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M198 HOWITZER AUXILIARY MOVER DEMONSTRATION. (U)  
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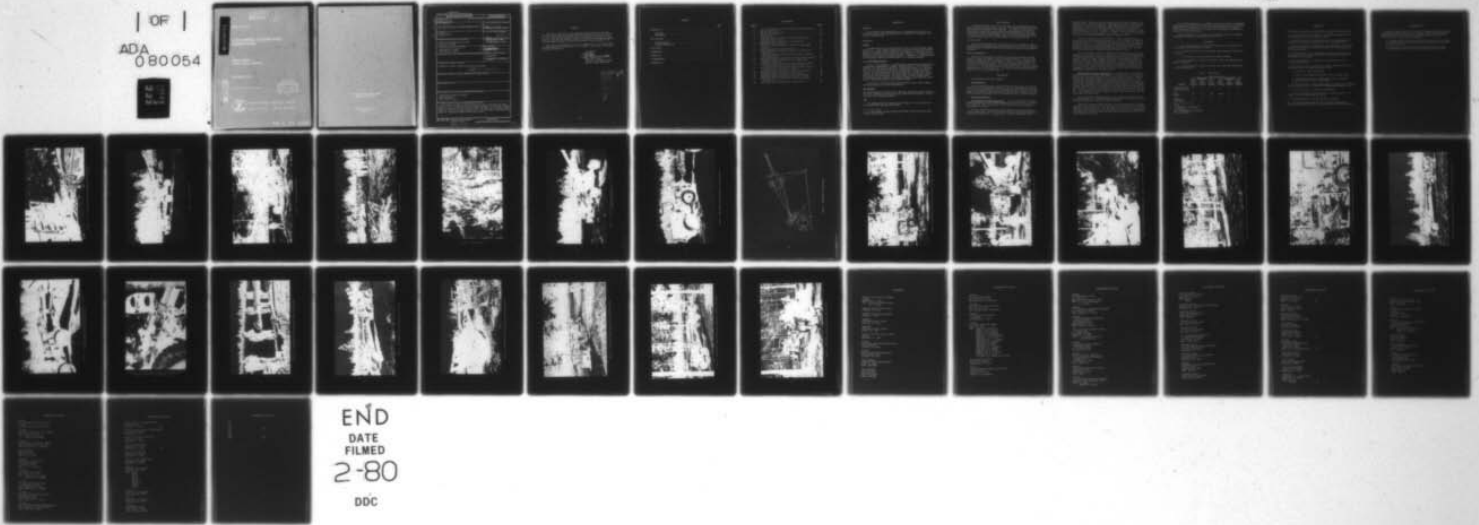
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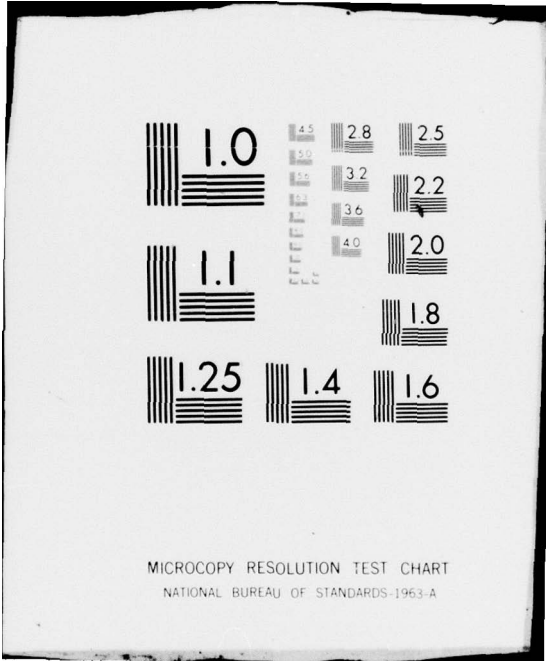
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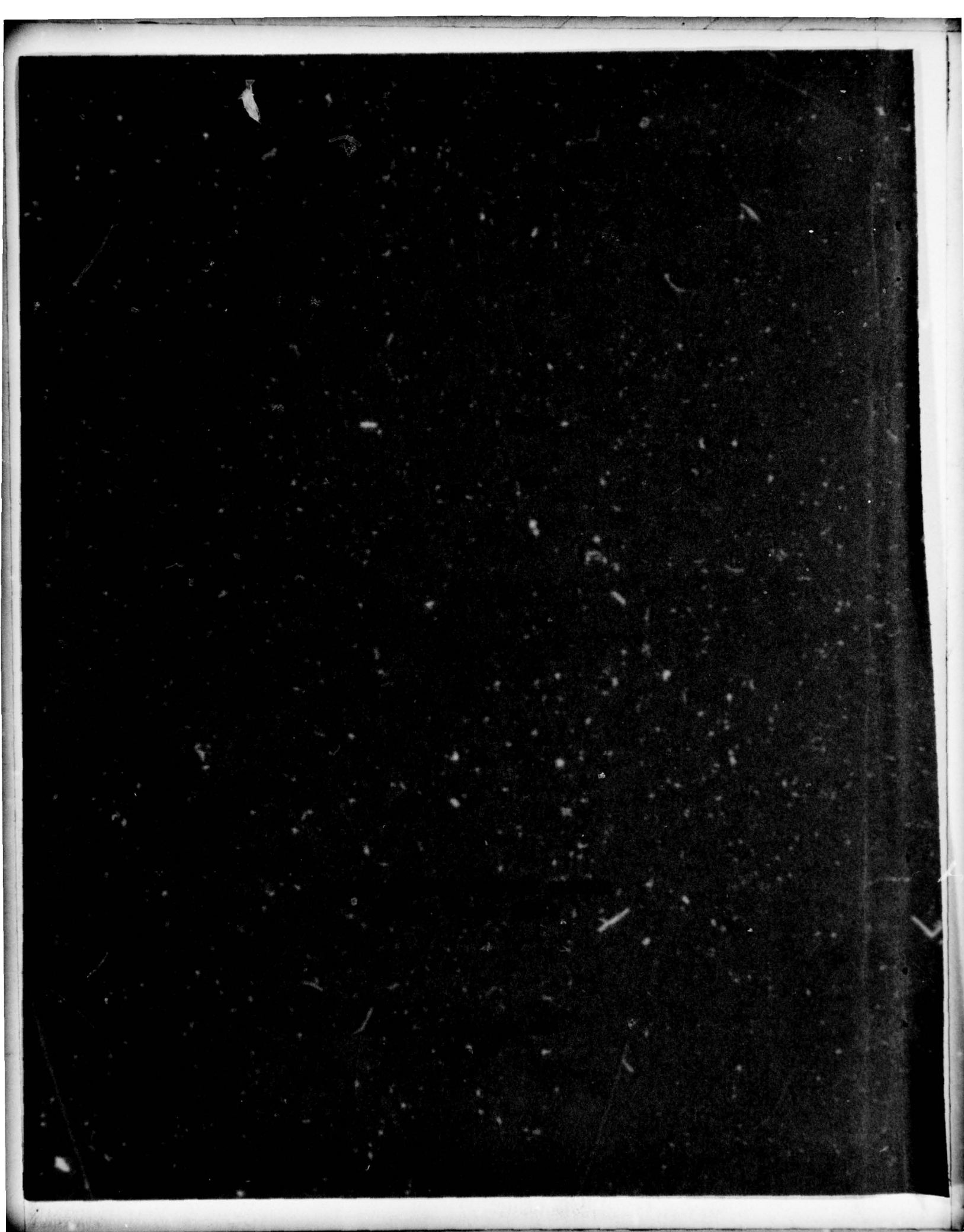
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report documents a limited operational test to determine the feasibility of the J. I. Case MC4000 rough terrain forklift as a candidate auxiliary mover for the M198 howitzer. The tests were performed using a standard MC4000 forklift fitted with an experimental pintle. The tests were conducted at Fort Bragg, NC, simulating typical landing zone terrain.			

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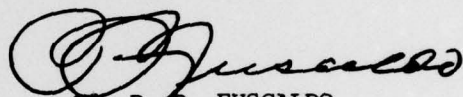
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FOREWORD

This report describes the auxiliary mover demonstration for the M198 howitzer. This effort was directed toward determining the feasibility of the J. I. Case MC4000 rough terrain forklift as an auxiliary mover for the M198 howitzer. The work was conducted as part of the Marine Corps Weaponry Exploratory Development Program of the Navy Strike Warfare Program Element 62332N.

This report was reviewed by: Mr. M. C. Shamblin; Mr. D. A. Wilson, Head, Systems Engineering Branch; and Mr. C. L. Dettinger, Acting Head, Gun Systems and Munitions Division.

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## INTRODUCTION

### OBJECTIVE

The objective of the demonstration was to determine whether the J. I. Case MC4000 rough terrain military forklift is feasible as a candidate M198 howitzer auxiliary mover.

### DESCRIPTION

#### General

The M198 howitzer will enter the Marine Corps as a direct support weapon during FY 81. Direct support weapons must be capable of helicopter mobility. Moreover, the weapon, whether delivered by helicopter or prime mover, must be capable of being moved on the ground for short distances. To accomplish this, the Marine Corps must have an auxiliary mover. Examination of existing Marine Corps equipment yielded the MC4000 forklift as a possible candidate.

#### J. I. Case MC4000 Forklift

The J. I. Case MC4000\* is a rough-terrain 4000-lb-capacity forklift with air/helicopter transportable, towable, fordable features. The Case MC4000 forklift is of articulated frame steer, 4-wheel-drive design. The articulation joint is located at the center of the wheel base to provide in-track turning. All heavy components (engine, transmission, and fuel tank) are located in the rear frame, while the forklift mast and the operator's compartment make up the front module. The drive system is diesel powered with a close-coupled torque converter and modulated hydraulic full powershift transmission, containing internal wet disc service brakes.

