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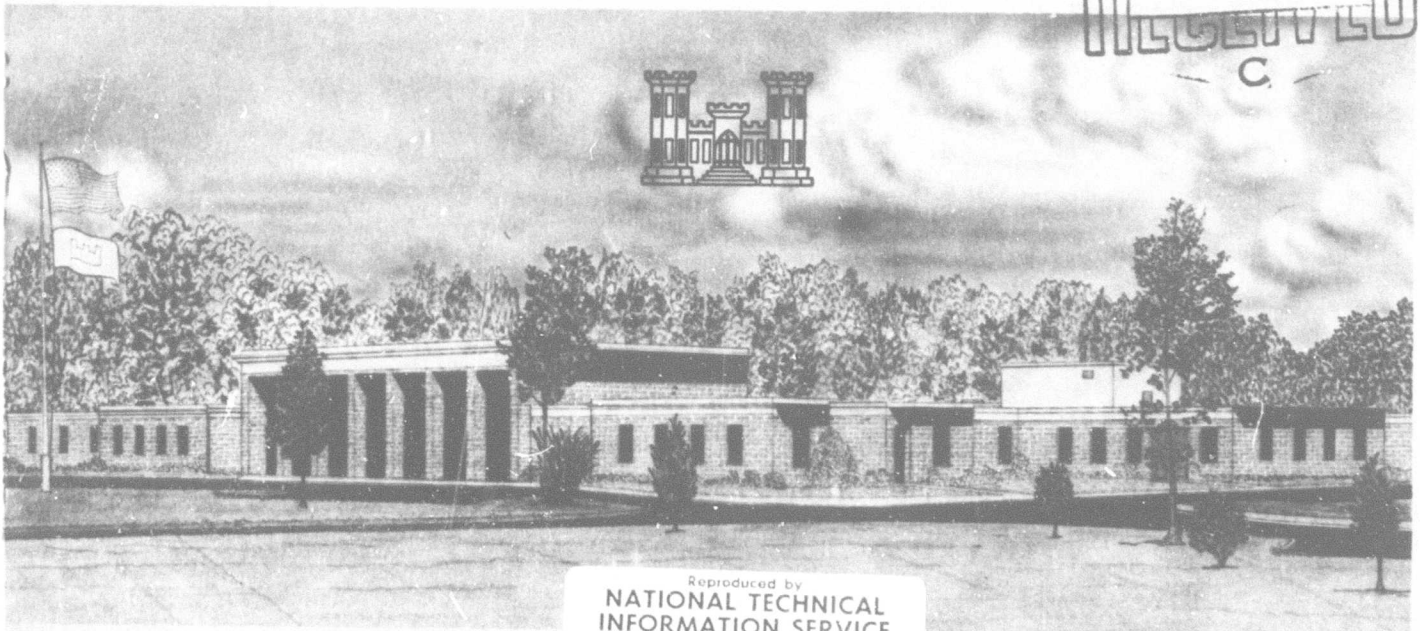
INSTRUCTION REPORT S-71-1

# TECHNIQUES FOR RAPID ROAD CONSTRUCTION USING MEMBRANE-ENVELOPED SOIL LAYERS

by

A. H. Joseph, S. L. Webster

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## FOREWORD

This instruction report was prepared as a part of the work authorized by the Office, Chief of Engineers, under Military Engineering Design and Expedient Construction Criteria, Project No. 4A062112A859, Task 01, "Expedient Road and Storage Area Design Criteria," Work Unit 001, "Rapid Road Construction." This report is being issued for field use until a technical manual covering the total project is issued.

Engineers of the Soils Division, U. S. Army Engineer Waterways Experiment Station (WES), who were actively engaged in the planning, testing, and analyzing phases of the study that led to the preparation of this report were Messrs. C. D. Burns, A. H. Joseph, W. B. Fenwick, and S. L. Webster. The illustrations were prepared by Mr. A. W. Stephens, Jr. This work was performed under the general supervision of Messrs. J. P. Sale and R. G. Ahlvin, Chief and Assistant Chief, respectively, of the Soils Division. This report was written by Messrs. Joseph and Webster.

Directors of the WES during the preparation of this report were COL Levi A. Brown, CE, and COL Ernest D. Peixotto, CE. Mr. F. R. Brown was Technical Director.

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CONVERSION FACTORS, BRITISH TO METRIC UNITS OF MEASUREMENT

British units of measurement used in this report can be converted to metric units as follows:

<u>Multiply</u>	<u>By</u>	<u>To Obtain</u>
mils	0.00254	centimeters
inches	2.54	centimeters
feet	0.3048	meters
square yards	0.836127	square meters
gallons (U. S.)	3.785412	cubic decimeters
pounds	0.45359237	kilograms
tons (2000 lb)	907.185	kilograms
Fahrenheit degrees	5/9	Celsius or Kelvin degrees*

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\* To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use the following formula:  $C = (5/9)(F - 32)$ . To obtain Kelvin (K) readings, use:  $K = (5/9)(F - 32) + 273.15$ .

## SUMMARY

The purpose of this instruction report is to provide information and guidance for the construction and maintenance of membrane-enveloped soil layers (MESL) as base courses on roadways in the theater of operations. The concept involves complete encasement of a compacted layer of fine-grained soil by a lower and upper waterproof membrane.

The upper membrane is capable of supporting limited rubber-tired traffic operations. It is formed by applying emulsified asphalt to the surface of the soil layer, placing polypropylene material, applying a second coat of asphalt, and then placing a blotter layer of sand.

An MESL road system is applicable for use on roadways where materials for conventional construction of foundation layers are not available without considerable expenditure of time, effort, or money. However, use of the MESL concept as permanent road construction practice has not been proved feasible.

Construction techniques for roads with shoulders utilize the in-place roadbed soil in the MESL. The process involves removing the soil and stockpiling it on the shoulders, placing the lower membrane, replacing the soil on the lower membrane, compacting the soil layer, and then installing the upper wearing membrane. The procedures can be combined to form a continuous train-type construction operation.

Construction techniques for roads without shoulders, such as through cuts or on narrow fills, involve working with half the road at a time. The in-place roadbed soil is used in the MESL.

Construction techniques for roads on soft subgrades, such as in low-lying areas with high water tables, are based on hauling a local soil having a suitable water content and using this soil in the MESL.

TECHNIQUES FOR RAPID ROAD CONSTRUCTION  
USING MEMBRANE-ENVELOPED SOIL LAYERS

PART I: INTRODUCTION

Purpose and Scope

1. This report provides information and guidance for the construction and maintenance of membrane-enveloped soil layers (MESL) as base courses on roadways in the theater of operations (TO). Use of the MESL concept as permanent road construction practice has not been proved feasible. However, an adequate roadway base can be built from purely fine-grained soils using the techniques of MESL-type construction described herein.

General Considerations

2. The decision to use MESL-type construction will depend on the availability of conventional base materials and the prevailing weather conditions during the proposed construction period. MESL-type construction should be employed only when the prevailing weather conditions during the construction period will remain relatively dry. The purpose of MESL-type construction is to provide a means of building a substitute for a base course when conventional materials are not available or to provide a means of building an all-weather roadway from purely fine-grained soils without the benefit of additional overlying structural layers. The general concept is to waterproof a compacted layer of fine-grained soil by complete encasement in waterproof membrane in order to prevent deterioration of the base soil as a result of exposure to rainwater at the surface and groundwater or capillary water in the subgrade.

Definitions of Terms

3. For clarity, certain terms used in this report are defined below:
- a. Fine-grained soils. Soils with more than 50 percent of the

material by weight passing the No. 200 U. S. standard sieve and which classify as CL, CH, ML, or MH according to the Unified Soil Classification System.

- b. Membrane. Thin waterproof film or layer used for surface and subsurface protection of the soil in an MESL base.
- c. MESL (membrane-enveloped soil layer) base. A base course for roadways constructed of compacted fine-grained soil and completely encased in waterproof membrane in order to prevent soaking and deterioration from surface and subsurface moisture. MESL construction is also sometimes referred to as mattress construction.

## PART II: DESCRIPTION OF MESL ROAD SYSTEM

4. An MESL road system consists of a subgrade upon which a foundation layer of compacted soil (constructed from natural subgrade soil or locally available soil) lies between lower and upper waterproof membranes. The membranes are joined and sealed along the edges, forming a waterproof encapsulated soil system. The upper membrane is capable of supporting limited rubber-tired traffic operations. An MESL can serve as the base course and pavement surface on secondary roads. Primary road systems will require a pavement over the MESL. An MESL road system is illustrated in fig. 1.

### Lower Membrane

5. A 6-mil-thick\* polyethylene is presently being used as a lower membrane in tests at the U. S. Army Engineer Waterways Experiment Station (WES). It is available in various widths up to 40 ft and in lengths of 100 ft and costs approximately \$0.07 per sq yd. Polyethylene is generally shipped in rolls folded widthwise several times for easy handling. The width of the membrane used should be approximately the desired road width plus 8 ft. A 32- by 100-ft roll (convenient for building a 24-ft-wide road) is generally supplied on an 8-ft-long, 3-in.-diam spool and weighs approximately 96 lb.

### Soil Layer

6. The soil layer must be compacted to a sufficient density to prevent rutting during traffic operations. Tests conducted at the WES have shown that a full 12-in. lift of soil, compacted to 95 percent of AASHO T-180 Method B density, will support traffic operations of a 5-ton, 6x6 military cargo truck loaded to its maximum weight for highway travel. Water content of the soil should be at or below optimum during construction;

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\* A table of factors for converting British units of measurement to metric units is presented on page vii.

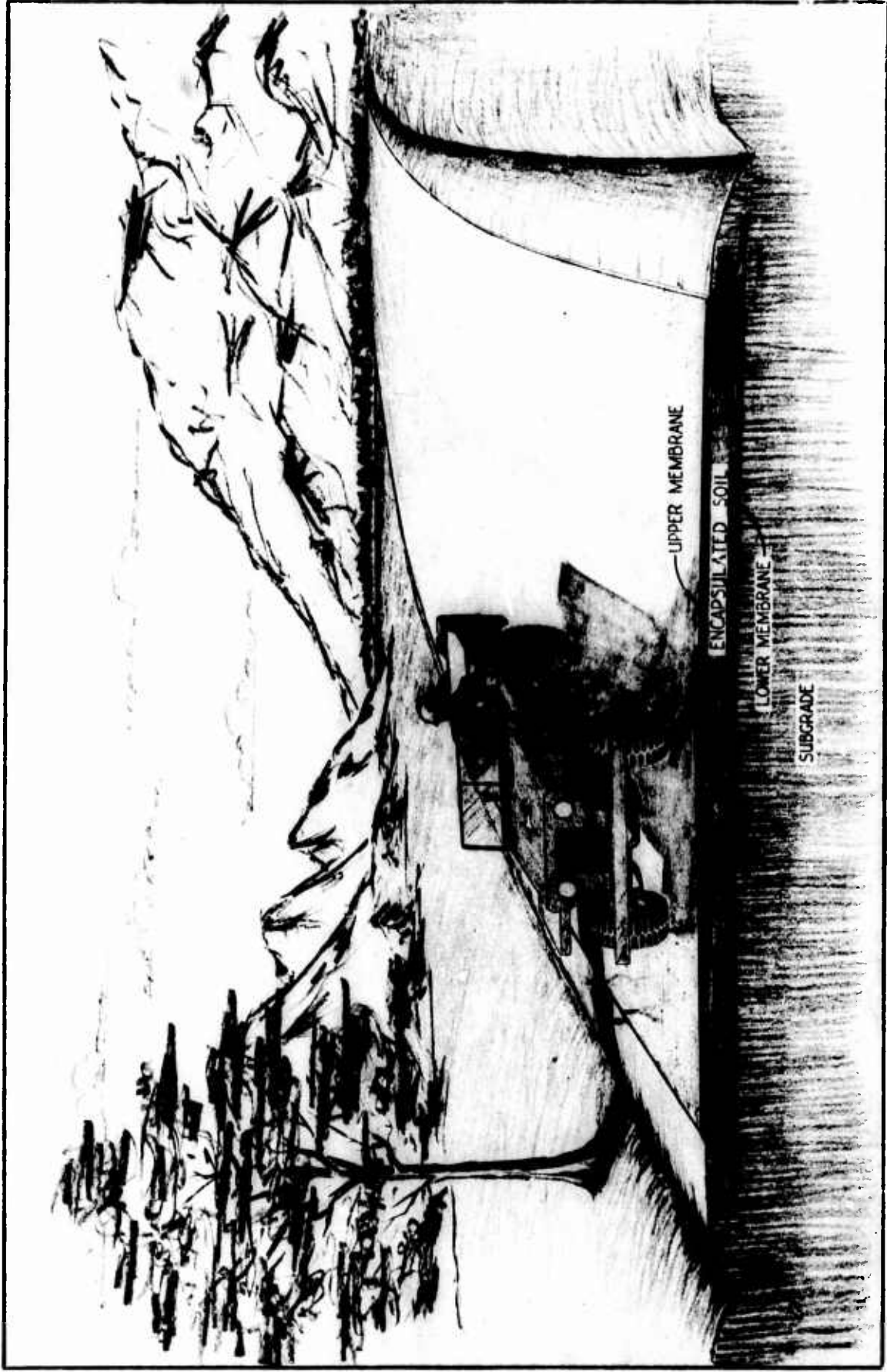


Fig. 1. An MESL road

preferably it should be slightly below optimum. Design thickness requirements will be the same as for conventional flexible pavement construction.

#### Upper Membrane

7. Polypropylene-asphalt membrane is used as the upper membrane to furnish a waterproof, dustproof wearing surface. It is formed by applying emulsified asphalt to the surface of the soil layer, placing the polypropylene material, applying a second coat of asphalt, and then placing a blotter layer of sand. This can form a wearing surface for light-duty traffic and a foundation for other surfacing materials for heavy-duty, long-life pavements.

#### Asphalt

8. The asphalt used in studies at WES to date has been a rapid-setting cationic emulsion (ASTM Designation C-RS-2, Asphalt Institute Designation RS-2K). This asphalt is available at a cost of approximately \$0.12/gal. Tests are in progress to investigate other types and grades of asphaltic materials for use in rapid road construction.

#### Polypropylene material

9. Several polypropylene materials, both woven and nonwoven, are currently being tested at the WES for use as an upper membrane. These tests have not been completed; however, preliminary results indicate that the nonwoven materials are superior to the woven materials. Rolls of polypropylene material 15-1/2 ft wide, approximately 350 ft long, and weighing approximately 225 lb have been found convenient for this work. The nonwoven polypropylene material tested to date ranges in cost from approximately \$0.20 to \$0.50 per sq yd.

### PART III: APPLICATIONS AND LIMITATIONS

10. An MESL road system is applicable for use on any roadway where materials for conventional construction of a foundation or roadway are not available or when tactical requirements do not justify the time, effort, or cost of conventional construction. This system can also be used on roadways where the employment of only an upper wearing membrane on the subgrade is not practical due to water intrusion into the subgrade soil. If good drainage can be provided and water kept from entering the roadway subgrade, then only an upper wearing membrane is needed. MESL construction is particularly applicable for use in low-lying areas where groundwater intrusion into the foundation materials is prevalent during the wet seasons.

11. Tests conducted to date at WES have shown that an MESL road system will adequately support traffic operations of rubber-tired military vehicles; however, the thin upper wearing membrane probably will not withstand the effects of traffic of tracked vehicles. Also, sliding locked wheels of heavy trucks may tear the membrane, necessitating immediate repair. If water enters the soil layer through tears in the upper membrane, the lower and upper membranes act as barriers and hold the water within the encapsulated soil. The water tends to migrate within the soil layer causing the soil to lose strength. Unless the wet soil is replaced and the upper membrane repaired, the water will continue to infiltrate and weaken larger areas. Traffic over a weakened area will form ruts and may cause failure of the upper membrane.

