army Sawmill equipped with additional lumber rolls.(22)

A PROPOSED EQUIPMENT PLAN

General

There should be no reason for a unit which is sufficiently prepared to go into action, having to experiment overseas because its equipment is faulty. Every unit that produced lumber for the armed forces improvised different ways of doing things, and those lacking farsighted, inventive personnel lost out in production. Standard procedure with equipment was entirely lacking.

Units operating in every conceivable type of condition have collectively endured practically every difficulty that would be encountered in logging and sawmilling. With this wealth of experience, the personnel who manned these units have sent their criticisms and recommendations that changes might be incorporated into the table of equipment, that trial-and-error methods might be eliminated, and that eventually an organization would be developed that could surmount any reasonable obstacle encountered in supplying lumber to modern armies.

Using the existing table of equipment(21) for the engineer forestry company as a base and placing efficient performance and mobility foremost, these recommendations have gone into the formation of the following plan:

Specific Proposals

A. Add the following items to the authorized equipment:

1. A power unit of the D-7 or D13000 type, or an electric

generator with separate motors for each machine. The latter is highly recommended, as it eliminates belting, the objectionable trim saw motor, and precise leveling and exact aligning of separate units. Operate the lighting unit and welding equipment off this generator. Mount this unit on wheels with a trailer hitch and jacks for leveling.

2. A separate headsaw ready for operation as it is mounted on a 20-ton flatbed trailer to cut timbers only. Include minimum essential logging equipment to go with this traveling unit.

3. A mobile, 6-wheel drive, rubber-tired loader of the Lorain type equipped with trailer hitch and with outriggers to give more leverage on load.

4. Up-to-date chain saws having less weight and fewer maintenance problems.

5. Three 6- to 7½-ton long-wheelbase trucks (prime movers) and three 20-ton flatbed trailers. Equip these vehicles with removable log bunks to allow for hauling logs, or to be stored in section under truck bed when lumber or equipment and personnel are to be transported.

6. A combination tractor and arch of about 80 horsepower on the order of the type previously described to replace one D-7 tractor.

7. A D-4 or D-6 type tractor with boom for utility lifting in woods, at mill, or at railhead.

8. An angle dozer for the one remaining D-7 tractor to facilitate cutting out roads.
9. An overhead type sawdust chain.
10. An electric welding set to be run off the sawmill power plant.

B. Delete the following items:

1. The dual-motor, gasoline-driven power unit.
2. The sawdust blower.
3. All belting, if the electric power plant is adopted for the sawmill.
4. The present chain saws.
5. The three 4-ton truck tractors and their trailers.
6. Two D-7 type tractors.
7. The logging arch.
8. The oxyacetylene welding set.

C. Redesign and revise the main sawmill. Replace iron castings with cast-steel or forged parts where there is shock or strain. Streamline to reduce weight: by replacing oak timbers with Douglas fir or yellow pine, by reducing size of metal parts where there is little stress, and by redesigning crates and skids with which packed. The power unit, as a leading problem, has already been eliminated by mounting it on wheels. Substituting fir timbers for oak will also simplify alignment and fitting of sections. Manufacture a 10-foot mandrel of larger diameter with three bearings to prevent shifting on the husk and to lessen the possibilities of

its breaking. Allow for more distance between headsaw and edger, using separate electric motors or longer belts; or include more belting if separate motors are not desired. Supply additional lumber rolls and special saws for hardwoods or softwoods respectively. Equip with overhead sawdust chain. It is more efficient and weighs 50 to 100 pounds less than the blower, depending upon the type desired. Space headblocks as recommended to reduce log play and vibration.

Design this mill so that the headsaw, husk, edger, track, and carriage will sit on one set of skids, and can be transported as a complete unit on a 20-ton flatbed trailer. Then, the remaining accessories of the mill can be placed in the body of the towing truck.