Specifically, the MC4000 Rough Terrain Forklift Truck, Vehicle Number 394598, was used for the entire demonstration.

#### Test Hardware

The MC4000 forklift was fitted with a temporary experimental pintle (Figure 1). The pintle assembly was from an M813 cargo truck and was mounted to the forklift mast with a fabricated adapter.

#### Site

The demonstration was conducted at Fort Bragg, NC, in the vicinity of firing point 206A, UTM grid point 659809.

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\* J. I. Case Company, Product Specification Model M-4000 articulated rough terrain forklift truck.

## TEST PROCEDURE

An M198 howitzer was airlifted by helicopter to the demonstration site, which simulated a typical landing zone (LZ). The MC4000 forklift, with front pintle mounted, was brought to the howitzer. For reasons of safety while traversing the terrain of slopes greater than approximately 6 percent, the M198 howitzer always remained downhill from the MC4000 forklift. The demonstration was to conduct the following tests, first with the M198 howitzer in the towed position and then with the howitzer in the stowed position.

### LIFTING ABILITY

With the M198 attached, the forklift mast was first elevated 10 times from minimum to maximum positions; secondly, the mast was tilted 10 times from maximum forward to rearward positions; and finally the mast was side shifted two times.

### MOBILITY/GRADEABILITY

Basically, the procedure consisted of pulling and/or pushing the M198 howitzer through flat, broken, sandy, and inclined terrain. The flat, flat-broken, and sandy conditions are shown in Figures 2, 3, and 4, respectively. The incline attempted was a trail (Figure 5) that had four obstacles: (1) a felled tree of 8.6-in. diameter, (2) a vertical obstacle with a 2.2-ft rise in 10 ft, (3) a vertical obstacle with a 4-ft rise in 10 ft, and (4) a vertical obstacle with a 1.1-ft rise in 5 ft. The forklift pintle was maintained between 30 to 33 in. from ground level.

## TEST RESULTS

The following results were attained:

### Lifting Ability

For both the M198 howitzer towed and stowed configurations, the forklift hydraulic lines and structural integrity of the mast were observed after lifting, tilting, and shifting cycles. No abnormalities were detected. With the weapon in the standard towed configuration and the forklift raised to its maximum lift height, the muzzle end of the howitzer was 60 in. from the ground.

### Mobility/Gradeability

M198 Howitzer in Towed Configuration. In this configuration, the M198 howitzer was both pulled and pushed through basically three types of terrain/soil conditions: flat, flat-broken, and flat sandy (slopes not exceeding approximately 3 percent).

The flat and flat-broken terrain soils conditions varied from hard to lightly packed sandy. The forklift pushed (Figure 6) and pulled the howitzer through these conditions. In packed sand, the MC4000 demonstrated some

tractive effort; however, it did not perform as well as would be shown in the stowed position. Some difficulty was encountered while trying to maneuver the howitzer in a tight circle (Figure 7). The radius of the circle for the outside forklift tire (R) while the M198 howitzer was pushed in a circle was approximately 32-1/3 ft, and the radius of the circle for the outside tire (r) of the howitzer was 20-1/2 ft (Figure 9). However, when the howitzer was being pulled in a circle, the radii were  $R = 25$  ft and  $r = 7-1/3$  ft. For this test, the engine cooling water temperature remained constant at 160°F.

On the flat sandy terrain, the MC4000 lost traction while attempting to push the weapon through the terrain (Figure 9). Another MC4000 was connected (in tandem), and both forklifts pulled the weapon back out from the sandy conditions (Figure 10). In a second attempt, the weapon was pushed successfully through the sandy soil; however, this time the vehicle driver built up and maintained a high speed before entering the sandy conditions. For this test, the engine cooling water temperature remained constant at 160°F.

In the loose sandy terrain, the MC4000 did not demonstrate a significant capability for pushing or pulling. The MC4000 did not pull the weapon through a slightly inclined sandy terrain because of the lack of traction (Figure 11). Several attempts were made; however, the MC4000 could not develop sufficient traction to pull the weapon through this terrain. Two MC4000s connected in tandem also failed to provide sufficient traction to pull the weapon (Figure 12). In all instances, the forklift did not have sufficient traction to traverse the terrain. Another MC4000 connected in tandem did not increase the tractability significantly. For this test, the forklift engine cooling water temperature increased 10°F from 160°F to 170°F.

M198 Howitzer in Stowed Configuration. The M198 howitzer in the stowed configuration with the muzzle brake mounted to the barrel was connected to the MC4000. With the forklift mast vertical and the forklift on center line with the howitzer, the muzzle brake was 7.5 in. from the mast (Figure 13). With the mast tilted maximum rearward, the muzzle brake was 16 in. from the mast (Figure 14). The muzzle brake did not interfere with MC4000 when a tight turn in the direction opposite the stowed barrel location (Figure 15) was attempted. However, the muzzle brake did interfere with the MC4000 when the direction of the turn shown in Figure 16 was reversed. The muzzle brake was removed (Figure 17). With the forklift mast vertical, the muzzle face was 31-1/3 in. from the mast. The demonstration with the howitzer in the stowed configuration was conducted with the muzzle brake.

Over flat and flat-broken terrain and soil conditions ranging from hard to lightly packed sand, the MC4000 forklift demonstrated the capability of both pulling and pushing the howitzer (Figures 18 and 19).

Through the sandy soil conditions and incline of approximately 3 percent, the MC4000 engine demonstrated the capability of traversing the terrain, either pushing or pulling (Figure 20). For the gentle incline (Figure 21), the forklift made several attempts to break through the sandy soil before accomplishing this phase. The engine cooling water temperature increased 15°F from 160°F to 175°F throughout this test.

In the final demonstration, the MC4000 forklift pulled the stowed howitzer up the inclined slope and over the obstacles described previously. The MC4000 demonstrated the capability of pulling the M198 howitzer over the obstacle trail of this test (Figure 22). The engine cooling temperature remained constant at 160°F during this phase.

Table 1 summarizes the feasibility of the MC4000 forklift as a possible auxiliary mover, based on the conditions of this test.

#### OBSERVATIONS

1. The lifting, lowering, and tilting capabilities of the MC4000 forklift provide a desirable mobility feature.
2. A different forklift tire tread design might enhance the traction of the vehicle.
3. It is desirable to have a winch on the MC4000 forklift.
4. Driver expertise is required in order to attain the maximum vehicle mobility potential.
5. A quite impressive increase in driver skill levels was attained during the demonstration.

Table 1. Test Results

Terrain	Vehicle Position					
	M198 Towed			M198 Stowed		
	One MC4000 Pulling	Two MC4000 Pulling	One MC4000 Pushing	One MC4000 Pulling	Two MC4000 Pulling	One MC4000 Pushing
Flat/Flat Broken (Some loose sand)	F	--	F	F	--	F
Flat Sandy	NF	NF	PWD	F/PWD	--	F
Incline Hard Packed	--	--	--	F	--	--

Notes:

- indicates "not attempted"
- F = feasible
- PWD = performed with difficulty
- NF = not feasible

## CONCLUSIONS

The following conclusions are drawn from the feasibility demonstration:

1. The MC4000 rough terrain forklift is a feasible auxiliary mover for the M198 howitzer under the conditions tested.
2. The MC4000 forklift with the M198 howitzer in the stowed position represents the most mobile combination for the conditions tested.
3. The MC4000 forklift has considerably less interference with the M198 howitzer in the stowed position than the M813 5-ton truck designated as the Army prime mover.
4. The MC4000/M198 in towed configuration has some capabilities as an auxiliary mover over flat and flat-broken ground under hard packed to loose sandy soil conditions.
5. The MC4000 forklift is steerable and controllable under all the conditions demonstrated.
6. The engine cooling system, hydraulic system, and mast structure were satisfactory under the conditions tested in that:
  - a. No hydraulic leaks were detected.
  - b. Engine cooling temperature remained within the normal range.
  - c. The mast functioned in a normal manner, with no evidence of excessive friction, bending, or deflection.
7. The MC4000 and M198 in stowed configuration were stable when traversing vertical obstacles up to the forklift's estimated maximum capabilities.
8. The pivoting pintle is a critical design feature.
9. For precise placement and maneuvering of the M198 howitzer, it is better to push the weapon than to pull it.
10. Tandem operation of the MC4000 forklifts is feasible.
11. The skills available under MOS 1345 are entirely adequate for operating the MC4000 forklift as an auxiliary mover for the M198 howitzer.

## RECOMMENDATIONS

Because the MC4000 forklift has proved to be capable of providing surface mobility for the M198 howitzer, it is recommended that detailed feasibility of the MC4000 forklift auxiliary mover concept be further explored. The following specific issues should be addressed:

1. A design that allows hook up between the MC4000 pintle and the lunette on the M198 howitzer (in the stowed or towed configuration) with weapon trails on the ground.
2. Provisions on the MC4000 for an air system to operate the M198 howitzer brakes. Also, a winch should be mounted on the rear frame.