#### PART IV: CONSTRUCTION TECHNIQUES FOR ROADS WITH SHOULDERS

12. The following construction procedures are for encapsulating the in-place soil for use as the base or foundation layer for the roadbed. Each construction procedure presented is applicable for use on straight or curved portions of roadway and up or down hills, unless otherwise stated. The procedures utilize construction equipment that is available to field military engineering units.

13. The procedures can be combined as illustrated in fig. 2 to form a continuous train-type operation for rapid road construction. Each procedure, or phase, is flexible and can be modified to obtain a smooth operation. If one phase of the train-type operation gets behind schedule, more construction effort can be applied to that particular phase.

14. It is required that construction take place when the water content of the soil is within proper limits, as indicated earlier in this report. If the soil is drier than required, water may be added to the roadbed prior to the earth removal process. However, if the roadbed soil is too wet, it must be processed to a drier state or construction must be postponed. It should be noted that during construction, the soil will generally lose some water.

15. For the purposes of this report, it is assumed that all preliminary grading has been completed and that grades and drainage have been established. These are generally the first steps to be completed in any type road construction. The construction techniques required for completing these steps are the same for MESL-type road construction as for conventional road construction.

#### Earth Removal

16. In order to place the underlying membrane and to encapsulate the roadbed soil, the soil must first be moved, the underlying membrane placed, and the soil replaced. This removal is accomplished by two D-7 bulldozers working in the manner shown in fig. 3. Each bulldozer, operating perpendicular to the road center line, drops its blade near the center line and

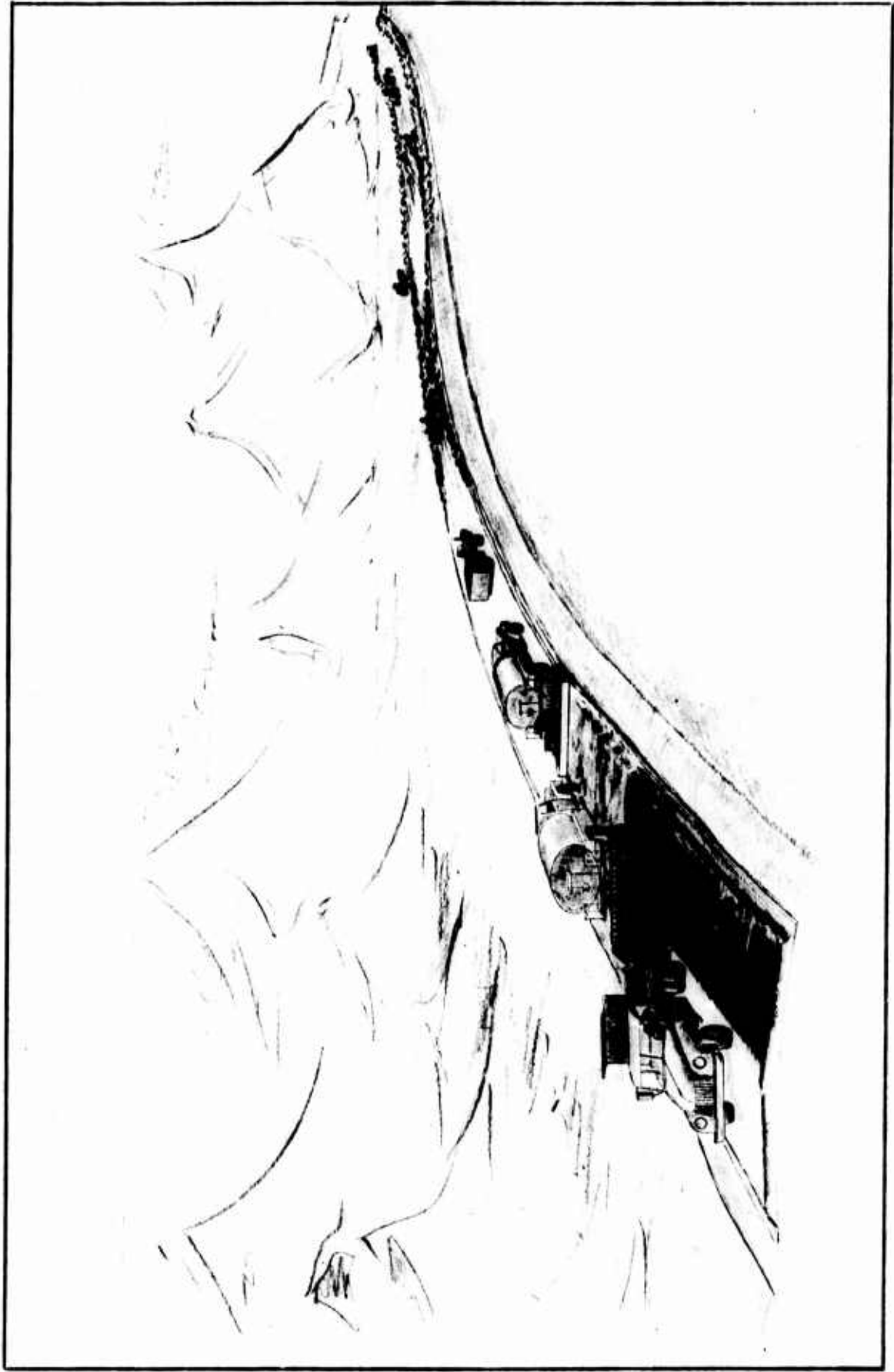


Fig. 2. General view of combined construction techniques

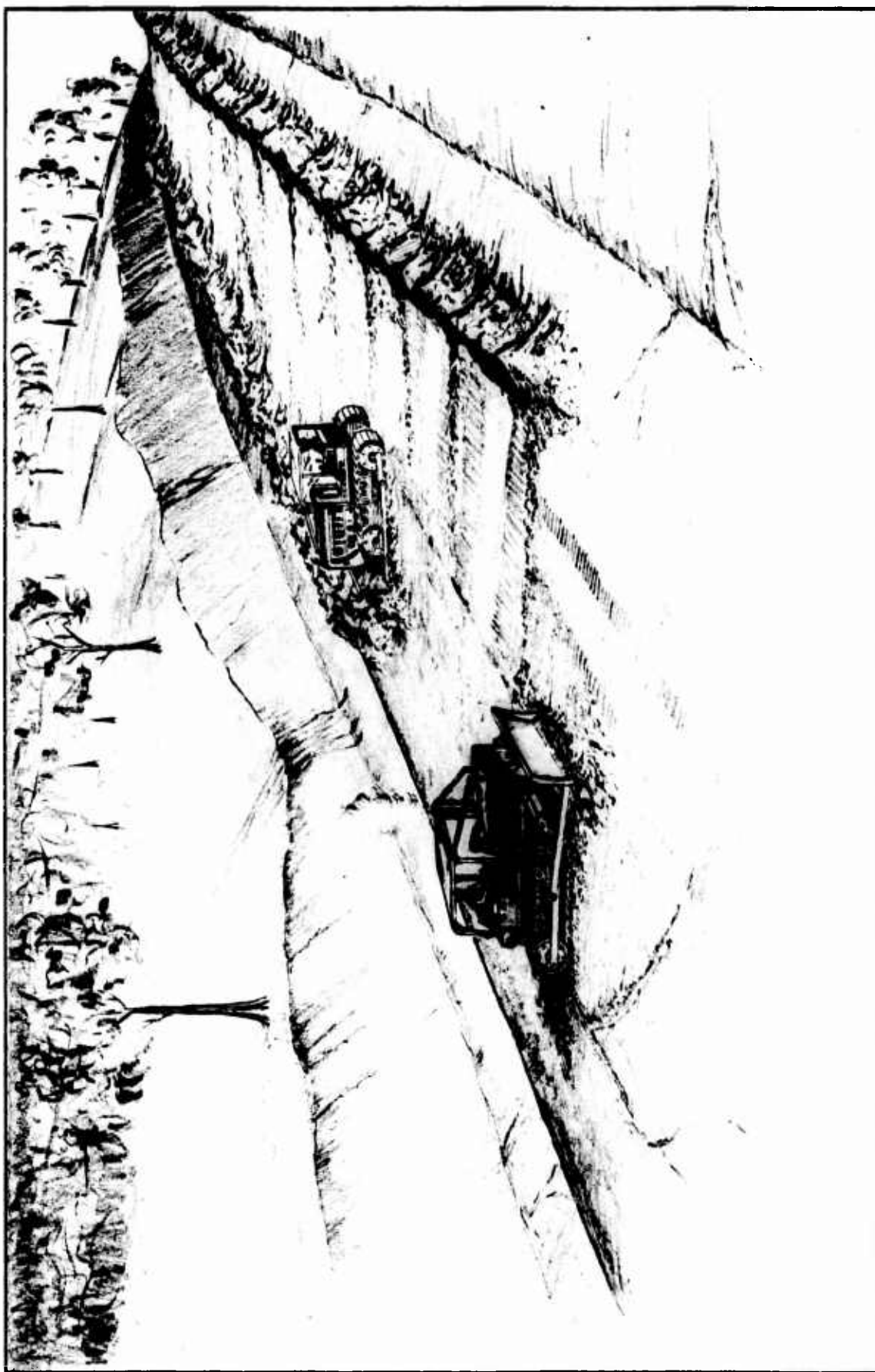


Fig. 3. Excavating and stockpiling soil for the MESL

pushes the soil across the center line to the shoulder area. The depth of cut should be 8 to 12 in. at the end of a pass. By backing up and repeating the process in a path adjacent to the one just completed, a continuous windrow of soil is stockpiled along each shoulder of the road. This process yields enough soil for an approximately 1-ft-thick MESL. However, the depth of cut can be adjusted to remove any desired amount of soil. The distance between the inside edges of the two windrows should equal the desired width of the completed roadbed plus approximately 10 ft. The forward progress for this earth removal technique is approximately 100 ft per 15 min.

17. After pushing the soil to the shoulder with the bulldozers, a road grader is used to smooth and prepare the roadbed surface for placement of the lower membrane. Fig. 4 shows the road grader smoothing the surface and blading loose material to the shoulder areas. It takes approximately 10 min for the road grader to smooth both sides of the roadbed a distance of 100 ft.

#### Lower Membrane Placement

18. The lower membrane is placed as shown in fig. 5. Three or four men unroll a section of membrane, unfold it, and place it flat on the subgrade surface. Membrane placement around curves is accomplished by gathering folds at uniform intervals along the inside portion of the curve. The folds are laid flat and held in place with a few shovelfuls of soil. A 5-ft lap joint is used at the ends between individual sections of membrane to ensure watertightness. Placement of a 100-ft section of membrane takes about 5 min.

#### Earth Replacement

19. The stockpiled soil on the shoulder areas is placed on the lower membrane by two or more front-end loaders. One front-end loader operates from each side of the road, as shown in fig. 6. Operation of a loaded front-end loader on the 6-mil polyethylene should be avoided if possible,



Fig. 4. Road grader preparing subgrade surface for lower membrane placement

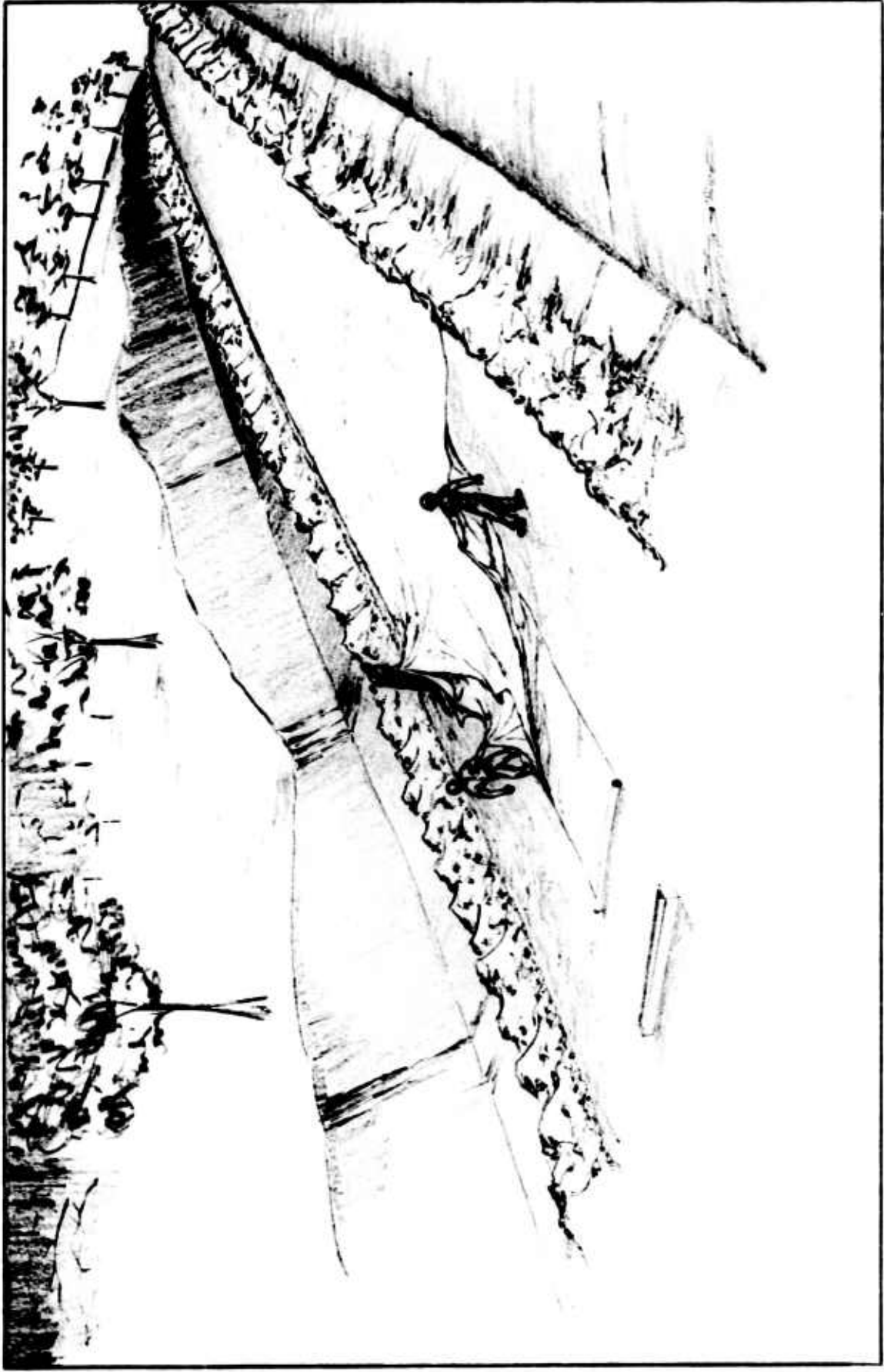


Fig. 5. Placing lower membrane on subgrade



Fig. 6. Replacing soil on lower membrane

but such a vehicle can operate on the polyethylene if care is taken not to spin or slide the wheels on the membrane. The soil is placed on the membrane leaving a minimum of 4 ft of exposed lower membrane along each side of the road for bonding to the upper membrane. The front-end loader operators must be careful not to allow the soil to bury the membrane edges when moving the soil from the shoulders back over to the membrane. The only way to safely recover buried membrane edges is by careful hand shoveling. During studies conducted at WES, buried membranes were damaged when a road grader or front-end loader was used for removing the soil from the membrane. Two front-end loaders can replace a sufficient amount of soil to build a 24- by 1-ft MESL at a rate of approximately 100 ft every 25 min.

### Spreading and Compacting

20. Spreading the soil on the lower membrane is accomplished as shown in fig. 7. A road grader and/or small bulldozer is used. A combination using both pieces of equipment is most effective for spreading the soil to a desired width on the lower membrane. The road grader is very versatile in spreading the soil and can operate at a much faster rate than the small bulldozer. The bulldozer is useful for handling the soil along the sides of the road where care must be taken to leave the lower membrane edges exposed for bonding with the upper membrane. The bulldozer tracks apply good initial compaction along the road edges.