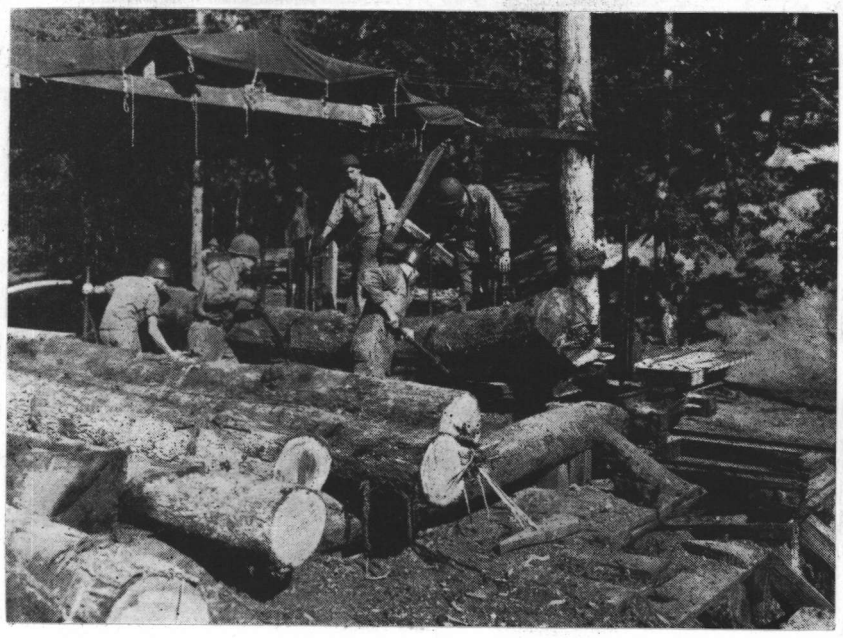

Figure 22. The army lumber producers require strong backs.

Plan for Movement

The ideal situation for a military organization is that it be able to move under its own issued transportation without calling on outside help, without requiring personnel to walk and without shuttling vehicles. The equipment suggested herein, though crowded, will allow such movement. The addition of two 2½-ton cargo trucks would handle surplus personnel and their individual equipment, thus eliminating overloading on the other vehicles. However, omitting these two trucks and distributing personnel with the load, the unit would be transported under the proposed plan with minimum essential equipment as follows:

Number and Type of Vehicles	Load
Headquarters platoon:	
2 1/4-ton trucks (Jeeps)	Administrative and supply personnel
1 1½-ton cargo truck	Maintenance equipment and service section personnel
1 ½-ton cargo trailer	Office equipment and miscellaneous items
1 2½-ton cargo truck	Kitchen equipment and mess personnel, towing 250-gallon water trailer
Manufacturing platoon:	
1 2½-ton cargo truck, machine gun mounted	Yard section personnel
1 ½-ton cargo trailer	Camoflauge and miscellaneous materials
1 motor crane	Towing sawmill power plant
1 prime mover	Main sawmill accessories and 20 men

Number and Type of Vehicles	Load
Manufacturing platoon: continued	
1 20-ton flatbed trailer	Complete unit of main sawmill
1 prime mover	D-4 type tractor, lighting equipment, miscellaneous milling equipment, and the remaining men of the milling section
1 20-ton flatbed trailer	The smaller headsaw unit
Logging platoon:	
1 1½-ton cargo truck	Logging section personnel and gear
2 2½-ton cargo trucks, one machine gun mounted	Miscellaneous organizational equipment and men
1 prime mover	Chain saws, logging equipment and remaining logging section personnel
1 20-ton flatbed trailer	Tractor-arch combination
1 prime mover	Logging equipment and hauling section personnel
1 20-ton flatbed trailer	D-7 type tractor and logging materials

On location, after the mill is in operation, all tractors and available trucks, less the combined headsaw unit and trailer, will revert to the logging platoon for log hauling; or if lumber is to be distributed by the company, rather than by the receiving agencies, one of the prime movers and a 20-ton trailer will be turned over to the yard section.

General Proposals

The question may arise now as to who will design this equipment and why was it not done in this paper. The purpose here was to consolidate criticisms and recommendations into a workable arrangement and not to design equipment. That is a problem for the staff of a manufacturing firm whose business it is to produce these items. The company which is furnished with the specifications and requirements for the mill, as indicated herein, can design a practical tool much better than someone who is unfamiliar with the equipment. Certainly the manufacturer with an eye toward a federal contract would grasp the opportunity to turn these suggestions into a workable unit.

Then in a general way it is recommended:

1. That suggestions herein be studied and actually tested to iron out further difficulties.
2. That tests be made with various standard commercial mills already tried and proven.
3. That interested manufacturers be asked to design equipment to fit the army's purpose.
4. That more recently developed ideas not yet in production be tested.
5. That, along with this research, effort be constantly applied toward increasing the mobility of the unit, thus permitting it to remain abreast of an advancing army and to supply its

lumber requirements adequately and unhaltingly.

Figure 23. A sawmill platoon sets up in the tropics.(5)

CONCLUSIONS

The foregoing criticisms, recommendations, and plan represent a consolidation of the opinions of men who served with engineer forestry companies during World War II and who had sufficient interest in their operations to induce them to conscientiously criticize the organic equipment of the unit, and to suggest improvements in order that future units might develop a reasonably higher degree of efficiency.

That weaknesses existed is apparent, and certainly a need for revision is obvious. In view of the critical state of lumber supply during military campaigns, it would then indicate that additional research and expense, founded on the basis of these actual tests, are justified.

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