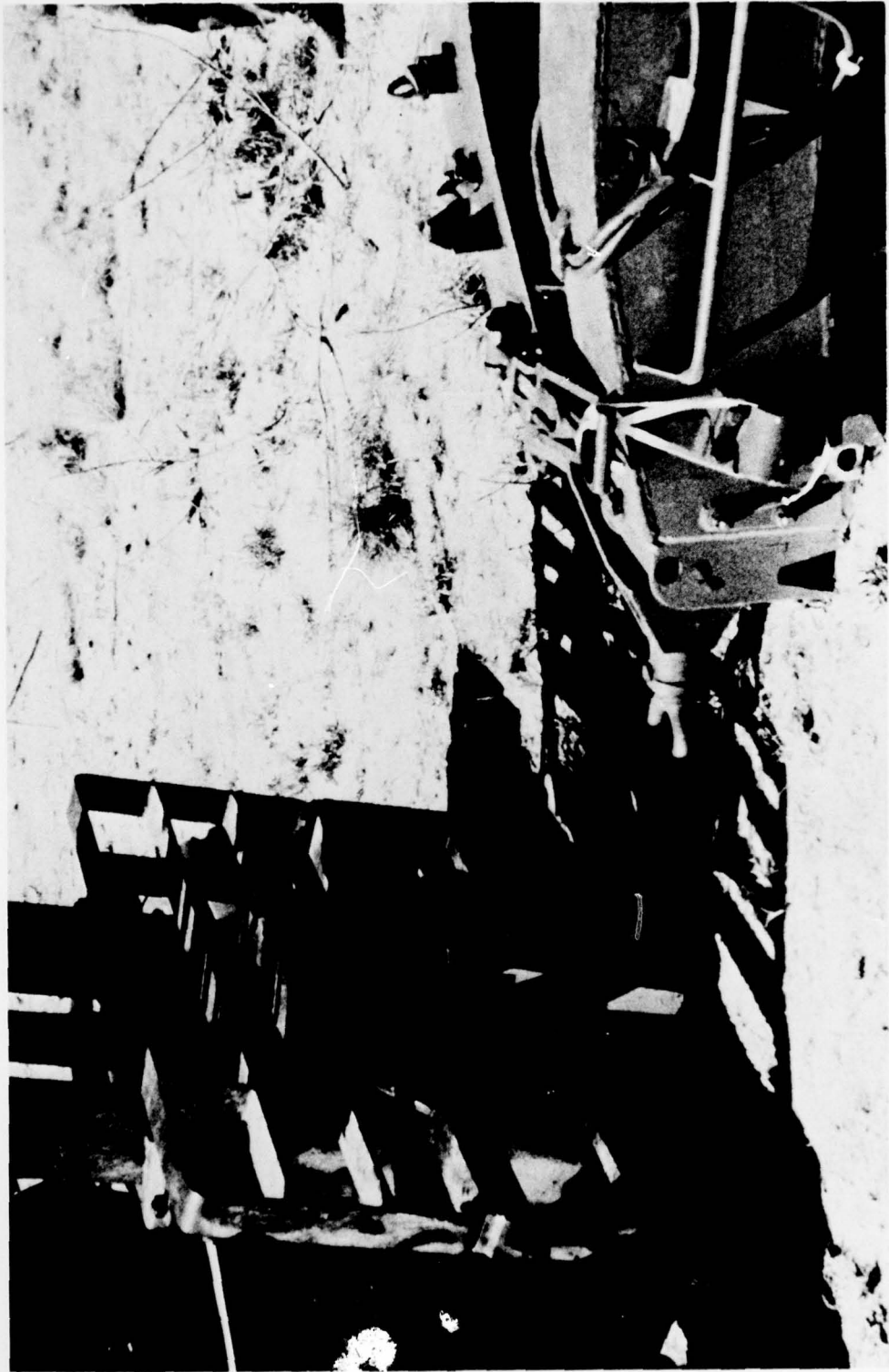


Figure 1. J. I. Case MC4000 Rough Terrain Forklift with Front Pintle

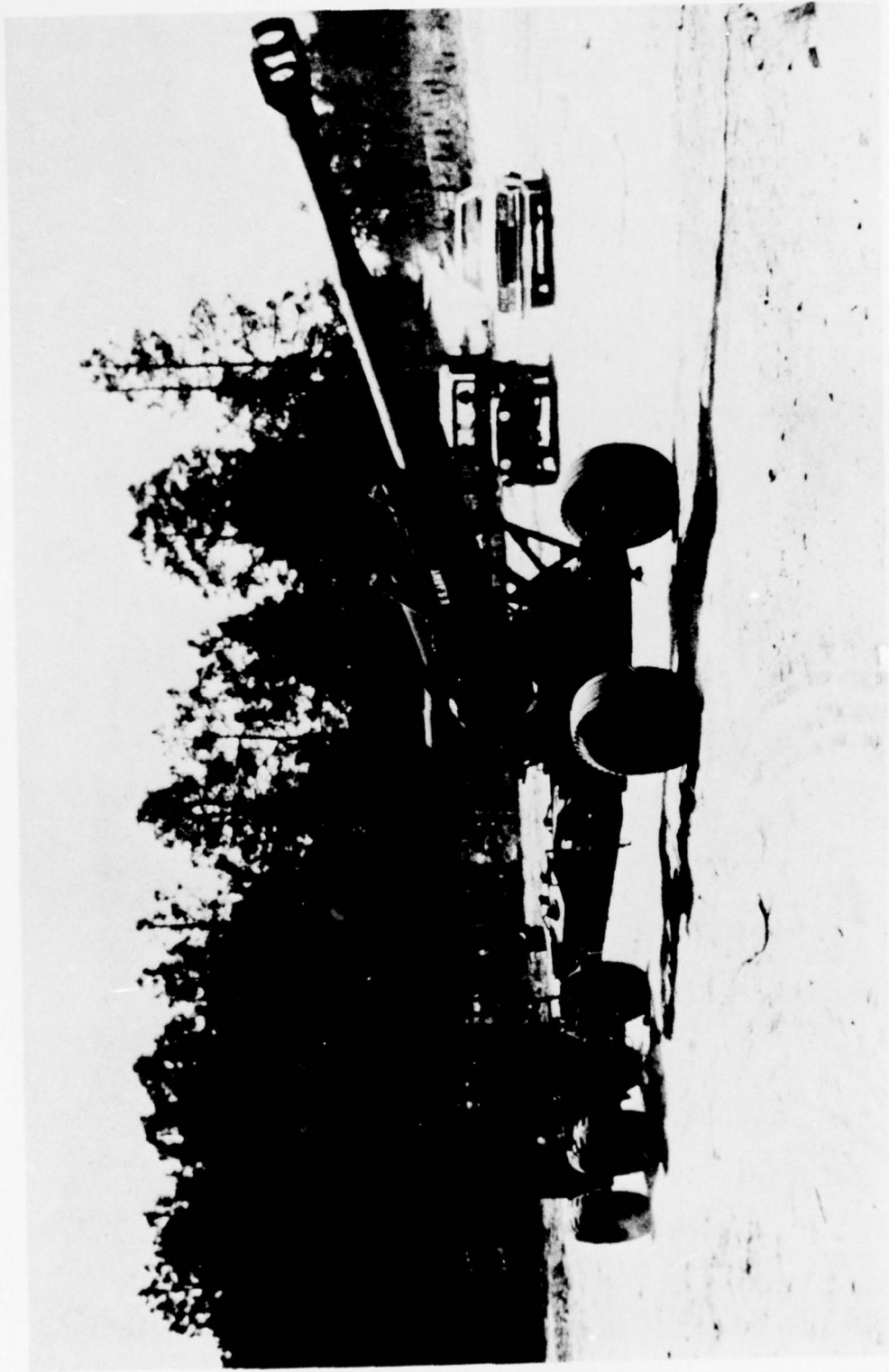


Figure 2. Typical Flat Terrain

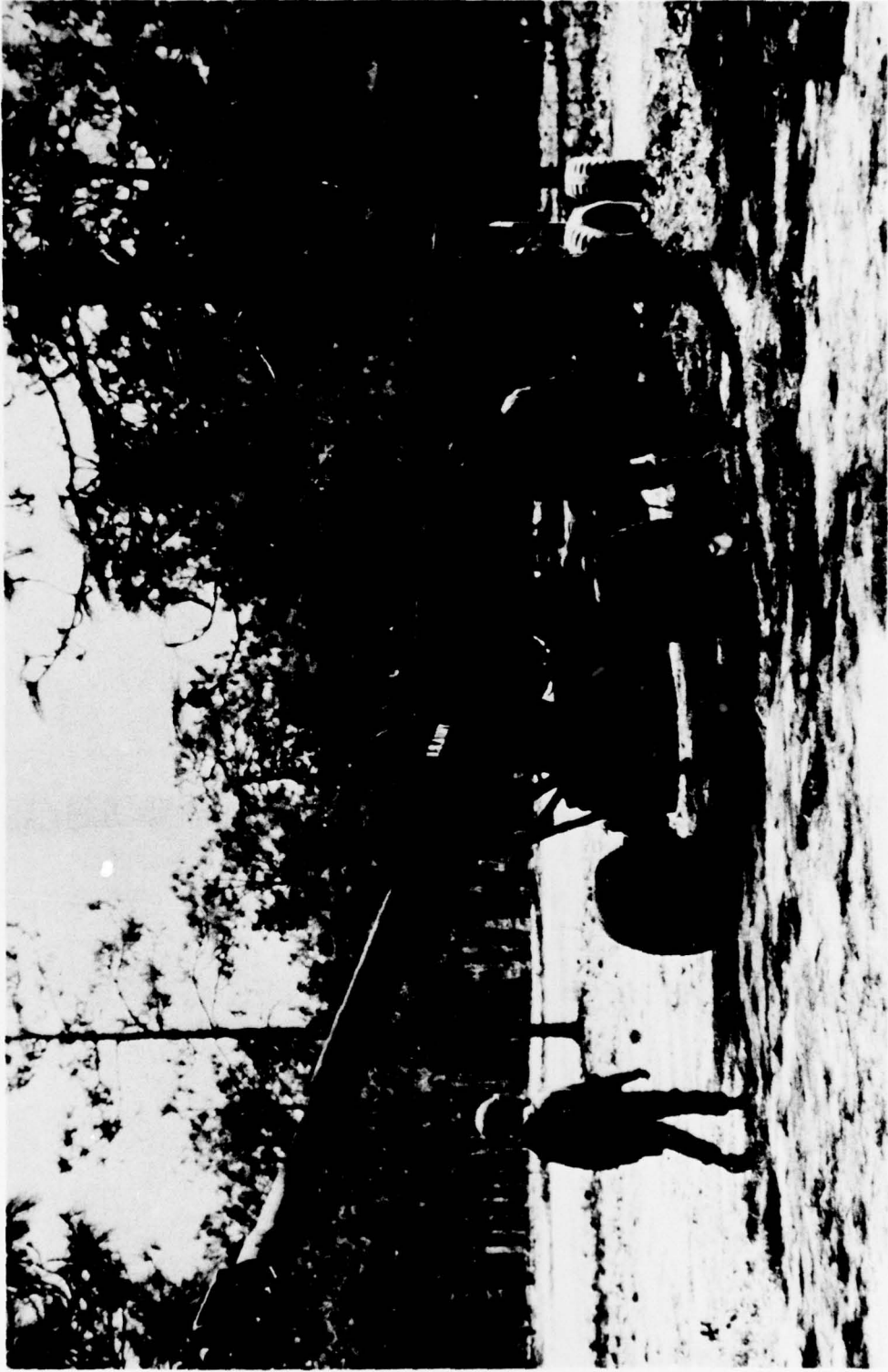


Figure 3. Typical Flat-Broken Terrain



Figure 4. Typical Sandy Terrain



Figure 5. Inclined Trail



Figure 6. MC4000/M198 Towed Configuration Being Demonstrated on Flat/Flat-Broken Terrain