21. Some initial compaction is obtained while spreading the soil. Desired compaction is achieved as shown in fig. 8. A self-propelled rubber-tired compactor may be used; however, care must be taken when compacting near the road edges. The soil near the road edges tends to shove outward when this type of compactor is used. Therefore, a smaller compactor, such as a towed wobble-wheel roller, will be required for the edges. Good compaction along the road edges is difficult to obtain; however, additional compaction along the edges will occur during shoulder construction. Some smoothing of the soil surface with a road grader will be required during compaction. A sufficient crown should be built into the soil surface to allow for quick drainage. The time spent spreading and compacting is

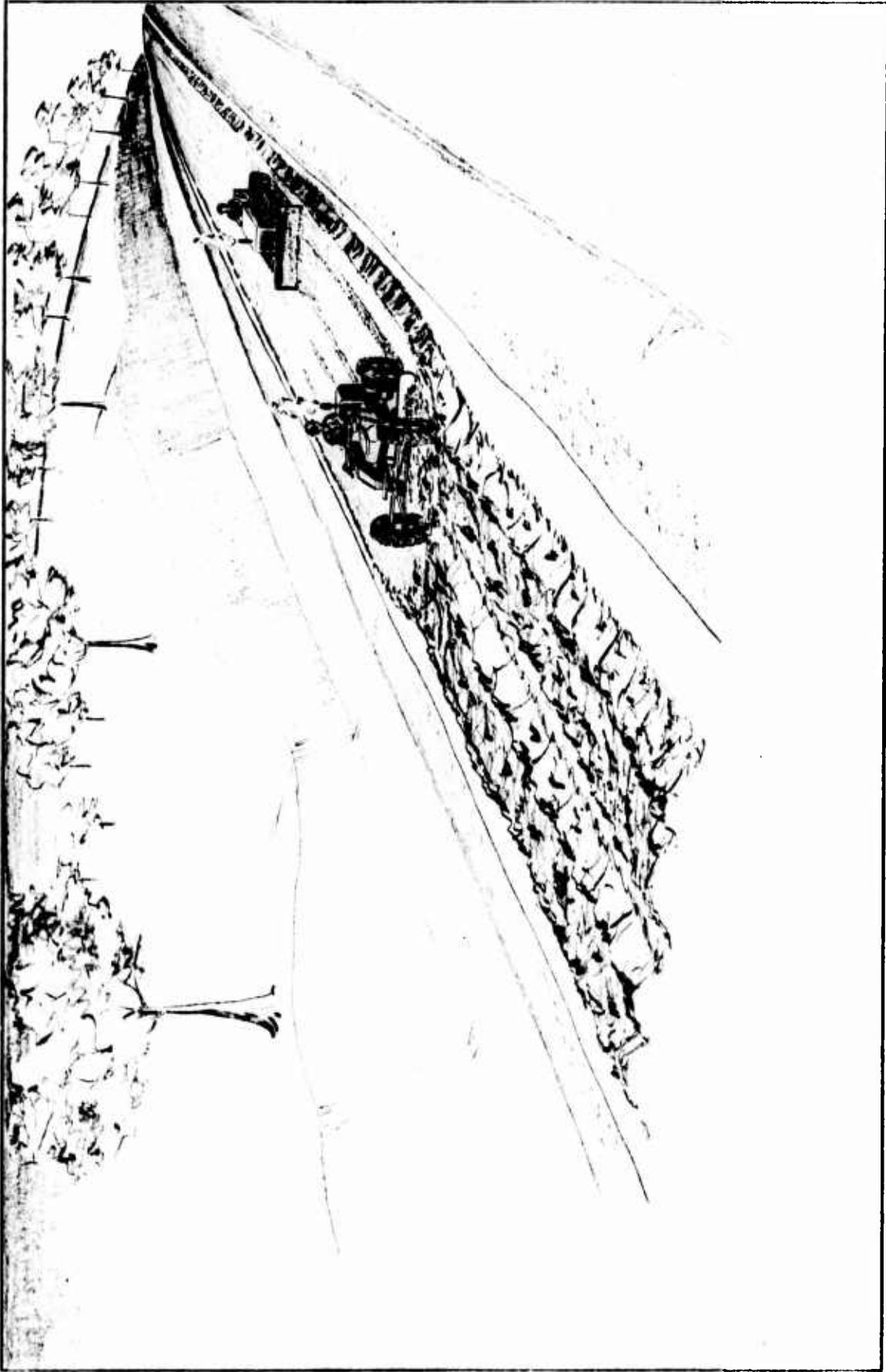


Fig. 7. Spreading soil on lower membrane

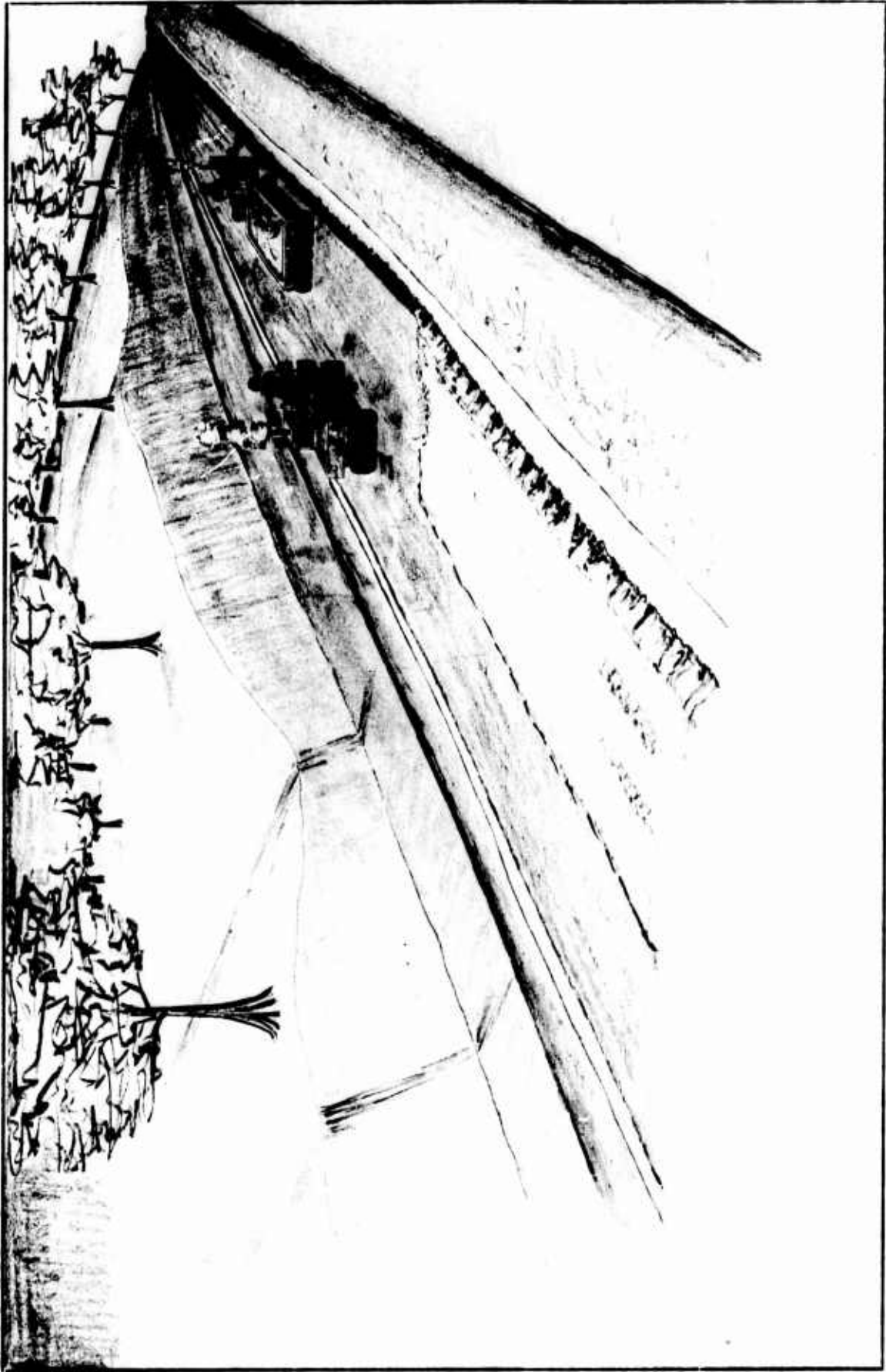


Fig. 8. Compacting soil on lower membrane (road with shoulders)

dependent on many factors, but in a train-type road building operation, it can be accomplished at a rate of about 100 ft per 20 min.

### Upper Membrane Placement

#### Equipment and personnel requirements

22. Installation of the upper wearing membrane requires the use of an asphalt distributor for spraying asphalt, a simple laying yoke for unrolling the membrane on straight sections of the roadway, and a dump truck with spreader box for applying a blotter course. The asphalt distributor and dump truck with spreader box are standard military equipment. A laying yoke, as illustrated in fig. 9, can be simply constructed out of light-weight materials. One end of the yoke should be pinned to allow quick replacement of new rolls of membrane. The yoke is pulled by the distributor truck during the actual laying operation.

23. Minimum personnel requirements for installing the upper membrane include an asphalt truck driver, distributor operator, dump truck driver, spreader box operator, and four men for handling the rolls of membrane. Three additional men are required when it becomes necessary for hand placing the membrane around curves. These men are required for unrolling and cutting sections of membrane needed for the hand placement operation. Production rates for installing the upper membrane in a train-type operation for a 24-ft-wide road are approximately 100 ft per 15 min.

#### Installation on straight roadway

24. The upper membrane is placed as shown in fig. 9. Based on soil type and condition, an initial application of 0.25 to 0.5 gal per sq yd of asphalt is placed. For best results, the asphalt should be applied at a temperature of 110 to 135 F. Also, a dry surface should be sprinkled lightly with water prior to the application of asphalt. The asphalt is sprayed over a sufficient width to completely coat the exposed lower membrane edge. The upper membrane is then placed immediately, using the laying yoke attached to the distributor truck. The outside upper membrane edge is placed in alignment with the outer edge of the asphalt-coated lower membrane. The resulting asphalt-sealed joint between the upper and lower

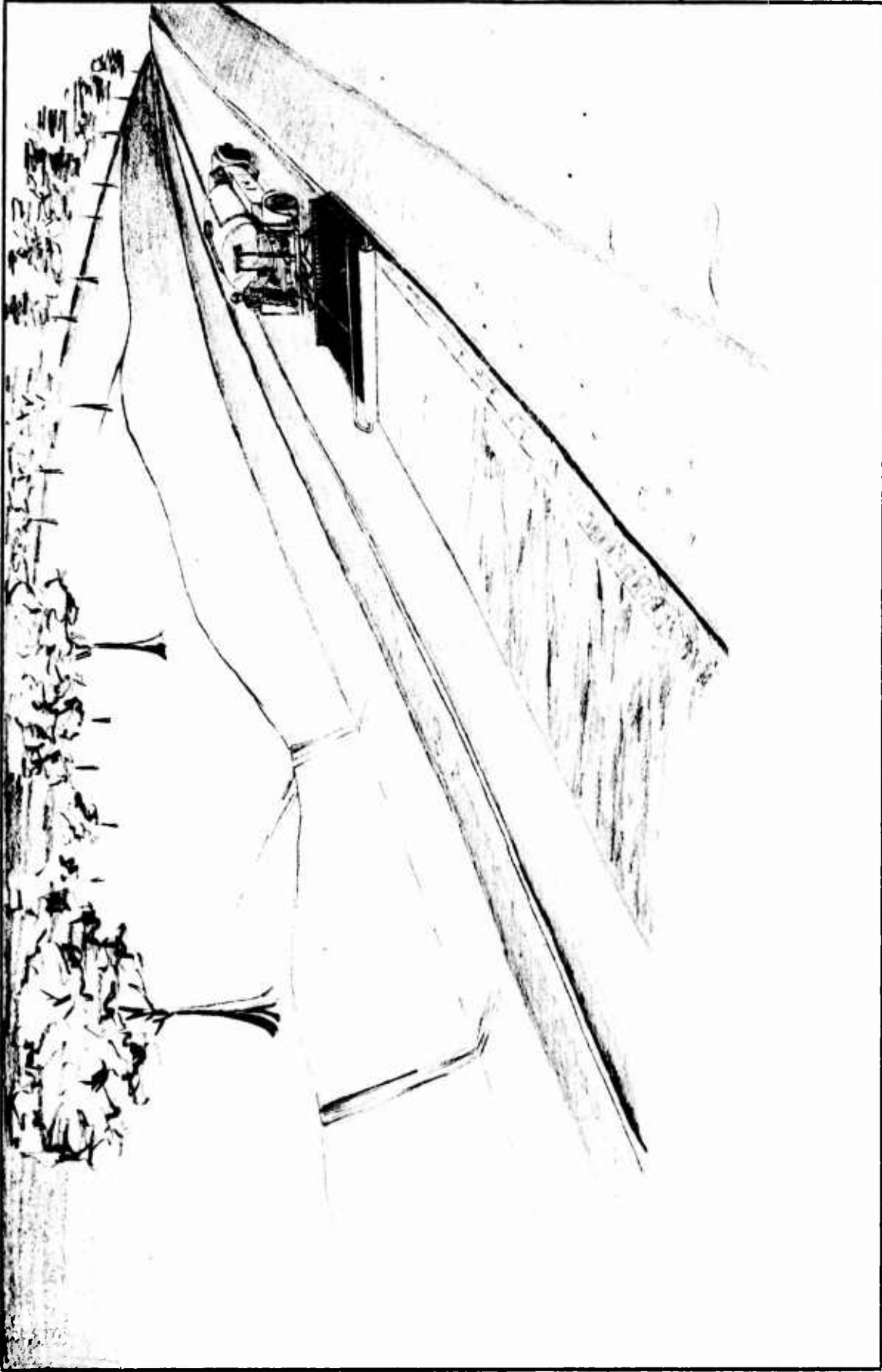


Fig. 9. Spraying asphalt and installing upper membrane (road with shoulders)

membrane edges protects the MESL from side-water intrusion.

25. Sections of upper membrane are joined together simply by spraying asphalt between overlapped sections of membrane. A minimum 1-ft overlap is recommended. The overlapping run should always be on the uphill side for better drainage and waterproofing. This method of joining sections of upper membrane applies to both lateral and longitudinal joints.

26. After the initial asphalt application and membrane placement, a final application of 0.2 to 0.3 gal per sq yd of asphalt is applied, as shown in fig. 10. The road surface is then blotted by a light application of fine sand or other suitable material, as illustrated in fig. 11.

#### Installation on curves

27. Membrane installation on curves is best accomplished without the use of the laying yoke. The distributor truck sprays asphalt on a section of road approximately 30 to 50 ft in length, depending on the sharpness of the curve. A section of membrane is cut, and four men hand place the membrane over the sprayed area. One man holds each corner of the membrane, wrinkles are stretched out, and the membrane is gently placed over the sprayed area. The distributor truck then backs up and sprays another 30- to 50-ft section of road, starting the spray over the membrane already installed. A sufficient portion of the installed membrane is coated with asphalt to allow for a minimum 1-ft lap joint. A new section of membrane is cut and installed forming an overlapping asphalt-sealed joint with the membrane already installed. The process is repeated throughout the curve. Final processing is as stated above.