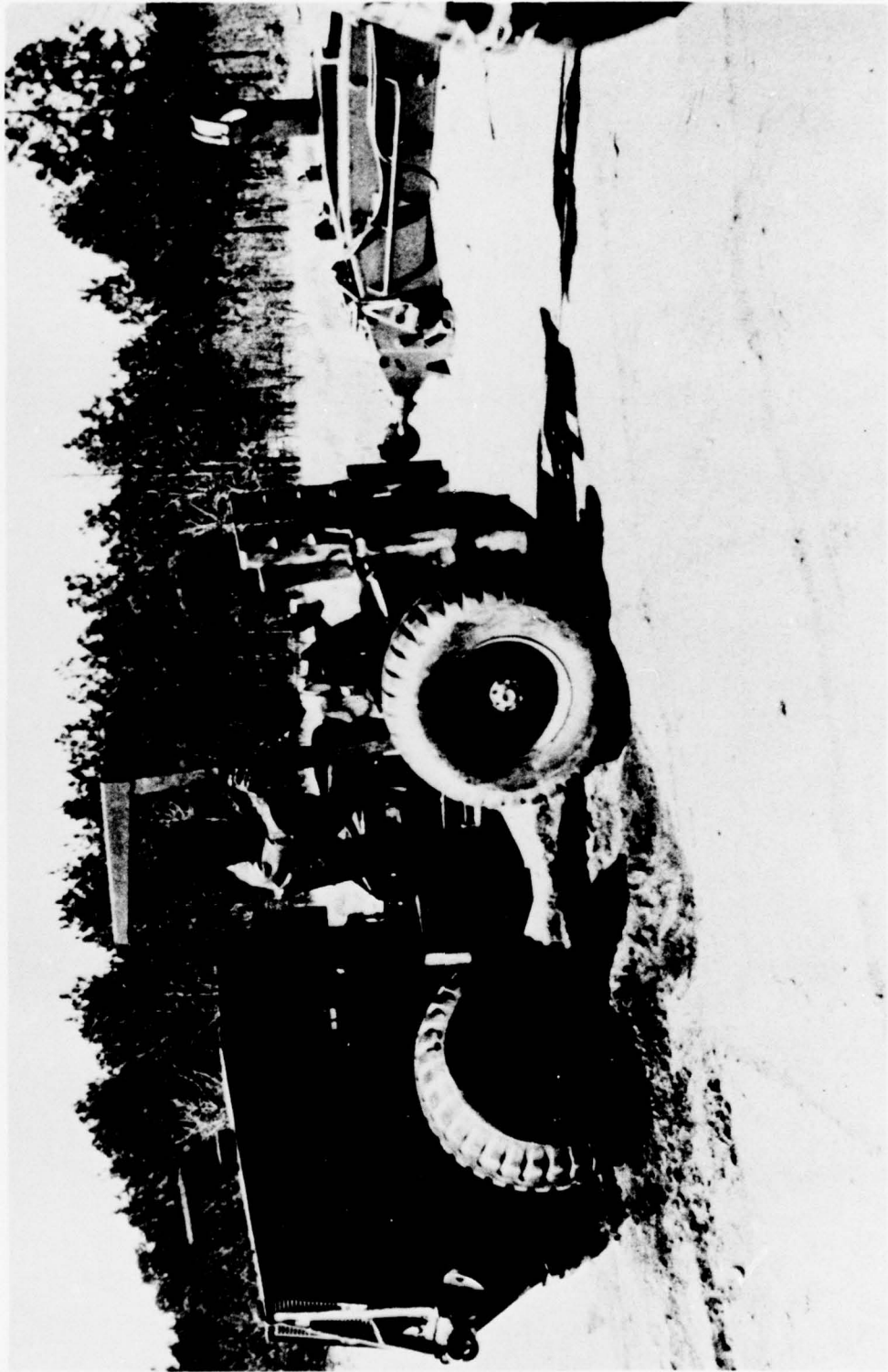


Figure 7. MC4000/M198 Towed Configuration--Turning Ability

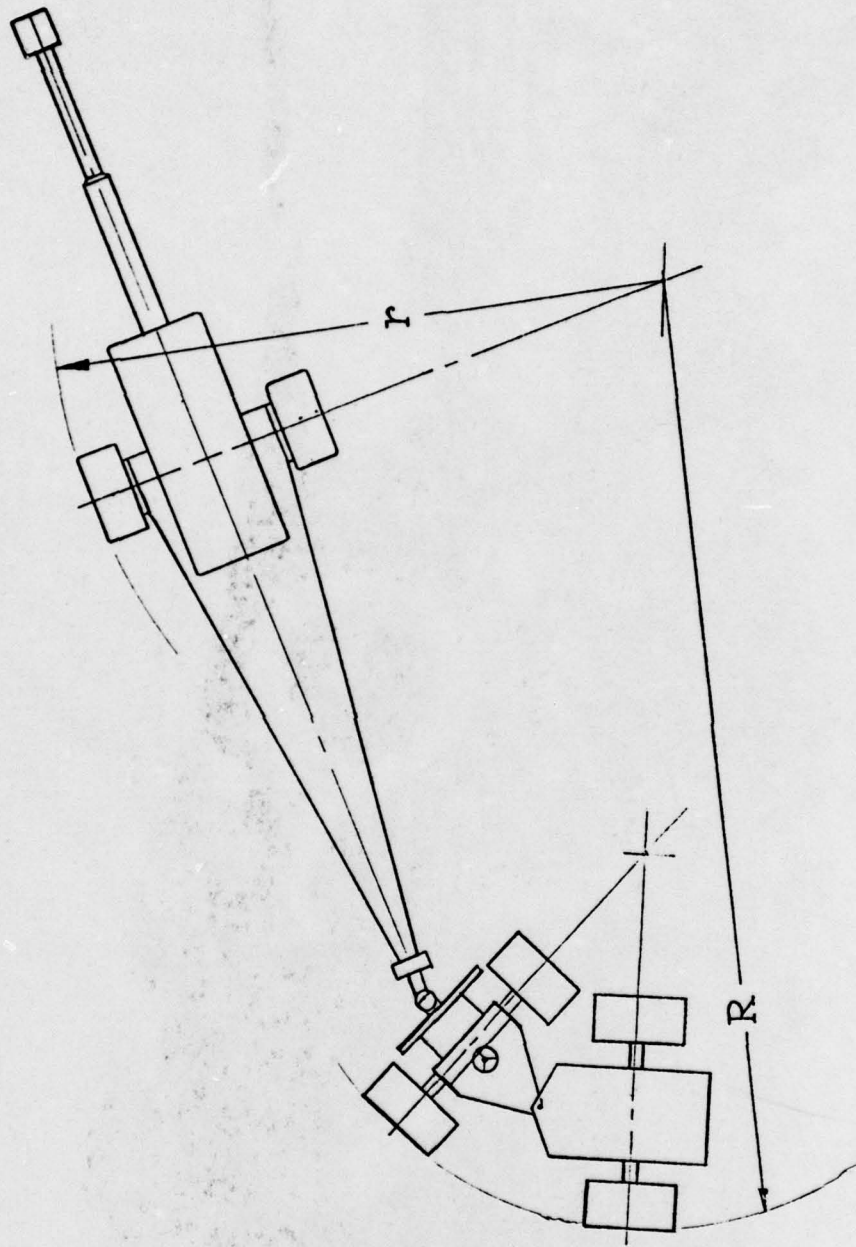


Figure 8. MC4000/M198--Turning Radius



Figure 9. MC4000/M198 Towed Configuration--Pushing Through Sandy Terrain

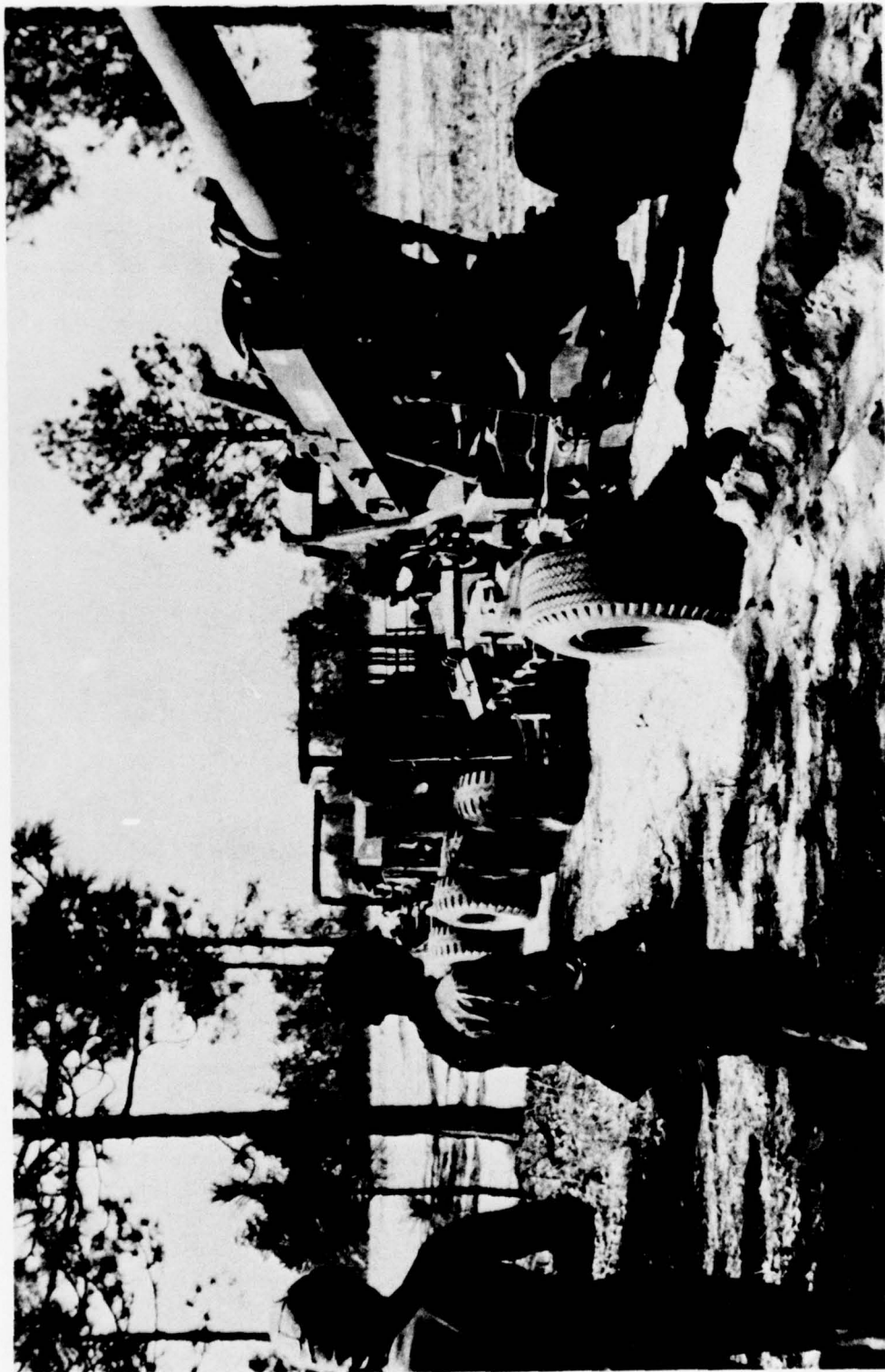


Figure 10. MC4000 Tandem-Towing in Sandy Terrain



Figure 11. MC4000/M198 Towed Configuration--Slightly Inclined (3%) Sandy Terrain



Figure 12. Tandem MC4000/M198 Towed Configuration--Slightly Inclined (38) Sandy Terrain

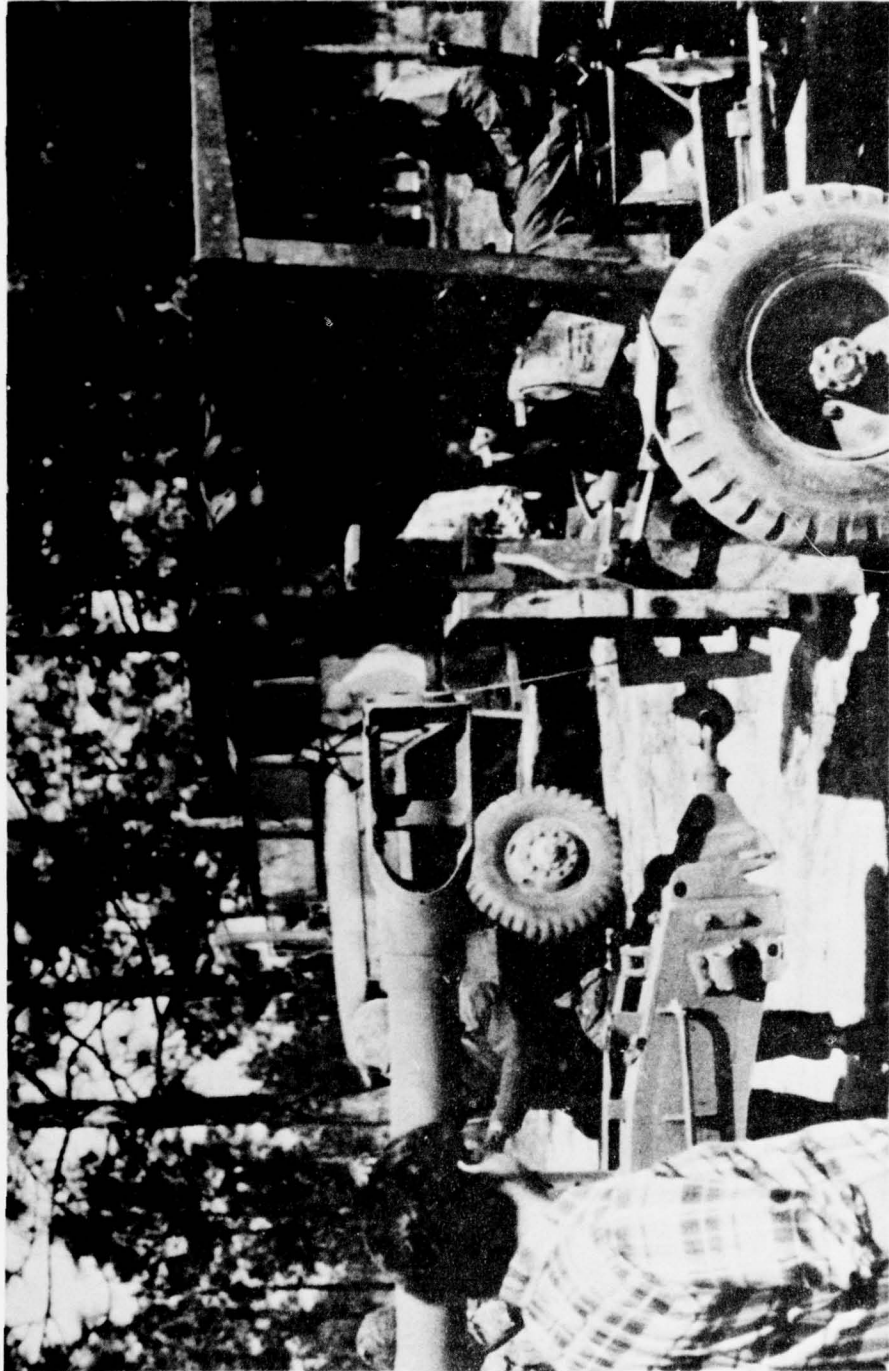


Figure 13. MC4000/M198 Stowed Configuration with Forklift Mast Vertical

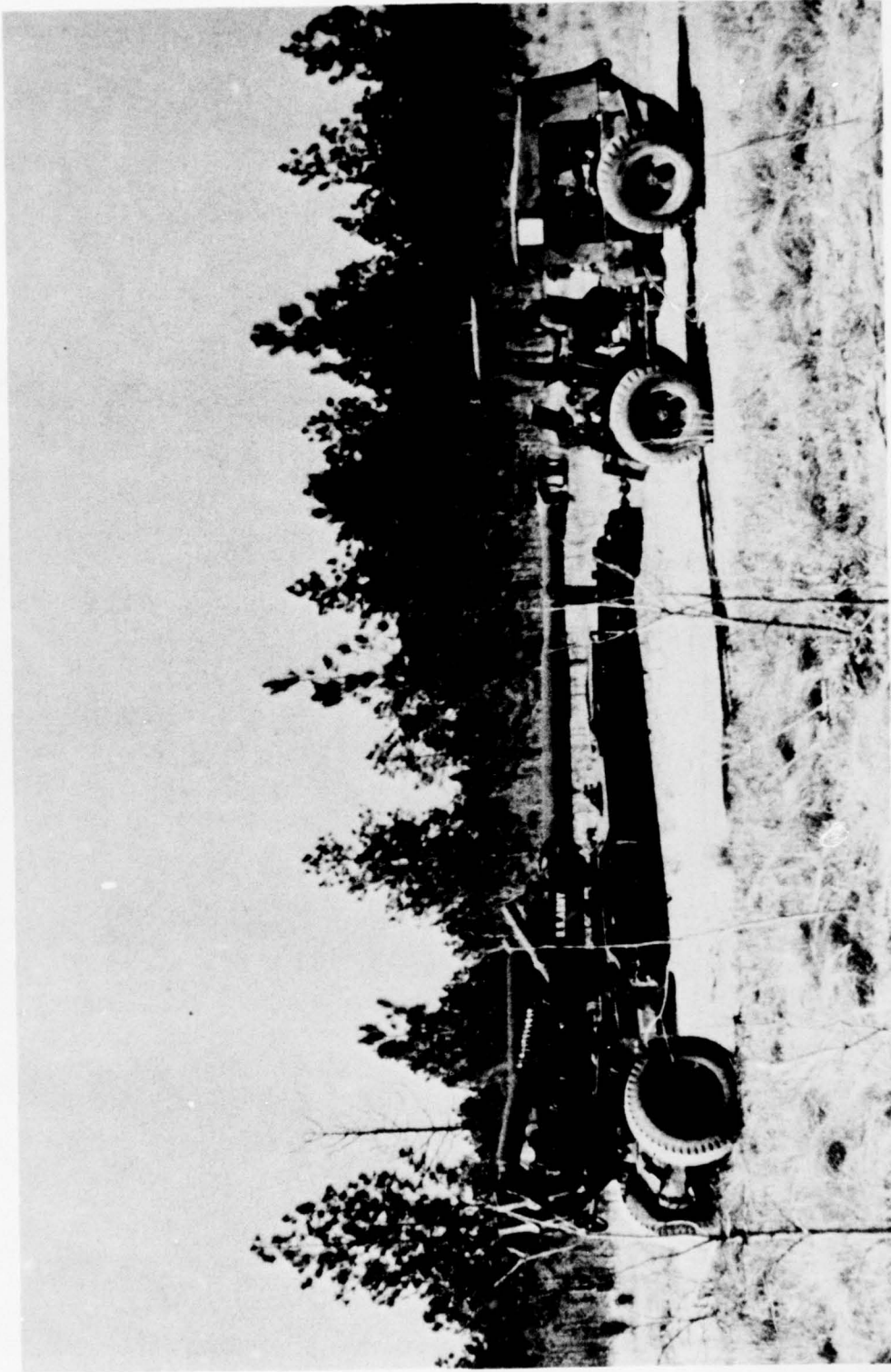


Figure 14. MC4000/M198 Stowed Configuration with Forklift Mast Maximum Rearward Tilt

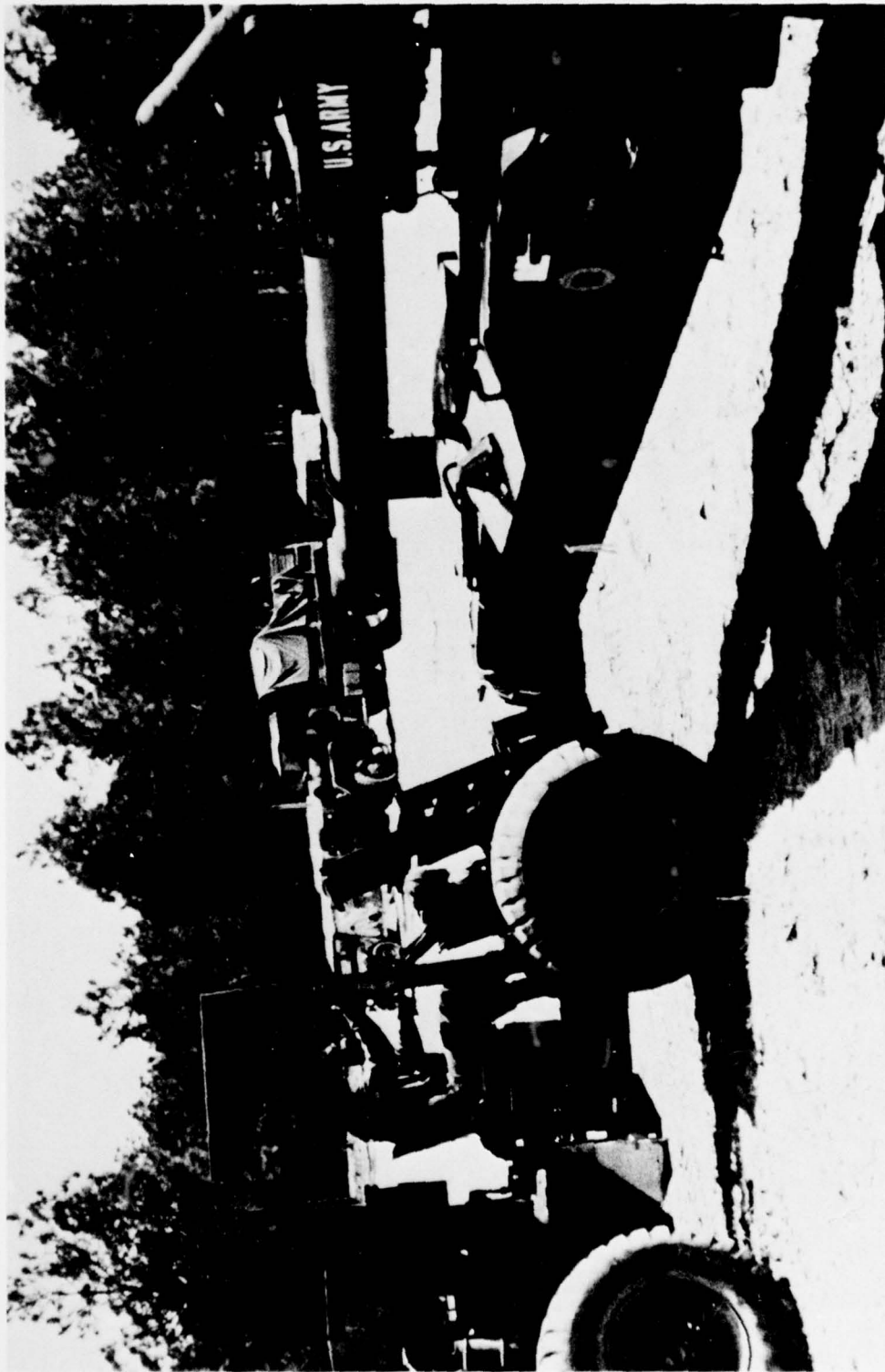