#### Shoulder Construction

28. Upon completion of upper membrane placement, the bonded upper and lower membrane edges are anchored as shoulders and drainage ditches are constructed. This is accomplished using a road grader and small compactor, as shown in fig. 12. The road grader cuts drainage ditches to a depth below the elevation of the bonded membrane edges. This is necessary to ensure that standing water will not remain above the membrane edges. The soil removed is bladed onto the bonded membrane edges forming the road

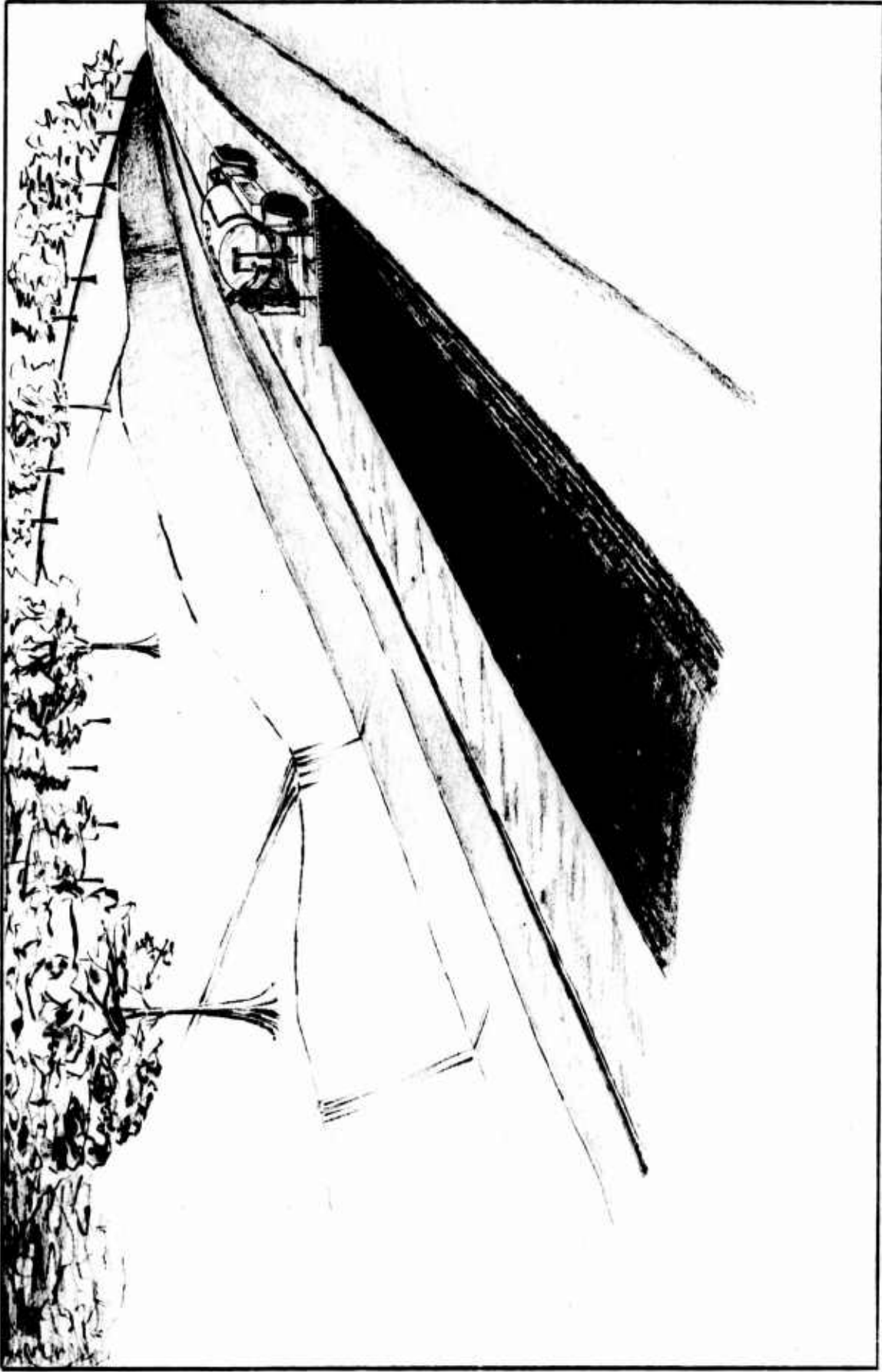


Fig. 10. Spraying asphalt on upper membrane (road with shoulders)

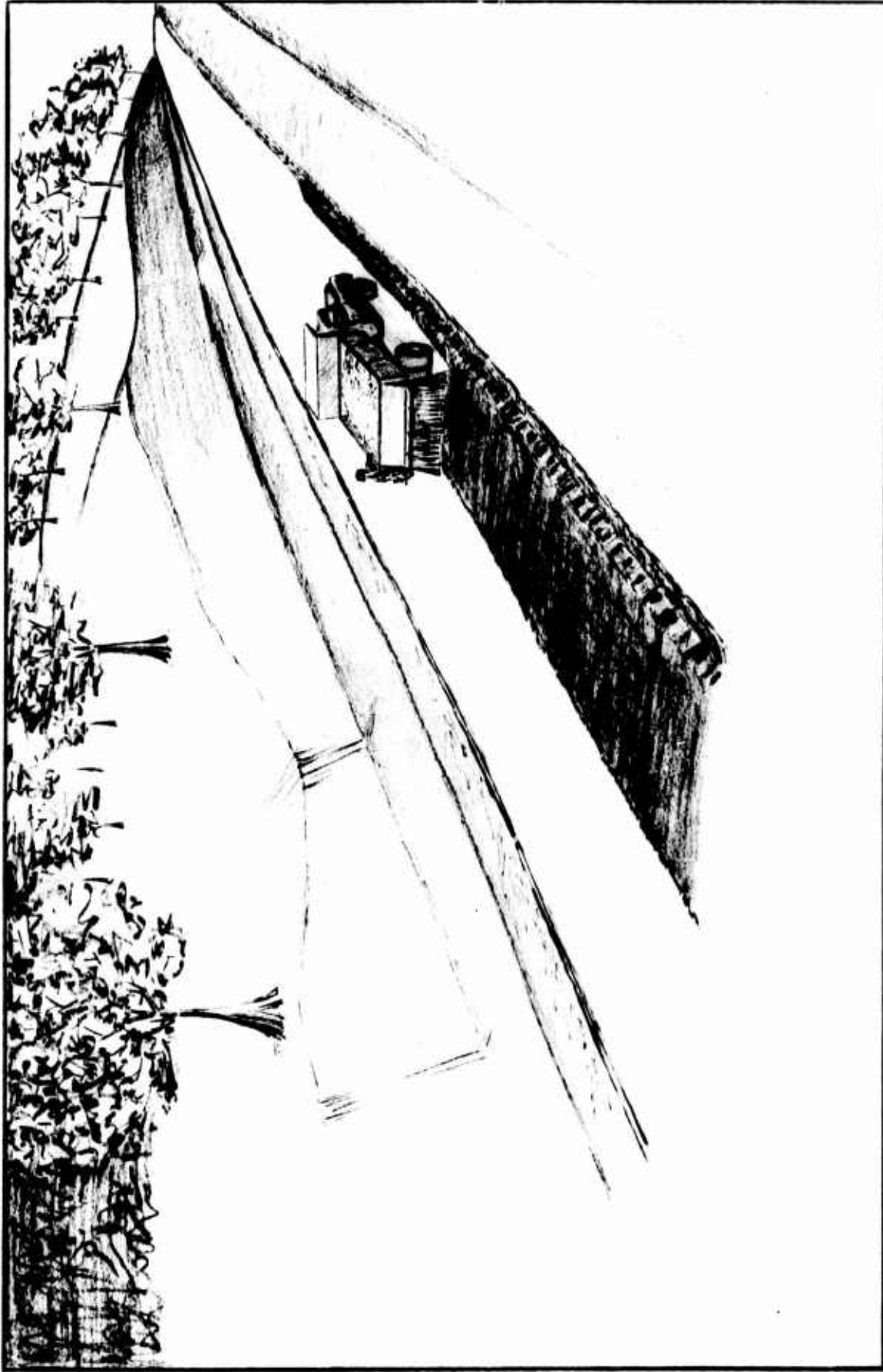


Fig. 11. Applying sand blotter course (road with shoulders)

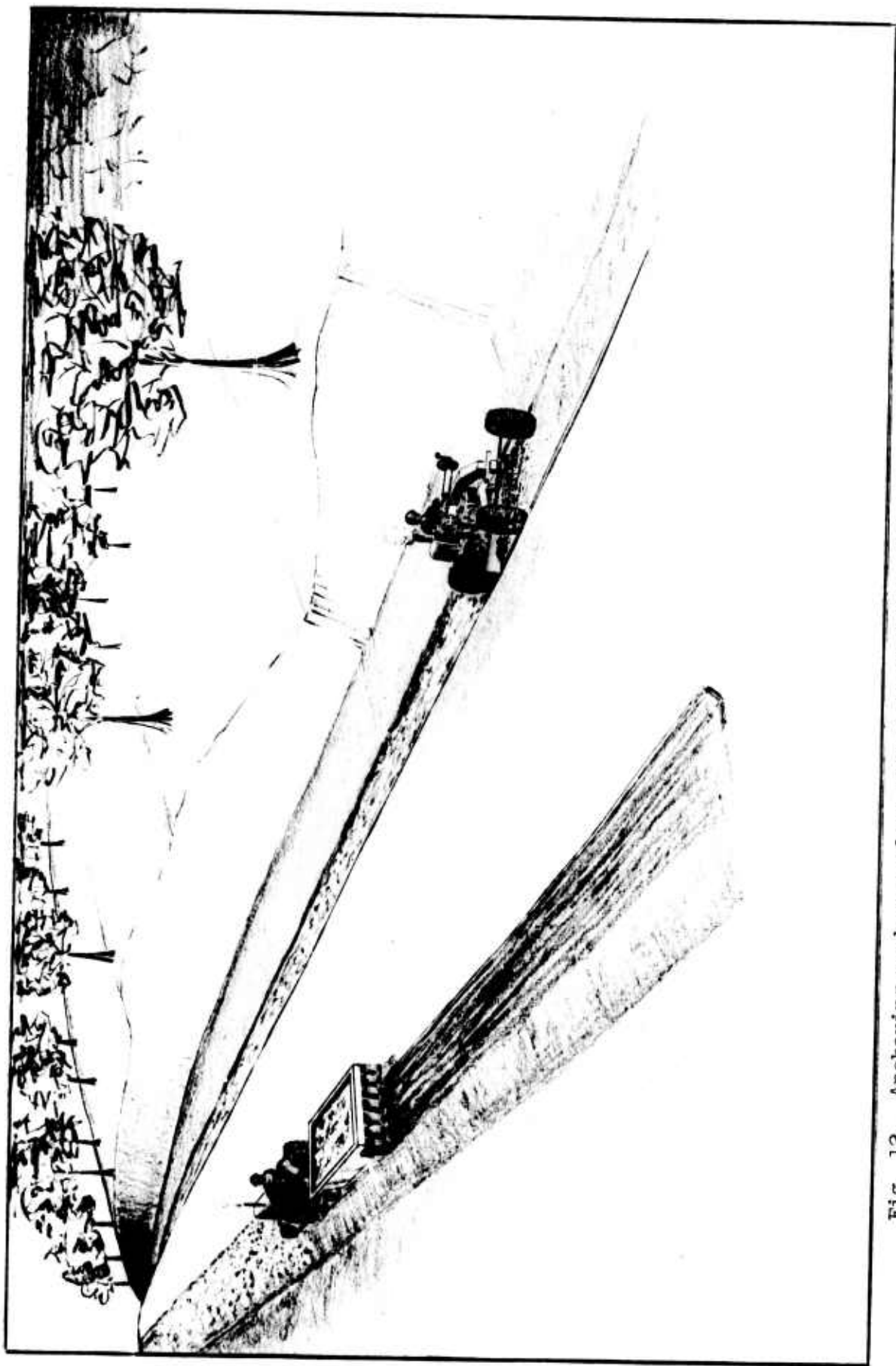


Fig. 12. Anchoring membrane edges while constructing shoulders and drainage ditches

shoulders. The shoulders are sloped to carry water from the MESL to the drainage ditches. Caution must be used when blading the soil near the membrane since the road grader can easily tear the membrane. The shoulders are then compacted as illustrated in fig. 12. Both shoulders can be completed at approximately 100 ft per 15 min.

## PART V: CONSTRUCTION TECHNIQUES FOR ROADS WITHOUT SHOULDERS

29. The following construction techniques are for use where working widths are restricted, such as through cuts or on narrow fills. It is assumed that grades and drainage have been established and that the roadbed soil to be encapsulated has a water content range that is within the proper construction limits. Using the following procedures, a roadbed width of approximately 35 ft is required for constructing an MESL road 24 ft wide.

### Earth Handling and Lower Membrane Placement

#### Earth removal along half of the road

30. The earth removal process is accomplished using a front-end loader. Fig. 13 illustrates how half of the soil to be used as the soil layer is removed and stockpiled on the other half of the road. First, a plow or ripper is employed to loosen the soil to the desired removal depth. The soil is loosened over the total road width plus approximately 8 ft. (By plowing the soil to a depth of 8 to 10 in. over a 32-ft-wide area, sufficient soil can be obtained for building a 1-ft-thick, 24-ft-wide MESL.) Next, the front-end loader removes the loosened soil from slightly more than half of the road and stockpiles this soil onto the other half of the road. Forward progress for this process is approximately 100 ft per 25 min.

#### Lower membrane placement on half of the road

31. A road grader is used as shown in fig. 14 for preparing the subgrade surface for lower membrane placement on half of the road. The grader smooths the surface and blades all loose soil onto the windrowed stockpile beyond the road center line. A lower membrane of sufficient width to cover only half the road is then placed as illustrated in fig. 15. The membrane is placed with approximately 6 in. overlapping the road center line. This overlap is necessary to provide a 1-ft center-line joint with the membrane to be placed later on the other half of the road. Approximately 5 min are required to place a 100-ft section of membrane.