Figure 15. MC4000/M198 Stowed Configuration Turning Ability (Turning in Direction Opposite to Stowed Barrel Location)

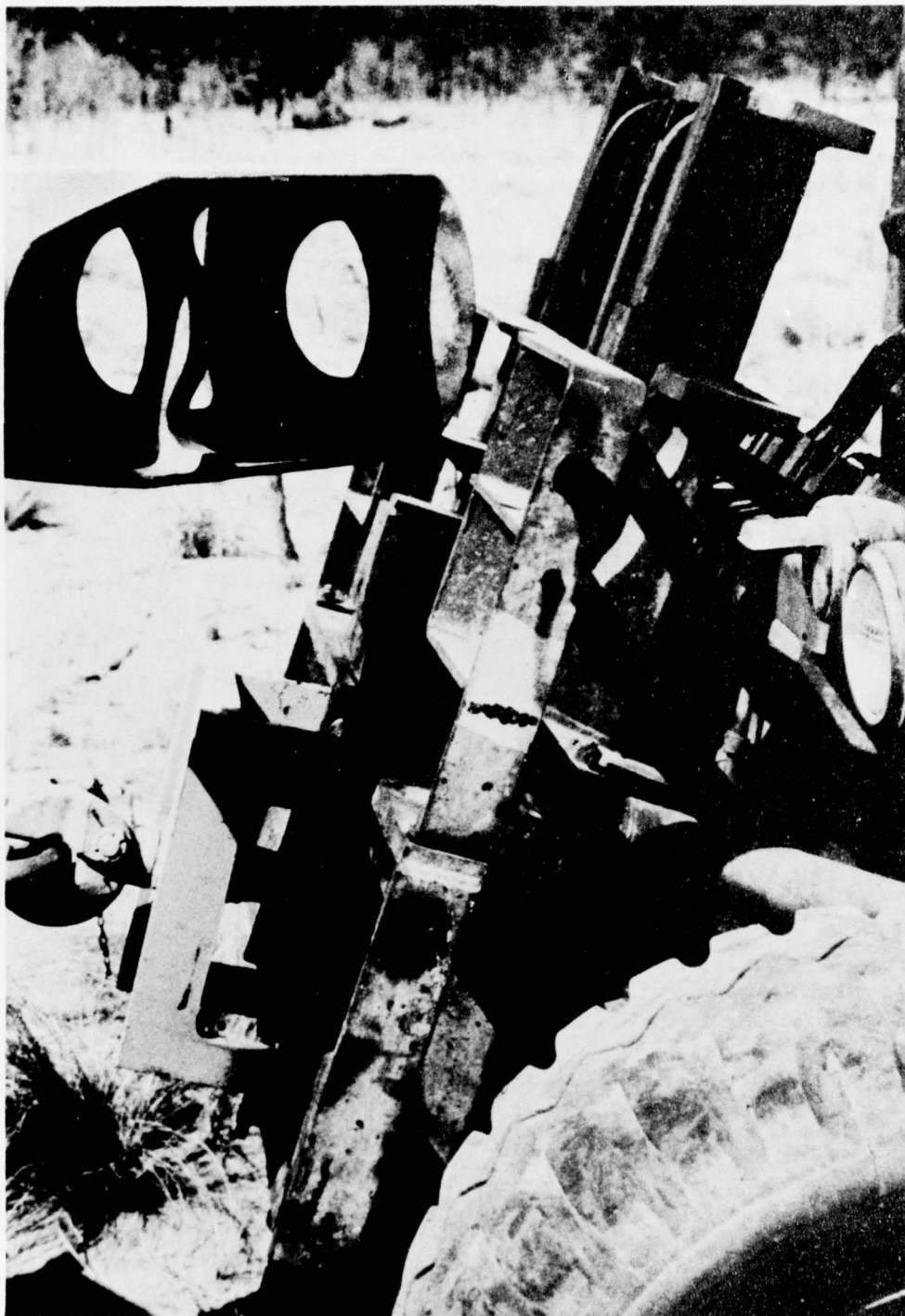


Figure 16. MC4000/M198 Stowed Configuration Turning Ability  
(Turning in Direction of Stowed Barrel Location)

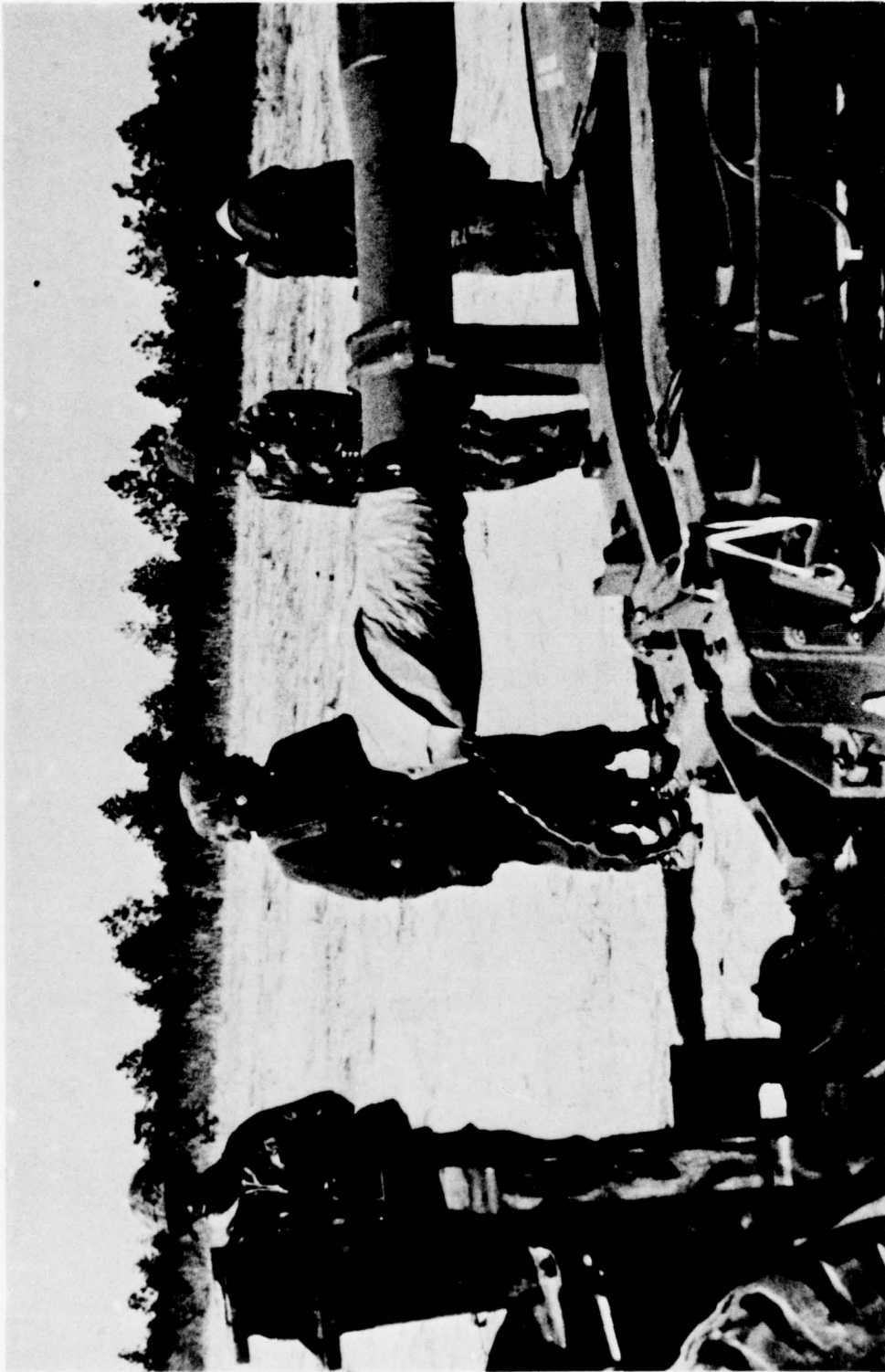


Figure 17. MC4000/M198 Stowed Configuration--Muzzle Brake Removed

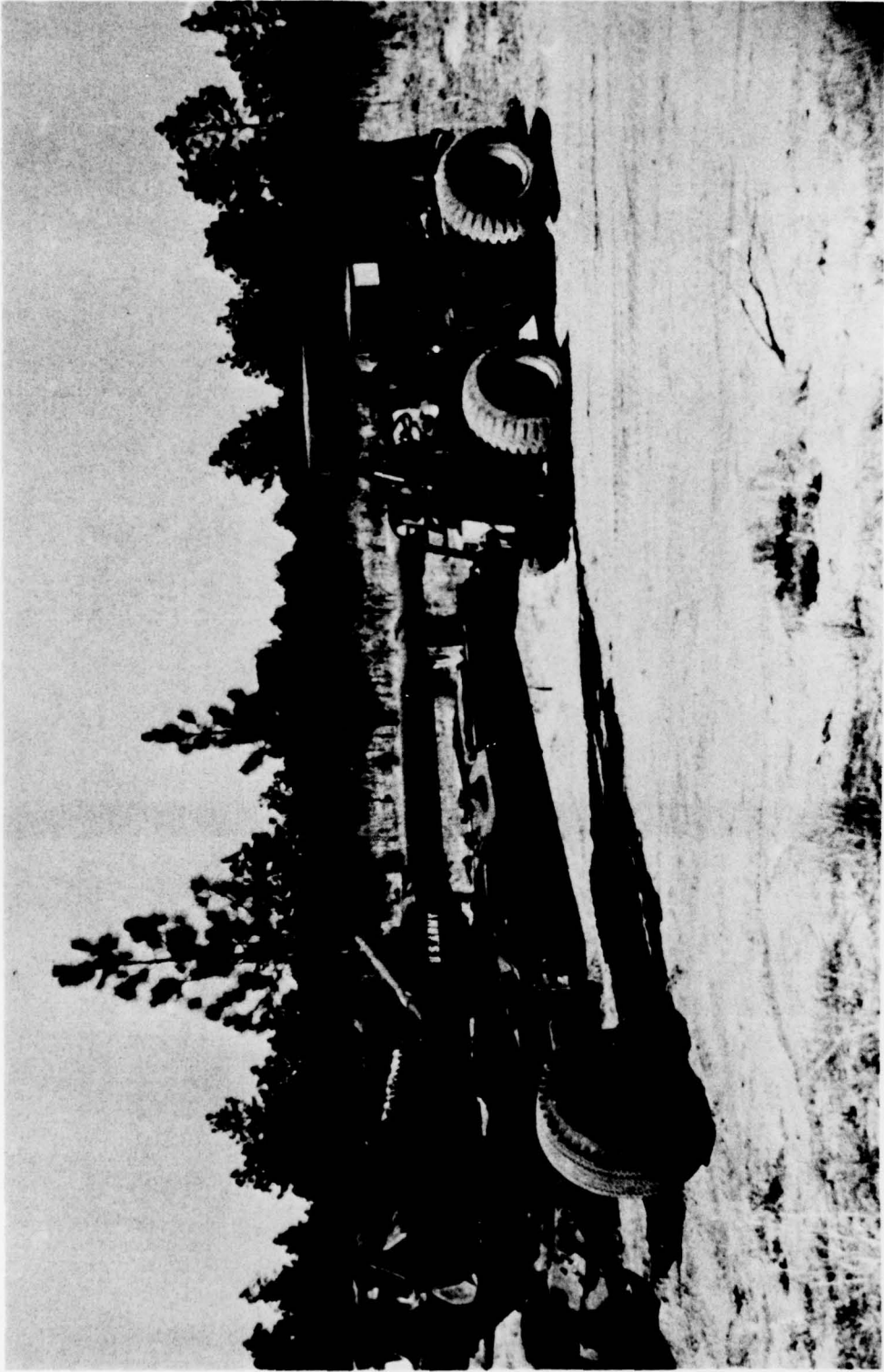


Figure 18. MC4000/M198 Stowed Configuration--Flat Terrain

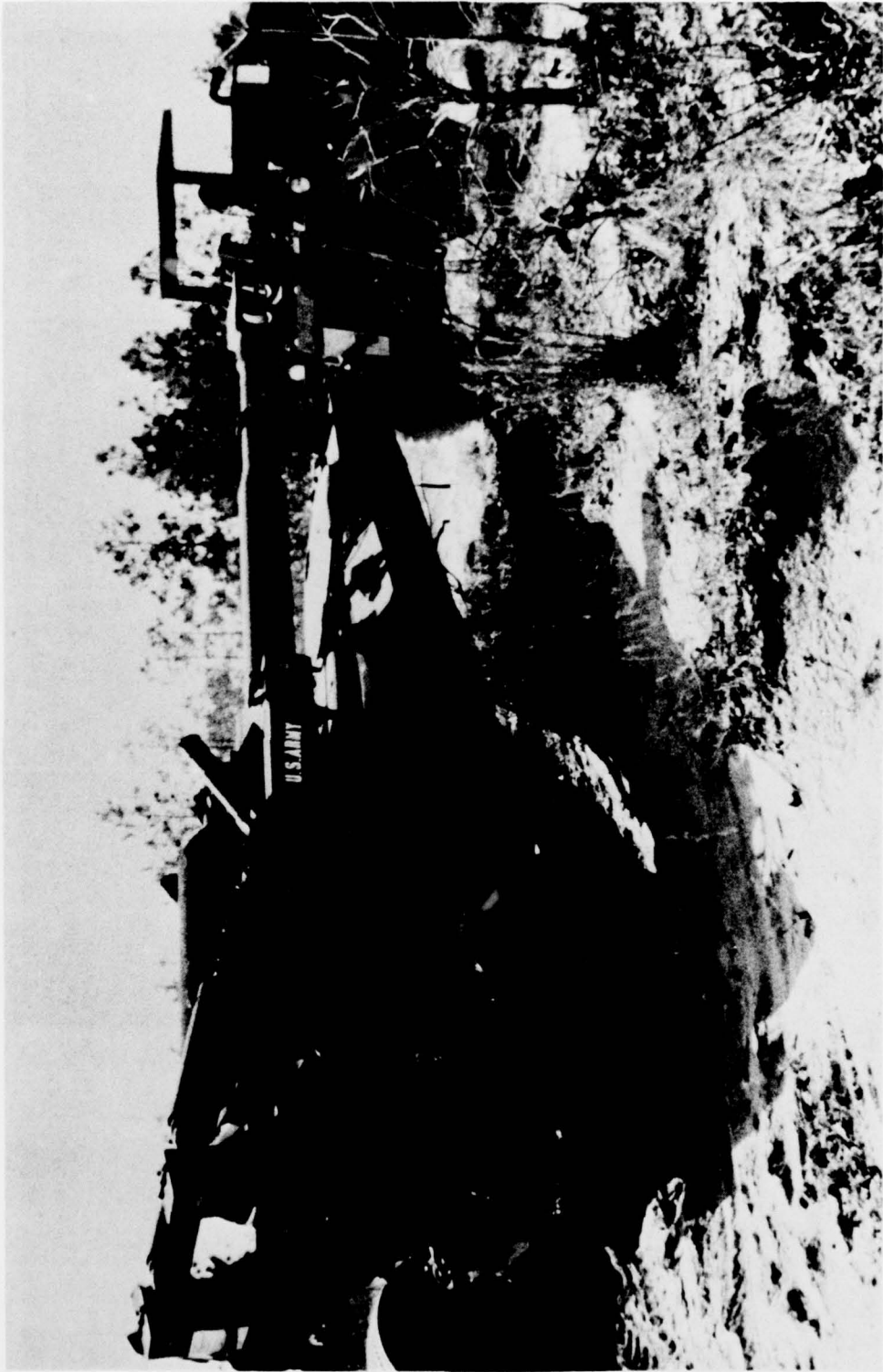


Figure 19. MC4000/M198 Stowed Configuration--Flat-Broken Terrain