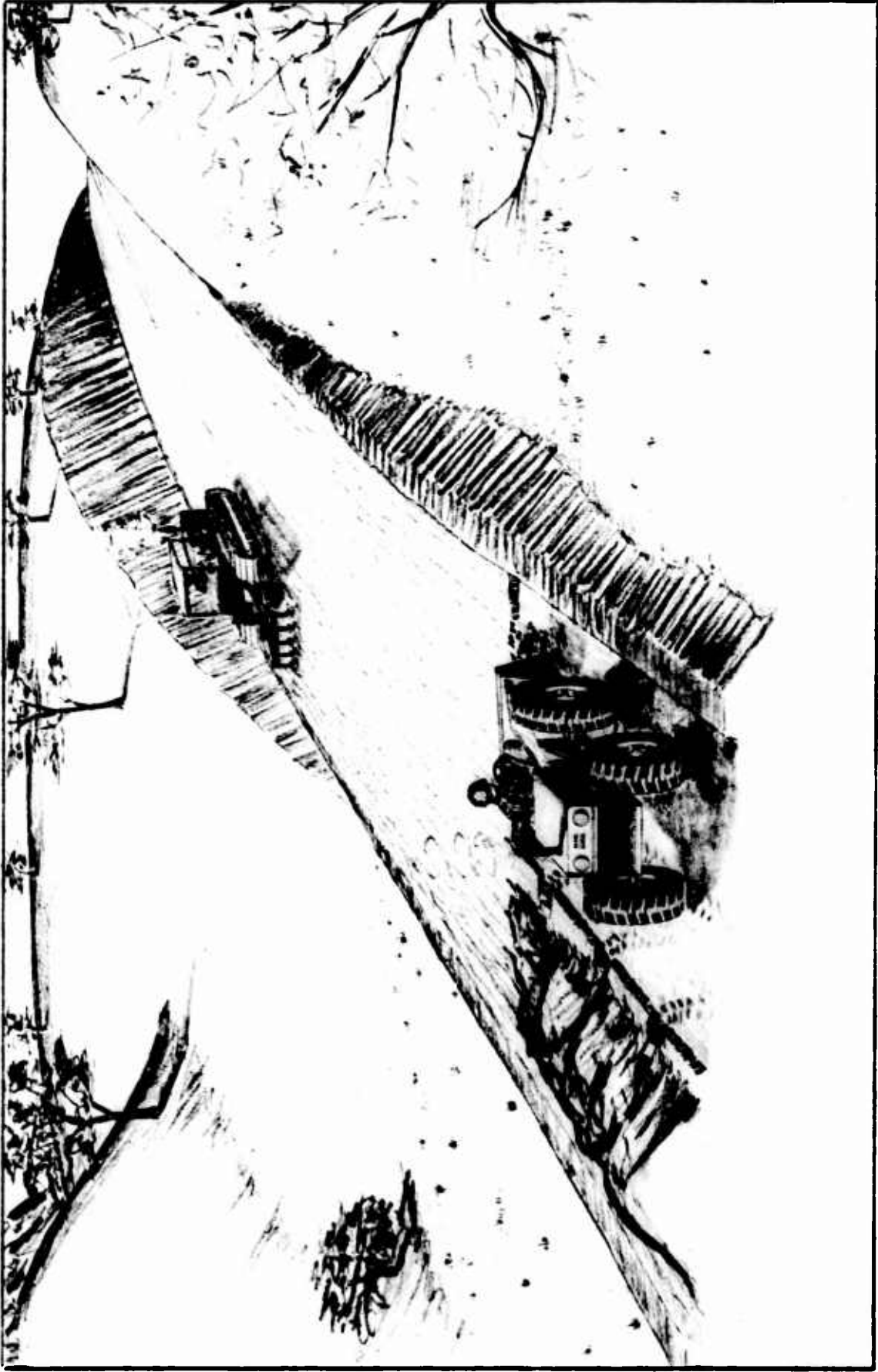


Fig. 13. Plowing soil for the MESL and stockpiling the soil from one half of the road onto the other half

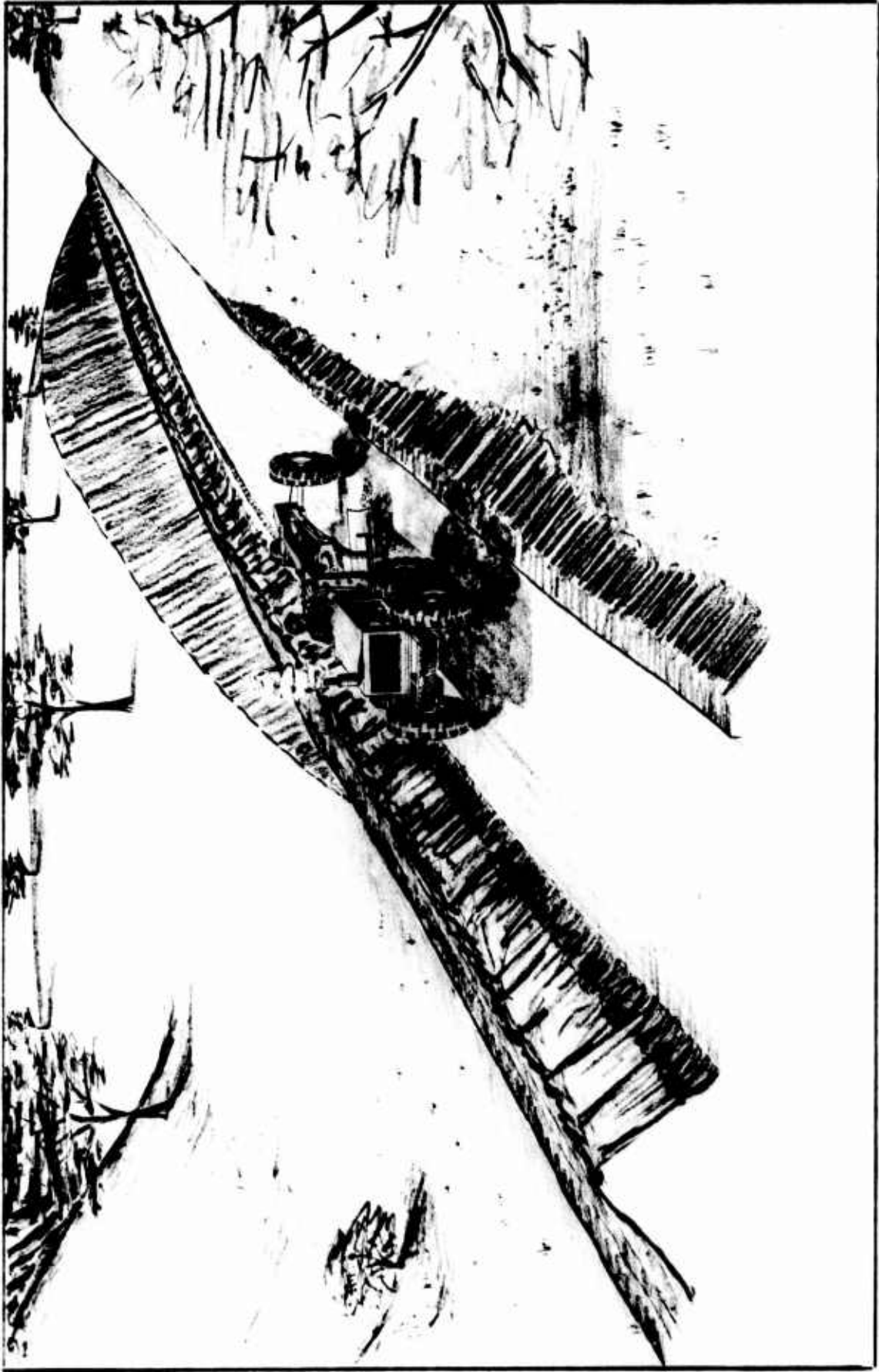


Fig. 14. Preparing subgrade surface for lower membrane placement on half of the road

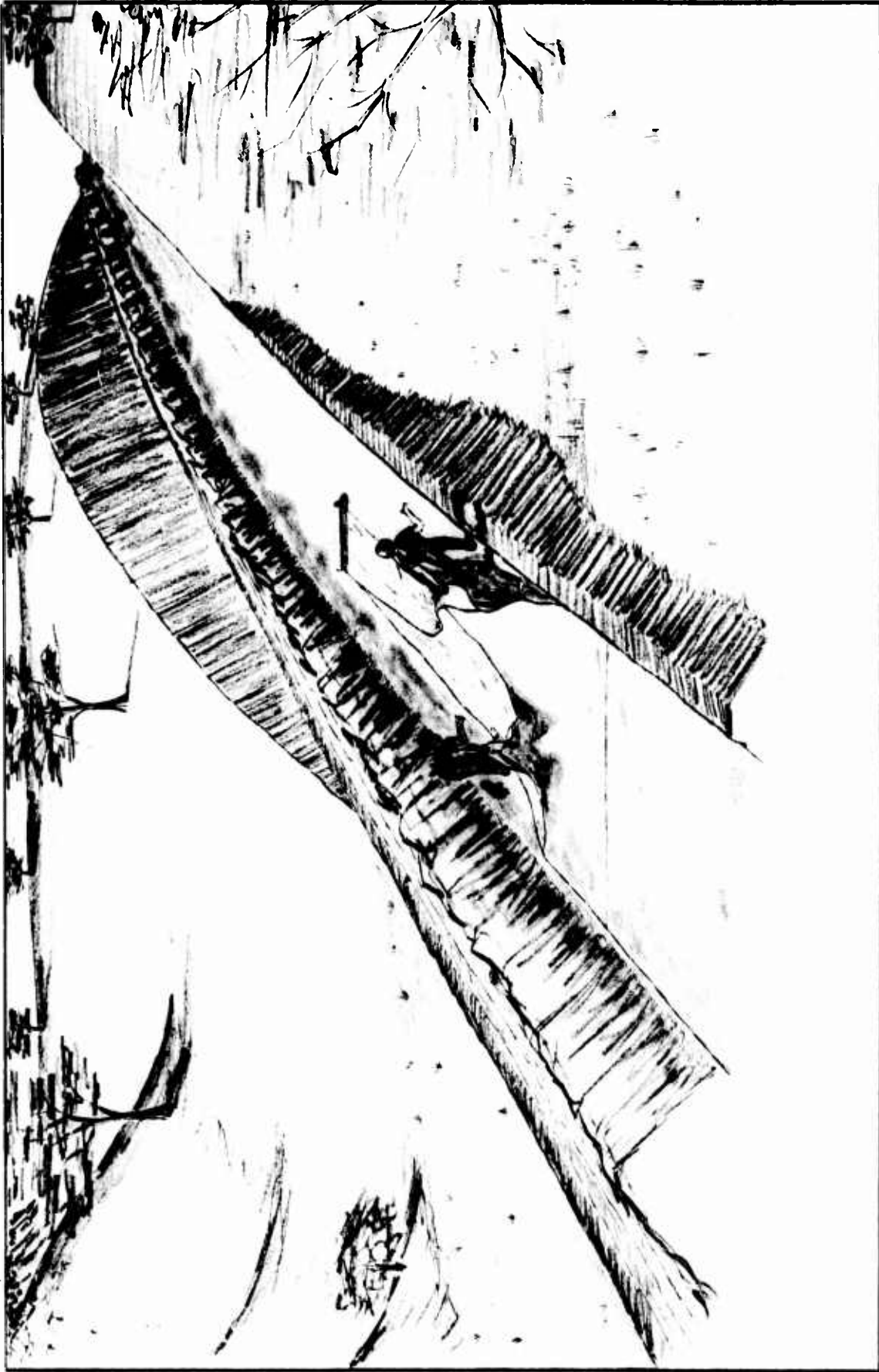


Fig. 15. Placing lower membrane on half of the road

### Lower membrane placement on other half of the road

32. Before the lower membrane can be placed on the other half of the road, the total soil for the MESL must be stockpiled on the membrane in place. This soil includes the stockpiled windrow of soil plus the plowed soil beneath it. Fig. 16 shows how this is accomplished using a front-end loader. Care must be taken to ensure that neither the center-line membrane edge nor the outside membrane edge is buried. One front-end loader can complete this phase of construction at a forward pace of about 100 ft per 45 min. Therefore, if this construction method is used over a long distance, additional front-end loaders should be employed at intervals to speed up the process.

33. The road grader smoothes the subgrade surface, blading any excess soil to the outside edge of the road. The lower membrane is then placed on this half of the road. One foot of the center-line edge of this membrane is placed underneath the lower membrane already in place. This forms a 1-ft center-line joint that will hold as the soil is spread back across the center line.

### Spreading and compacting

34. A road grader and/or small bulldozer is used to spread the soil. Fig. 17 shows a grader spreading the soil uniformly over the two halves of the lower membrane. A minimum of 2 ft of membrane edge is left exposed along each side of the road for bonding with the upper membrane. The soil is then compacted in the same manner as discussed under construction techniques for roads with shoulders. Fig. 18 shows the soil being compacted with a self-propelled rubber-tired compactor.

### Upper Membrane Placement and Anchoring

35. Upper membrane placement is accomplished in the same manner as for roads with shoulder areas. Figs. 19-21 show the membrane being applied, sprayed with asphalt, and blotted with sand, respectively. After the upper membrane is installed and sand blotted, a road grader and small rubber-tired compactor are used for anchoring the bonded upper and lower membrane