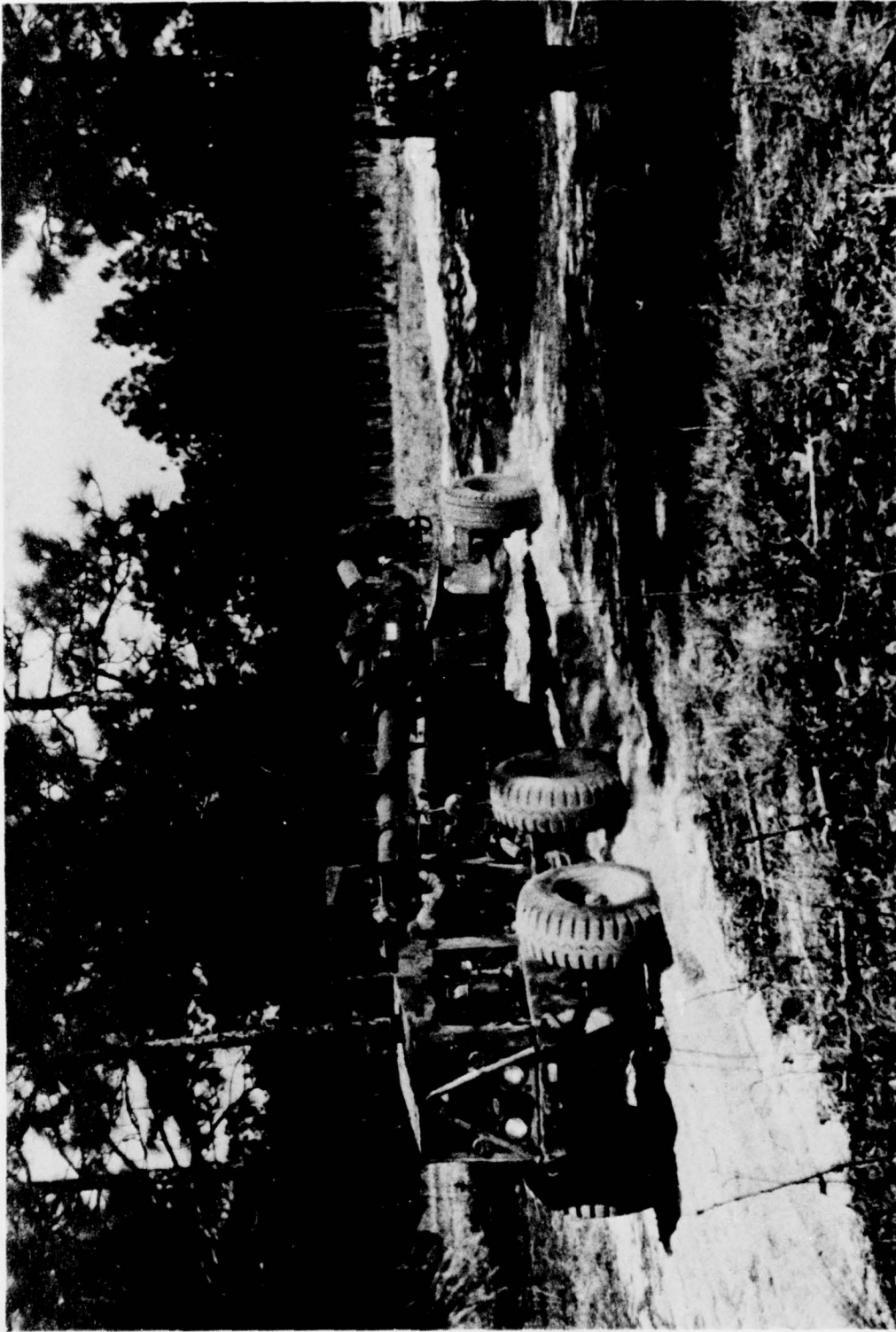


Figure 20. MC4000/M198 Stowed Configuration--Sandy Soil Terrain

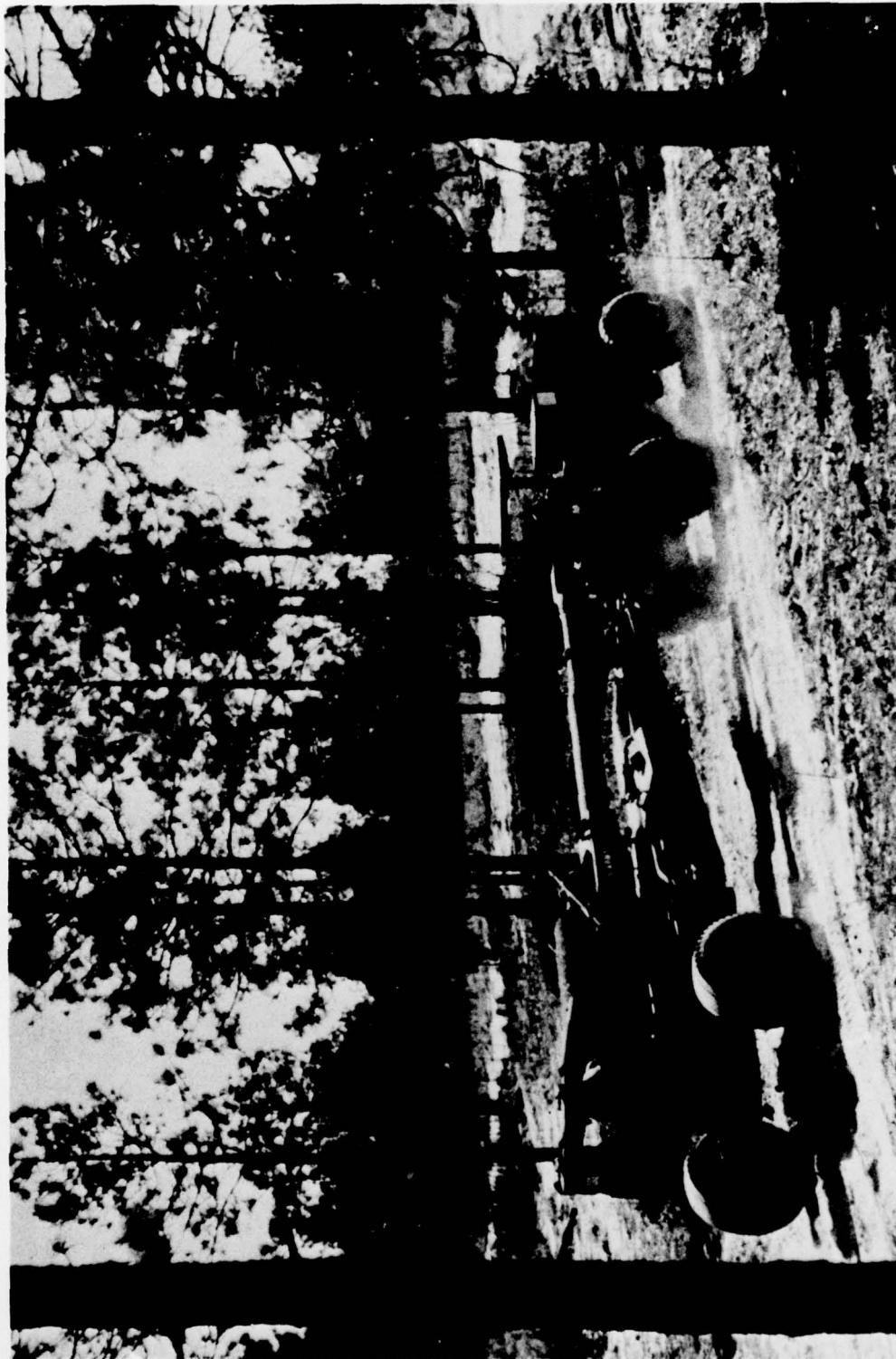


Figure 21. MC4000/M198 Stowed Configuration--Sandy Soil-Inclined (3%) Terrain



Figure 22. MC4000/M198 Stowed Configuration--Inclined Trail

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