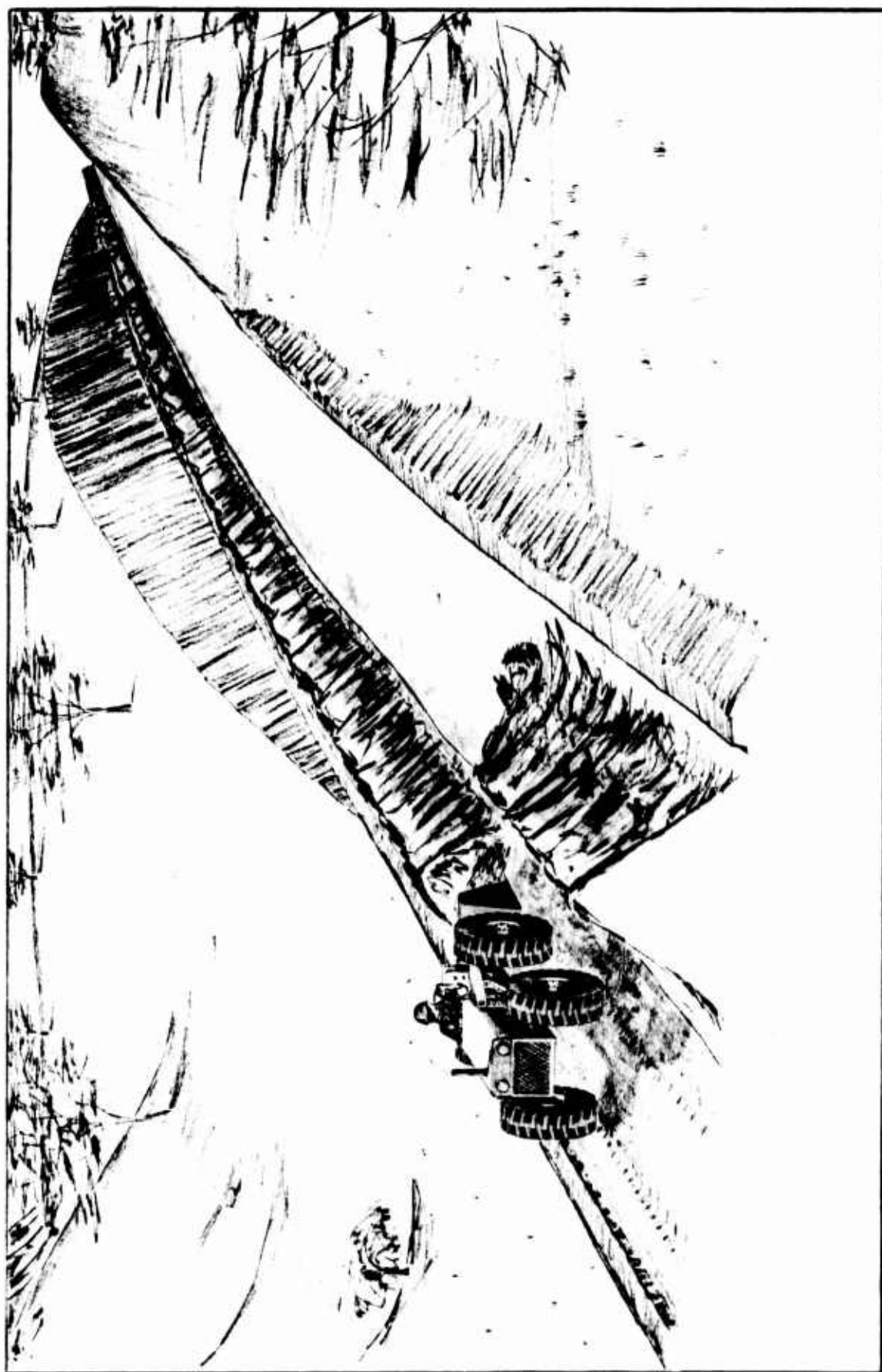


Fig. 16. Placing total soil for the MESL on the lower membrane

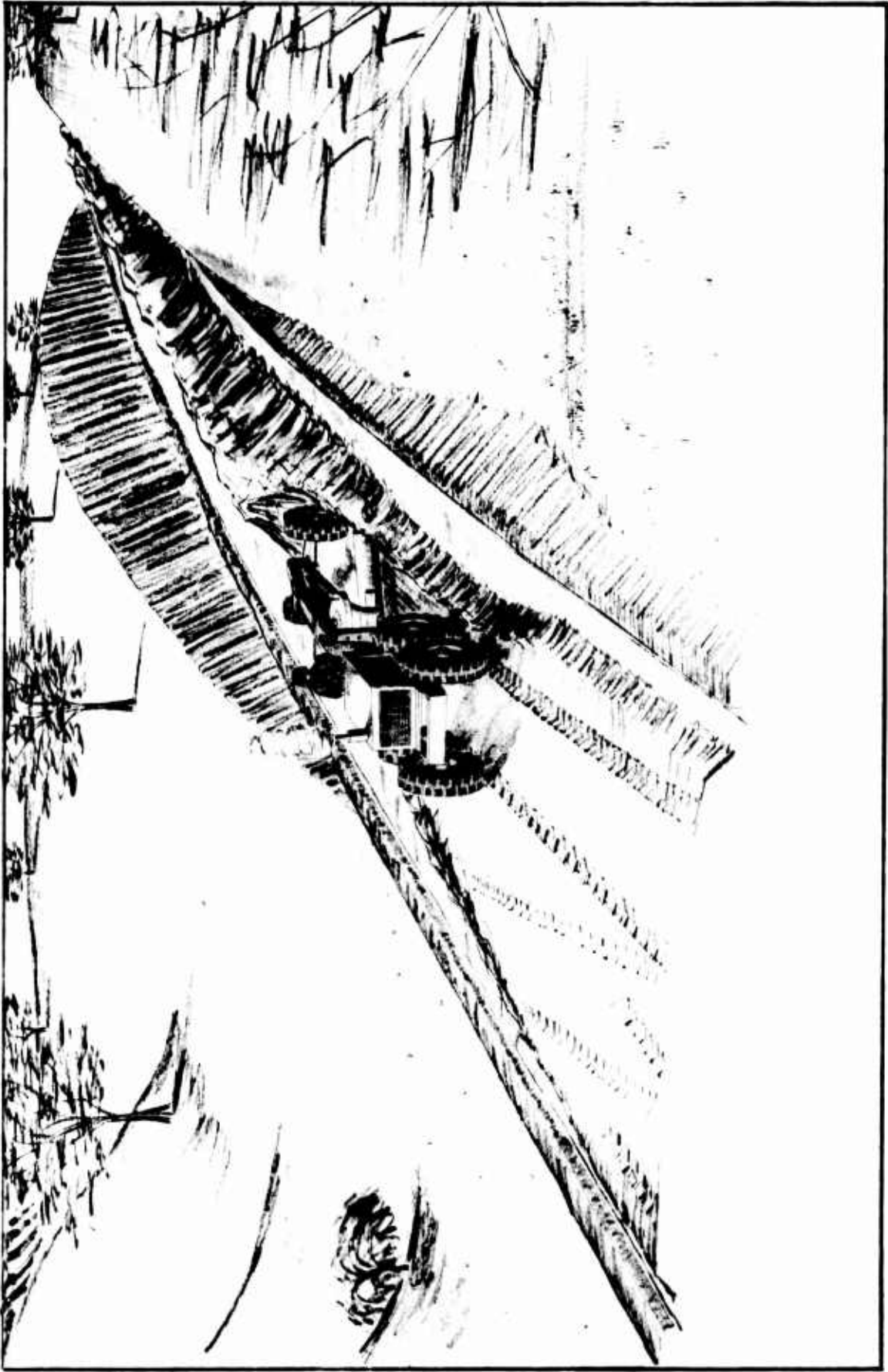


Fig. 17. Spreading the soil after placement of membrane on the second half of the road

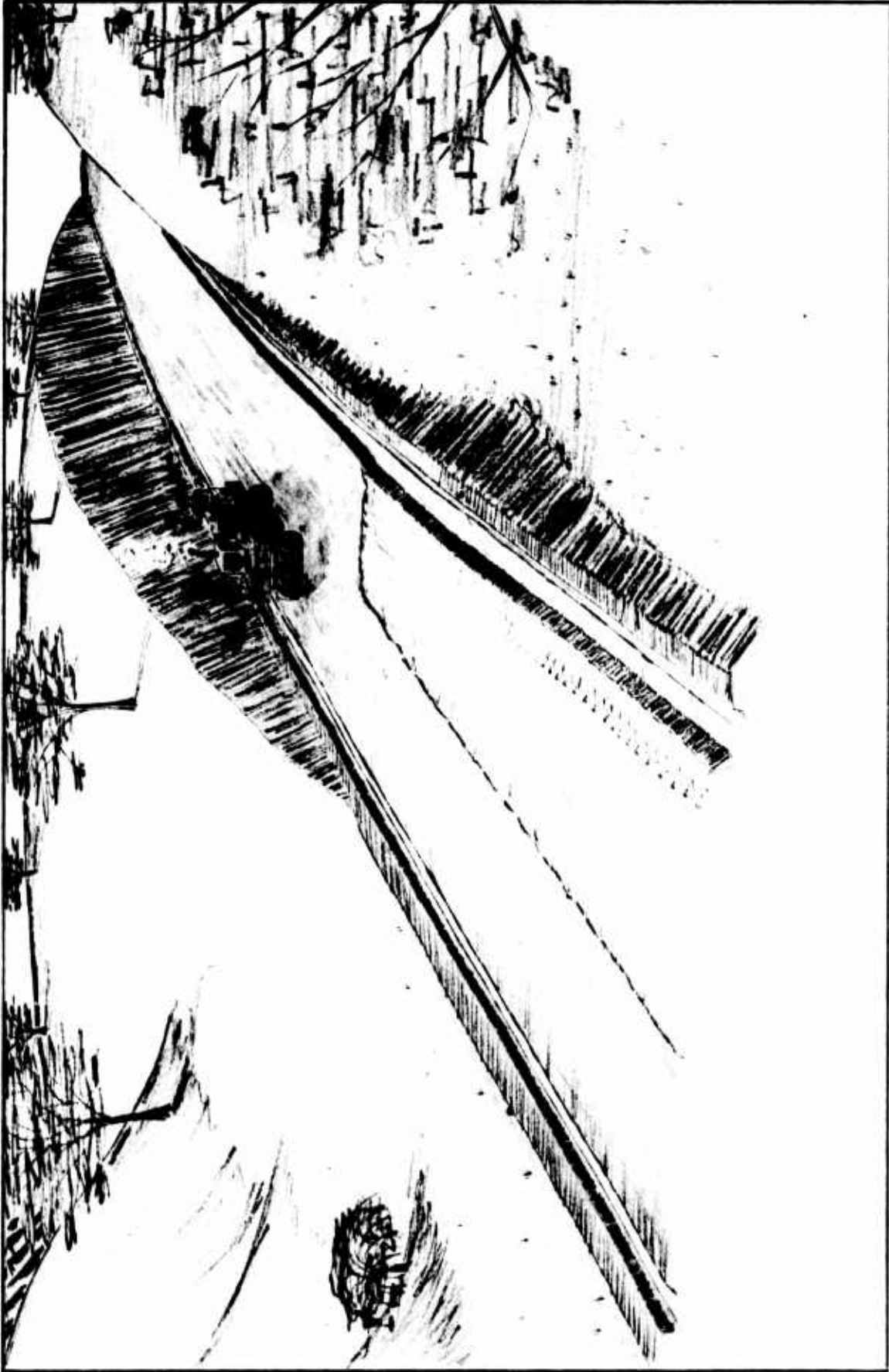


Fig. 18. Compacting soil on lower membrane (road without shoulders)

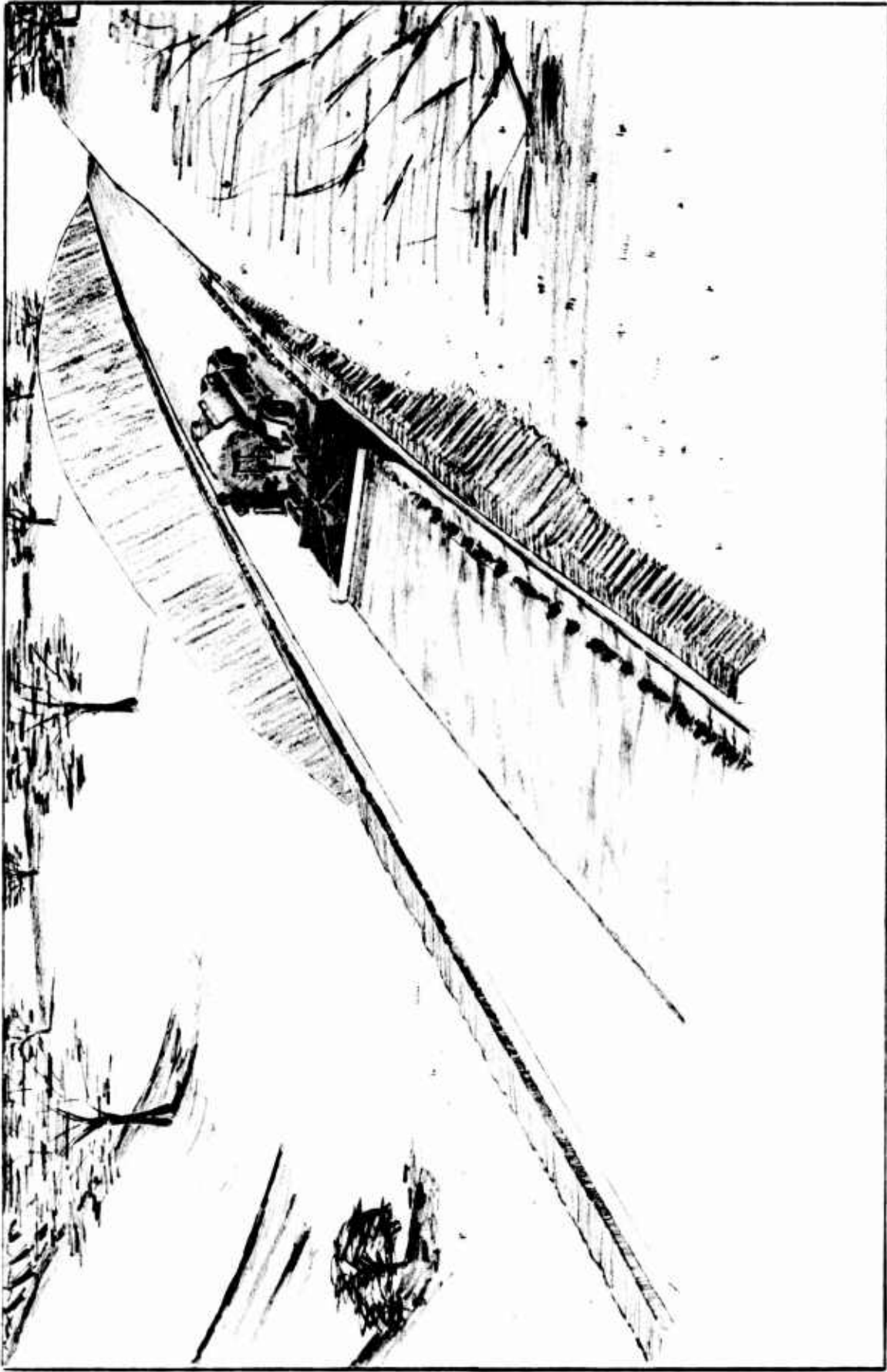


Fig. 19. Spraying asphalt and installing upper membrane (road without shoulders)

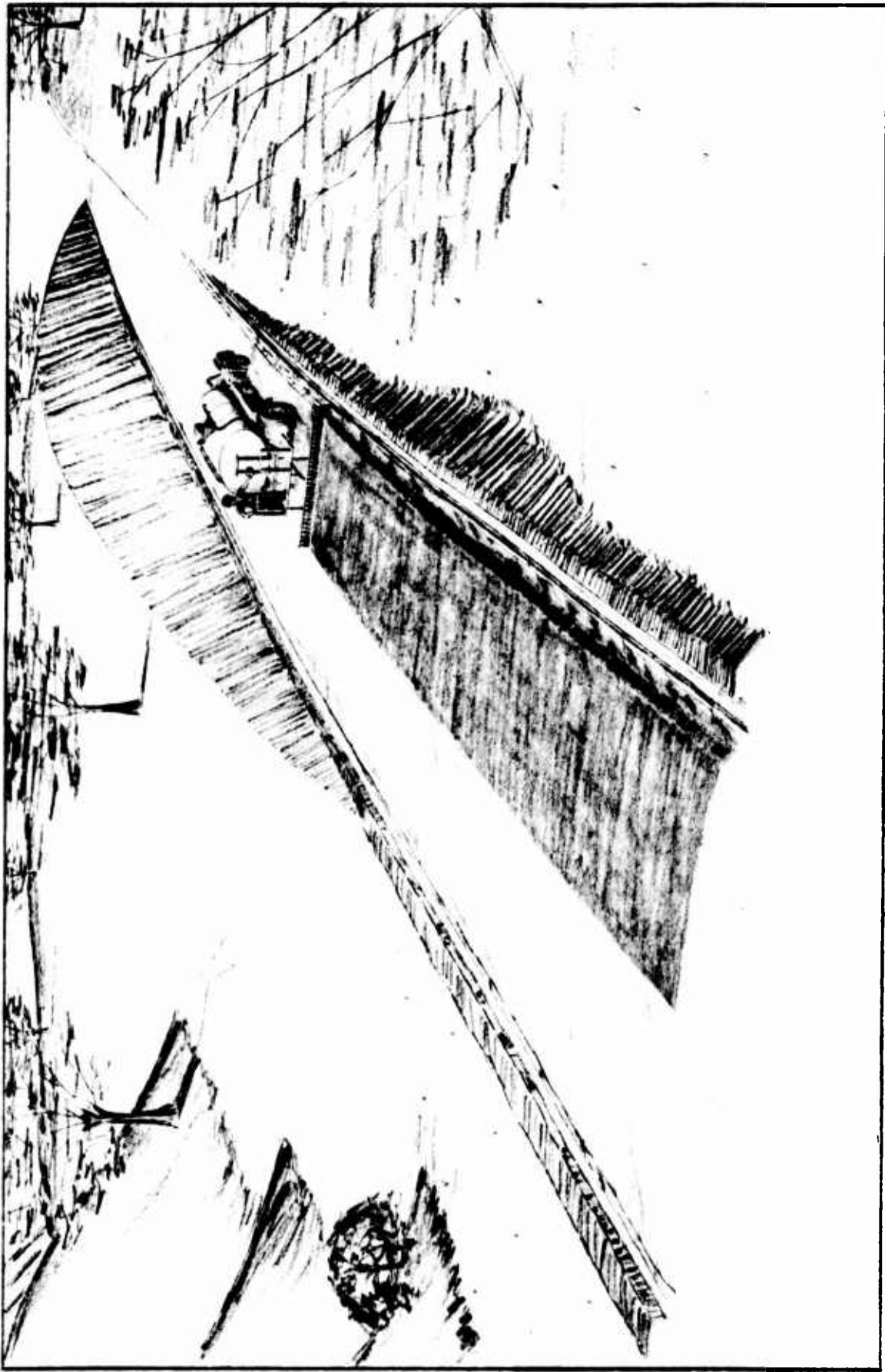


Fig. 20. Spraying asphalt on upper membrane (road without shoulders)

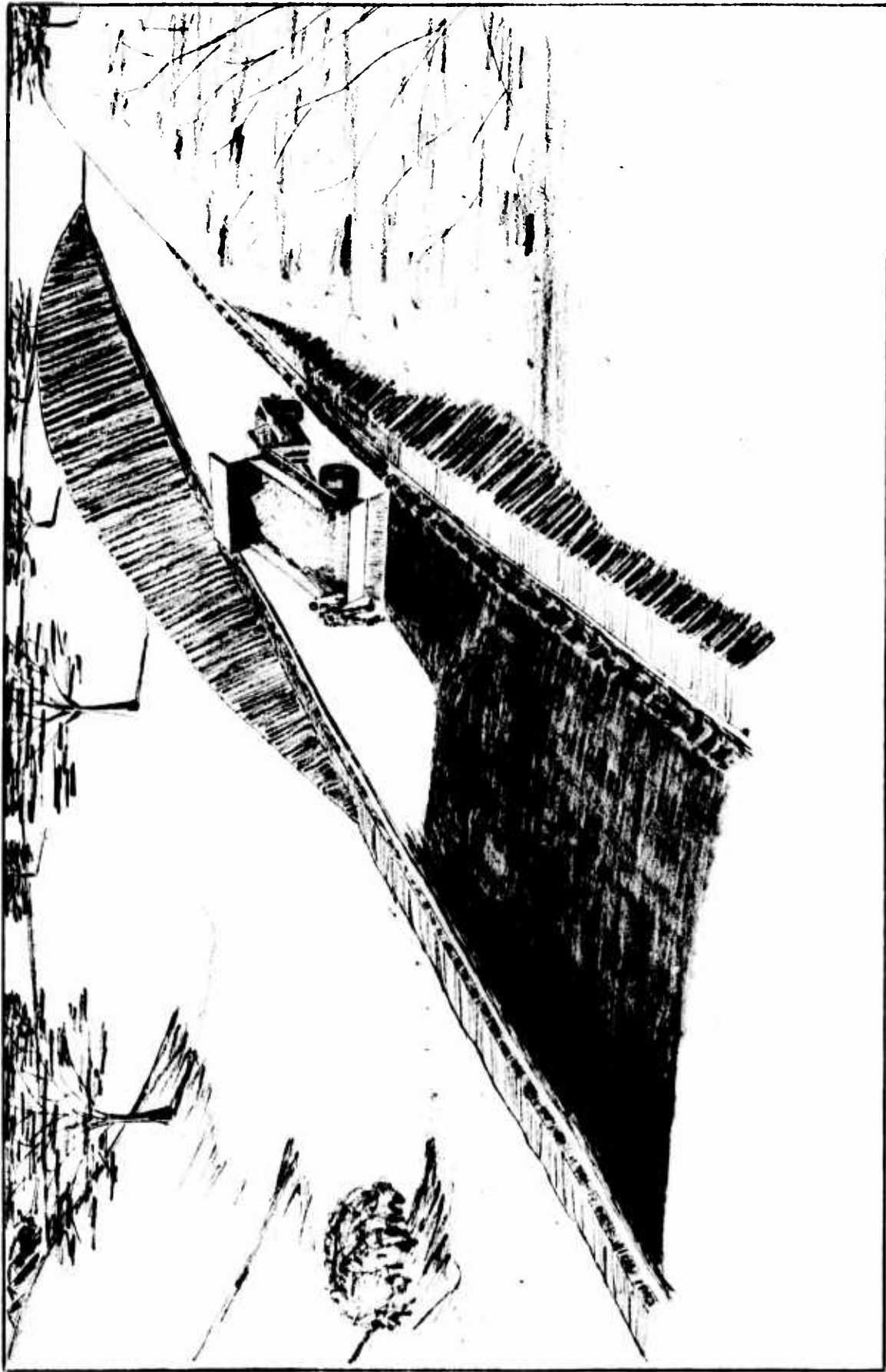


Fig. 21. Applying sand blotter course (road without shoulders)

edges. This process is accomplished as shown in fig. 22. The grader, operating with half of its wheels on the completed upper membrane, is maneuvered to carefully blade the side soil onto the membrane edges. When operating in a narrow cut area, the grader forms the side drainage ditch as it buries the membrane edges. The grader operator must be very careful not to allow the blade or tires to damage the upper membrane. The soil is then compacted using the small compactor.

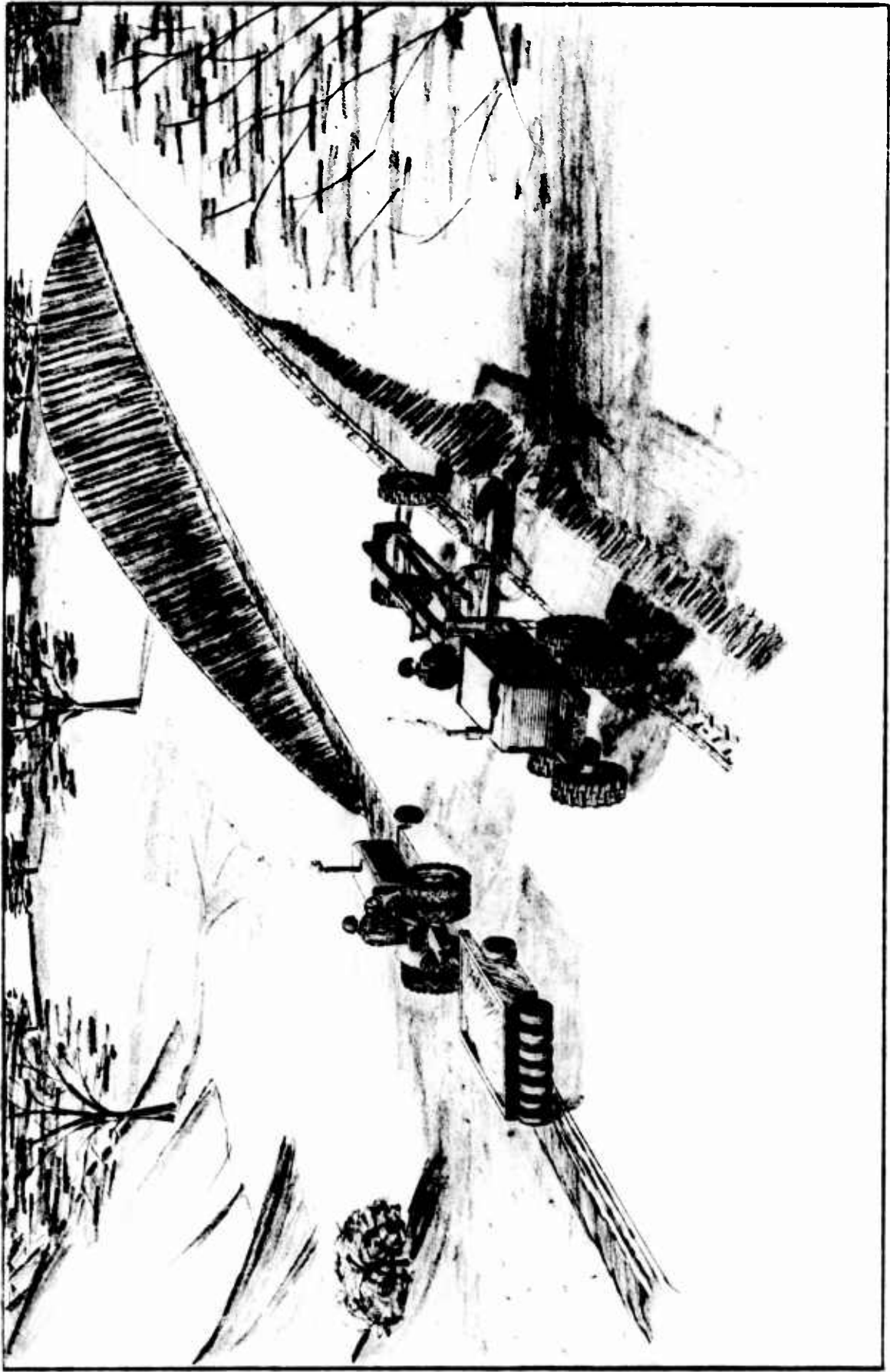


Fig. 22. Anchoring membrane edges while constructing necessary drainage

## PART VI: CONSTRUCTION TECHNIQUES FOR ROADS ON SOFT SUBGRADES

36. The following construction techniques are for use where the in-place soil is too wet to be encapsulated, such as in low-lying areas that have high water tables. The procedures are based on hauling local soil having a suitable water content and using this soil in the MESL.

### Earth Handling and Lower Membrane Placement

#### Shoulder construction

37. The first procedure involves constructing shoulders to contain the soil that is to be hauled in. A road grader is used as shown in fig. 23 for constructing the shoulders. The shoulders are spaced so as to establish the desired road width. The height of the inside portion of the shoulders should equal the design thickness of the MESL. The inside faces of the shoulders should be as nearly vertical as possible.

#### Lower membrane placement

38. The lower membrane is placed as shown in fig. 24. The membrane is unrolled, unfolded, and placed flat on the subgrade surface. The width of the membrane should be adequate to lap each shoulder a distance of approximately 2 ft past the vertical edge. Membrane placement around curves and lap joints between sections of membranes are accomplished in the same manner as described for roads with shoulders.

#### Earth installation

39. Earth installation is accomplished by a back-dump procedure as illustrated in fig. 25. A dump truck loaded with suitable local soil back-dumps the soil on the lower membrane. A small bulldozer spreads the soil. While the bulldozer spreads the soil on one side of the road, another load of soil is dumped on the other side. The initial lift of the soil placed on the lower membrane must be thick enough to support the operations of the construction equipment. Otherwise, soft subgrades will rut, causing damage to the lower membrane. Additional lifts of soil are then installed until the desired MESL thickness is obtained. Compaction of each lift of soil can be obtained by having the loaded dump trucks drive over different paths

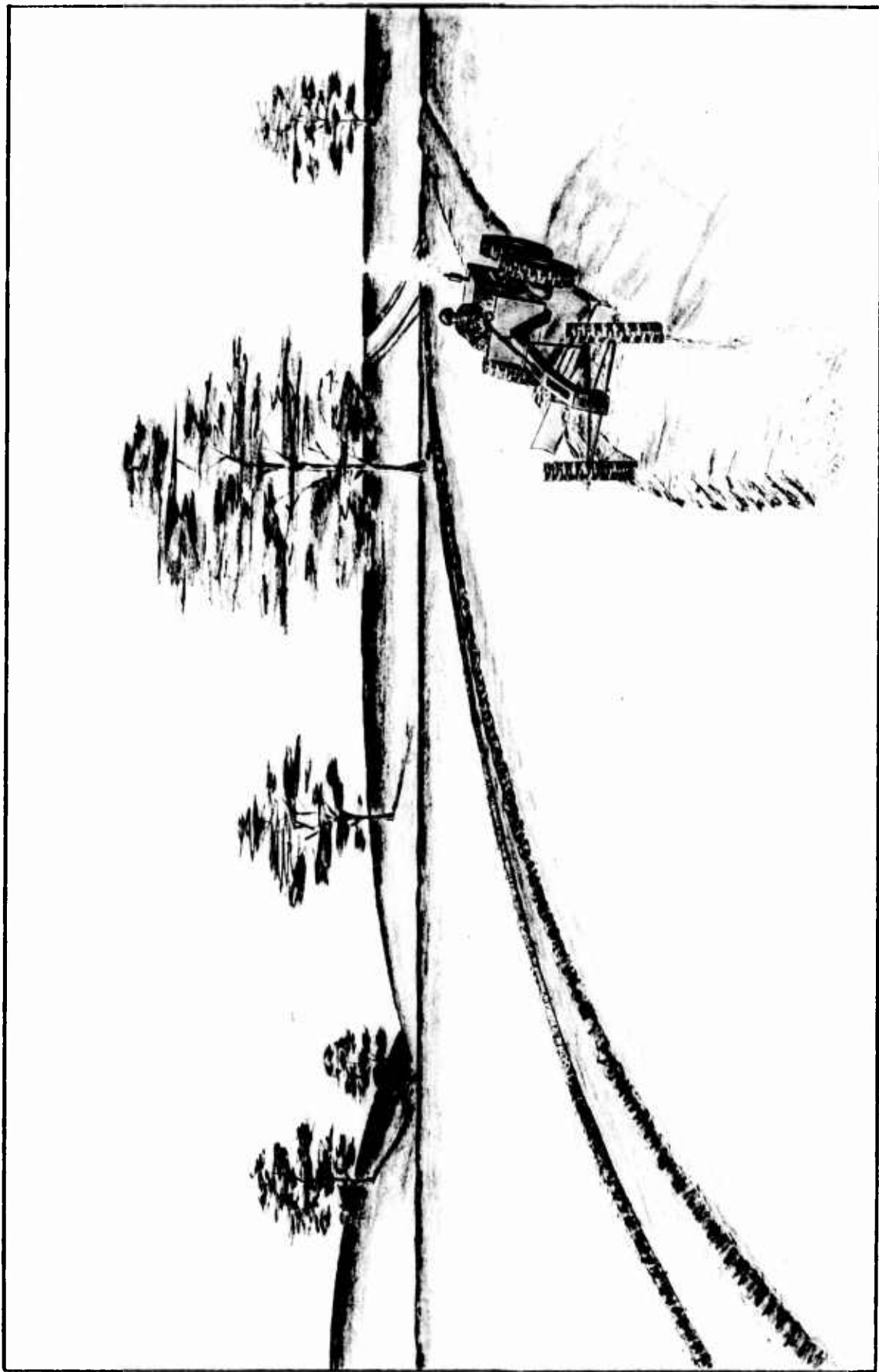


Fig. 23. Constructing shoulders

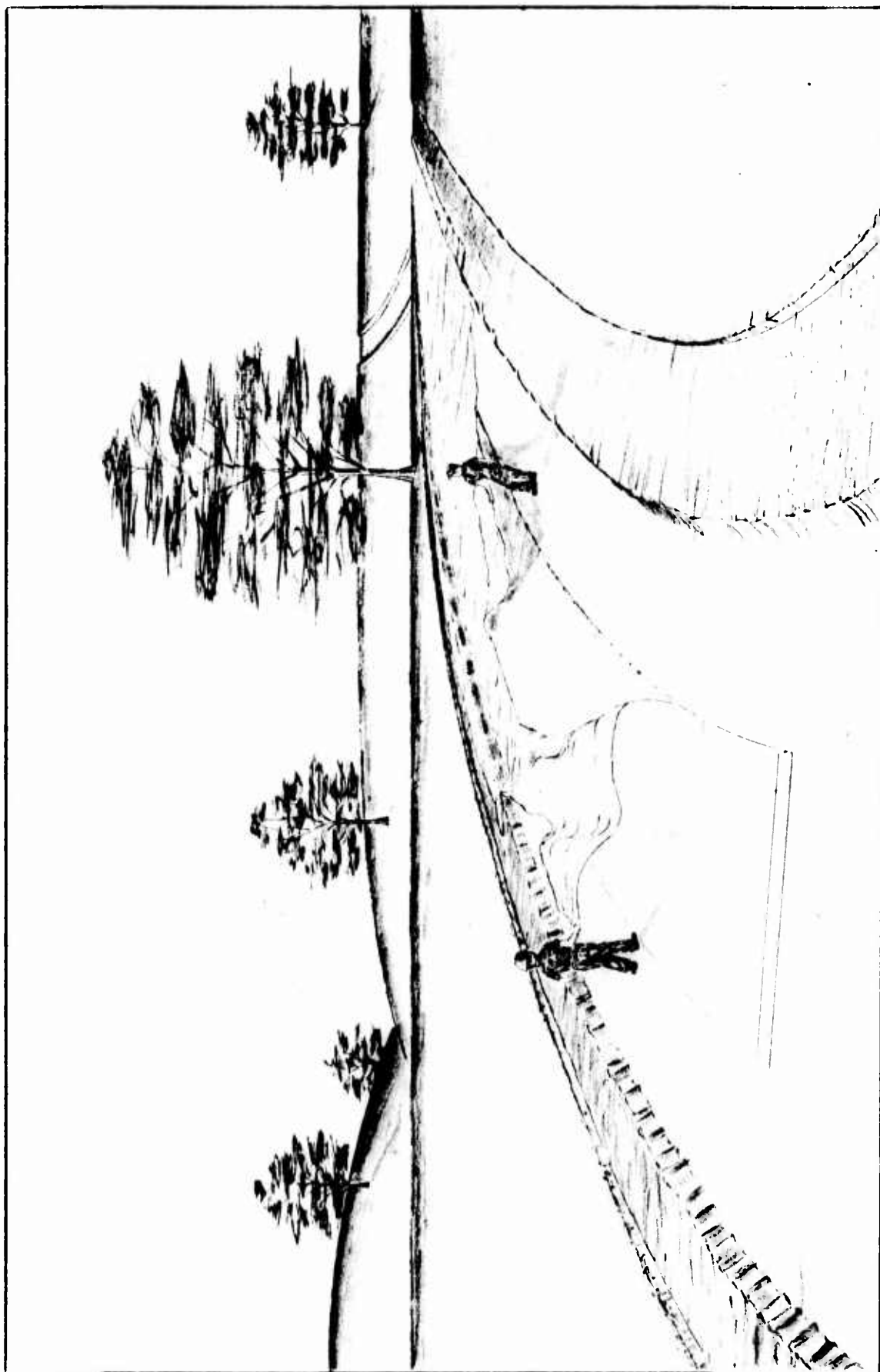


Fig. 24. Placing lower membrane

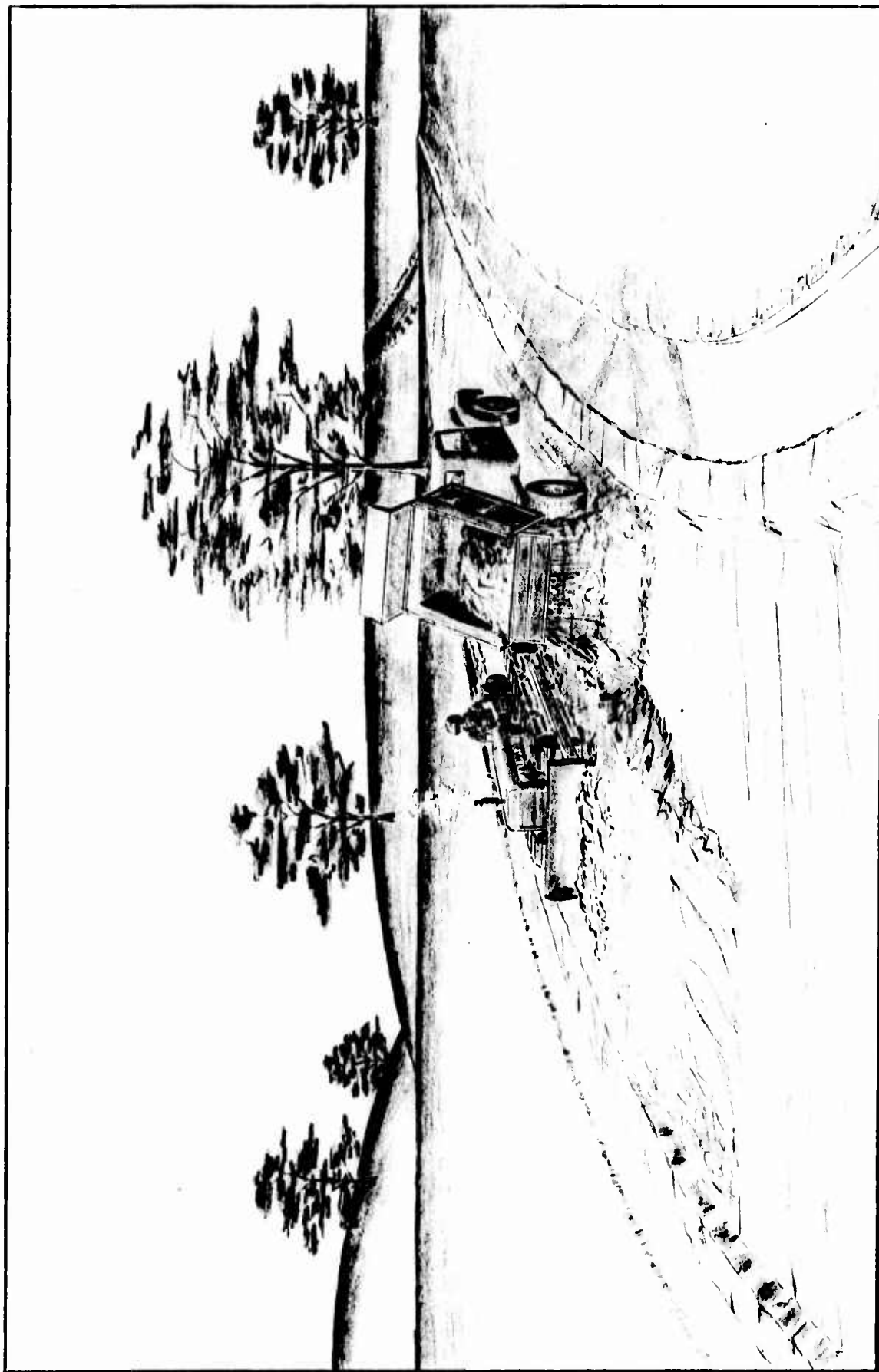


Fig. 25. Installing soil on lower membrane

as they deliver the soil. After the final lift of soil is installed, a road grader is used to form a crown in the road. Caution must be exercised in order not to tear or bury the edges of the membrane. A rubber-tired compactor is then used to compact the surface soil to the desired density.

40. Progress rates and equipment requirements for this type earth installation are dependent on many factors, such as haul distances, MESL thickness, subgrade strength, etc. Accurate estimates can be made when the factors involved for a particular road situation are known.

#### Upper Membrane Placement and Anchoring

41. Before the upper membrane is installed, the road grader cuts an anchor ditch along the road. This ditch is made as shown in fig. 26. The lower membrane edges are folded back upon the compacted soil, and the road grader cuts a ditch along the edge approximately 6 in. from the membrane. The lower membrane is then folded back into this ditch, and the road is ready for upper membrane placement.

42. The upper membrane is installed following the same procedures described earlier in this report. The upper membrane edges are placed so that they lie over the asphalt-coated lower membrane edges that are in the ditch. Fig. 27 shows the upper membrane being installed around a curve. After the upper membrane is installed, the road grader blades soil back into the ditch, anchoring the asphalt-bonded membrane edges. The shoulders are then shaped for proper drainage and compacted using a rubber-tired compactor.

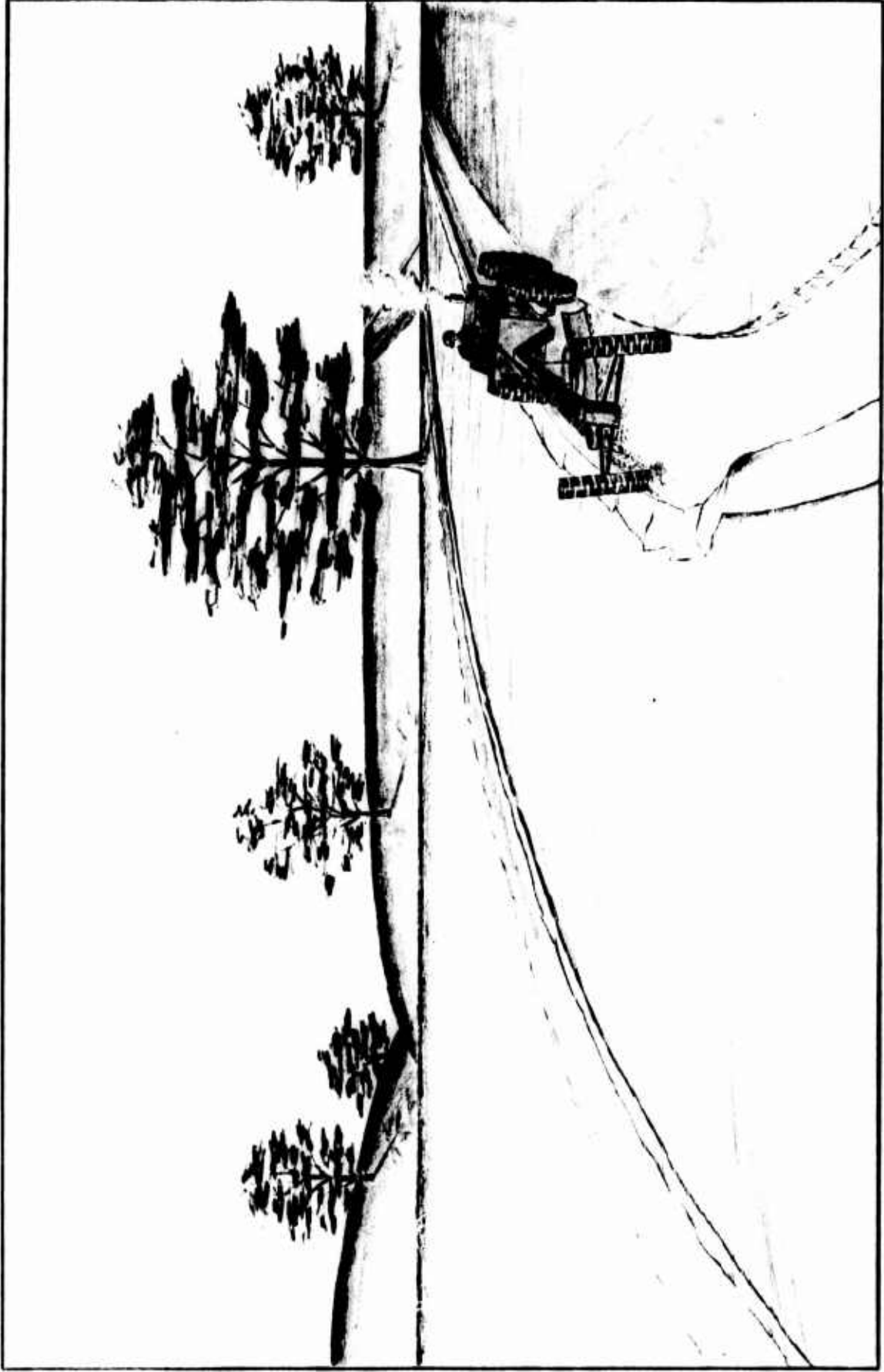


Fig. 26. Cutting ditch for anchoring membranes

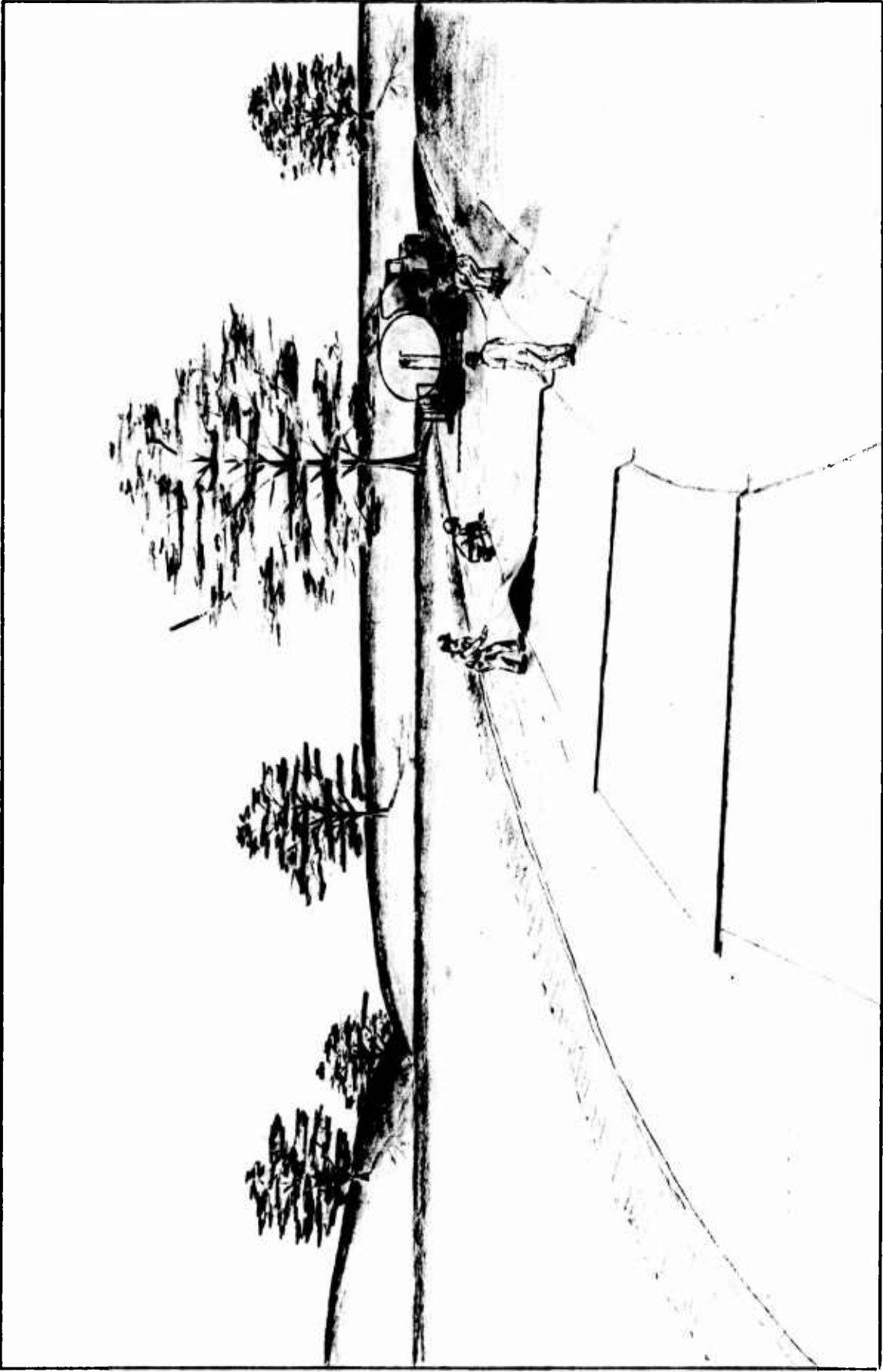


Fig. 27. Installing upper membrane around curve

## PART VII: MAINTENANCE AND REPAIR

### Preventative Maintenance

43. Shoulder areas can be treated to prevent water erosion and increase the useful life of an MESL road system. An excellent inexpensive shoulder treatment is obtained by using a polypropylene-asphalt membrane. This membrane can be applied in the same manner as the upper road membrane. A less expensive polypropylene material and smaller amounts of asphalt can be used. If the edge of the road is swept clean, the polypropylene-asphalt shoulder membrane will form an excellent bond with the road surface.

### Repair

44. When tears or other damage occur in the upper wearing membrane, repairs should be made immediately to prevent water from entering the MESL. If water enters the soil layer, the wet soil must be removed and replaced. Patching the upper membrane is accomplished with a piece of membrane 2 ft larger than the area to be patched. When failures in the upper membrane are detected before damage occurs in the soil layer, patches can be applied directly over the failed surface.

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<b>13. ABSTRACT</b> The purpose of this instruction report is to provide information and guidance for the construction and maintenance of membrane-enveloped soil layers (MESL) as base courses on roadways in the theater of operations. The concept involves complete encasement of a compacted layer of fine-grained soil by a lower and upper waterproof membrane. The upper membrane is capable of supporting limited rubber-tired traffic operations. It is formed by applying emulsified asphalt to the surface of the soil layer, placing polypropylene material, applying a second coat of asphalt, and then placing a blotter layer of sand. An MESL road system is applicable for use on roadways where materials for conventional construction of foundation layers are not available without considerable expenditure of time, effort, or money. However, use of the MESL concept as permanent road construction practice has not been proved feasible. Construction techniques for roads with shoulders utilize the in-place roadbed soil in the MESL. The process involves removing the soil and stockpiling it on the shoulders, placing the lower membrane, replacing the soil on the lower membrane, compacting the soil layer, and then installing the upper wearing membrane. The procedures can be combined to form a continuous train-type construction operation. Construction techniques for roads without shoulders, such as through cuts or on narrow fills, involve working with half the road at a time. The in-place roadbed soil is used in the MESL. Construction techniques for roads on soft subgrades, such as in low-lying areas with high water tables, are based on hauling a local soil having a suitable water content and using this soil in the MESL.			

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